

USER'S MANUAL FOR

***LRFD PRESTRESSED CONCRETE
GIRDER DESIGN AND RATING
(PSLRFD)***



pennsylvania
DEPARTMENT OF TRANSPORTATION

Version 2.17.0.0

**USER'S MANUAL FOR
COMPUTER PROGRAM PSLRFD
LRFD PRESTRESSED CONCRETE GIRDER DESIGN AND RATING
VERSION 2.17.0.0**

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SUMMARY OF AUGUST 1997 REVISIONS - VERSION 1.1

PSLRFD Version 1.1 contains the following revisions:

1. Pedestrian loads can now be considered for live load analysis. The following limit states were added to consider pedestrian loads: Strength IP, Service IP and Service IIIP.
2. The upper and lower limits for the allowable stress parameters of the CONCRETE MATERIAL ALLOWABLE PROPERTIES (MCA) Command were reviewed and several limits were revised.
3. The lower limit for the Drape Point Location parameter of the DRAPE POINT LOCATION (DPL) Command was increased to prevent a decimal value from being entered.
4. The default deflection distribution factor computed by the program was revised to include the multiple presence factor.
5. A new User's Manual has been published to reflect the program revisions.

SUMMARY OF NOVEMBER 1997 REVISIONS - VERSION 1.2

PSLRFD Version 1.2 contains the following revisions:

1. The SPECIAL AXLE LOAD Input Summary table was corrected. An incorrect conversion factor resulted in printed axle loads greater than the input Special Axles Loads. However, the correct axle loads were used for analysis.
2. A conversion factor was not appropriately applied to the SPECIAL LIVE LOAD Lane Load for analysis. This resulted increased live load effects for the Special Live Load analysis. The conversion factor was added to the Special Live Load lane loading.
3. Analysis Live Load options "B" and "C" were corrected. Previously, analysis runs using Live Load option "B" included the PHL-93 live loading instead of the HL-93 loading and an analysis runs using Live Load option "C" included the HL-93 live loading instead of the ML-80 loading .
4. The debonded strand configuration check for the bottom row of strands was corrected. Also, corrective measures were added when the number of debonded strands required for crack control debonding at the end of the beam exceeds the total number of prestressing strands.
5. The "DBS" command was revised to require user input for the "Debonded Length", "Strand Row Number" and "Strands Debonded" parameters. Previously, when these parameters were left blank, a fatal program error resulted.
6. These revisions did not affect the User's Manual.

SUMMARY OF OCTOBER 1998 REVISIONS - VERSION 1.3

Since the release of PSLRFD Version 1.2 several errors reports and user requested enhancements have been received. This release of PSLRFD Version 1.3 contains only the error corrections that required a short amount of development time or that are vital for productive use of the program. There are still several outstanding problems that will have to be addressed in future releases of PSLRFD. What follows are two lists, one containing the revisions included in Version 1.3 and the other containing the remaining errors from Version 1.2 that were not corrected in Version 1.3.

PSLRFD Version 1.3 contains the following revisions:

1. Several corrections and adjustments have been made to the design procedure which result in more economical designs.
2. The HL-93 live load option has been corrected. Previously, the HL-93 load case was run using the PHL-93 loading.
3. The lower limit for the "Distance to First Row" parameter of the SCA command was changed to 1" (25mm) to allow older beams to be analyzed and rated.
4. A tolerance check that occasionally allowed the moment capacity at analysis points near the support to be set to zero has been corrected. This problem would result in negative rating factors.
5. A check was added the STI command to insure the "Stirrup Location" entered is greater than the previous one entered.
6. The gross vehicle weights for ML-80 and HS20 were corrected. The incorrect vehicle weights resulted in incorrect rating tonnage for these live loads.
7. Previously, some straight strand designs and debonded strand designs resulted in strand patterns with no strands in the bottom row. Although these were valid designs, it is more desirable to spread the prestressing force over more of the beam cross section. Therefore, the strand pattern design routine was revised to leave some strands in the bottom row. The strand pattern design routine was also revised to select a strand pattern within a specified tolerance of the theoretical eccentricity depending on whether initial stresses or final stresses control the design. Previously, the program assumed final stresses controlled and selected strand patterns based on this assumption. When initial stresses controlled, the strand pattern selected could result in some minor overstressing at release causing the program to reject the beam and select a larger beam than actually required.
8. The beam tables were revised to allow more than 20 rows of strands for deeper beams.

9. The parameter definition file was revised to allow the use of the Special 270K ½" diameter low lax strand by increasing the upper limit of the "P/S Strand Area" parameter of both the SCD and SCA commands to 0.167in² (107.74mm²).
10. The default dead load point of contraflexure locations were corrected for the interior and last spans.
11. The "Skew Angle" limits for the SKW command were corrected in the parameter definition file.
12. The units heading for "Distance" in the "Shear Reinforcement and Resistance" output table was changed to "(in)" instead of "(ft)".
13. A case was found where an actual computed dead load point of contraflexure fell outside the allowable input range causing an error and stopping program execution. Therefore, the program was revised to print a warning message and continue execution in such a case.
14. The program was revised to extend the design negative moment capacity into the negative DL+LL moment range. This was done to avoid negative moment rating factors of less than one for analysis points outside the dead load points of contraflexure when the DL+LL moment is negative. Although designers are only required to provide negative moment reinforcement in the slab between the DL points of contraflexure and the normal slab reinforcement will carry these small negative moments, this temporary fix was required to ensure the controlling negative moment rating reported by the program was from the critical design location. This will be addressed in future releases.
15. The SI upper limit and default for the "Depth Difference" parameter of the DES command was changed from 150mm to 155mm since there are consecutive beams in the beam table whose depth difference is 155mm.
16. A code failure is no longer reported when end block stresses exceed allowable stresses. Instead, a message is printed below the "End Block Stresses" output table stating that crack control debonding is required.
17. Several pages of the User's Manual have been revised.

The following is a list of reported errors, user requests and clarifications from PSLRFD Version 1.2 that have not been addressed in Version 1.3.

1. User cannot restrict the use of the two corner strand positions to allow room for confinement steel.
2. There seems to be several problems when using the symmetry option for input. One such problem is when entering diaphragms for a symmetric multi-span bridge using DIA, the program reports an input error for diaphragm locations beyond the mid-span of any full span that is before the point of symmetry. This can be avoided by using the CLD or DLD commands to input diaphragm weights.

3. Two span symmetrical design runs may not result in symmetrical beam sizes for both spans. Entering a "0.0" for "Depth Difference" in the DES command seems to take care of this problem.
4. There have been several requests to provide user defined beam dimensions and strand layout for design runs. Currently, the program only considers standard beams from the beam table for design.
5. The program cannot perform a strand design for a specific beam size. However, this can be accomplished somewhat by setting the "Minimum Depth" and "Maximum Depth" parameters of the DES command to the same required depth. For box beams, this will restrict the design to a specific beam size. For I-beams, this will restrict the design to a specific beam depth, but there may be more than one beam with the same depth.
6. The program output gives no indication what caused intermediate beam design trials to be rejected.
7. The program does not print the total jacking force. The initial prestressing force printed includes the initial losses.
8. The fatigue analysis calculations are not performed when live load option "B" is selected for an analysis run and all zeros are printed in the "Fatigue Stress Range in Prestressing Steel" output table.
9. Specification errors reported for end block stress check do not mean that the beam design is deficient. It should alert the user that crack control debonding is required to reduce the end block stresses.
10. The point of contraflexure errors alert the user that points of contraflexure entered using the ECP command or the default points of contraflexure are not within 5% of the actual computed points of contraflexure. The problem should be rerun using the computed points of contraflexure from the previous run in the ECP command. The points of contraflexure are used to calculate the effective slab width and to place axle loads when computing negative moments.
11. The program computes distribution factors according to DM-4. AASHTO LRFD distribution factor equations are currently not available. The user can enter "hand" computed AASHTO distribution factors using the UDF command. (Not applicable to PennDOT.)
12. The shear design/analysis module seems to ignore load factors entered using the LDF command, using instead the default load.
13. The program does not apply the design lane load with the design permit vehicle. (Not applicable to PennDOT.)

14. The skew correction factor for reactions should not be applied at interior supports according to DM-4 Article 4.6.2.2.3c. However, the program sets the reaction distribution factor equal to the shear distribution factor including the skew correction factor for shear. The application of the shear skew correction factor depends on the value entered for "Apply Skew Correction Factor" parameter of the SKW command. Therefore, if the user applies the shear skew correction factor according DM-4 Figure 4.6.2.2.3c-1, the program will apply a skew correction to the reaction distribution factor to the interior supports. This results in conservative reactions for the interior supports with sharp skews.
15. Some shear rating factors for design runs are being reported as slightly less than 1.0. This seems to be a problem with rating including creep and shrinkage.
16. There have been instances where the minimum prestressing steel check fails for the design sections. This is the result of a reduced moment capacity due to the beam section at an analysis point falling into the over-reinforced section category. DM-4 Article 5.7.3.3.1 requires that over-reinforced sections shall not be used. This can also result in rating factors of less than 1.0. In such cases, the user is advised to rerun the design with one or more of the following changes: increase the slab concrete strength, increase the beam concrete strength and/or restrict the minimum beam depth to the next available beam depth.

SUMMARY OF NOVEMBER 1999 REVISIONS - VERSION 1.4

PSLRFD Version 1.4 contains the following revisions and enhancements:

1. All dates have been modified to display a 4-digit year in the output file.
2. The program has been converted to the Digital Visual Fortran Version 6.0B compiler as a Win 32 application. It will run on Windows 95, Windows 98 and Windows NT Version 4.0 operating systems. It will NOT run under the DOS 6.22 or below operating systems.
3. The Diaphragm Details (DIA) command was corrected to allow the input for diaphragm locations beyond the mid-span of any full span that is before the point of symmetry without reporting any error.
4. Provisions have now been made to compute the negative moment capacity at all analysis points. Negative moment steel is now designed for every analysis point in the negative moment region between the DL points of contraflexure and a negative moment capacity is now computed based on the nominal slab reinforcement for all analysis points in the positive DL moment regions.
5. Provisions have now been made to check creep and shrinkage stress against the corresponding allowable using stress tolerance as specified in DM-4.
6. The maximum acceptable ratio of the depth of the neutral axis to effective depth (c/d_e) to check for an over-reinforced section was changed to 0.43000. Previously, the program considered sections with a ratio of greater than 0.42000 as over reinforced. The c/d_e ratio is now printed in the MINIMUM PRESTRESSING STEEL CHECK output table.
7. In the previous version, the CGS values at the beam-end and at the mid-span were reported as the same value for a debonded girder. This has been corrected.
8. In the previous version, the program would fail to develop a successful debonded strand pattern when the inflated allowable initial tensile stress becomes very close to the actual initial allowable stress. In this revision, during a cycle of debonded strand design, if the inflated allowable initial tensile stress becomes equal to the actual initial allowable stress, then the problem is treated as straight strand design.
9. The Multiple Presence Adjustment Factor (either default or user-specified) is applied to the Deflection Distribution Factor.
10. Some consistency checks to make sure that the lane-width is consistent with the roadway width and the number of lanes were added.

11. Provisions have been made to analyze a multi-span beam without creep (i.e., with shrinkage only). This was needed to analyze the existing structures where the deck is to be replaced. A new parameter, "Shrinkage Only Analysis", was added to the CTL input command for this purpose. A warning message is generated and the parameter reset to "N" if the parameter was entered as "Y" for a design run.
12. Changed the limits used in Distribution Factor Applicability Checks for I, J, and K_g to include all standard PennDOT beam sizes.
13. The debonding module was corrected to ensure that not more than 25% of the total strands at the mid-span are debonded at the beam-end.
14. Algorithms in draped strand design were corrected to prevent failure while retrieving the value of section properties sought. While checking the availability of cross-section at a given location, if the cross-section data could not be retrieved from an adjacent left cross-section, then a cross-section on the right is used.
15. Distribution Factor computations include the DM-4 revisions set forth by the strike-off letter entitled "Live Load Distribution Factors and Shear Provisions For P/S Beams".
16. Distribution Factors are computed for all possible loaded lane combinations from one lane loaded up to the input "Number of Design Lanes". The maximum distribution factor is then selected. Distribution factors are printed along with the corresponding number of loaded lanes.
17. Several modifications were made to the debonded design procedure to address certain code failures without rejecting the current beam size. This results in more economical designs.
18. When computing the Final DL + P/S Stress for box beam sections with draped strands within 3' (900 mm) of the centerline of bearing, the prestressing force is reduced by 25%. This stress is compared to the allowable stress. If there is a failure, then a "***" symbol is printed to indicate that "Actual stresses will be less due to crack control debonding".
19. The transfer length used in the shear rating computations was corrected to use 60 times the strand diameter.
20. If a code failure occurs in the SHEAR DESIGN / ANALYSIS output table, a note is printed to refer the user to the STRENGTH SHEAR RATING output table for the live load corresponding to the controlling limit state to check the rating factor and determine if the code failure is valid. Since the shear capacity is load dependent, the iterative method used to determine the shear rating more accurately computes the actual shear capacity than the shear design/analysis procedures. The shear rating capacities are based on the maximum live load shear that the section can carry while the shear design/analysis capacities are based on the maximum shear produced by the governing live load.
21. The defaults for the "P/S Strand Diameter" and "P/S Strand Area" parameters in the SCA and SCD commands were changed to correspond to the dimensions for the special 1/2 " diameter strand. The upper and lower limits were made consistent between the user manual and the .PDF file.

22. The program now uses soft metric rebars rather than "hard-metric" rebars sizes. The default stirrup area for the STI command was changed to 258 mm² (2 legs of a #13 rebar).
23. The warning messages pertaining to unsuccessful design trails were removed from the output file.
24. A logical flaw that resulted in an erroneous stirrup spacing was corrected.
25. Overhang violations for P/S adjacent box beams were changed from an error to a warning.
26. A change was made to prevent a divide by zero when the neutral axis of a composite section falls in the slab.
27. The Total Jacking Force is printed and references to "initial prestress" were changed to "transfer prestress".
28. The live load reactions were corrected. Previously, the live load reactions were determined using shear distribution factor including the skew correction factor. The reaction skew correction factor was then multiplied to these reactions. In effect, the skew correction factor was being applied twice. Also, the "Reaction Distribution Factor" was corrected to properly apply the skew correction factor according to DM-4 and user input. A "Reaction Skew Correction Factor" is no longer printed.
29. The Point of Contraflexure percent difference is rounded to the nearest whole percent. The rounded percent difference is then compare to the 5% limit. The input point of contraflexure locations in the ECP command for the end spans are no longer restricted to a range of 10% to 50% of the span length from the end supports.
30. Stirrup locations beyond midspan can now be entered in the STI command for shear analysis runs. This will allow for analysis of unsymmetric stirrup layouts.
31. The upper limit of "Area of Steel" parameter of the SST command was changed to 30 in² (20,000 mm²).
32. The end zone stirrup design was revised to apply the 2000 AASHTO Interim requirements. Also, the warning message printed when f_y exceeds 400 MPa is longer printed.
33. The "Shear Reinforcement and Resistance" output table correctly reports the stirrup area when different stirrup bar sizes are used.
34. Sidewalk and additional FWS loads are correctly reported as "User input" loads in the "Distributed Loads" output table.
35. The latest version of the Department's Continuous Beam Analysis (CBA Version 3.2) program has been implemented.
36. The load factors for creep and shrinkage are now printed in the "Load Factors and Combinations" output table.

37. An error in the moment capacity equation was corrected to use b'_w rather than b' .
38. A change was made in the CTL command to allow additional processing if an error is found in the CTL command.
39. The C.G.S parameter of the SLB command is now required as input for continuous girders only as stated in the user manual.
40. A correction was made to prevent a divide by zero error for non-composite I-beam analysis.
41. The DBS commands are sorted according debonded length to prevent an infinite loop.
42. Computed distribution factors that are governed by cross-frame action are noted in the output.
43. The maximum number of strands in the bottom row from the beam tables (AABEAMUS.tab and AABEAMSI.tab) was reduced by two strands to restrict the use of the corner strand positions allowing room for confinement steel. Provisions were also made to prohibit draping from the bottom strand row of box beams since the two corner locations are the only locations available for draping in the bottom row.
44. The SI upper limit for the "Weight of Formwork" parameter of the OVH command was changed to 0.0019 MPa to be consistent with the US unit limit of 40 psf.
45. The program now correctly analyzes a concentrated diaphragm load directly over a support.
46. The assumed value for the distance from the extreme compression fiber to the centroid of the non-prestressed tensile reinforcement (d_s) used for the positive moment connection steel design was changed from using the total depth of the section to using the total depth minus the c.g. of prestressing strands. This distance along with the controlling factored positive moment is now printed in the "Positive Moment Connect. Steel at Continuous Support" output table.
47. The longitudinal steel is now neglected when computing the effective shear depth (d_v) for analysis runs. Previously, it was neglected only for design runs. This created problems when stirrup spacings from a design run were used for an analysis run.
48. The beam design / shear design mode was corrected to apply the assumed crack control debonded as described in User Manual Section 3.12.2. Previously, the assumed crack control debonding was only applied for the beam analysis mode. As a result, shear designs that were produced in the beam design mode would result in code failures and insufficient shear rating when run as an analysis.
49. The dead load rotations are now printed to the same precision as the live load rotations.
50. A problem when using the symmetry option input that caused the transposed diaphragm locations for the right half of the structure not to be printed and stored in decreasing order was corrected.

51. Several changes were made to the strand pattern routines to allow a smaller beam to be selected for some draped design problems. With these changes a draped design and a debonded design for the same spans will in general select the same beam sizes.
52. The shear design routines were corrected to consider the assumed maximum crack control debonding for straight and draped strands as described in User Manual Section 3.12.2.
53. The governing limit state used for the tensile resistance check for the longitudinal mild steel was previously set to the same limit state that governed the stirrup design/analysis. This was changed to allow the governing limit states to be different. Without this change some analysis runs based on stirrup spacing from a design run could report code failures.
54. The default value for the "Total Max Jacking Force" parameter was increased to 3000 kips (13,345kN).
55. The proposed 2000 AASHTO Article 5.8.3.4.2 revisions for shear have been implemented.
56. Corrections were made to allow structures up to 20-spans to be analyzed or designed.
57. Over-reinforced sections are flagged in the "Minimum Prestressing Steel Check" output table.
58. Draped strand routines were revised to prevent draping of an odd number of strands from a row containing an even number of strands.
59. The computation of factored rotations was revised to correctly consider the maximum/minimum load factors for dead load. All rotations are printed to the same accuracy.
60. The shear distribution factor for fatigue was corrected to remove the skew correction factor when the user has requested it not be applied.
61. Several pages of the User's Manual have been revised.

The following is a list of reported errors, user requests and clarifications that have not been addressed in Version 1.4.

1. There have been several requests to provide user defined beam dimensions and strand layout for design runs. Currently, the program only considers standard beams from the beam table for design.
2. The program cannot perform a strand design for a specific beam size. However, this can be accomplished somewhat by setting the "Minimum Depth" and "Maximum Depth" parameters of the DES command to the same required depth. For box beams, this will restrict the design to a specific beam size. For I-beams, this will restrict the design to a specific beam depth, but there may be more than one beam with the same depth.
3. The program output gives no indication what caused intermediate beam design trials to be rejected.

4. The fatigue analysis calculations are not performed when live load option "B" is selected for an analysis run and all zeros are printed in the "Fatigue Stress Range in Prestressing Steel" output table.
5. A "points of contraflexure check" failure alerts the user that points of contraflexure entered using the ECP command or the default points of contraflexure are not within 5% of the actual computed points of contraflexure. The problem should be rerun using the computed points of contraflexure from the previous run in the ECP command. The points of contraflexure are used to calculate the effective slab width and to place axle loads when computing negative moments.
6. The program computes distribution factors according to DM-4. AASHTO LRFD distribution factor equations are currently not available. The user can enter "hand" computed AASHTO distribution factors using the UDF command. (Not applicable to PennDOT.)
7. The program does not apply the design lane load with the design permit vehicle. (Not applicable to PennDOT.)
8. There have been instances where the minimum prestressing steel check fails for the design sections. This is the result of a reduced moment capacity due to the beam section at an analysis point falling into the over-reinforced section category. DM-4 Article 5.7.3.3.1 requires that over-reinforced sections should not be used. This can also result in rating factors of less than 1.0. In such cases, the user is advised to rerun the design with one or more of the following changes: increase the slab concrete strength, increase the beam concrete strength and/or restrict the minimum beam depth to the next available beam depth.
9. The program may produce a design with minimum prestressing steel failures for short span bridges. These failures are due to the lack of development in the prestressing strands. To eliminate these failures, either use 3/8" diameter strands which will decrease the development length; or rerun as an analysis using a few more strands.
10. The program may produce a design with Service III ML-80 ratings significantly less than 1.0. This is due to the DM-4 requirement to design for a Service III PHL-93 load using a load factor of 0.8 and rate other vehicles using a Service III load factor of 1.00. If the Service III limit state controls the design, rating of less than 1.0 are possible for rating only vehicles.
11. The program does not report DM-4 debonding restriction violations for analysis runs.
12. The program does not compute end block stresses when all spans are debonded. If at least one span is debonded, end block stresses are computed.
13. User request to allow zero to be entered for the "Span Number" parameter for any command to denote that the input applies to all spans. This is currently done for the MCS, MCA and MST commands only.
14. There still some cases, especially for I-beams, where the strand pattern produced by the program is not desirable. In such cases, an analysis with an adjusted strand pattern can be run.

15. User request for an abbreviated output which provides the user with only the most critical data.
16. Dead load reactions reported by the program only account for loads between the centerlines of bearing. Additional weight, e.g., for the beam projection, would have to be entered as a concentrated load (using the CLD command) at the centerline of bearing. The program automatically does this for interior supports when a user defined uniform load is entered (using the DLD command) with the start and end spans covering multiple spans.
17. User request to print live load reactions including distribution factor but without impact that can be used directly for elastomeric bearing pad design.
18. Input crack control debonding (using the DBS command) for straight and draped strand analysis runs is only considered for shear calculations and is NOT considered for stress calculations.

SUMMARY OF AUGUST 2002 REVISIONS - VERSION 2.0

Since the release of PSLRFD Version 1.4a several problem reports and user requested enhancements have been received. This release of PSLRFD Version 2.0 contains the following revisions and enhancements:

1. When calculating the DF2 moment distribution factor, the program now uses a weighted average for section properties that vary in adjacent spans. – (R154#3)
2. The word “Additional” was removed from the “Additional Stirrups Required for End Zone Bursting Stresses” output table heading. This was done to clarify that stirrups required for shear design and those required by the BD Standard can be included to satisfy bursting stress requirements. – (R154#4)
3. A footnote was added to the “Additional Stirrups Required for End Zone Bursting Stresses” output table to recommend a way to satisfy the bursting stress requirement when the required area of steel does not fit within the X(sr) distance. – (R154#5)
4. A 1.5% tolerance was added the minimum prestressing steel check. A code failure will only be reported when the ultimate moment capacity is exceeded by more than 1.5%. – (R154#6)
5. A new input parameter, “Slab Reinforcement Area per unit width”, was added to the SLB command. This parameter specifies longitudinal slab reinforcement outside the regions defined by the SST command. It is used compute the negative moment resistance. – (R154#8 and Request 024)
6. The lower limit for the “Stirrup Spacing” parameter for the STI command was changed from 2.5” (63mm) to 3” (75mm). In addition, the design stirrup spacing is limited to a minimum spacing of 3” (75mm). –R154#9)
7. When the tension in the longitudinal steel controls the shear design, a message is printed instructing the user to verify the slab reinforcement input. – (R154#11)
8. The Distribution Factor module was updated to include the DM-4 2000 revisions. – (Request 175)
9. The analysis module was updated to include changes from the Department’s Continuous Beam Analysis program, CBA Version 3.4. – (Request 176)
10. In previous versions, the program would abort when an interior diaphragm was entered using the DIA command for an I-beam. A revision was made that allows the program to continue running with a warning ignoring the interior diaphragm load. I-beams with interior diaphragms defined using the DLD or CLD commands are treated in the same manner. – (R154#16 and Request 129)
11. The future wearing surface moment is no longer included in the positive connection moment design. - (Request 131)

12. The April 2000 DM-4 changes applicable to PSLRFD were implemented. Changes include a final net camber check for sag not greater than $L/2000$, an increased maximum prestressing force to 3000 kips (13,345 kN), setting the critical section for shear as the larger of $0.5 d_v \cot \theta$ or d_v , changing metric reinforcing steel grade from 400 to 420, and allowing the use of the oversized 0.52" (13.2 mm) diameter strands. – (Requests 162, 163, 177, 179, 181)
13. The governing HL93/PHL93 live load case for deflections is reported in the "Live Load Effects" output tables.
- (R154#19 and Request 185)
14. The factored effect reported in the "Factored Analysis Results" output table now correctly applies the minimum and maximum load factors for dead load, and correctly applies the load modifier for minimum and maximum effects. – (B153#1)
15. The debonded design procedure was revised to check initial compressive stresses at debonding transfer locations at both ends of the beam to avoid any stress problems related to slight variations in analysis results. Previously, stresses were only check for the left end of the beam assuming symmetric analysis results. – (T153#1)
16. For analysis runs, the negative moment resistance, reported in the "Negative Moment Capacity" output table, is computed based on the slab reinforcement as defined by SLB parameter 10, "Slab Reinforcement Area per unit width", for analysis point outside the reinforcement range defined by the SST command. Previously, these resistances were reported as zero. – (T153#2)
17. A problem causing different final losses to be used for symmetrical 2-span debonded design run was corrected. – (T153#5)
18. The distribution factor applicability range violations for d_e is suppressed when the lever rule controls. Additionally, range violation warning messages are now printed with units. – (Requests 126, 127 and 140)
19. The distribution factor applicability ranges for the moment of inertia (I) and torsional constant (J) were extended to include standard plank sections. – (Request 136)
20. When the tension in the longitudinal steel controls the shear (actual longitudinal tension less than required tension), the shear rating is reduced by the ratio of the actual tensile resistance less the required dead load resistance over the required live load resistance. – (Request 144)
21. The torsional constant (J) based on the composite section is printed for composite adjacent box beam. This is used to compute the distribution factor. Previously, the non-composite torsional constant was printed. – (Request 149)
22. The d_e distance, defined in AASHTO as the "distance from exterior web of exterior and the interior edge of curb or traffic barrier", is now referenced from the centerline of the exterior web of the exterior beam instead of the exterior face of the web. – (Request 152)

23. When the distribution factor applicability range for d_e is violated for the without sidewalk case, the program will compute the distribution factor using both d_e and the violated limit, and then select the greater of the two distribution factors. – (Request 153)
24. The upper limit of the applicability range for d_e used when computing the exterior adjacent box beam shear distribution factor was corrected to be 600 mm instead of 610 mm.– (Request 164)
25. The skew correction factor is now applied to the I-beam distribution factor considering cross-frame action. – (Request 172)
26. An instance where asterisks, instead of the maximum spacing, were printed for stirrup spacing in “Shear Reinforcement and Resistance” output table for an analysis point that did not require stirrup was corrected. – (Request 173)
27. The 2000 DM-4 revised limits for beam spacing and span length applicability ranges were added. – (Request 175)
28. The defaults for the load modifiers (eta factors, CTL parameters 20, 21 and 22) were changed to 1.0. – (Request 184)
29. The User’s Manual was converted into PDF format. – (Request 186)
30. The use of several input parameters for the CDF command is explained in more detail in Section 6.8 of the User’s Manual. – (Request 190)
31. The program was revised to apply either the default 10% loss or the input “Estimated % P/S Loss” (MPS command) to the jacking force to compute the deflections due to prestressing. Previously, the program applied the loss to transfer prestressing force, which already includes the instantaneous loss. This change eliminates the directives set forth by Strike-off Letter 431-01-14. – (Request 195)
32. The DM-4 Article 5.8.3.5 requirement that the area of longitudinal reinforcement for shear on the flexural tension side of the member need not exceed the area required to resist the maximum moment alone was implemented. This will correct instances where the stirrup spacings required by the program would decrease near the midspan. – (Request 196)
33. Strike-off Letter 431-01-07 revised DM-4 to require that the maximum dynamic load allowance (IM – live load impact) for the P-82 permit vehicle be reduced to 20% in accordance with a dynamic load study conducted for AASHTO by the Calibration Task Group. A new input parameter, “P-82 Dynamic Load Allowance”, with a default of 1.20 was added to the CTL command to satisfy the requirement. – (Request 197)
34. Camber calculations no longer include the deflection due to future wearing surface. – (Request 198)

35. The minimum and maximum live load rotations now reported as the negative most rotation and positive most rotation, respectively. – (Request 204)
36. The stress parameter, f_{po} , for shear design/analysis is taken as the stress in the prestressing strands with the assumption that the strands are fully developed at the transfer length in accordance with DM-4 Article 5.8.3.4.2. - (Request 212)
37. A convergence problem in the shear rating factor procedure has been corrected. - (Request 213)
38. The BDM command can now be used for a design run to enter a specific beam designation, enter a user-defined beam or override beam table dimensions. If the BDM command is used to design a user-defined beam (CTL command parameter “Beam Designation” is “U”), the SCD command must be used to define the available strand pattern. – (Requests 5, 7b, 12)
39. A problem that prevented strand patterns with zero-strand rows from being able to successfully design draped beams has been corrected. – (Request 7c)
40. An error message is printed after the Prestressing Data output tables and in the Specification Check Summary when the limit on total number of debonded strands is violated for an analysis run. – (Request 82)
41. There were a few instances in which a multi-span draped strand design run resulted in a successful design, but reported compressive stress code failures for Final DL+P/S load case near the supports. Since this problem can be corrected with crack control debonding, the prestressing force is reduced by 25% for analysis points within 3' (900 mm) of the centerline of bearing for this stress check. – (Request 88)
42. In an attempt to reduce the volume of output, a new output option parameter was added to the CTL command. The default output option is to only print results at critical locations. Other output options are to print data for 10th points plus critical locations or for 20th points plus critical locations. For shear-related output tables, 10th point results will also be printed for the critical point only output option. – (Request 100)
43. A zero can be entered for the “Span Number” parameter for the following commands to denote that the input applies to all spans: BDM, DIA, DBS, DPL, SCA, SCD, SPL, SSI, STI, and UDF. – (Request 101):
44. A zero can be entered for the “Support Number” parameter for the following commands to denote that the input applies to all supports: SKW and SST. – (Request 101):
45. A problem, which produces incorrect shears and moment due to diaphragm load at the diaphragm locations, was corrected. – (Request 102, 137)
46. The distances reported in all output tables are now locally referenced from the left support of the current span. Previously, some output tables used a global distance from the leftmost support of the entire structure. – (Request 104)

47. User-defined distribution factors for pedestrian live load are now correctly transposed to the right half of the structure when the symmetric option is used. This problem resulted unsymmetrical analysis result for a symmetrical structure. – (Request 130)
48. A problem resulting in unsymmetrical creep loads for a symmetrical structure has been corrected. – (Request 130)
49. The program was sometimes reporting unsymmetrical camber values for symmetric spans with debonded strands. This program malfunction has been corrected. – (Request 132)
50. The program was enhanced to allow input files to be in a different directory than program executable (Pslrfd.exe). – (Request 148)
51. The SCD command no longer supports the repeatability of parameters 1 through 7 so that two new input parameters could be added. This allows the user to override the design beam tables and enter user-defined strand limit per row. The “Number of Strands Rows at Midspan” and the “Number of Positions in Row I at Midspan” have been added to the SCD command. – (R154#15 and Requests 4, 7c)
52. In accordance with DM-4 Article 5.14.1.2.7a, the program has been enhanced to analyze multi-span structure as both continuously supported spans and simply supported spans for composite dead load and live load. When combining factored effects for the simple span check analysis option for a particular limit state, simple span analysis composite dead load effects are only combined with simple live load effects. Likewise, continuous composite dead load effects are only combined with continuous live load effects. – (Request 147)
53. For simple span check analysis option, both simple analysis and continuous analysis results are printed for composite dead loads. – (Request 147)
54. The sign convention for rotations used by PSLRFD is now the same as that used by the Continuous Beam Analysis (CBA) program. – (Request 147)
55. Output codes were added to the live load reactions and rotation to indicate whether the result is from the simple analysis or a continuous analysis for the simple span check analysis option. – (Request 147)
56. The MCA command parameters for creep and shrinkage allowable stresses are initialized properly when left blank so that the default values are assigned. – (Request 147)
57. A “Chief Bridge Engineer” warning message will be issued if the simple span check analysis option is not selected for multiple span bridges. This alerts users that DM-4 requires the simple span check be used expect in situation described in DM-4 Article 5.14.1.2.7a. – (Request 147)
58. For the simple span check analysis option, the following output reports will not be printed: Points of Contraflexure, Dead Load Creep and Shrinkage Moments, and Positive Moment Connection. These output tables do not apply when the simple span check analysis option is used. – (Request 147)

59. Another instance was found where data was not properly transposed to the right half of the structure when using the symmetry option resulting in an infinite loop. This has been corrected. – (Request 171)
60. The assumed default minimum area of deck steel in the negative moment region was increased from #4@12" to #4@12" top and #4@9" bottom for composite spread box beams and I-beams. – (Request 147)
61. The strand design procedure has been revised so that, when a beam is oversized due to depth difference requirement or user input minimum depth and the eccentricity cannot be obtained due strand pattern restraints, the program add strands before rejecting the beam. – (Request 147)
62. The program was revised to stop processing the final stress-check loop that was checking both the left and right drape points of a span (or transfer length locations of non-draped spans) if a failure occurred for the first location. If the loop was allowed to continue, the failure flag could be reset to successful while checking the second location. This resulted in code failures reported for an otherwise good design. – (Request 147)
63. The correct effective slab width use now used for the shear design to avoid a possible shear rating of less than 1.0. – (Request 147)
64. The "End Block Stresses" output table only prints stresses for non-debonded spans. – (Request 98)
65. During the design process, spans that were entered as debonded can be changed to straight strands if debonding is not required for a particular beam size. When this occurred in previous versions of the program, the strand type was not reset to debonded when the beam was rejected and a new beam is tried. The program will now reset the strand type to debonded. – (Request 155)
66. The percentage, entered in "Percent Increase" parameter of the SLL command, is now correctly applied to the special live load. – (Request 156)
67. The "Special Axle Load" input summary output table correctly displays the input values when more than 7 axles are entered. Similarly, the "Span Lengths" input summary table correctly displays the input span lengths when more than 14 spans are entered. – (Request 158)
68. The file extension for the parameter definition file that contains various values for input parameters was changed from .pdf to .pd to avoid association with Adobe Acrobat files. – (Request 159)
69. Several possible conditions that could result in division by zero or a floating-point underflow message were addressed. – (Request 161)
70. Before exiting, the program will pause and require the user to press the enter key. This will allow the user to scroll back to view the runtime messages. – (Request 167)

71. Non-production versions of the program will have the text “ (TEST)” as part of the version number. – (Request 174)
72. Non-production versions of the program will print an additional beta test copyright notice. – (Request 168)
73. A problem, which caused the 1.2 M_{cr} requirement to never control the negative design moment for a solid section, was corrected. – (Request 146)
74. The correct span numbers are now printed at the transition from end of one span to the beginning of the next span. – (Request 145)
75. Section 3.7.17 Live Load Rotations was added to the User’s Manual to explain the different live load distribution used for rotations and deflection. – (Request 185)
76. The “Prestressing Data” output tables were moved closer to the beginning of the output after the input summary and before the section properties. – (Request 209)
77. A problem, where entering the same debonding length on multiple DBS command lines for the same span resulted in an infinite loop during the debonding analysis, was corrected. - (Request 133)
78. The creep and shrinkage moments are now included in the negative moment steel design. – (Request 221)
79. The allowable tension stress with creep and shrinkage included, and the allowable slab compression stress are now reported in the "Allowable Concrete Stresses" output tables. – (Request 215)
80. For analysis runs, crack control debonded strands are excluded when checking the 25% total debonding limit. Additionally, crack control debonded strands are checked for the 50% total debonding limit. – (Request 216)
81. The headings of the "Prestress Values Based on Losses at Midspan of Simple Span" output table use the terminology "Effective" rather than "Final" to be consistent with the current AASHTO LRFD specification. – (Request 217)
82. The maximum allowable overhang for composite adjacent boxes was changed from 5"(125mm) to 8"(200mm). – (Request 223)

The following is a list of reported program limitations that are being considered for future development.

1. Serviceability checks for slab reinforcement in the negative moment region are not performed by the program. - (Request 41)
2. Concentrated loads entered at the centerline of bearing are not included in the reported reactions. - (Request 105)

3. The program does not report live load reactions that can directly be used for bearing pad design. The reaction distribution factors must be applied to the controlling truck and lane loads without distribution and impact, reported by the program, to compute the live load reaction input required for BPLRFD. - (Request 105)
4. Crack control debonding, entered using the DBS command, for straight and draped strand analysis runs is only considered for shear calculations and is not considered for stress calculations. - (Request 121)
5. The SLL command must be entered before the SAL command. - (Request 141)
6. Only one special live load can be entered per run. Users have requested the capability of running several special live loads for a given run. - (Request 143)
7. The ds (distance from extreme compression fiber to the centroid of the prestressing strands) used for positive moment connection steel design is based on the beam section to the right of the support. The program will be revised to compute the required reinforcement using ds for both adjacent beam sections and use the larger area of steel. - (Request 154)
8. For non-composite sections, the heading for DC2 and FWS analysis output tables incorrectly refer to composite section properties. - (Request 165)
9. The program only provides the horizontal shear reinforcement required. It does not provide analysis/specification checking for the horizontal shear reinforcement entered in the STI command. - (Request 187)
10. The program does not report reactions in a form that can be directly used for substructure design (as input for ABLRFD). - (Request 188)
11. The parapet width used to compute the number of design lanes is assumed to be 17.6 inches. The current BD standards use a 17.25 inch parapet. - (Request 189)
12. When designing the negative moment connection steel at the support, the program assumes a hollow section using the beam concrete. A solid section using the diaphragm concrete strength should also be checked. - (Request 191)
13. The "Points of Contraflexure" output table is not printed when "S" is entered for the multi-span analysis option parameter of the CTL command. Three points of contraflexure are no longer needed to determine the effective slab width, but they still used during analysis. - (Request 192)
14. The "Factored Analysis Results – Reaction" output table should include the Service I Limit State to check uplift. - (Request 199)
15. The TK-527 rating vehicle is not included as a built-in live load. It must be entered as special live load. - (Request 202)

16. For continuous analysis, the program assumes that there is a single point of contraflexure in the end spans and two points of contraflexure in the interior spans. If this is not the case after the program determines the actual points of contraflexure locations, the assumed points of contraflexure (see ECP command description) are used to analyze the structure. This can result in inaccurate live load effects at analysis points near the assumed points of contraflexure. However, these locations are not typically near any critical design locations and the live load effects are relatively small. - (Request 203)
17. The program is reporting incorrect "Additional DC1" distributed loads in the "Loads and Load Modifiers" table. Additionally, the program does not account for the girder, slab and haunch weights in the beam projection and between bearings of an interior support. A concentrated load should be applied at the bearing. - (Request 205)
18. The average stress in the prestressing stands, f_{ps} , which is used to compute the longitudinal resistance, is not reported in the output. - (Request 208)

SUMMARY OF AUGUST 2003 REVISIONS - VERSION 2.0a

PSLRFD Version 2.0a contains the following revisions and enhancements from Version 2.0

1. The program now uses the correct Limit States for Special Live Load Ratings. – (Request 201)
2. The program now uses the Service III Load Factor entered on the LDF command for Special Live Load. – (Request 237)
3. The program now stops with an error, if the user does not enter a UDF Pedestrian Live Load command, for an input file with Pedestrian Live Load and no CDF commands. – (Request 270)
4. The program now always initializes the number of debonding locations at the start of the strand design process. Previously, a design run could have resulted in a larger beam than required being selected. – (Request 274)

SUMMARY OF SEPTEMBER 2006 REVISIONS - VERSION 2.1.0.0

Since the release of PSLRFD Version 2.0a several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.1.0.0 contains the following revisions and enhancements.

General Revisions

1. Consistent tolerances are now being used to store and retrieve cross sections internally. Previously, a tolerance issue would cause an occasional program crash (Request 232).
2. The maximum overhang check for spread box beams now computes the overhang-spacing ratio using the overhang referenced for the centerline of the exterior web of the box beam (Request 266).
3. The paving notch depth is now based on PennDOT Standard BC-755M (Request 276).
4. The example input files now run without any warning messages (Request 313).
5. The program is able to run a 20 span problem. Previously, the latest test version would crash in the analysis sub-modules (Request 333).
6. The program now computes dead load shears and moments correctly at span twentieth points when concentrated loads are placed between span twentieth points (Request 339).

Input Revisions

7. The program will now stop with an error when non-composite I-beams are specified (Request 238).
8. The PSLRFD program will now issue Chief Bridge Engineer Warning if the overhang exceeds 50% of the girder spacing for analysis and design. Specific to design, if the overhang exceeds 62.5 % of the girder spacing, the program will stop with an input error (Request 311).
9. Only interior support numbers or a zero support number may now be entered for support numbers on the slab reinforcement command (SST) (Request 273).
10. The parapet width is now an optional input item on the GEO command with a default value of 20.25 inches (515 mm) (Request 189).
11. The description for the Deck Width parameter of the CDF command now indicates this parameter is only for non-composite adjacent box beams (Request 234).
12. The upper limit for span length is now 200 feet (61 m) and a violation of the upper limit now results in a warning message (Request 290).

13. The program now ensures that the input final allowable tension stresses that consider creep and shrinkage effects are greater than or equal to the input final allowable tension stresses that do not consider creep and shrinkage effects (Request 124).
14. The input allowable initial tension must now be less than or equal to the input allowable final tension (Request 327).
15. The maximum jacking force is now 4000 K (17795 kN) (Request 328).

Output Revisions

16. New reaction output reports that summarize the reactions required for bearing pad, abutment and pier designs have been added to the output (Requests 105/188).
17. For non-composite girders, the analysis results output heading now indicates basic beam properties are being used. Previously the results mistakenly appeared under a composite beam properties output heading (Request 165).
18. Service I Limit State reactions have been added to the "Factored Analysis Results – Reactions" output table, and uplift is now checked only for Service I Limit State. Also, the column heading for the factored analysis reactions now has a blank line between the "Left or Right" column heading and the beginning of the table data (Request 199).
19. Final tensile stress failures are now reported in the specification check failure summary (Request 230).
20. Leaving the deck width blank for a non-composite adjacent box beam run now results in a reported error message in the output file and the program stops (Request 234).
21. A specification check warning output table similar to the specification check failure output table is provided to give a summary of any warnings contained in the output tables. The warning indicates conditions that do not fail a specification check, but may need to be reviewed by the user (Request 275).
22. The prestressing data output table for debonded strands now reports the distance from the bottom of the beam to the strand row to two decimals for US units (Request 287).
23. The PSLRFD program has been revised to include a Required Counterweight table when uplift is detected (Request 322).

Users Manual Revisions

24. The User Manual now clarifies the allowable overhang for adjacent box beams and plank beams and the input deck overhang (Request 264).

25. The PSLRFD User Manual has been verified that the explanation on how the user should compute the deflection distribution factor does include the multiple presence factor (Request 285).
26. The purpose of the principal stress output has been clarified in the User's Manual (Request 306).
27. The Summary of Revisions for v2.0a is now included in the User Manual (Request 312).

Continuous Beam Analysis Related Revisions

28. Vehicle axle loads and spacing for standard vehicles are now determined by the Department's Continuous Beam Analysis program, CBA. Previously, this information was stored separately in the PSLRFD program (Request 210).
29. Increased precision is now used to prepare loading location data for the CBA analysis module. Previously, loads applied exactly at the support were being ignored for some problems (Request 319).
30. CBA Version 3.6.0.0 has been incorporated into the program (Request 346, 339, 235, 318).

Beam Section Properties Revisions

31. When computing local span number and span distance from a global distance, tolerances are now considered when comparing distances. Previously, a tolerance issue could sometimes result in slightly unsymmetrical CBA results for a symmetrical bridge (Request 278).
32. The Department's Beam Section Properties program, BSP Version 1.5.0.1 has been incorporated into the program (Request 325).

Live Load & Live Load Distribution Revisions

33. For continuous span analysis with simple span check, corresponding moments and shears are used consistently with the live load structure model. Previously, the program was not retrieving the proper corresponding shears for pedestrian loadings (Request 271).
34. The program now correctly computes deflections and rotations related to pedestrian live load (Request 236).
35. Live load code "D" may now be specified on the CTL command to have the ML-80 vehicle considered as an additional design vehicle (Request 170).
36. Live load code "E" may now be specified on the CTL command to have both the ML-80 and TK527 vehicles considered as additional design vehicles. For analysis runs, live load code "F" may now be specified to have the TK527 vehicle used for the analysis (Request 202).

- 37. Distribution factor applicability warning messages are no longer printed when the lever rule controls (Request 231).
- 38. The range of applicability limits for computing distribution factors is now consistent with DM-4 and the 2002 AASHTO LRFD Interims (Request 289, 358).
- 39. The live load with pedestrian deflection specification check now consistently reports failures in the summary of specification checks. Previously, a live load with pedestrian deflection limit table could have appeared in the summary when a failure did not exist in the table (Request 314).
- 40. The live load with pedestrian deflection limits output table now reports location distances relative to the left support of the span containing the location (Request 315).
- 41. The weight of the ML80 vehicle no longer includes the 3% scale tolerance when computing the rating tonnage (Request 324).

Miscellaneous Load Revisions

- 42. For non-composite girders, the following revisions have been made: 1.) Analysis results for future wearing surface is now printed with the non-composite loads, 2.) Entering composite dead loads or miscellaneous composite dead loads now will result in an input error, and 3.) The Total Composite Dead Load output table is no longer produced (Request 165).
- 43. The computed exterior diaphragm weight for an exterior beam is now one-half the weight computed for an interior beam. Previously, the interior beam diaphragm weight was being applied to exterior beams (Request 228).
- 44. Concentrated diaphragm loads for the last span of a structure which are located at 100% of the simple span length are now placed at the end of the last span (Request 282).
- 45. Composite dead loads for simple span analysis of multiple span structures are now applied for each span considering the global position of the load relative to the local position of each span. Previously, the composite dead loads of the first span were being applied to each span for the simple span analysis (Request 316).
- 46. Trapezoidal loads applied for a run using the symmetry option now result in symmetrical loadings (Request 323).
- 47. Minimum factored reactions now exclude future wearing surface loads (Request 353).

Shear Revisions

- 48. The user entered horizontal shear reinforcement is used to report the provided horizontal shear resistance for beam analysis runs when the shear analysis option is selected. Previously, the program would always

design the horizontal shear reinforcement. Also, the horizontal shear output table now includes a column for the maximum nominal shear allowed for each span. For design runs, any columns related to provided spacing or provided shear are no longer printed in the output table (Request 187).

- 49. The effective shear depth, $d(v)$, in a design run is now computed based on the neutral axis distance based on the longitudinal slab reinforcement at the support (Request 272).
- 50. The controlling shear load case is now based on the ratio of shear resistance to factored shear for both analysis and design. Previously, analysis and design runs were not consistent in determining the controlling shear load case (Request 272).
- 51. The shear distribution factors used for each single span analysis of the simple span check now correspond to the shear distribution factors for each span of the continuous span analysis. Previously, the shear distribution factors for the first span were being used for each simple span analysis (Request 280).
- 52. During the shear design, the comparison of the factored shear to the shear resistance is now consistently handled. Previously, a tolerance issue would result in the Resistance of Longitudinal Steel output table reporting an Actual Factored Tension value of zero (Request 286).

Moment Capacity Revisions

- 53. Computation of negative moment capacity for analysis runs now use the correct variables for the case of the neutral axis being in the web. Previously, the negative moment capacity was always computed assuming the neutral axis was in the flange (Request 272).
- 54. Negative moment capacity analysis considering solid rectangular section is now only made for box beams. Previously, the program mistakenly used a solid rectangular section for I Beams (Request 272).

Prestressing and Reinforcement Revisions

- 55. Increasing the distance to the first strand row for box beams from the default value now causes the bottom slab thickness to be increased by an equal amount to provide cover for the prestressing strands. Normally, the distance to the first strand row would be increased to account for dapping. For I-beam type girders changing the distance to the first strand row now controls which strand pattern of available strands per row is selected from the beam tables (Request 233).
- 56. When computing the maximum allowable strand eccentricity during the design, the correct composite dead load moment at the left transfer location is now used. Previously a symmetrical 2-span structure was designed with different eccentricities between span 1 and span 2 (Request 267).
- 57. For draped box beams, the final stresses under dead load and prestress within 3 feet of the end of the beam are now reported in the output without a 25% reduction (Request 326).

- 58. The maximum number of debonding cutoff locations per half span is now 5 for a design problem. The maximum number of strands that can be debonded is now 30 (Request 329).
- 59. The required distance for distributing end zone transverse steel in multiple span structures is now based on the beam depth of each span (Request 265).
- 60. For positive moment connection reinforcement, the distance to the non-prestressing reinforcement, $d(s)$, is now based on the prestressing steel location at mid-span. Previously, the program would sometimes return an incorrect value for $d(s)$ (Request 277).
- 61. Longitudinal slab reinforcement for negative moment is now designed considering serviceability requirements. For analysis problems, the allowable and the actual stresses in the longitudinal slab reinforcement are now checked at each analysis point where Service I Limit State moment is negative (Request 041).
- 62. For analysis problems, the program now reports both crack control debonding in excess of 25% in the region from 6 inches to 3 feet from the end of the beam, and crack control debonding in excess of 50% in the region from the end of the beam to 6 inches from the end of the beam, when both apply (Request 216).
- 63. The program now reports all of the crack control debonding entered for an analysis problem (Request 317).

Bulb Tee Revisions

- 64. The program is now able to analyze and design the Department's standard PA Bulb-Tee beams (Request 284).
- 65. All standard Bulb Tee beams have been exercised by the program for simple spans using practical ranges of span lengths, beam spacings and concrete strengths for all strand types (Request 330).

Programming Revisions

- 66. The program is now compatible with the Department's Automated Permit and Route Analysis System (APRAS) (Request 183).
- 67. The program may now be run from a network server (Request 295).
- 68. The program is now compatible with BRADD v3.1.0 (Request 298).
- 69. The Intel Visual Fortran compiler is now used to create the program (Request 331).

Engineering Assistant Revisions

- 70. A zero may now be entered in EngAsst for the span number on the MCA command (Request 281).
- 71. The images used by Engineering Assistant now contain caption text to help identify the image (Request 299).

72. Files used by the Engineering Assistant program (EngAsst) are now compatible with the Engineering Dataset Manager program (EngMgr) (Request 307).
73. The input tab, SpecLL, is now used by Engineering Assistant to enter the special live load records SLL and SAL. Previously the tab was named SLL (Request 344).

SUMMARY OF APRIL 2008 REVISIONS - VERSION 2.2.0.0

Since the release of PSLRFD Version 2.1.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.2.0.0 contains the following revisions and enhancements.

Input Revisions

1. The program has been revised to provide an input warning message indicating that stirrup locations can only be entered up to midspan for a shear design run (Request 283).
2. An input check has been added to the program which issues a warning when the End CGS parameter on the SCA command has a value entered for non-draped strands (Request 291).
3. An input check has been added to the program which requires the user to define strand pattern information, if the Vertical Spacing of Rows parameter on the SCA and SCD commands is not set to 2 inches (50.8 mm) (Request 336).
4. An input check has been added to the program to issue a warning message if the entered Strand Diameter and Strand Area on the SCA command is less than the DM-4 minimum. For Design runs the program halts with an error if the entered Strand Diameter and Strand Area on the SCD command is less than the DM-4 minimum (Request 337).
5. An input check has been added to determine if the distance between drape points violates the DM-4 minimum. For analysis runs the program will continue with a warning. For design runs the program will stop with an error (Request 338).
6. The program has been revised to allow up to 80 axles to be specified for the Special Axle Load (SAL) command (Request 334).
7. An input check has been added to the program to make sure debonding does not remove all strands (Request 351).
8. The program has been revised to allow the Special Axle Load (SAL) Command to be repeated (Request 305).
9. A new input parameter has been added to the Slab (SLB) Command for the top transverse slab reinforcement bar size (Request 377).
10. The program has been revised to correctly consider the skew angle limitation when selecting spread box beams, I-beams, and Bulb-Tee beams to be considered during a design run. Previously the skew angle limitation was being ignored for spread boxes, I-beams, and Bulb-Tee beams (Request 381).

11. The upper limit for the Bar Number of the SST Command is now a #6 [19] when the location of the longitudinal bar is in the bottom of the slab (Request 383/385).
12. The maximum number of ranges of reinforcement for each interior support is now six for the SST Command. This allows three top longitudinal bar ranges and three bottom longitudinal bar ranges to be specified for each interior support (Request 386).

Output Revisions

13. The program has been modified to show a new Points of Contraflexure output table when requested on the OAN command even when an "s" is entered on the multi-span analysis option on the CTL (Request 192).
14. The Negative Moment Capacity output table has been revised so the minimum temperature reinforcement footnote only appears when minimum steel controls for a location within the table (Request 292).
15. Service Cracking Moment is now checked within the region of debonded strands. Previously the program was only check service cracking moment at the transfer length location (Request 304).
16. The dead load reaction output tables have been revised to give left support and right support values on separate rows of the output table (Request 376).
17. The program has been modified to correct a programming issue that was resulting in multiple debug messages being sent to the screen (Request 382).

Live Load Distribution Factor Revisions

18. The reaction distribution factor for box beams (spread and adjacent) at interior supports have been modified so average span lengths and section properties are used in the calculation of the Distribution Factor (Request 357).
19. The program has been modified to prevent a divide by zero error when a sidewalk case has a single design lane and the lever rule is used to compute the distribution factor (Request 350).
20. The distribution factors for exterior adjacent boxes have been modified to agree with the 2004 AASHTO Specifications (Request 374).
21. The upper limit on the range of applicability for the longitudinal stiffness parameter, K_g , has been increased to include all standard bulb-tee sections (Request 378).

Flexure Revisions

22. The program has been modified to consider the haunch depth when calculating M_r and M_n for analysis runs. Previously the haunch depth was neglected for analysis runs (Request 309).

23. The program has been revised to consider crack control debonding when computing stresses (Request 121).
24. The program has been revised to use the 2007 DM-4 Specifications for the Control of Cracking by Distribution of Reinforcement (Request 345).

Applied Load Revisions

25. The program has been modified so the “Pedestrian” and “Future Wearing Surface” loads are now applied continuously over piers. Previously the program would not apply the loads between the bearings on a pier (Request 348).
26. The program has been revised to not include program modified concentrated loads with a magnitude of zero or program modified distributed loads with a starting location greater than the ending location. Previously these loads would appear in the concentrated and distributed load tables but were not being applied (Request 205).
27. The program has been revised to compute the dead load points of contraflexure based on a uniform composite load. For interior spans without positive moment from the uniform composite load the dead load points of contraflexure are placed at mid-span (Request 203).

User Manual Revisions

28. The Users Manual has been revised to describe how the strand row locations at the centerline of bearing for draped strands are calculated (Request 288).
29. The Users Manual has been revised to add parameter 6, number of spans, to the Control (CTL) command. This parameter had been inadvertently deleted while making prior revisions to the Users Manual (Request 363).

SUMMARY OF MAY 2009 REVISIONS - VERSION 2.3.0.0

Since the release of PSLRFD Version 2.2.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.3.0.0 contains the following revisions and enhancements.

Input Revisions

1. The DLD command has been enhanced to allow the application of distributed loads along a span or entire structure without having to specify the start and end ranges. (Request 166)
2. A series of input checks has been added to the program to ensure the required commands have been entered correctly for each span. Previously, the program would provide errors that were not very informative asking the user to modify the input to run to completion. (Request 279)
3. The upper limit on the Deck Overhang parameter on the OVH command has been removed. Previously, the program would incorrectly display a Chief Bridge Engineer Warning when the upper limit was exceeded in addition to a second message indicating the deck overhang to span ratio has been exceeded. (Request 310)
4. A new haunch thickness for Section Properties has been added to the SLB command. Previously, the program used a single haunch thickness parameter for dead load calculations and section properties. This made it difficult to compare an analysis and design run. The existing haunch thickness parameter has been renamed to reflect its use for dead load calculations only. (Request 361)
5. The program has been revised to include a new counterweight force load type on the CLD and DLD commands as well as a specification check to ensure that any counterweight load entered is adequate. Previously, the program would only provide the user with the required counterweight force if uplift was detected. (Request 355)
6. The program has been revised to include a new category for plank beam designations in the beam tables. Previously, the program would incorrectly include plank beam designations as a valid box beam designation. (Request 366)
7. New input checks have been added to ensure an STI command has been defined for each span for an analysis run. Previously the program would generate incorrect shear resistance values when the shear stirrup information was missing for the span. (Request 368)

Output Revisions

8. The program has been revised report the average stress in the prestressing strands at nominal flexural resistance in the new output table "Prestress Values at Nominal Flexural Resistance". (Request 208)

9. The “Prestress Loss Values” table has been modified to provide detailed prestress loss information. Previously, the program would only show the “Initial Loss” and “Final Loss” values. (Request 218)
10. The program has been modified to no longer print HS20 and H20 deflection output for live load codes C, D, E and F for analysis runs. Previously, the program would always show the HS20 and H20 deflection table which would cause an error message to print in the output. (Request 320)
11. The “Ultimate Moment and Serviceability Checks” table in the output has been modified to now include the Creep and Shrinkage Moment in the Factored Moment STRENGTH $M(u)$ column. Also, an issue has been corrected where the program would sometimes indicate a failure occurred in the “Ultimate Moment and Serviceability Checks” table in the “Specification Check Failures” table when actually there was no failure. (Request 356)
12. The program has been revised to print out points in output tables where failures have occurred, even if they have not been selected for printing. Previously, the program would indicate a failure in the “Specification Check Failures” table even though there was no indication of failure in the referenced table, due to the failed point not having been selected for printing. (Request 362)
13. The Department’s Beam Section Properties program, BSP Version 1.5.0.3 has been incorporated into the program. The deck concrete unit weight and the beam concrete unit weight are now considered for the calculation of the modular ratio passed to the BSP program when composite section properties are calculated. Previously, PSLRFD would assume the concrete unit weight for the beam and deck were always 150 pcf which resulted in unconservative composite moment of inertia values. (Request 396)

Stirrup Revisions

14. The program has been revised so the stirrups for spans where the left support is on a pier and the right support is on an abutment will now symmetrically place stirrups with respect to the midpoint of the beam. Previously, the program would incorrectly locate the midpoint of the beam using the centerline of the pier instead of the centerline of the bearing. (Request 367)

Flexure Revisions

15. The Positive Moment Connection Flexural Resistance design iteration process has been modified to prevent the addition of extra reinforcement area once an acceptable resistance has been found. Previously, the program would add an extra increment of steel area so hand verified resistances values were larger than the program resistance values. (Request 375)

Shear Revisions

16. The program has been revised to calculate the positive and negative shear rating factors for each point of interest on the structure. This revision ensures that the rating factors shown in the output are the controlling factors. Previously, the program would only calculate one shear rating based on the sign of the controlling dead load moment. (Request 342)
17. An issue was corrected for debonded design runs producing acceptable P-82 ratings that once they are converted into analysis runs the P-82 ratings become unacceptable. The root cause of this problem was the calculation of the $d(\text{critical})$ location differed between design and analysis runs which lead to different values of the Shear Resistance of Concrete $V(c)$. (Request 370)

User Manual Revisions

18. The User Manual has been modified to provide direction for incorporation of the beam notch depth criteria from the Standard Drawings BD-661M and BD-662 during the design process for draped strands. (Request 360)

SUMMARY OF MAY 2010 REVISIONS - VERSION 2.4.0.0

Since the release of PSLRFD Version 2.3.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.4.0.0 contains the following revisions and enhancements.

Input Revisions

1. An input check has been added for the Support Distance parameters of the SKW command requiring a minimum distance of the input beam projection plus 1/8" for interior supports. This will provide a minimum 1/4" gap between the beam ends. Previously, the support distances could be equal to the beam projection and for some debonded examples incorrect debonded strand data was reported. An additional check was added for the Support Distance parameters to provide a minimum 4" gap between beam ends at an interior support in accordance with BD Standards. Violation of this check will only result in a warning and the program will continue execution using the input support distances. (Request 395)
2. The program has been revised to avoid a program crash and stack dump caused by a larger number of diaphragm loads and concentrated loads occurring in a single span. Previously, an example with 14 diaphragm loads and 6 concentrated loads would result in a stack dump. (Request 380)
3. The program has been enhanced to allow up to 5 special live loads to be entered in a single run. The input commands SLL and SAL now includes "Special LL Number" as the first parameter. Any existing input files that use SLL and SAL commands will need to be modified. (Request 143)
4. The program has been enhanced to allow each parameter of a command to be processed when a previous parameter had an error. Previously, when an error was detected for a parameter the remaining parameters were skipped. Multiple runs were required to detect other parameters with errors on the same command. (Request 359)

Output Revisions

5. The program has been revised to correctly identify the regions where shear rating are not computed. Previously, locations were identified as interior supports even for single span runs. (Request 400)
6. The program has been revised to apply the user entered MC2 load factors to MC2 loads. Previously, the DC load factors were being applied to the MC2 loads. (Request 369)
7. The program has been enhanced to provide a PDF output file in addition to the text output file. When possible, the PDF file contains bookmarks for easier navigation of the output. The PDF file also makes it easier to print and paginate the program output. (Request 398)

8. The program has been revised to use the larger of the two C.G.S. values when computing the positive moment connection steel at an interior support with equal beam depths. Previously, unsymmetrical positive moment connection steel was designed for a 3-span symmetric bridge. (Request 154)

Distribution Factor Revisions

9. The program has been verified to be using the correct multiple presence factor when computing deflection distribution factors for bridges that include sidewalks. (Request 392)
10. The program has been modified to consider the violated d(e) limits when computing the distribution factors for fascia beams for both 1) bridges with no sidewalks and 2) bridges with sidewalks investigated for the sidewalk not present. Previously, the case of bridge with no sidewalks was not considering the violated d(e) limits when computing the distribution factors. (Request 372)
11. The program has been modified to apply the correct distribution factor to positive moments located between the point of contraflexure and interior supports for the live load analysis with the sidewalk present. Previously, the DF2 distribution factor was being used rather than the DF1 distribution factor. (Request 303)

Specification Revisions

12. The program has been revised to use the simplified effective slab width from AASHTO 2008 Interims Article 4.6.2.6. Implementation of the simplified effective slab width has made the ECP (Effective Contraflexure Points) command unnecessary and is now ignored. (Requests 399)
13. As a result of a decision by the AASHTO Subcommittee on Bridges and Structures to no longer publish SI unit specifications, the program only supports US customary (US) units. (Request 403)
14. The program has been updated to use the final version of CBA 3.6.0.0. (Request 391)

Debonding Revisions

15. The debonding design algorithm has been revised to allow a reduced inflated allowable to be tried before forcing strands to be added when the current trial fails because the cutoff length exceeds the maximum allowed. Previously, the debonding design would fail or require a large number of strands. (Requests 246, 247)

User Manual Revisions

16. The Revision Request Page of the User Manual has been revised to the current names of the Bureau, Division and Section organizations to be contacted for requests about the program. (Request 388)

17. The User Manual has been updated to include equations from the PS3 User manual for computing the uniform dead load from formwork. (Request 229)
18. The ECP (effective Contraflexure Points) command has been removed from the User Manual since it is unnecessary with implementation of the simplified effective slab width. (Request 399)

SUMMARY OF MARCH 2011 REVISIONS - VERSION 2.5.0.0

Since the release of PSLRFD Version 2.4.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.5.0.0 contains the following revisions and enhancements.

Input Revisions

1. The program has been revised to avoid a warning message for the "X1" dimension of a bulb tee beam on the BDM command when the dimension was specified as less than the upper limit given in the User Manual. Previously, the upper limit was reported as 13 inches rather than 18 inches. (Request 404)
2. An input check has been added to report a warning message when an unsymmetrical debonding pattern is specified. Previously, no warning message was provided when an odd number of strands were debonded in a row containing an even number of bonded strands. (Request 415)
3. The program has been revised to report a Chief Bridge Engineer (CBE) message when the strand diameter or the strand area input parameters exceed the upper limits on the SCD or SCA command. Previously, a warning message was provided when the diameter or area upper limit was violated. This allows strands larger than the oversized 1/2" strand (diameter 0.52") to be used with a corresponding CBE message reported. (Request 446)
4. The upper limit for the Drape Point Location parameter has been revised from 40% to 45% on the DPL command. (Request 447)

Output Revisions

5. The program has been enhanced to provide a Summary Output. The summary output consists of three sub-reports: TS&L / Design Summary, Q/A - Q/C Summary, and Detailer Summary. (Request 296)
6. The program has been revised to clarify the warning messages provided for debonded analysis runs with the total number of debonded strands exceeding the maximum allowable number of debonded strands. (Request 340)
7. The program has been enhanced to report Chief Bridge Engineer (CBE) in the Summary of Specification Check Warnings Table. Previously, each page of the output report needed to be checked to ensure no CBE warning existed. (Request 417)
8. The program has been revised to report the correct CGS at the centerline of bearing for debonded and straight spans. Previously, for debonded spans of design runs the centerline of bearing CGS was reported as the same as the mid-span CGS when the last span of the bridge was debonded. Also, for debonded and straight spans of analysis runs the centerline of bearing CGS was reported as zero. (Request 427)

9. The program has been revised to report the composite section modulus at the top of beam as negative when the neutral axis is located above the top of the beam. (Request 402)

Structural Analysis Revisions

10. The program has been modified to consider a cross section at the first interior support. Previously, a cross section was not considered at the first interior support which could result in unsymmetrical DC2 results for a symmetrical bridge. (Request 425)
11. The program has been revised to modify the location of concentrated dead loads placed near the end of the bridge to avoid a tolerance issue that could result in the load being ignored for reactions. (Request 426)

Distribution Factor Revisions

12. The program has been modified to identify distribution factors when violated applicability checks apply for non-controlling distribution factors. Previously, Chief Bridge Engineer warning messages for violated applicability checks could be reported when the distribution factor was controlled by cross frame action, but the Computed Distribution Factors output table would not identify which distribution factors had range of applicability warning messages. (Request 416)

Strand Design Revisions

13. The program has been modified to reduce the number of strands selected when designs are controlled by minimum reinforcement requirements by ensuring the maximum eccentricity is being considered. Previously, a longer span length could have fewer strands than a shorter span length with all other geometry being the same. (Request 256)
14. The program has been modified to reduce the number of strands selected for certain draped cases where strands were added to resolve failed draping rather than trying to reduce the eccentricity. Previously, some designs had more strands selected than required. (Requests 257, 258, 263)

Rating Revisions

15. The program has been revised to use the sign of the live load stress to determine if a rating factor can be computed rather than the sign of the live load moment. Previously, when the neutral axis for the composite transformed section was located in the slab the rating factors computed at the top of the beam could print as asterisks in the rating tables. Also, when the neutral axis is above the top of the beam, the opposite live load moment is considered when computing rating factors for the top of the beam. (Request 402)
16. The program has been revised to set the drape point based on the current span being rated. Previously, the drape point was being set based on the first span resulting in possible shear ratings less than one near the draping point of design runs. (Request 428)

Specification Revisions

17. The program has been revised to use 0.42 as the maximum ratio of c/d_e before considering the section over-reinforced. Previously, 0.43 was used as the limit for prestressed sections due to a sharp drop off in the ultimate moment capacity of over-reinforced sections. The sharp drop off was rectified by a correction to the moment resistance equation for over-reinforced sections as part of Request 38. (Request 394)

Design Revisions

18. The program has been enhanced to consider the minimum beam depth requirements of AASHTO LRFD Article 2.5.2.6.3 as required by DM-4 Article D2.5.2.6.3. The Minimum Depth parameter on the DES command defaults to being computed by Article 2.5.2.6.3. A CBE warning message is provided if the beam depth violates the minimum required. Previously, the Minimum Depth defaulted to the minimum beam depth in the standard beam tables. (Request 413)

User Manual Revisions

19. The standard detail reference for the beam notch depth has been updated from BC-755M to BD-661M and BD-662M. (Request 438)

SUMMARY OF AUGUST 2012 REVISIONS - VERSION 2.6.0.0

Since the release of PSLRFD Version 2.5.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.6.0.0 contains the following revisions and enhancements.

Specification Revisions

1. The PSLRFD program has been updated to the AASHTO LRFD Bridge Design Specifications Fifth Edition 2010 and the 2012 PennDOT Design Manual Part 4.
2. The live load factor for Strength IA Limit State has been revised to use 1.35 rather than the previous value of 1.10 per 2012 DM-4 Table 3.4.1P-2. (Request 468)
3. The modular ratio has been revised to not be limited to a minimum of 6. (Request 475)
4. The minimum prestress reinforcement requirements have been revised to exclude the ends of the beam in the development zone per 2012 DM-4 Article 5.7.3.3.2. (Request 476)
5. The modulus of rupture for calculating the cracking moment has been revised to use a 0.37 factor times the square root of the design concrete strength. The default allowable tension for final stresses with creep and shrinkage uses a 0.24 factor. Previously, a 0.24 factor was used for both calculations. (Request 489)
6. Transfer and Development Lengths of prestressing strands have been updated to AASHTO LRFD 2010 and 2012 DM-4 Article 5.11.4. (Request 488)
7. Violations of the Span-to-Depth Ratio criteria of AASHTO LRFD Article 2.5.2.6.3 now report an information message that the optional ratio has not been met. Previously, a Chief Bridge Engineer warning message was given. (Request 481)
8. Eta factor values other than 1.0 gives a warning message that PennDOT DM-4 requires Eta factors to be taken as 1.0. (Request 496)

Input Revisions

9. The beam concrete structural design strength (f'_c) has been limited to between 5 ksi and 10 ksi as per 2012 DM-4 Article 5.4.2.1. A warning message that justification must be submitted at TS&L stage for approval has been added for design strengths greater than 8 ksi. The default value for f'_c is now 8 ksi on the DES command. The default values for f'_c and f'_{ci} have been removed from the MCS command. The f'_{ci} to f'_c ratio, on the DES command, now has a default value of 0.85. (Request 470)
10. The strand diameter and area upper limits have been revised to allow 0.6" strands as per 2012 DM-4 Article 5.4.4.1. A warning message that justification must be submitted at the TS&L stage for approval has been added for strand diameter and area of 0.6" strands. (Request 446)

11. The lower limit for the yield strength of reinforcement bars has been revised to 40 ksi as per 2012 DM-4 Article 5.4.3.1. Also, a Chief Bridge Engineer warning message has been added when the yield strength equals 40 ksi. (Request 474)
12. The upper limit for the initial concrete strength (f'_{ci}) has been changed to 8.5 ksi per 2012 DM-4 Commentary DC5.9.4.4P. Also, a check of the f'_c/f'_{ci} ratio has been added to warn when the following criteria is validated: $1.05 f'_{ci} \leq f'_c \leq 1.18 f'_{ci}$ (Request 477)

Output Revisions

13. The average prestressing steel stress is now reported at mid-span rather than at the transfer length from the end of the beam. This change was made to eliminate a difference between a design run and an analysis run for the same beam. (Request 482)
14. Computed Distribution Factor warning messages have been revised to print once for violations of torsional or moment of inertia limits. Previously, violations of the limits for adjacent box beams could result in multiple pages of warning messages. (Request 484)
15. For Design runs, if an unsymmetrical strand rows is discovered, where an odd number of strands are in a row with an even number of available strands, those unsymmetrical strand rows are flagged with a "U" character in the strand output table and a warning is printed at the bottom of the table. The strand table is also added to the Specification Check Warning table at the end of the output report. Currently, Analysis runs provide warnings if unsymmetrical strands rows are entered so no revisions were necessary. (Request 495)

Flexural Resistance Revisions

16. The flexure resistance factor, ϕ , is now based on the net tensile strain in the tension steel per AASHTO Article 5.5.4.2.1 Fifth Edition 2010. (Request 405)
17. The flexural resistance computations have been revised based on 2012 DM-4 Article 5.7 (April 2012). (Request 479)

Prestress Loss Revisions

18. Prestress loss computations are now based on AASHTO Article 5.9.5 Fifth Edition 2010. A new input parameter has been added for the beam concrete age at deck placement to the CTL Command. (Request 486)
19. Creep coefficients for determining restraint moments are now computed using creep equations per AASHTO Article 5.4.2.3.2 Fifth Edition 2010. (Request 471)

20. The top flange width is now removed when computing the Volume to Surface Area (V/S) ratio for the slab per 2012 DM-4 Commentary DC5.4.2.3.2. Also, the V/S ratio has been limited to 6 inches. (Request 472)
21. Shrinkage strain for determining restraint moments are now computed using shrinkage equations per AASHTO Article 5.4.2.3.3 Fifth Edition 2010. (Request 473)

Shear Resistance Revisions

22. Longitudinal strain, ϵ_x , calculations used to determine shear resistance have been updated to use AASHTO Appendix B5 Fifth Edition 2010. (Request 431)
23. The total effective prestressing strand area at debonding cutoff locations has been revised to correctly determine the longitudinal strain used to compute the concrete shear resistance. Previously, before this change was made the concrete shear resistance would drop sharply at debonding cutoff locations which would result in an odd reduction in stirrup spacing. (Request 490)

Fatigue Revisions

24. The Fatigue I Limit State is now used when checking fatigue in prestressing steel per 2012 DM-4 Article 5.5.3.3. An additional final compressive stress check for the Fatigue I combination with one-half of dead load and one-half of prestress load has been made and reported in a new output table. (Request 464)

Debonding Revisions

25. The effects of debonding and transfer length on the eccentricity of the prestress force are now correctly considered when computing stresses, shear capacity, and camber. This change allows analysis of draped strands with normal debonding (non-crack control debonding). For straight strand analysis the debonding location is checked to ensure only crack control debonding has been entered. If non-crack control debonding has been entered an error is reported and the user is required to change the strand type to debonded on the SSI command. (Request 454)

Engineering Assistant Revisions

26. The lower limit for the start span number on the DLD Command now allows 0 to be entered to indicate all spans have the same load and the start distance, end span number and end distance values are ignored. (Request 492)
27. The field help for the Span Number of the SSI Command has been revised to correctly describe the span number. Previously, before this change the help text applied to the Support Number of the SST Command. (Request 493)

SUMMARY OF JULY 2013 REVISIONS - VERSION 2.7.0.0

Since the release of PSLRFD Version 2.6.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.7.0.0 contains the following revisions and enhancements.

Design Revisions

1. A design run now checks the live load deflection criteria during the beam selection iteration process and will select the next available beam when the criteria are not met. Previously, a beam that was successfully designed would sometimes have a specification check failure for live load deflection criteria. (Requests 422 / 456)

Input Revisions

2. The DES command lower limit for the Minimum Depth parameter, for I-Beams and Bulb-Tee Beams, has been changed to 29 inches. Previously, the lower limit was 30 inches which prevented the 29.25 inch deep Bulb-Tee Beam from being specified. (Request 421)
3. Specifying a strand type other than Low Relaxation on the CTL command now results in a Chief Bridge Engineer approval required message. (Request 432)
4. Specifying a reinforcement bar yield strength of other than 60 ksi on the MST command or the SLB command now results in a Chief Bridge Engineer approval required message. (Request 433)
5. Violating the upper or lower limits for prestressed concrete structural design strength, f'_c , on the MCS command or the DES command now results in a Chief Bridge Engineer approval required message. (Request 434)
6. Violations of the upper or lower limits for the Skew Angle are now reported when the UDF command is used. Previously, upper and lower limits of the Skew Angle were only checked when the CDF command was entered. The User Manual documentation for the SKW command now indicates violation of the Skew Angle limits result in a Chief Bridge Engineer approval required message. (Request 435)
7. Analysis runs with debonded strands specified on the SSI command now require the strand pattern to be provided on parameters 9 and 10 of the SCA command. Previously, this requirement was documented but not enforced by the program. (Request 439)
8. The BDM command lower limit for fillet dimensions (B1, B2, B3, and B4) is now 1.5 inches for adjacent and spread box beams with rectangular voids. The change was made to accommodate box beams that are 21 inches deep or less. (Request 452)

9. The BDM command upper limit for the bottom slab thickness is now 6.75 inches for adjacent and spread box beams with rectangular voids. This change was made to allow for dapped beams. (Request 453 / 459)
10. The check for an unsymmetrical strand pattern is now skipped for user defined sections since the number of available strand positions for each strand row is unknown. (Request 455)
11. The CTL command Beam Designation and Beam Shape parameters are now checked for valid combinations. Invalid combinations will now result in an input error. (Request 461)
12. Strands for plank beam design runs must now be ½" special strands (0.52-inch diameter) as per PennDOT SOL 483-13-01. If other size strands are entered for a plank beam design run the program will now stop with an error. (Request 506)
13. Design runs that do not specify CTL command Live Load code "E" now result in a warning message that live load code "E" should be used to ensure ML-80 and TK527 inventory rating are greater than 1.0 as per DM-4. (Request 508)

Output Revisions

14. On the first page of the output the program title now aligns with the other data of the program. This issue was corrected in version 2.6.0.0, but was not included in the 2.6.0.0 Summary of Revisions. (Request 444)
15. The end zone stirrup output table now uses the term "Splitting" stresses rather than the term "Bursting" stresses to agree with the AASHTO LRFD Bridge Design Specifications Fifth Edition 2010. (Request 478)
16. Warning messages are now issued if the optional span-to-depth ratios are not satisfied for analysis runs that do not meet live load deflection criteria. Informational messages are now issued if the optional span-to-depth ratios are not satisfied for analysis runs that do meet live load deflection criteria. (Request 481)
17. Bookmarks corresponding to items in the Table of Contents that appear on the first page of the PDF output file, are now linked to the first page of the PDF output file. Previously, these bookmarks were not linked to any page of the PDF output file. Also, an f'c optimization run output file that contains multiple Table of Contents is now correctly processed to a PDF file. (Request 527)

Documentation Revisions

18. The User Manual and Engineering Assistant help now indicates the last axle spacing on the SAL command must be entered as zero. (Request 460)
19. The User Manual and Engineering Assistant help now indicates that certain default print options depend on the Multi-Span Analysis Method on the CTL command. (Request 485)

New Features

20. Type F NEXT beams can now be analyzed or designed by the program. Type F NEXT beam distribution factors are conservatively computed based on cross section type “k” defined in AASHTO Table 4.6.2.2.1-1. (Request 424)
21. PennDOT Standard Bulb-Tee Beams with a 36 inch top flange can now be analyzed or designed by the program. (Request 463)

Distribution Factor Revisions

22. The Range of Applicability check for curb to exterior web of exterior girder (d_e) for non-composite adjacent boxes now only checks an upper limit and applies a minimum to “e” of 1.0. These changes were made to follow the equations in the AASHTO LRFD Specification. (Request 465)

SUMMARY OF MAY 2014 REVISIONS - VERSION 2.8.0.0

Since the release of PSLRFD Version 2.7.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.8.0.0 contains the following revisions and enhancements.

Programming Revisions

1. *The method of calling the engineering program DLL from the Engineering Assistant has been changed for compatibility with EngAsst v2.5.0.0 which uses Microsoft's .NET Framework, version 4.5. Because of this, PSLRFD will no longer work with EngAsst v2.4.0.6 or v2.4.0.9 unless the EngAsst "Edit / Run EXE - Command Window" option is selected. PSLRFD will no longer work with EngAsst v2.4.0.0 and earlier. (Request 544)*
2. The program is now compiled with Intel Visual Fortran Composer XE version 2011.9.300 using Visual Studio 2010. (Request 503)

Input Revisions

3. When individual dimensions are entered using the BDM command, dimension compatibility requirements are now checked and any violations result in an error message. (Request 436)
4. An input check for the total number of debonded strands being greater than the total number of strands is now performed for straight or draped strands with crack control debonding. Prior to this change multiple warning messages were printed during the shear design and/or analysis when the total crack control debonded strands exceeded the total strands. (Request 498)
5. The DES command now allows the 9th parameter, Bottom Flange Thickness, to be defaulted (comma specified after the previous parameter in the input file) on the command line for non-Bulb-Tee beam shapes. Previously, the user manual indicated the 9th parameter should be left blank for all non-Bulb-Tee beam types but manually adding a comma after the 8th parameter in the input file would result in an error. (Request 511)
6. The skew angle limitations for beams entered on the BDM command are now being correctly set. (Request 532)

Output Revisions

7. The reaction and rotation distribution factor output table now reports the same flags (indicating the number of lanes loaded and any range of applicability warnings) as the moment and shear distribution factors. (Request 442)

8. The Horizontal Shear output report is no longer processed for non-composite beams during the rating vehicle specification checking. Previously, the reports were processed for non-composite beams and reported in the summary table to have specification check errors, but the reports could not be requested to print. (Request 462)
9. The ratings note in the Detailers Summary output now states that future wearing surface is included in the ratings, or excluded in the ratings base on the presence of the FWS loading entered by the user. Previously, the note always stated that future wearing surface was including in the rating even when a FWS loading was not entered. (Request 507)
10. A new output table named "EFFECTIVE C.G.S. AND NUMBER OF STRANDS" was added to the program to report the effective center of gravity of the strand pattern and the effective number of strands along each span. This new table includes partially effective strands that occur when a new cutoff location occurs within a transfer length region for strands that were previously cutoff. (Request 513)
11. The design of a non-composite adjacent box beam now produces a CBE message and references SOL 431-06-01. (Request 519)
12. The strand output tables now provide a consistent output format for Straight Strands, Draped Strands, Debonded Strands or Debonded / Draped Strands. (Request 534)
13. The Rating Summary output for the Detailer Summary Report now displays the correct Limit State for the PHL-93 Operating rating when Strength IA controls the rating. Previously, the Strength II Limit State was being reported when the Strength IA Limit State controlled. (Request 547)

Documentation Revisions

14. The User Manual and Engineering Assistant help now indicate the cutoff points for the longitudinal slab reinforcement entered on the SST command are the physical cutoff locations and the development length is calculated by the program. (Request 509)
15. PennDOT has discontinued support for Windows XP and references to Windows XP have been removed from the User Manual. (Request 546)

Ratings Revisions

16. A new input item on the ORF command now allows ratings to be generated both with and without the Future Wearing Surface (FWS) load in a single analysis run. Previously, the user had to make two separate analysis runs to obtain both sets of ratings. (Request 441)

Distribution Factor Revisions

17. The fatigue distribution factor calculations for non-composite adjacent beams now set the number of design lanes to the number of design lanes entered on the CDF command. Previously, the number of design lanes was being set to one for the fatigue distribution factor calculations. Also, the C equation is limited to be less than or equal to K per a proposed DM-4 revision. The User Manual now documents the distribution factor equations used by the program for composite and non-composite adjacent beams. (Request 483)

Continuous Beam Analysis Revisions

18. When locating vehicle axles at the maximum shear influence line ordinates, tolerances are now avoided by setting the axle location exactly equal to the corresponding shear influence line abscissa. Previously, for certain bridge geometry conditions a tolerance issue could result in slightly unsymmetrical CBA shear results for a symmetrical bridge. (Request 457)
19. The Department's Continuous Beam Analysis program, CBA Version 3.6.0.5, has been incorporated into the program. (Request 494)

Live Load Rotation Revisions

20. The total positive live load rotation is now correctly considered when determining the controlling value for live load rotation. The moment distribution factors are now applied at the left side of the support when factoring live load rotations. Previously, a symmetrical bridge would have unsymmetrical total positive live load rotations. (Request 458)

Specification Revisions

21. DM-4 Section 9.7.1.5.1P, Overhang of Deck Slab on Concrete and Steel Girder Bridges is now being considered for analysis and design runs. For analysis runs a Chief Bridge Engineer warning message is given when the beam depth violates the overhang limit and the run continues. For design runs, by default, beams that violate the overhang limit will not be considered. For design runs, if a specific beam is specified to be designed, an error message is given when the beam depth violates the overhang limit and the program stops. A new input item, Overhang to Beam Depth Override, on the CTL command can be set to 'Y' to allow the program to consider designing beams that violate the overhang limit. If the design run is successful, a Chief Bridge Engineer warning message is given even when the override parameter is set to 'Y'. (Request 487/501)

Shear Revisions

22. For shear analysis runs, stirrup change locations are now added as analysis points and reported in shear related output tables. Previously, stirrup change locations did not appear in the shear related output table unless they occurred at a 20th point. (Request 499)

23. A consistent tolerance is now used when computing the d(critical) location for shear in design and analysis runs. Previously, a different tolerance was used for design and analysis which resulted in different d(critical) locations. The different d(critical) locations could result in analysis runs, based on the design run, having shear ratings less than 1.0. (Request 538)

Debonding Revisions

24. A tolerance is now considered when comparing the first debonding cutoff location to debonding constant DB10, minimum recommended debonded cutoff length from centerline of bearing (6 inches for I-beams, bulb-tee beams and Type F NEXT beams; 30 inches for box beams). Previously, certain input files with f'c optimization could result in an endless loop. (Request 491)

Computed Loads Revisions

25. The calculation of exterior diaphragm loads now accounts for the skew angle in accordance with BD-653M. Intermediate exterior diaphragms are placed along the skew when the skew angle is between 90 and 75 degrees. End diaphragms are always placed along the skew. (Request 517)

Strand Pattern Revisions

26. The post-tensioning duct in adjacent box beams and adjacent plank beams is now located at the beam mid-depth per Sheet 2 of BC-775M (Change 2). The standard strand patterns have been revised to avoid interference between the post-tensioning duct pocket and prestressing strands. Two commands, Tendon Location (TND) and Strand Configuration at Beam End (SCE), now define the strand and tendon geometry to allow the program to check for interference. (Request 534)

SUMMARY OF FEBRUARY 2015 REVISIONS - VERSION 2.9.0.0

Since the release of PSLRFD Version 2.8.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.9.0.0 contains the following revisions and enhancements.

Specification Revisions

1. The stress limit for Splitting Resistance of End Zone Stirrups is now 20 ksi as specified in AASHTO Article 5.10.10.1. Previously, a limit of 24 ksi was being used. (Request 335)
2. The warning messages for exceeding the 25% and 50% limits on debonded strands as specified in Pub 408 Section 1107.01(b)1.b now references the debonding regions. (Request 437)
3. The minimum beam depth for exterior adjacent plank beams is no longer based on the deck overhang. Previously, DM-4 Section 9.7.1.5.1P, Overhang of Deck Slab on Concrete and Steel Girder Bridges, was being incorrectly applied to set the minimum beam depth for exterior adjacent plank beams. (Request 557)

Rating Revisions

4. The program can now rate an existing bridge for the Strength II Limit State with P-82 in one lane and PHL-93 in the other lanes in accordance with DM-4 Article 3.4.1. This is accomplished by using Live Load Code "G" for an Analysis Run. (Request 480)
5. A new rating table has been added to the program after the OVERALL RATING SUMMARY table that will report rating information in a table similar to DM-4 Part A Table 1.8.3-1. (Request 523)
6. Detailed rating output tables now include a column to identify rating values that are less than 1.0. Also, output tables with rating factors less than 1.0 are now added to the Spec Check Failure table. (Request 536)
7. For program runs that produce With FWS and Without FWS ratings in the same run, the program now uses the negative slab steel to determine rating factors when making a second pass to compute ratings without future wearing surface. Previously, the incorrect negative slab steel was being used for the second pass resulting in an incorrect rating for the Without FWS case. (Request 553)
8. For symmetrical bridges the program now considers the right critical shear located to the right of mid-span when determining the controlling shear rating of a symmetrical structure. Prior to this change the program would report an incorrect shear rating if the critical shear location to the right of mid-span controlled for a symmetrical structure. (Request 541)

Documentation Revisions

9. The User Manual and Engineering Assistant help now notes that the ORF Command parameter 5, Ratings without Future Wearing Surface, should not be used when the FWS load type includes utility loads. (Request 540)
10. The User Manual and Engineering Assistant help now explicitly refers to plank beams as adjacent plank beams to clarify that the program cannot design or analyze a spread plank beam. (Request 533)
11. The Tendon Longitudinal Location parameters of the TND Command now identifies that the tendon location distance is measured along the beam. (Request 559)
12. The User Manual and Engineering Assistant help now references the correct sections of DM-4 when describing the Ductility, Redundancy, and Operational Importance load modifiers on the CTL command. (Request 566)

Input Revisions

13. Invalid combinations of beam type and diaphragm type now result in an input error message. Previously, the program inconsistently treated invalid combinations as a warning for some combinations, aborts for some combinations, and no messages for other combinations. The program checks diaphragms specified by the DIA command or by the CDL or DLD load commands. (Request 556)

Output Revisions

14. The rating table output in the Summary output now uses roman numerals in the Limit State names to be consistent with other references to the Limit States within the program. (Request 548)
15. The Reaction Summary Tables for non-composite beams now labels the sidewalk dead load reactions as "S/W DL". Previously, these reactions were incorrectly labeled as "Total DC2" reactions. The Factored Analysis Results-Reactions output table now includes Strength IP and Service IP Limit States when pedestrian loading is entered. (Request 555)
16. The page layout of the output file now allows for more characters per page width and more lines per page in the PDF output file. The new layout has 88 characters per page width and 74 lines per page. The Table of Contents now includes second level bookmarks. (Request 558)

Debonding Revisions

17. All failed debonding checks for analysis runs are now reported in the program output. Also, the criterion for computing the maximum cutoff location is now based on the strand development length. Previously, the criterion was based on the strand transfer length plus six feet. (Request 525)

18. The strand debonding design module has been verified to meet the restrictions for strands in webs. The restrictions are that box beam webs do not allow debonding in consecutive rows and I-Beam webs do not allow consecutive rows to have two strands debonded. (Request 524)
19. The program now requires strands to be fully developed at mid-span. An error is reported for design runs when the strands are not fully developed and a warning is reported for analysis runs. (Request 520)

Analysis Revisions

20. Analysis points that are off of the bridge are now ignored. Previously, when the beam projection was larger than the transfer length, resulting in the transfer location being before the first support, the program would crash. (Request 522)
21. The program now uses a consistent precision to compute analysis locations and load locations. Previously, the location of exterior diaphragms could sometimes result in unsymmetrical shear values. (Request 542)

Strand Pattern Revisions

22. The Beam table for PA I-Beams no longer includes strand patterns with both even and odd available number of strands in a row. This change was made as a short term fix to prevent unsymmetrical strand patterns from being designed. If a design run would produce an unsymmetrical strand pattern the program now provides a warning message. Previously, for PA I-Beams a design run occasionally would result in an unsymmetrical strand pattern without a warning message. (Request 570)

Programming Revisions

23. The program is now compiled with Intel Visual Fortran Composer XE 2013 Update 4 and Visual Studio 2012. (Request 543)
24. The program now stops execution on the rare occurrence of a floating point error. Previously, on the rare occurrence of a floating point error the program would continue execution, which would result in the program calculating incorrect results and sometimes stopping execution later in the program with a different error. (Request 563)

SUMMARY OF MAY 2016 REVISIONS - VERSION 2.10.0.0

Since the release of PSLRFD Version 2.9.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.10.0.0 contains the following revisions and enhancements.

Specification Revisions

1. The PSLRFD program has been updated to the AASHTO LRFD Bridge Design Specifications Seventh Edition 2014 and the April 2015 PennDOT Design Manual Part 4.
2. The Assumptions and Limitations section in Chapter 2 of the User's Manual now notes that Blast Loading is not considered by the program. (Request 577)
3. The shear distribution factor for interior I-beams is now computed by the lever rule when the number of beams is three. (Request 579)
4. The program now does not consider sections to be under-reinforced or over-reinforced. Previously, sections having a "c/de" ratio greater than 0.42 were considered to be over-reinforced as defined in AASHTO Article 5.7.3.3.1. AASHTO Article 5.7.3.3 notes that Article 5.7.3.3.1 was deleted in 2005. (Request 580)
5. The variation of the resistance factor, ϕ , for sections in the transition zone between tension-controlled and compression-controlled is now defined by the net tensile strain in the extreme tension steel and the compression-controlled and tension-controlled strain limits. Previously, the variation in the resistance factor was expressed in terms of the ratio d_t/c . (Request 581)
6. The cracking moment, M_{cr} , now includes three factors to account for 1) variability in the flexural cracking strength of concrete, 2) variability of prestress, and 3) the ratio of nominal yield stress of reinforcement to the ultimate tensile strength of the reinforcement. Previously, the factored flexural resistance was required to be at least equal to the lesser of 1.33 times the factored moment and 1.2 times the cracking moment. The 1.2 factor has been removed from the cracking moment. (Request 582)
7. The modulus of rupture used to determine the cracking moment is now computed as 0.24 times the square root of the compression strength of the concrete. Previously, a coefficient of 0.37 was used rather than 0.24. (Request 583)
8. Distribution factor range of applicability violations now result in a warning message noting the violation requires the approval of the District Bridge Engineer. Previously, these violations required approval of the Chief Bridge Engineer. (Request 584)

9. Violations of the maximum deck slab overhang length now result in a warning message noting the violation requires the approval of the District Bridge Engineer. Previously, these violations requires approval of the Chief Bridge Engineer. (Request 585)
10. Computation of the factored interface shear force is now based on the procedure in AASHTO Article 5.8.4.2 rather than the classical strength of material approach. The Slab Beam Interface parameter of the MCG command now includes the option for a cast-in-place slab on a roughened surface. The minimum area of interface shear reinforcement now considers the lesser of $0.05A_{cv}/f_y$, $1.33V_{ui}/\phi$, and $0.019 \text{ in}^2 \text{ per in.}$ (Request 586)
11. The calculated tensile stress in mild steel reinforcement at the service limit state is now limited to $0.60f_y$ when computing the allowable spacing for control of cracking by distribution of reinforcement. (Request 593)
12. The program is now correctly checking the overhang limit for design runs of adjacent box beams based on DM-4 Article 9.7.1.5.1P. Previously, the program incorrectly measured the overhang to the centerline of beam for adjacent box beams, instead of the centerline of the adjacent box beam web. (Request 598)

Rating Revisions

13. The controlling shear rating location is now the same in the Rating Summary Report and the Bridge Load Rating Report. Previously, when the controlling shear rating location was at a “d” critical location for a symmetrical structure, rarely one of the reports would identify the controlling shear location at the symmetrical “d” critical location in the opposite end of the span. (Request 560)
14. The shear ratings now correctly compute the component of effective prestressing force resisting shear for draped strands with debonding. (Request 578)

Documentation Revisions

15. For obsolete input parameters, the User Manual and Engineering Assistant help now notes “this parameter is no longer used” in the Chapter 5 Description and all other description, upper and lower limits, units, and defaults have been removed to avoid confusion. (Request 569)
16. The User Manual now includes Windows 10 in the list of supported Windows operating systems in Chapter 4. (Request 603)

Input Revisions

17. The program is now able to be run with a very long file name and/or path name, up to 256 characters in length. Previously, a path and file name combination over 204 characters would result in a program crash. (Request 602)

Output Revisions

18. Crack control debonding is now reported in the PRESTRESSING DATA output report for all strand types for analysis runs. Previously, crack control debonding was not reported in the PRESTRESSING DATA output report for draped or straight strand analysis runs. (Request 564)
19. The PRESTRESSING DATA output report for a draped design run that does not having any draped strands now prints completely without errors. Previously, the program would abort when this condition occurred. (Request 574)
20. The Flexural Resistance output table now includes the location of the neutral axis used to determine the nominal flexural resistance of the section. Previously, only the neutral axis location for elastic stresses on an uncracked section was given in the Section Properties output. (Request 521)
21. The Debonded/Draped Strand Output Table is now reporting the correct number of straight strands in the Straight/Debonded portion of the output table. Previously, when the strand rows in the Straight/Debonded portion of the output table also had draped strands in the same row, the draped strands were incorrectly reported with the straight/debonded strands. (Request 601)

Strand Design Revisions

22. The beam table for PennDOT I-beams now includes available strand patterns having mixed even and odd strand rows and the strand design routines now produce symmetrical strand patterns with mixed even and odd strand rows are present. (Request 571)

Distribution Factor Revisions

23. The moment distribution factor for exterior beams no longer considers cross frame action. (Request 567)

Plank Beam Revisions

24. The program now sets variables used to compute negative moment capacity correctly for plank beams. Previously, a 2-span plank beam design run would result in abort error message. (Request 575)

Programming Revisions

25. The program is now compatible with BRADD version 3.2.2.0. and 3.2.3.0. (Requests 576, 607)
26. The program is now verified to be compatible with APRAS NextGen. (Request 390)

SUMMARY OF JUNE 2017 REVISIONS - VERSION 2.11.0.0

Since the release of PSLRFD Version 2.10.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.11.0.0 contains the following revisions and enhancements.

Input Revisions

1. The default values for the Distributed Load command (DLD) are now applied as documented in the User Manual. Previously, an issue could cause distribution loads to only be applied to a single span rather than to the entire bridge. (Request 600)
2. The upper limit on the Number of Draped Strands of the SCE command is now computed based on the specified beam designation. Previously, the upper limit was hard coded to three. (Request 591)
3. A new load type is now available to specify Utility Loads. This allows Future Wearing Surface loads to be separated from Utility loads, but have the same load factors. This in turn, allows ratings “with FWS” and “without FWS” to be correct when utility loads are present. (Request 552)
4. The check for an odd number of strands in a row with an even number of available strands is now skipped for the second half of a symmetrical bridge. Previously, incorrect warning messages could be given for the second half of a symmetrical bridge. (Request 549)

Rating Revisions

5. The Bridge Load Rating Table now reports the resistance that corresponds to the controlling rating factor. When a shear rating controls, the rating the resistance is in units of kips. When a moment rating controls, the resistance can be in units of either kip-ft or ksi. The resistance will be in units of kip-ft when either flexural resistance or serviceability controls the rating. The resistance will be in units of ksi when the allowable concrete stress controls the rating. (Request 606)
6. The rating tonnage and distribution factor is no longer reported for the P-82C combination vehicle in the Bridge Load Rating Table or the Load Rating Summary Table due to the P-82C being a combination of multiple vehicles. (Request 599)

Output Revisions

7. An informational message has been added to the output file to indicate when the number of available strand locations has been reduced due to the presence of the transverse tendon in adjacent box beams or plank beams. (Request 596)
8. The Flexural Resistance Factors output table title is now displayed in all capital letters to be consistent with other program output table titles. (Request 595)

9. The “Effective C.G.S. and Number of Strands” output table now includes the simple bearing location for each span. The effect of crack control debonding is now considered in the output table when the “Effective C.G.S.” and “Effective Number of Strands” are computed for straight or draped strands. (Request 562)
10. A new output table named “Shear Reinforcement for Drawings” has been added to the program to assist in detailing the stirrups reinforcement on the drawings. This output table provides required stirrup areas and spacings for various stirrup reinforcement bars at key locations along each span of the bridge. The output is based on the stirrup data computed by the program and/or entered by the user and the corresponding BD Standards (BD-661M and BD-662M). The new input command Beam Details (BDT Command) must be entered for the new output table to be produced. (Request 554)

Shear Revisions

11. The Horizontal Shear output table now correctly compares the provided horizontal shear resistance to the required horizontal shear resistance. Previously, a tolerance issue could result in two resistance values that appear the same when printed being identified as a code failure. (Request 587/615)
12. The shear analysis and design calculations now incorporate AASHTO 5.8.2.4 (Regions Requiring Transverse Reinforcement) when considering AASHTO 5.8.2.5 (Minimum Transverse Reinforcement). When the factored shear force is less than or equal to one-half of the sum of the factored shear resistance from the concrete and the prestressing force, the minimum transverse reinforcement is no longer considered. The Maximum Spacing of Transverse Reinforcement (AASHTO 5.8.2.7) is considered at all locations along the beam regardless of the magnitude of the factored shear force. (Request 510)

Debonding Revisions

13. A tolerance is now considered when determining if a debonding location is at a crack control debonding location. Previously, warning messages for regular debonding were sometimes being applied to a crack control debonding location. (Request 590)
14. A check has been added to the program to not allow the debonding of draped strands. The program assumes only straight strands will be debonded. (Request 561)

Box Beam Revisions

15. The program now sets variables used to compute the negative moment capacity correctly for box beams with circular voids. Previously, a 2-span box beam with three circular voids analysis run would result in multiple pages of abort messages. (Request 535)

NEXT Beam Revisions

16. For Type F NEXT beams, the GEO command Deck Overhang parameter can now be entered as a dimension up to 8 inches larger than half of the beam width, allowing the deck to extend up to 8" past the Type F NEXT beam flange. Previously, the deck overhang was computed by the program to be one-half of the Type F NEXT beam width. (Request 515)

SUMMARY OF NOVEMBER 2018 REVISIONS – VERSION 2.12.0.0

Since the release of PSLRFD Version 2.11.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.12.0.0 contains the following revisions and enhancements.

New Features

1. The PCI NorthEast Type D NEXT beam can now be analyzed by the program. Type D NEXT beam distribution factors are conservatively based on cross type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. (Request 611)
2. The user can now request the center strand to be used in spread box beams. Previously, PSLRFD always assumed a dowel was present for spread box beams and would not use the center strand. (Request 618)

Documentation Revisions

3. The Engineering Assistant input field help has been verified and revised when needed to be consistent with the User Manual Description, Upper Limit, Lower Limit, Default and repeat parameter information. (Request 269)
4. The User Manual now provides the correct defaults for the Negative Moment Capacity output on the OSC command. (Request 592)
5. Chapter 5 of the User Manual now provides the criteria for when End Block Stresses are printed. (Request 573)
6. Chapter 4 now identifies that the shortcut to the PSLRFD program is on the Start Menu rather than on the PennDOT Programs folder. (Request 609)
7. User Manual section 2.7, Assumptions and Limitations, has been updated to the current version of the program. (Request 612)
8. The PSLRFD program has been verified to match the PA I-Beam section properties on BD Standard drawing BD-652M released April 2016. The BD-652M drawing had some recent revisions to a few PA I-Beam section properties and it was confirmed that PSLRFD was already using the updated values. (Request 616)
9. The description of the drapage point location on the DPL command now clearly defines the input to be a percentage of the simple span length. The figure now shows the distance to be measured from the right simple bearing at the continuous support. (Request 617)

10. The User Manual now documents that the weight of end blocks for box beams are not automatically included by the program. Also, the User Manual documents that the weight of beam extensions beyond the simple bearing are not automatically include by the program. (Request 633)

Output Revisions

11. The SHEAR REINFORCEMENT AND RESISTANCE table now includes “nominal” in the heading title for shear resistance. Previously, it was unclear if the shear resistances were factored or nominal. (Request 627)
12. The program now produces additional output files that can be used by version 2.5.4.0 or greater of EngAsst to display graphs of moments, shears and deflections for various dead loads and live loads. (Request 528)
13. The program now includes a note at the end of the Summary of Reactions output table that the weight of box beam end blocks is not automatically included by the program. Also, the note indicates that weight of the beam extensions beyond the simple bearing are not automatically included by the program. (Request 621)

Debonding Revisions

14. The program now reports a warning message for analysis runs with debonding of strands for consecutive rows of the webs of box beams. (Request 610)

Design Revisions

15. The program now uses the smallest applicable skew angle associated with the girder to calculate the shear correction factor when the girder has multiple skew angles per DM-4 Commentary C4.6.2.2.3c. Previously, the skew angle at the nearest support was used. (Request 518)
16. The program now computes the area of concrete on the flexural tension side of the member for Type F and Type D NEXT Beams. This value is used to compute the longitudinal strain at the mid-depth of the member when computing shear parameters β and θ using the general procedure for shear design where the initial calculation of the strain is negative. Previously, this value was taken as zero which resulted in the shear resistance of the concrete being larger for about the end-third of the span. For some Type F Beams the large concrete resistance resulted in the stirrup spacing being incorrectly controlled by the maximum spacing of $0.8 \cdot d_v$. (Request 640)

Input Revisions

17. The program now correctly processes defaults for the DLD command for symmetrical structures. Previously, for bridges run with the Symmetry option, if the Start Span was set to 0 the DLD loads applied to the bridge were not always applied symmetrically. (Request 628)

18. The program now allows the number of strand rows and the number of available strands per row to be specified on the SCD command for a design run that does not use the BDM command. Previously, the number of strand rows and number of available strands per row entered on the SCD command was ignored for design runs that did not use the BDM command. (Request 635)

BRADD Revisions

19. The program now passes the debonding configuration correctly for BRADD runs. Previously, for some debonding problems, the debonding configuration reported in the output was not correctly passed to the BRADD drafting routines. (Request 632)

Programming Revisions

20. The program is now compiled with Intel Visual Fortran Parallel Studio XE 2017 Update 5 and Visual Studio XE 2017. (Request 619)

SUMMARY OF NOVEMBER 2019 REVISIONS - VERSION 2.13.0.0

Since the release of PSLRFD Version 2.12.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.13.0.0 contains the following revisions and enhancements.

New Features

1. Girder stability checks can now be analyzed by the program for a girder lifted from the top with devices attached to the web or embedded in its top near each end of the girder. The girder stability checks can be made for "I" shaped cross sections (PennDOT and AASHTO I-beams and PA Bulb Tee beams). (Request 631, 679)

Input Revisions

2. The Special Live Load command (SLL) now includes a Vehicle Type parameter to identify the Dynamic Load Allowance (Impact Factor) to be used for the vehicle. The Dynamic Load Allowance type can be either Design or Permit. (Request 624, 671)
3. The Load Factor command (LDF) now allows the first parameter to identify a specific Special Live Load vehicle by numbers 1 through 5. Previously, the Load Factors for Special Live Load vehicles were specified by SLL for parameter one of the LDF command and were applied to all Special Live Load vehicles. This allows different Load Factors to be specified for each Special Live Load vehicle. (Request 625)

Output Revisions

4. The debonding warning messages now displays the full message. Previously, for some of the messages part of the text was missing. (Request 623)
5. The range of applicability variables reported in the output for the NEXT Beam shear distribution factor and the skew correction were not being reported correctly. This has been fixed. This issue did not affect the value of the distribution factor. (Request 700)

Continuous Beam Analysis Revisions

6. Three vehicles specified as part of the FAST Act (EV2, EV3, and SU6TV) have been added as a live load option to the program (Analysis Live Load Code H). The program now uses version 3.7.0.0 of CBA which contains the FAST Act vehicles. (Request 613, 672)
7. The program can now analyze a second permit design vehicle, the P2016-13 which has 13 axles and two sets of variable axle spaces (Design Live Load Code F, Analysis Live Load Codes I, J, and K). The program now uses version 3.7.0.1 of CBA which allows PSLRFD to control the axle spacing increments used for the two sets of variable axle spaces. (Request 614, 674)

Analysis Revisions

8. Analysis Live Load Code A on the CTL command now considers three analysis vehicles, PHL-93, ML-80, and TK527, like the way Design Live Load Code E considers these three vehicles. Previously, for some analysis runs the Final Tensile Stresses-Design Loads would not have any failures, but the Service III rating factors for ML-80 and TK527 would be less than 1.0 because the ML-80 and TK527 vehicles were not considered when computing the final tensile stresses. Now that the three analysis vehicles are included with Analysis Live Load Code A, the Final Tensile Stresses-Design Loads output table now shows the failures that correspond to the ratings being less than 1.0. (Request 626, 656, 675)
9. The multiple presence factor is now applied to the pedestrian deflection distribution factor. Additionally, the multiple presence factor for analysis with sidewalks now adds one to the number of loaded lanes with sidewalk when computing the multiple presence factor. (Request 659, 676)

Shear Rating Revisions

10. The Shear Design/Analysis output table now considers a tolerance when comparing the Factored Shear Resistance to the Factored Shear. The shear design/analysis now uses consistence tolerances with the shear rating routines to avoid inconsistent results between shear design/analysis and shear rating. The shear rating iteration process was revised to reduce the number of iterations and increase the precision of the computed shear resistance. (Request 629, 673)

Plank Beam Revisions

11. The effective overhang for Plank beams (measured from the beam edge) is now used when checking DM-4 9.7.1.5.1P (Overhang of Deck Slab on Concrete and Steel Girder Bridges). Previously, the overhang used for plank beams was being computed from the centerline of the beam. (Request 665)
12. For composite plank beams the horizontal shear area now defaults to 0.80 in², which corresponds to the four locations where the horizontal stirrup bar extends through the top of the plank beam, as shown on the Plank Beam detail on BD-661M, Sheet 7. Previously, the horizontal shear area defaulted to 0.40 in². (Request 701)

User Manual Revisions

13. Chapter 9 of the User Manual now has a combined Technical Question and Revision Request form with up to date contact information, and the form was updated to request input data of more than 4 or 5 lines to be provided as a file attachment to an e-mail. (Requests 655, 666)
14. The User Manual example problems now use the PennDOT skew angles designation. Previously, the AASHTO skew angle designation was used. (Request 630)

15. The User Manual now presents the data in Tables 2.5-1 (Live Loadings for Design) and 2.5-2 (Live Loadings for Analysis) in a manner consistent with similar tables in the STLRFD User Manual. The revised tables identify which vehicles are Design, Rating and Analysis vehicles for each limit state. (Request 653)

SUMMARY OF FEBRUARY 2021 REVISIONS - VERSION 2.14.0.0

Since the release of PSLRFD Version 2.13.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.14.0.0 contains the following revisions and enhancements.

Updates for AASHTO 8th Edition and DM-4 2019 Edition

1. The live load factor for the Fatigue I Limit State is now 1.75. Previously, the factor was 1.50. (Request 683)
2. The live load factor for the Service III Limit State is now 1.0 and the live load factor for Service IIIP Limit State is now 0.80 for PHL-93. For all other rating vehicles, the factor is 1.0 per note 4 of DM-4 Table 3.4.1.1P-2. Previously, these factors were 0.80 and 0.65. (Requests 684, 720)
3. The sidewalk live load is now counted as an extra loaded lane when computing the Multiple Presence Factor. For pedestrian load (Strength IP, Service IP) limit states only the multi-lane distribution factors will be considered when the AASHTO / DM-4 equations are used. When the lever rule is used to determine the distribution factor, the multiple presence factor is computed for one more loaded lane than the number of loaded lanes used for the lever rule. (Request 685)
4. The concrete modulus of elasticity now is based on values given in DM-4 Section 5.4.2.4 for standard concrete unit weights (normal weight and lightweight) and concrete strengths. Standard unreinforced normal weight concrete is 145 pcf and standard unreinforced lightweight concrete is 110 pcf. The concrete modulus of elasticity for non-standard unreinforced unit weights are computed by equations and rounded to the nearest 100 ksi. Also, the Modular Ratio for standard unreinforced normal and lightweight concrete are now based on the values given in DM-4 Section 5.4.2.1. (Request 686)
5. The Pennsylvania Traffic Factor (PTF) is no longer used by the program. Previously, the PTF was applied to the live load factor for the Fatigue I Limit State, but the Fatigue I live load factor has now been changed from 1.50 to 1.75 in the 2019 DM-4 eliminating the need for the PTF. (Request 688)
6. The modular ratio between the slab concrete elastic modulus and the beam concrete elastic modulus is now rounded to the nearest tenth. Previously, the modular ratio was not rounded. (Request 689)
7. The first debonding location for box beams is now located 1'-6" beyond the End Block. The length of the end block depends on the various geometry at the end of the beam. This geometry is given on the Beam Detailing (BDT) command. For design runs of box beams with debonded strands the Beam Detailing command is now required. NOTE: EXISTING INPUT FILES FOR BOX BEAM DESIGN RUNS WITH DEBONDED STRANDS MUST BE REVISED TO INCLUDE THE BDT COMMAND. (Request 690)
8. Most warning messages requiring approval are now District Bridge Engineer (DBE) messages. The approval authority in DM-4 for most cases is now the District Bridge Engineer (DBE) rather than the Chief Bridge Engineer (CBE). (Request 692)

9. The prestress beam allowable concrete tension stress computed by the program now has an upper limit of 0.300 ksi. Previously, the computed allowable concrete tension stress did not have an upper limit. For prestress beam concrete strengths above 10 ksi the computed allowable tension stress could be greater than 0.300 ksi, but prestress beam concrete strengths above 10 ksi are not allowed by DM-4. (Request 693)
10. The basic development length computed by the program for mild reinforcement now agrees with the AASHTO 8th Edition. The User Manual now includes detailed information for the calculation of the development length modification factors. (Request 696)
11. Specification references in the User Manual, program output, and EngAsst configuration files are now updated for the reorganization of the AASHTO 8th Edition Section 5 article numbers. (Request 697)
12. The time development factor for creep is now computed based on the AASHTO 8th Edition equation. (Request 699)

Input Revisions

13. A special live load run (Live Load Code E) now requires the SLL and SAL commands. Previously, requesting a special live load run without providing SLL and SAL commands would result in a program crash (Request 703)
14. The option to allow strands at the centerline of spread boxes is now disabled. Strands at the centerline would interfere with the 1" drain hole shown in BD-661M. (Request 667)
15. A new input item on the SLB command now identifies the location of the top transverse reinforcement in the slab. The top transverse bar can be either Above or Below the top longitudinal bar. Previously, the top transverse bar was always above of the top longitudinal bar, but BD-601M revised this in negative moment regions. (Request 663)
16. The input for Relative Humidity (CTL command) and Estimated P/S Loss (MPS command) in Engineer Assistant now allows decimal values. Previously, reading an input file that included a decimal point in the Relative Humidity or Estimated P/S Loss would result in an error when the input file was opened by the Engineer Assistant program. (Request 651)

Output Revisions

17. The reactions and rotations for the Strength IP and Service IP limit states now use the live load distribution factor with sidewalks. Previously, the design live load distribution factor was being used which is incorrect. (Request 705)

18. The Bridge Load Rating output table now correctly reports the controlling rating criterion when Service I or Service IP Compression at the Bottom or Service III or Service IIIIP Tension at the Top controls. Previously, a lowercase “u” was printed. (Request 710)
19. The Detail Rating Factor output for shear ratings now reports the factored shear resistance used to compute the shear rating factor. (Request 658)
20. The Shear Design/Analysis output now identifies factored shear resistance values that are controlled by the nominal shear resistance of the web concrete. The nominal shear resistance is limit by $0.25 \cdot f'_c \cdot b_v \cdot d_v + V(p)$. (Request 652)

Slab Reinforcement Revisions

21. The default slab reinforcement area now accounts for the bottom longitudinal bars not placed over portions of spread beams (boxes, I-beams, and Bulb tees) per BD-601M. (Request 647)
22. The design of the longitudinal slab reinforcement at continuous support is now based on the following criteria. (Request 646, 715)
 - 1 Minimum spacing of longitudinal reinforcement is 4.5 inches (BD-601M)
 - 2 Top reinforcement at least 2/3 of total design area (DM-4 6.10.1.7)
 - 3 Bottom reinforcement at least 1/3 of total design area (DM-4 6.10.1.7)
 - 4 Total design area at least 1% of slab area (DM-4 6.10.1.7)
 - 5 Minimum clear distance between top and bottom mats is now checked separately for longitudinal bars and transverse bars using a clear distance of 2 inches (BD-601M)

Design Revisions

23. Checks for Service I and Service III stresses now consider that the location of the maximum moments may occur at different locations. Previously, the location was assumed to be the same and could result in design runs having final tensile stress failures. This condition was noted in for a span length of 25 feet. (Request 706)
24. For design runs the program now checks the final compression stresses under dead load and prestress for a simple span with straight strands. Previously, on rare occasions, a design run would have a stress failure at the end of the transfer length for straight strand problems because this check was not included during the design process. (Request 707)
25. The final stress tolerance is now 1.0% for final stresses that are used to compute ratings. Previously, the final stress tolerance was 2.5%. This change was made because the larger final stress tolerance would occasionally result in a design run with a controlling rating factor less than 1.00. (Requests 664, 721)

Rating Revision

26. The option to provide ratings for with Future Wearing Surface and without Future Wearing Surface in a single run for Shear Analysis (stirrup spacing provided) now produces consistent results compared to making two separate runs. Previously, the ratings with Future Wearing Surface in the single run were conservative when the shear ratings were controlled by the longitudinal reinforcement. Also, the d(critical) location for the without Future Wearing Surface ratings in the single run could be incorrect. (Request 726)

New Feature

27. The program is now able to check girder stability for the following conditions: (Requests 668, 725)
- 1 Seating of the first girder with construction active wind condition
 - 2 All girders seated with construction inactive wind condition
 - 3 Deck casting with construction active wind conditions

Box Beam Revision

28. The upper limit for the thickness of the bottom slab of box beams is now 7 inches. For design runs, the thickness of the bottom slab is set based on the distance to the first strand row as given in the dapping tables shown on Bridge Design Standard BD-661M sheet 3 of 8. Previously, the upper limit was 6.75 inches. (Request 724)

User Manual Revisions

29. The User Manual now defines interior diaphragms to be internal to the beam and exterior diaphragms to be external to the beam. Figures for typical I-beam and spread box beam bridges diaphragms have been added to User Manual Chapter 6 for the DIA command. (Request 589)

System Revisions

30. The program is now developed using Visual Studio 2019 and Intel Parallel Studio XE 2019 Update 5. (Request 678)

SUMMARY OF APRIL 2022 REVISIONS - VERSION 2.15.0.0

Since the release of PSLRFD Version 2.14.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.15.0.0 contains the following revisions and enhancements.

Input Revisions

1. An input check will now give a warning message when the CDF command parameter Centerline Exterior Beam to Curb minus CDF command parameter Distance to Outermost Wheel is less than 2 feet. (Request 669)
2. The Sidewalk Dead Load on the PLD Command now allows negative values both in Engineering Assistant and in PSLRFD without a warning message. Previously, a negative value could not be entered in Engineering Assistant. (Request 711)

Output Revisions

3. Concrete stress output reports that correspond to Service Rating Factors now include Live Load Stresses. These reports are printed for Design Loads and each rating vehicle used for Service Rating Factors. These live load stresses allow simpler verification of the Service Rating Factors that depend on concrete stresses. Also, a new output report now gives the moment capacity based on 90% of f_{py} stress in the bottom row of prestressing strands at each analysis point. Previously, the moment capacity based on 90% of f_{py} was reported once per span. (Request 657)
4. All input commands are now reported in the Input Summary section of the output. Previously, some of the input data was only being reported other sections of the output. (Request 531)
5. A new Specification Checking output option allows reporting of intermediate values used to compute shear resistance. (Request 650)
6. The message at the bottom of the Final Tensile Stresses output table has a more detailed explanation of the meaning of the plus sign that appears in the "If Code Failure" column of the output table. (Request 708)
7. For NEXT Type F and Type D Beam analysis runs with zero strands specified in the first strand row, a warning message will now appear and up to five alternate strand patterns are provided which have strands in the first strand row. The alternate patterns will have the same number of strands and the strand CGS at mid-span will be the same as the original strand pattern or slightly less than the original strand pattern CGS. (Request 604)

Design Revisions

8. The criteria for selecting strand patterns in I-beam cross sections now avoids patterns where lower strand rows in the bottom flange have fewer strands than higher strand rows in the bottom flange. Previously, sometimes the bottom strand row would have as few as three strands while the second row would have five strands and the third row would have 15 strands. This caused fabrication issues for the prestressed beam fabricators. (Request 722)
9. The optimization of the beam concrete strength (f'_c) uses the beam sizes selected for the initial f'_c value entered by the user and now redesigns the beams for reduced f'_c values. The new behavior may produce a beam with a smaller f'_c value because the strand pattern is designed each time the beam is redesigned. The prior procedure used the selected beam sizes and the initial strand pattern and performed an analysis with the reduced f'_c values. (Request 512)

Distribution Factor Revisions

10. The program now runs when distribution factors are entered as zero. Previously, a program crash would result when the distribution factors were entered as zero. An input check requires the pedestrian distribution factor to be zero when entered with the design distribution factor entered as zero. (Request 741)
11. The program now runs when reaction distribution factors are entered as zero for an analysis run with the P-82C loading combination. Previously, a program crash would result when the reaction distribution factors were entered as zero for an analysis run with the P-82C loading combination. Additionally, the program will now report reactions equal to zero for other live loads. Previously, the program would return reaction values calculated with the shear distribution factor if the reaction distribution factors were entered as zero. (Request 742)

User's Manual Revisions

12. The User's Manual beam designations given in Tables 3.22-1 through 3.22-8 now agree with the valid Beam Designations for parameter 2 of the BDM Command. The description for parameter 2 of the BDM Command refers the user to Tables 3.22-1 through 3.22-8 for available designations. (Request 505)
13. Chapter 5 of the User's Manual now provides information on limits for repeatable parameters of input command for Engineering Assistant. (Request 588)
14. The equations used to compute the required area of longitudinal slab reinforcement have been verified to be based on AASHTO LRFD 8th Edition Equations 5.6.3.1.1-3 and 5.6.3.2.2-1. (Request 709)
15. The Revision Request Forms (User Manual and Word Template) do not refer to a PennDOT fax number. (Request 744)

Special Live Load Revisions

16. The program has been enhanced to allow up to 8 special live loads to be entered in a single run. Previously, the limit was 5 special live loads in a single run. (Request 423)
17. The limit states used for Special Live Loads now depends on the Vehicle Type specified on the SLL command. Specifying the 'P' Vehicle Type results in ratings for the Strength II and Service IIIA limit states. Specifying the 'D' Vehicle Type results in ratings for the Strength I, Strength II, Service I, Service III, and Service IIIA limit states (if pedestrian loads are entered, ratings will also be calculated for the Strength IP, Service IP, and Service IIIP limit states). (Request 670)

Debonding Revisions

18. The program was revised to correctly identify debonding strand patterns that would result in strands in adjacent columns being debonded. Previously, debonding strand patterns that did not require strands in adjacent columns to be debonded would report an inaccurate warning message. (Request 735)

Girder Stability Revisions

19. The Bearing Rotational Stiffness parameter is now correctly written to the input file for BRADD runs of PSLRFD. Also, the numbering of parameters on the GS3 command is now correct in the User's Manual. (Request 738)
20. On the GIRDER STABILITY/HANGING GIRDER output report, the bottom of beam stress check status is now correctly reported at debonding locations. Prior to this change, the stress check status reported at the debonding location was actually the stress check status for the midspan location. The allowable stress value is also now reported for the debonding and midspan locations. (Request 739)

Programming Revisions

21. The "strand row to start debonding", parameter 4 on the SCD command, can now be larger than the number of strand rows being used in the current design trial. Previously, this would result in an endless loop. (Request 723)
22. The program is now updated to be consistent with BRADD version 3.2.6.0. (Request 727)
23. PSLRFD has been revised to use the Intel Fortran Compiler Classic OneAPI version 2021.4.0 for compilation and linking. (Request 734)

SUMMARY OF MARCH 2023 REVISIONS - VERSION 2.16.0.0

Since the release of PSLRFD Version 2.15.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.16.0.0 contains the following revisions and enhancements.

Input Revisions

1. Users can now input minimum load factors for Strength limit states for MC1 and MC2 loads on the LDF command. If not entered by the user, the minimum Strength load factors for MC1 and MC2 will default to 0.0. Any input files with MC1 or MC2 loads may need to be revised to provide minimum load factors other than 0.0. (Request 551)

Output Revisions

2. The Input Summary output report now prints the correct Vertical Row Spacing. Previously, the Distance to 1st Row was being printed for the Vertical Row Spacing. (Request 754)

Distribution Factor Revisions

3. Distribution factors for exterior adjacent beams (box and plank) now use interior adjacent beam properties when computing the distribution factor for interior adjacent beams. The exterior adjacent beam distribution factors are computed from the interior adjacent beam distribution factors. The interior beam properties used to compute distribution factors are reported. (Request 419)

Programming Revisions

4. The program now checks for large numbers of concentrated loads exceeding the capacity of the program and reports an error message. Previously, a large number of concentrated loads would result in a program crash. (Request 406)
5. The compression-controlled strain limit for non-prestressed reinforcement with a specified minimum yield strength, f_y , less than or equal to 60.0 ksi is now taken as f_y/E_s but not greater than 0.002. Previously, for $f_y \leq 60.0 \text{ ksi}$ the compression-controlled strain limit was taken as 0.002. (Request 733)
6. For APRAS runs with Pedestrian loads (PLD command), the Additional FWS load is now ignored by setting it to zero. This is consistent with FWS specified by DLD command being ignored for APRAS runs. (Request 758)

Design Revisions

7. The strand design process for NEXT beams now avoids strand patterns with zero strands in the bottom strand row. Previously, about one-third of the P/S Curves successful designs had zero strands in the bottom row. (Request 736)
8. The debonding strand design now avoids debonding the outer-most strands in bottom flange rows within the full width of the bottom flange for I-beam cross sections (PennDOT I-Beams, AASHTO I-Beams, and PA Bulb Tee Beams). Also, strands within the horizontal limits of the web for I-beam cross sections are not debonded. (Request 737)
9. The Slab Reinforcement Design for negative moment at interior supports for spread beams now requires the top layer reinforcement area to equal at least $\frac{2}{3}$ of 1 percent of the slab area and the bottom layer reinforcement area to equal at least $\frac{1}{3}$ of 1 percent of the slab area. Previously, the top layer was required to be $\frac{2}{3}$ of the required area for flexural resistance and the bottom layer $\frac{1}{3}$ of the required area for flexural resistance. (Request 751)

SUMMARY OF FEBRUARY 2026 REVISIONS - VERSION 2.17.0.0

Since the release of PSLRFD Version 2.16.0.0 several revision requests and user requested enhancements have been received. This release of PSLRFD Version 2.17.0.0 contains the following revisions and enhancements.

User Manual Revisions

1. A non-composite sidewalk dead load has been added to the Pedestrian command to allow consideration of changes to non-composite dead load when the bridge has sidewalks. (Request 430)
2. A brief description of rotation distribution factors has been included in User Manual section 3.5. (Request 539)
3. The basic development length modification factor for epoxy-coated bars detailed in User Manual section 6.18.4 has been revised to include clear spacing limits for the 1.5 factor value and the 1.2 factor value for other epoxy-coated bars. Note that this change reflects the criteria that was being used to compute the coating factor. (Request 579)
4. Note 2 of the BDM command in the User Manual has been updated for clarity. (Request 732)
5. The User Manual and Engineering Assistant have been updated to include information about load factor applications and instructions on inputting custom load factors. (Request 753)
6. References to Windows 8.1 as a supported operating system have been removed from Chapter 4 of the User Manual. (Request 770)

Input Revisions

7. Additional input checks have been added for the TND command for the tendon longitudinal locations. (Request 755)
8. Input file names starting with either “APRAS” or “apras” are no longer considered to be APRAS runs. (Request 762)

Output Revisions

9. The Detailed Rating Factor report for Strength Moment Ratings now reports the computed rating factors at simple bearings near interior supports. Previously, ratings at these locations were reported as 999.99. Also, ratings factors are now computed for negative live load moment at locations where the total minimum factored moment is positive, and the minimum live load moment is negative. Previously, these ratings were reported as 999.99. (Request 729)

10. Design runs requesting f'c optimization now have new top-level bookmarks that provide greater navigation in the PDF output. (Request 740)
11. The output report for the Service IIIA check of 90% Yield Stress of P/S Strands has been revised to ignore analysis points located between simple bearings at interior supports. Before this change analysis points located between simple bearings would report a Code Failure for analysis points that were not at the interior support. (Request 748)
12. The Overhang Width output report only defaults to print when a valid OVH command has been given by the user. (Request 757).
13. For the debonding strand analysis of I-beam cross sections (PennDOT I-Beams, AASHTO I-Beams, and PA Bulb Tee Beams), a strand pattern visualization will be generated and printed in the output report. (Request 761)
14. For the debonding strand analysis of I-beam cross sections (PennDOT I-Beams, AASHTO I-Beams, and PA Bulb Tee Beams), warnings have been added to the report when the specified debonding pattern requires debonding of the outer-most strands in the full width portion of the bottom flange or strands within the horizontal limits of the web. (Request 771)

Design Revisions

15. Debonded strand design runs now include an explicit minimum reinforcement check. Previously, on rare occasions a debonded strand design run would report a failure for the Minimum Prestressing Steel Check. (Request 064)
16. Multiple shear areas (horizontal and vertical) can be specified for shear design runs within a span. Previously, multiple areas could be entered but only the first area was being used. (Request 704).
17. The design spacing for horizontal stirrups in box beams has been limited to a minimum of 6 inches to agree with Standard BD-661M Box Beam Reinforcement Details. Box beam designs requiring less than 6 inch spacing of horizontal stirrups will fail for the current beam size. A horizontal stirrup area of 0.62 in² (2 - #5 bars) does not result in a warning message in the Shear Reinforcement for Drawings output. (Request 746)
18. The minimum number of strands in the bottom row for adjacent boxes with debonded strands has been changed to 8 to allow 2 strands to be debonded when only a total of 8 strands are required for the design. Previously, designs requiring only 6 strands in the bottom row could fail the debonding design. (Request 760)

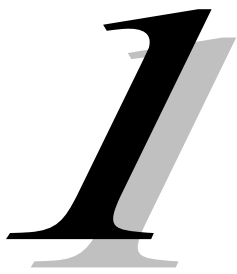
Engineering Assistant Revisions

19. The figure names used in Engineering Assistant's tabs and descriptions have been updated to be consistent with the figure names used in the User Manual. (Request 763)

Programmer Revisions

20. The tendon location from the right simple bearing no longer considers zeroes input by the user in tendon location calculations. Previously, the program would determine tendon locations using any value entered, including zero. This would set the tendon location to a distance outside of the span length. The program now disregards tendon locations of zero for end block calculations. (Request 774)
21. The tolerance used to determine if a debonding location corresponds to crack control debonding has been changed to +/- 0.5 inches. Previously, the tolerance was 0.0001 feet or 0.0012 inches. (Request 775).
22. The program has been revised to use Visual Studio 2022 and Intel Fortran Compiler Classic 2021.12.0. (Request 777)
23. The program has been made compatible with the forthcoming release of Engineering Assistant v3.0.0.0. Changes include:
 - 1) switching image formats from Enhanced Metafile (.emf file) to Portable Network Graphic (.png file) required by the new Engineer Assistant,
 - 2) associating a Tab Name with the current 3 letter tab abbreviation,
 - 3) resolving issues when setting floating-point precision on 64-bit systems. (Request 784)

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GENERAL DESCRIPTION

1.1 PROGRAM IDENTIFICATION

Program Title:	LRFD Prestressed Concrete Girder Design and Rating
Program Name:	PSLRFD
Version:	2.17.0.0
Subsystem:	Superstructure
Authors:	Pennsylvania Department of Transportation, Michael Baker International, and Modjeski and Masters, Inc.

ABSTRACT:

The LRFD Prestressed Concrete Girder Design and Rating program (PSLRFD) performs an analysis and specifications check, in accordance with the AASHTO LRFD Bridge Design Specifications and the Pennsylvania Department of Transportation Design Manual Part 4, for pretensioned concrete beams with cast-in-place concrete slabs. As result of a decision by the AASTHO Subcommittee on Bridges and Structures to no longer publish SI unit specifications, the program only supports US customary (US) units. The prestressed concrete beam section can consist of an I-beam, a bulb-tee beam, a Type F or Type D NEXT beam, an adjacent plank beam, a box beam with a rectangular void, or a box beam with one, two, or three circular voids. The plank beams are adjacent beams. Box beams can be either adjacent beams or spread beams. The beam can be a standard shape beam or the user can define the dimensions. The section can be composite or non-composite for adjacent plank or adjacent box beams; the section can only be composite for I-beams, bulb-tee beams, Type F NEXT beams and spread box beams. The section can only be non-composite for Type D NEXT beams.

The program can perform an analysis or design of a simple span bridge or a multi-span bridge made continuous for live load. For multi-span bridges, the structure is considered to be simply supported for non-composite dead load and continuous for composite dead load and live load. The creep and shrinkage moments for the continuous structure are computed using a modification of the 1969 PCA bulletin entitled Design of Continuous Highway Bridges with Precast, Prestressed Concrete Girders. The live load can be an LRFD loading or a user-defined loading, including a combination of truck and lane loading. The live load analysis is performed in accordance with the AASHTO LRFD Bridge Design Specifications.

Chapter 1 General Description

After the analysis is performed, PSLRFD checks for compliance with the AASHTO LRFD Bridge Design Specifications and the Pennsylvania Department of Transportation Design Manual Part 4. The program computes and checks specifications for initial stresses, final stresses, moments, shears, fatigue stresses, prestress losses, debonding or draping, and deflections. Shear and flexural rating factors are also provided. The program has a design option, which determines the optimal beam size, prestress force and eccentricity, beam concrete strength, shear stirrups, and debonding for each span.

Chapter 1 General Description

1.2 ABBREVIATIONS

This section provides definitions of abbreviations that are commonly used throughout this User's Manual.

AASHTO	- American Association of State Highway and Transportation Officials.
BSP	- PennDOT Beam Section Properties program.
CBA	- PennDOT Continuous Beam Analysis program.
DM-4	- Pennsylvania Department of Transportation <u>Design Manual Part 4: Structures, December 2019 Edition</u> . This publication can be ordered from: PennDOT Sales Store P.O. Box 2028 Harrisburg, PA 17105-2028 This publication can also be downloaded free of charge from PennDOT's website.
LRFD Specifications	- <u>AASHTO LRFD Bridge Design Specifications</u> , 8th Edition, 2017, published by: American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, D.C. 20001
PennDOT	- Pennsylvania Department of Transportation.
PSLRFD	- LRFD Prestressed Concrete Girder Design and Rating program.

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PROGRAM DESCRIPTION

2.1 GENERAL

The purpose of this program is to provide a tool for bridge engineers to analyze and design prestressed concrete girders, both composite and noncomposite. PSLRFD performs an analysis and specifications check in accordance with the AASHTO LRFD Bridge Design Specifications and the Pennsylvania Department of Transportation Design Manual Part 4. As result of a decision by the AASHTO Subcommittee on Bridges and Structures to no longer publish SI unit specifications, the program only supports US customary (US) units.

The analysis is based on a single girder and the fraction of the design live load that is carried by the girder. The user can input live load distribution factors or the program will compute them. The cross section can consist of an I-beam, a bulb-tee beam, a Type F or Type D NEXT beam, an adjacent plank beam, a box beam with a rectangular opening, or a box beam with one, two, or three circular openings. Plank beams are adjacent beams. Box beams can be either adjacent beams or spread beams. The section can be composite or noncomposite for adjacent plank or adjacent box beams; the section can only be composite for I-beams, bulb-tee beams, Type F NEXT beams and spread box beams. The section can only be non-composite for Type D NEXT beams.

The program can perform an analysis or design of a simple span bridge and of a multi-span bridge made continuous for live load. The live load can be an LRFD loading or a user-defined loading, including a combination of truck and lane loading. The live load analysis is performed in accordance with the AASHTO LRFD Bridge Design Specifications.

After the analysis is performed, the program checks for compliance with the AASHTO LRFD Bridge Design Specifications and the Pennsylvania Department of Transportation Design Manual Part 4. The program computes and checks specifications for initial stresses, final stresses, moments, shears, fatigue stresses, prestress losses, debonding or draping, and deflections. Shear and flexural rating factors are also provided. The program has a design option, which determines the optimal beam size, prestress force and eccentricity, beam concrete strength, shear stirrups, and debonding for each span.

Chapter 2 Program Description

2.2 PROGRAM FUNCTIONS

PSLRFD performs the following functions:

1. Input Processing - The program prompts the user for the name of the input file and output file and then processes the input. The program checks the user-entered input values and compares them with lower and upper limits stored in the program. If the user-entered value is less than the lower limit or greater than the upper limit, an error or warning is issued. If an error is detected, the program will stop processing; otherwise the program will continue on to initialize all constants used by the program that depend on the input values.
2. Constant Initialization - The program initializes constants used by the program that are dependent on input values. Constants that are initialized include moduli of elasticity, modular ratios, prestress yield stresses, prestress jacking stresses, allowable concrete stresses, modulus of rupture, stress block ratios, load factors, resistance factors, dynamic load allowance, debonding constants, and creep factor for camber.
3. Section Properties - The program uses the PennDOT Beam Section Properties (BSP) program to compute the section properties. It computes basic beam and composite beam section properties for the gross and transformed section.
4. Distribution Factor - The program computes the moment, shear, reaction, and deflection distribution factors for a design vehicle and a fatigue vehicle. For a design vehicle, the distribution factor is based on the number of loaded lanes that produces the controlling distribution factor. For a fatigue vehicle, the distribution factor is based on one lane loaded; the resulting distribution factor is then divided by 1.20, in accordance with LRFD Specifications Article C3.6.1.1.2. Moment, shear, and reaction skew correction factors are included as appropriate.
5. Loads - The program computes the various loads to be used as input in the structural analysis. Loads used by the program include girder weight, slab and haunch weight, interior diaphragm weight, exterior diaphragm weight, non-composite and composite counterweight load, additional DC1 weight, additional DC2 weight, miscellaneous non-composite dead load weight, miscellaneous composite dead load weight, and future wearing surface weight.
6. Structural Analysis - The program uses the PennDOT Continuous Beam Analysis (CBA) program to compute the moments, shears, reactions, rotations, and deflections for the permanent loads and transient loads. For analysis, the user-input sections are used. For design, the program iterates the section dimensions until the LRFD Specifications, including live load deflections, are satisfied and an optimal design is obtained. Permanent loads are dead loads of structural components and nonstructural attachments (DC), and dead loads of future wearing surfaces (FWS) and utility loads (UT1 for non-composite and UT2 for composite). DC loads applied to the non-composite section are referred to as DC1 loads, and DC loads applied to the composite section are referred to as DC2 loads. In addition, miscellaneous loads, which act on the non-

Chapter 2 Program Description

composite section, are referred to as MC1 loads, and miscellaneous loads, which act on the composite section, are referred to as MC2 loads. Transient loads consist of the vehicular live load (LL) and vehicular dynamic load allowance (IM).

7. Strand Design/Analysis - The program checks the user-defined strand pattern for an analysis problem and determines a feasible strand pattern for a design problem's optimal prestress force and eccentricity. The program includes the computation of prestress losses, prestress eccentricities, transfer and development lengths, girder cracking moments, girder flexural capacities, initial concrete stresses, and final concrete stresses.
8. Creep and Shrinkage Effects - The program computes the restraint moments due to creep and shrinkage. The program uses the PennDOT Continuous Beam Analysis (CBA) program to compute the restraint moments due to dead load creep and prestress creep, and the differential shrinkage between the beam and slab. These moments, along with the factored positive live load moment, are used to design the positive moment steel at the interior supports. If the creep and shrinkage effects produce negative moments at the interior supports, the creep and shrinkage moments are used in the design or analysis of the negative moment reinforcement. The creep and shrinkage moments can be negative at interior supports for the "shrinkage only" option.
9. Debonding Design/Analysis - The program checks the debonded strand configuration against specified limits; it calculates and checks final and initial, compressive and tensile, concrete service stresses; it calculates and checks ultimate capacities against positive, extreme effect, applied moment loads; it calculates and checks yield capacities against positive, extreme effect, applied moment loads; and it calculates and checks cracking ratios against specified limits. For a design run, the program formulates a debonded solution to an existing fully-bonded girder configuration. For an analysis run, the program performs an analysis of a user-defined debonded girder configuration.
10. Negative Moment Capacity - The program calculates the negative moment capacity required for prestressed concrete beams made continuous for live load. For the case in which the longitudinal slab reinforcement is to be designed, the program calculates the required area of longitudinal reinforcement to resist the applied composite negative flexure loads. For the case in which the longitudinal slab reinforcement is not to be designed but is entered by the user, the program computes the negative moment capacity of the composite prestressed concrete beam based on the area of longitudinal reinforcement specified.
11. Shear Design/Analysis - The program is used to design or analyze for shear in a prestressed concrete beam. The program calculates the critical section for shear, the shear resistance due to concrete, prestressing, and mild reinforcing steel, and the tensile resistance and required resistance of the longitudinal steel, both prestress and mild steel. Horizontal shear requirements are also considered. For a design problem, the required stirrup area and spacing are computed.

Chapter 2 Program Description

12. End Zone Stirrups - The program calculates the required area of transverse stirrup steel and the distribution distance to resist end zone splitting stresses in the girder.
13. Positive Moment Connection - The program determines the required area of steel for the positive moment connection at a support for prestressed concrete beams made continuous for live load.
14. Fatigue Stress Check in Prestressed Strands - The program checks the fatigue stress range in the prestressing steel at the location of maximum fatigue live load and at drape points if draped strands are used. The effective fatigue stress range is checked against allowable limits.
15. Live Load Ratings - The program computes ratings for service moment, strength moment, and strength shear at all applicable analysis points. Rating factors are computed for each applicable live load vehicle. Rating summary tables are developed which present the controlling rating factors for each vehicle, as well as the corresponding location and rating tonnage.
16. Deflection and Camber - The program computes the camber for prestressed beams. Deflection values are computed based on prestressing; girder self-weight, including interior diaphragm weight; slab, formwork, and exterior diaphragm weight; and superimposed dead load weight. Camber values are computed based on initial camber; initial camber, adjusted for creep; and final camber.
17. Maximum Parapet Overhang - The program computes an approximation for the maximum overhang width such that the final stress in the interior and exterior girders is the same. The program assumes that the interior and exterior girders have the same section properties.
18. Strand Code Detail Checks - The program checks the vertical and horizontal minimum strand spacings.
19. Principal Stresses - The program computes the approximate principal stresses at significant locations along the girder.
20. Girder Stability Checks – The program computes stability checks for a girder suspended from the top.

The above functions are described in further detail in Chapter 3, entitled "Method of Solution."

Chapter 2 Program Description

2.3 BRIDGE TYPES FOR ANALYSIS AND RATING

This program can be used to perform an analysis of a single prestressed concrete girder. The program can analyze the exterior or interior girder of a multi-girder prestressed concrete bridge.

The beam cross sections which can be input include an I-beam, a bulb-tee beam, a Type F or Type D NEXT beam, an adjacent plank beam, a box beam with a rectangular void, or a box beam with one, two, or three circular voids. Plank beams are adjacent beams. Box beams can be either adjacent beams or spread beams. The sections can be composite or non-composite for adjacent plank or adjacent box beams; the section can only be composite for I-beams, bulb-tee beams, Type F NEXT beams and spread box beams. The section can only be non-composite for Type D NEXT beams.

Several examples of prestressed concrete bridge cross sections are presented in Figures 1 through 6. An I-beam bridge cross section is presented in Figure 1, a spread box beam bridge cross section is presented in Figure 2, an adjacent box beam bridge cross section is presented in Figure 3, an adjacent plank beam bridge cross section is presented in Figure 4, a Type F NEXT beam bridge cross section is presented in Figure 5, and a Type D NEXT beam bridge cross section is presented in Figure 6. In addition, a cross section of each beam type that can be used in this program is presented in Figures 5.21-1 through 5.21-14.

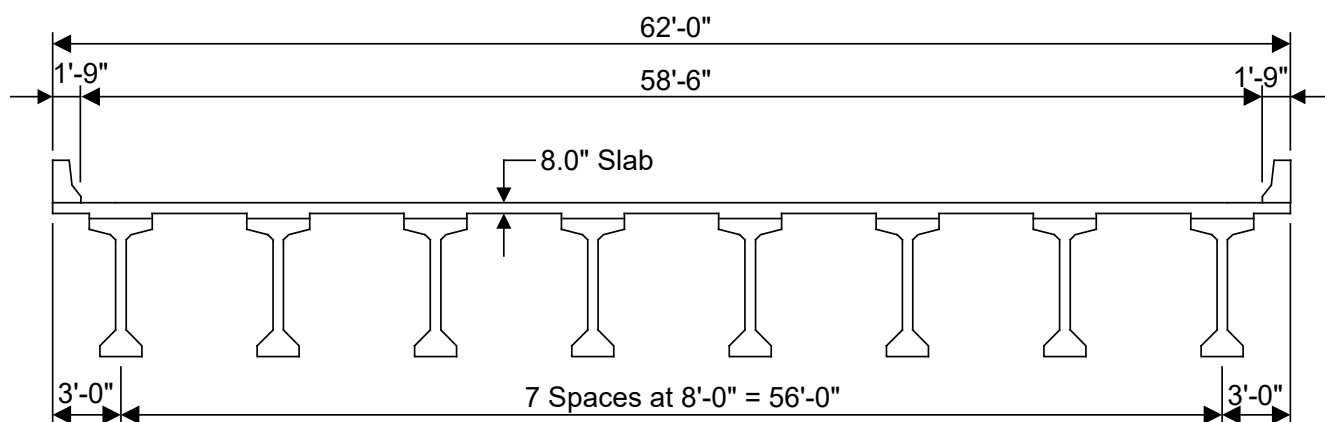


Figure 2.3-1 I-Beam Bridge Cross Section

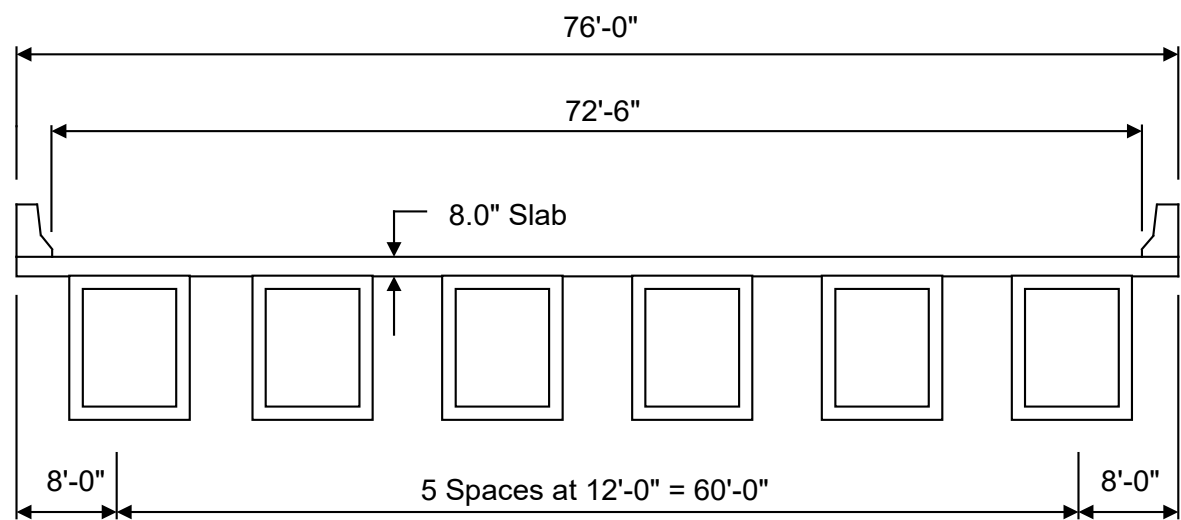


Figure 2.3-2 Spread Box Beam Bridge Cross Section

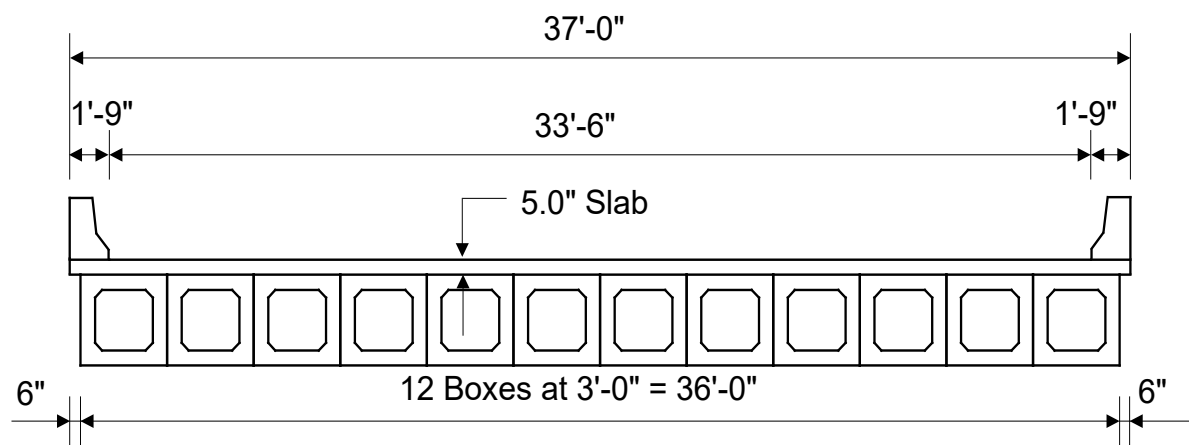


Figure 2.3-3 Adjacent Box Beam Bridge Cross Section

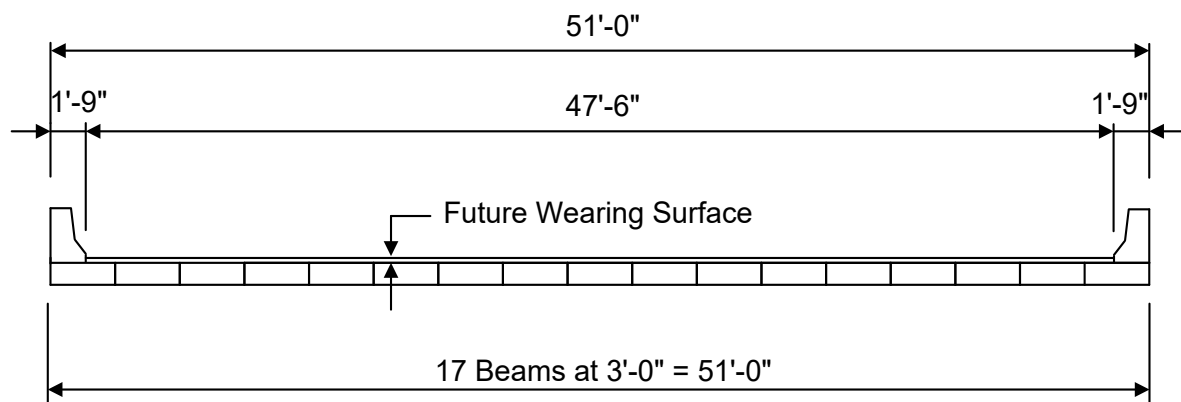


Figure 2.3-4 Adjacent Plank Beam Bridge Cross Section

Chapter 2 Program Description

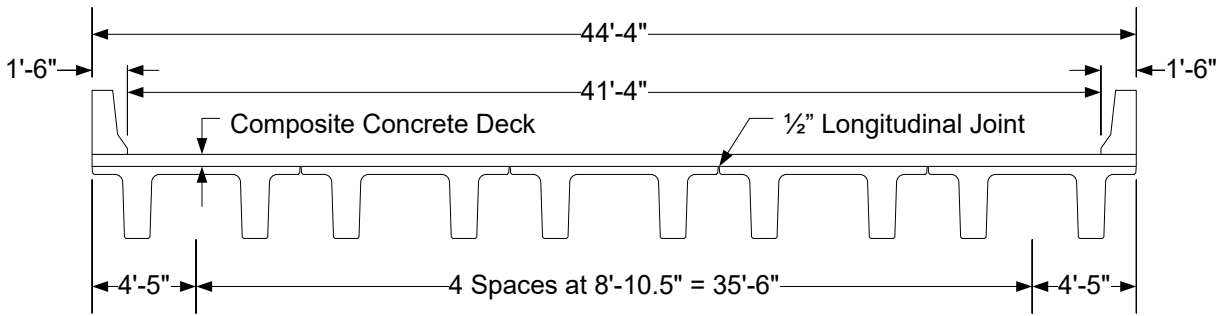


Figure 2.3-5 Type F NEXT Beam Bridge Cross Section

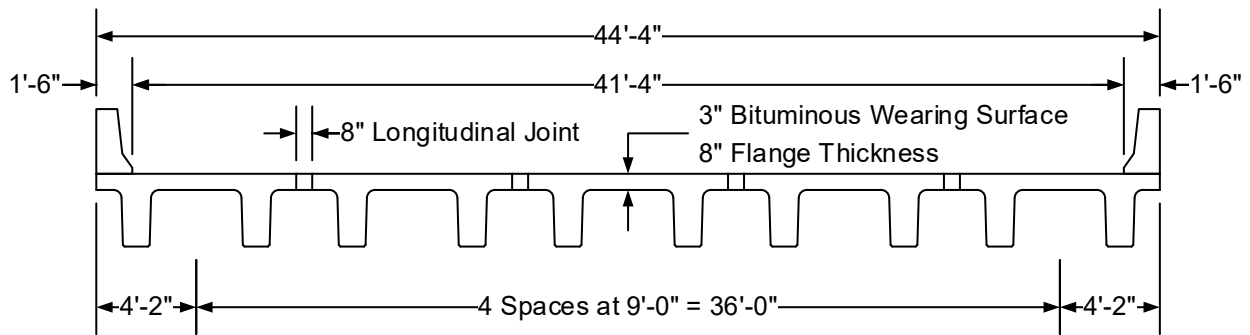


Figure 2.3-6 Type D NEXT Beam Bridge Cross Section

The program can perform an analysis of a simple span bridge, or a multi-span bridge made continuous for live load having up to twenty spans for all bridge types except for Type F NEXT Beams and Type D NEXT Beams. The Type F NEXT Beams and Type D NEXT Beams are limited to single spans.

The live load can be an LRFD loading or a user-defined loading, including a combination of truck and lane loading. The live load analysis is performed in accordance with the LRFD Specifications.

After the structural analysis is performed, the program checks for compliance with the LRFD Specifications and DM-4. The program computes and checks specifications for initial stresses, final stresses, moments, shears, fatigue stresses, prestress losses, debonding or draping, and deflections. Shear and flexural rating factors are also provided.

Chapter 2 Program Description

2.4 BRIDGE TYPES FOR DESIGN AND RATING

The program can perform an iterative design for prestressed concrete girders for a simple span bridge, or a multi-span bridge made continuous for live load having up to twenty spans.

The design option of the program can be used to optimize one or more of the following for each span:

1. Beam size
2. Prestress force and eccentricity
3. Beam concrete strength
4. Shear stirrups
5. Debonding

The beam cross sections which can be designed by the program are an I-beam or bulb-tee beam (see Figure 2.3-1), a Type F NEXT beam (see Figure 2.3-5), an adjacent plank beam (see Figure 2.3-4), an adjacent box beam with a rectangular void (see Figure 2.3-3), and a spread box beam with a rectangular void (see Figure 2.3-2). The design option cannot be used for an adjacent box beam with circular voids, a spread box beam with circular voids, a spread plank beam, or a Type D NEXT beam (see Figure 2.3-6).

Chapter 2 Program Description

2.5 LIVE LOADINGS

The user has several live load options for performing an analysis or design. The following live loadings may be considered:

PHL-93	- PennDOT LRFD live loading
HL-93	- AASHTO LRFD live loading
P-82	- PennDOT permit live loading
ML-80	- PennDOT maximum legal live loading
TK527	- PennDOT new legal live loading
HS20	- AASHTO HS20 live loading
H20	- AASHTO H20 live loading
SLL #i	- User-defined special live loading number "i" where i can be from 1 to 8 inclusive.
P-82C	- PennDOT permit live load, P-82, in one lane with PHL-93 in other lanes
EV2	- PennDOT single rear axle emergency vehicle
EV3	- PennDOT tandem rear axle emergency vehicle
SU6TV	- PennDOT heavy-duty tow and recovery vehicle
P2016-13	- PennDOT 13 axle permit design vehicle
P2016-13C	- P2016-13 in one lane with PHL-93 in other lanes

The HL-93 loading is the vehicular live load consisting of the design truck, design tandem, and design lane load as defined in the LRFD Specifications. The PHL-93 loading is the same as the HL-93 loading except that the axle loads on the design tandem for the PHL-93 loading are multiplied by a factor of 1.25. In addition, for negative moment between points of dead load contraflexure, the factor for the effect of two design trucks combined with the design lane load is 100% for the PHL-93 loading and 90% for the HL-93 loading. The 1.25 factor is not applied to the design tandem pair for the PHL-93 loading.

The PennDOT maximum legal live loading (ML-80) is the maximum legal truck allowed in Pennsylvania. Strike-Of-Letter 431-01-15, dated October 30, 2001, defined new legal load configurations for single trucks with 5 to 7 axles. The seven axle configuration produces moments and shears in excess of the five and six axle configurations and is used as the controlling vehicle (TK527). The PennDOT permit live loading (P-82) is a notional load used to check Strength II, Service IIIA, and Service IIIB limit states. The AASHTO HS20 live loading and AASHTO H20 live loading are in accordance with the AASHTO Standard Specifications for Highway Bridges. For special live loadings (SLL), the user can input the axle loads, the axle spacings, uniform lane loading, and the corresponding load factors for each limit state.

The axle loads and axle spacings for the HL-93 and PHL-93 design truck, HL-93 design tandem, PHL-93 design tandem, HL-93 and PHL-93 design tandem pair, the ML-80 rating truck, and the TK527 rating truck are presented in Figure 1. The P-82 permit truck, HS20 truck, H20 truck, and HS20 and H20 lane loading are presented in Figure 2. The design lane load for both the HL-93 and PHL-93 loading is taken as 0.64 kips per linear foot.

Chapter 2 Program Description

The live loads to be used for an analysis or design are designated by the user by entering a live load code. The live load code is an upper case alphabetic character (A through E for design and A through G for analysis). The live load designations used for each live load code and each load case are summarized in Tables 1 and 2. The load cases are for the LRFD limit states, fatigue check, deflection check, and ratings. Separate rating tables are generated for each live load designation. Table 3 summarizes the live load used for analysis, design, rating and printing specific reaction tables that could be used for bearing, abutment and pier designs based on the live load code entered by the user.

EV2, EV3, and SU6TV loads are described in the FHWA FAST Act, effective December 4, 2016.

The P2016-13 permit load was developed by Penn State University in May 2016. It has 13 axles with two varying spacings following axles 7 and 10. The first varying spacing between axles 7 and 8 ranges from 30' to 50'. The second varying spacing between axles 10 and 11 ranges from 5' to 14'.

For the ML-80, TK527, P-82, EV2, EV3, SU6TV, and P2016-13 live loadings, only one truck unit is considered longitudinally on the structure. The program generates influence lines for deflections for each analysis point and for support reactions and rotations. The influence lines for moments and shears at analysis points are generated from the reaction influence lines. The effect of a live loading is calculated by placing the load at various locations on the influence lines. In calculating the effect of a design truck, design tandem, fatigue load, design truck pair, or design tandem pair for the LRFD loading, only the axle loads which contribute to the effect being sought are considered. The spacings between the last axles of the design truck, between the design truck pair, and between the design tandem pair are as per the LRFD Specifications.

The P-82C live loading is a combination of the P-82 live loading in one lane with PHL-93 live loading in the other lanes. Similarly, the P2016-13C live loading is a combination of the P2016-13 live loading in one lane with PHL-93 live loading in the other lanes. These combination loadings may be used for the rating of existing bridges with the Strength II Limit State.

In place of the above live loadings, the bridge can be analyzed for 1 to 8 special live loading by specifying the axle loads, axle spacings, and the uniform lane loading of each special live loading. This can be used to analyze permit loads or to analyze more than one truck unit on the structure longitudinally, or to check the combination of a truck load and a lane load. Each special live load may have up to a maximum of 80 axles.

Chapter 2 Program Description

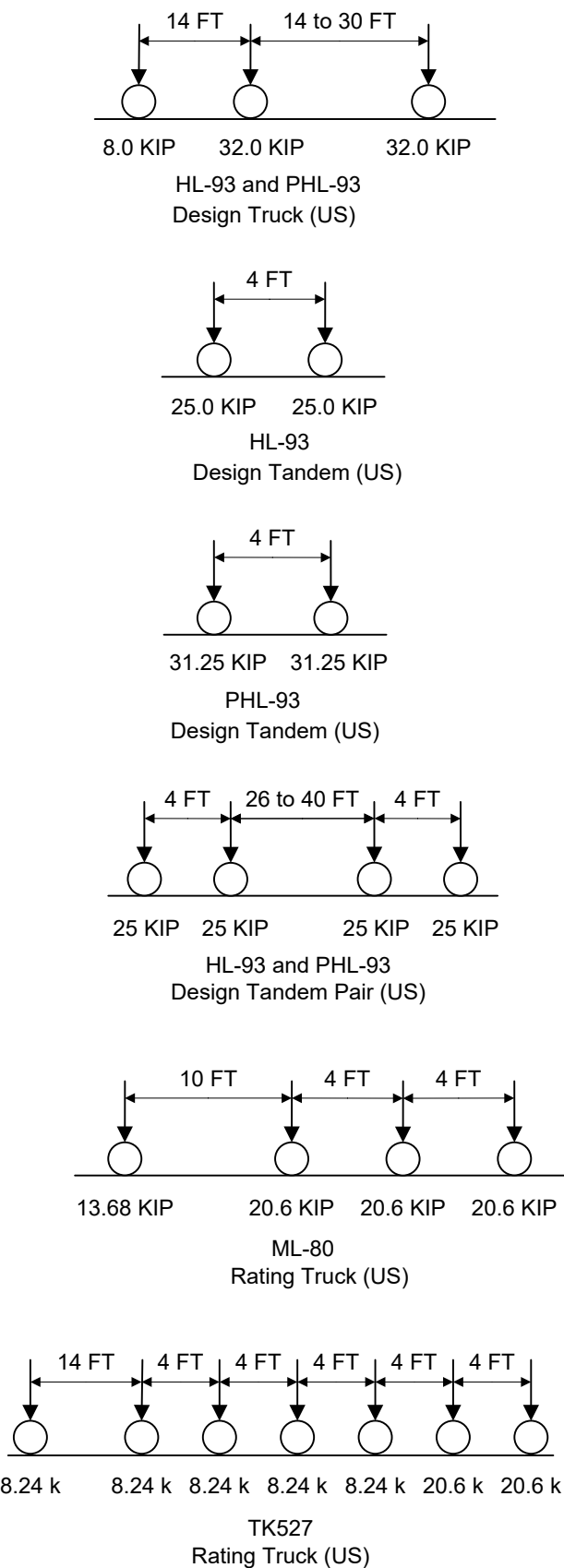


Figure 2.5-1 LRFD, ML-80, and TK527 Live Loading

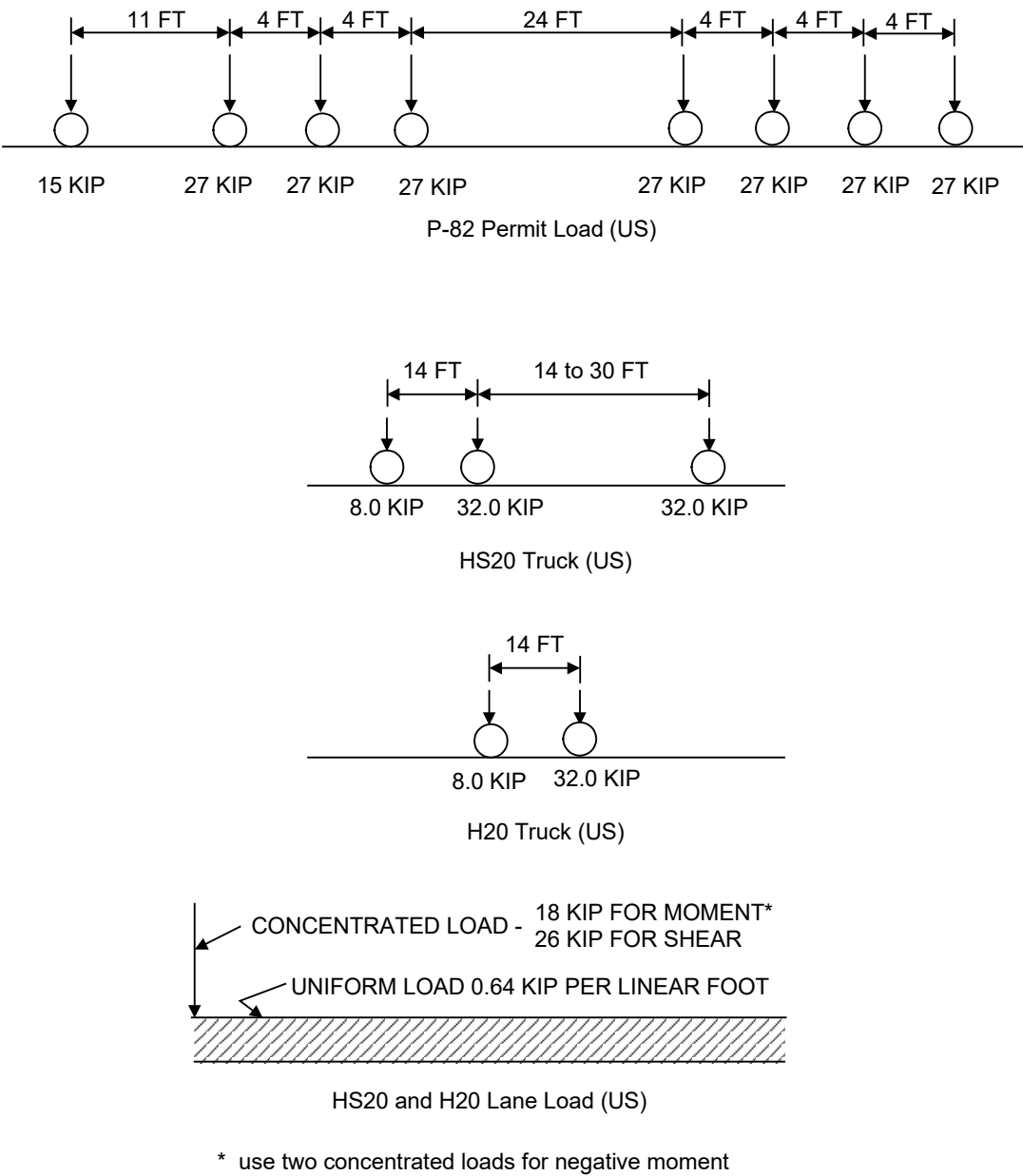


Figure 2.5-2 P-82, HS20, and H20 Live Loading

Chapter 2 Program Description

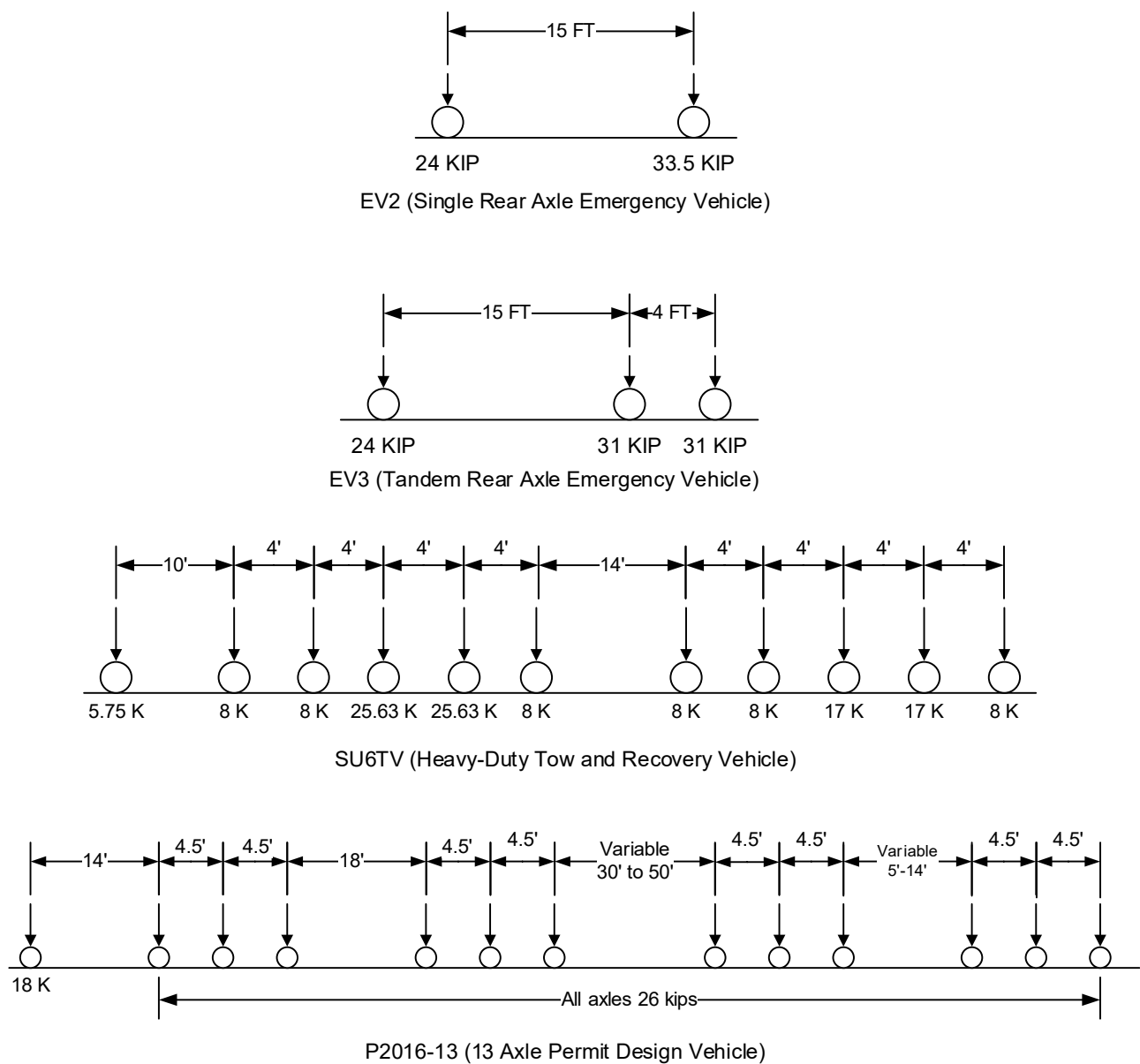


Figure 2.5-3 EV2, EV3, SU6TV, and P2016-13 Live Loadings

Chapter 2 Program Description

Table 2.5-1 Live Loadings for Design

Limit State		Live Load Code for Design					
		A	B	C	D	E	F
Strength I Strength IP	Design	PHL-93	HL-93	HL-93	PHL-93 ML-80	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527
	Inventory Rating	PHL-93 ML-80 TK527 HS20 H20	HL-93 ML-80 TK527 HS20 H20	HL-93 HS20 H20	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20
Strength IA	Design	PHL-93	HL-93	HL-93	PHL-93 ML-80	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527
	Operating Rating	PHL-93	HL-93	HL-93	PHL-93	PHL-93	PHL-93
Strength II	Permit	P-82	P-82	None	P-82	P-82	P-82 P2016-13
	Operating Rating	P-82 ML-80 TK527 HS20 H20	P-82 ML-80 TK527 HS20 H20	HS20 H20	P-82 ML-80 TK527 HS20 H20	P-82 ML-80 TK527 HS20 H20	P-82 P2016-13 ML-80 TK527 HS20 H20
Service I Service IP Service III Service IIIP	Design	PHL-93	HL-93	HL-93	PHL-93 ML-80	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527
	Inventory Rating	PHL-93 ML-80 TK527 HS20 H20	HL-93 ML-80 TK527 HS20 H20	HL-93 HS20 H20	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20
Service IIIA	Design or Permit	PHL-93 P-82	HL-93 P-82	HL-93	PHL-93 ML-80 P-82	PHL-93 ML-80 TK527 P-82	PHL-93 ML-80 TK527 P-82 P2016-13
	Operating Rating	PHL-93 P-82 ML-80 TK527 HS20 H20	HL-93 P-82 ML-80 TK527 HS20 H20	HL-93 HS20 H20	PHL-93 P-82 ML-80 TK527 HS20 H20	PHL-93 P-82 ML-80 TK527 HS20 H20	PHL-93 P-82 P2016-13 ML-80 TK527 HS20 H20

Chapter 2 Program Description

Table 2.5-1 Live Loadings for Design (continued)

Limit State		Live Load Code for Design					
		A	B	C	D	E	F
Service IIIB	Design or Permit	PHL-93 P-82	HL-93 P-82	HL-93	PHL-93 ML-80 P-82	PHL-93 ML-80 TK527 P-82	PHL-93 ML-80 TK527 P-82 P2016-13
	No Rating						
Fatigue I	Design	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle
	No Rating						
Deflection	Design	PennDOT Deflection Loading	LRFD Deflection Loading	LRFD Deflection Loading	PennDOT Deflection Loading	PennDOT Deflection Loading	PennDOT Deflection Loading
	No Rating						

Notes:

1. "none" denotes that the specified live load designation does not apply for the live load code.

Chapter 2 Program Description

Table 2.5-2 Live Loadings for Analysis

Limit State		Live Load Code for Analysis						
		A	B	C	D	E	F	G
Strength I Strength IP	Analysis	PHL-93 ML-80 TK527	HL-93	ML-80	None	SLL #i (D)	TK527	PHL-93 ML-80 TK527
	Inventory Rating	PHL-93 ML-80 TK527 HS20 H20	HL-93 HS20 H20	ML-80	None	SLL #i (D)	TK527	PHL-93 ML-80 TK527 HS20 H20
Strength IA	Analysis	PHL-93	HL-93	None	None	None	None	PHL-93
	Operating Rating	PHL-93	HL-93	None	None	None	None	PHL-93
Strength II	Permit	P-82	None	None	P-82	SLL #i (D or P)	None	P-82C
	Operating Rating	P-82 ML-80 TK527 HS20 H20	HS20 H20	ML-80	P-82	SLL #i (D or P)	TK527	P-82C ML-80 TK527 HS20 H20
Service I Service IP Service III Service IIIP	Analysis	PHL-93 ML-80 TK527	HL-93	ML-80	None	SLL #i (D)	TK527	PHL-93 ML-80 TK527
	Inventory Rating	PHL-93 ML-80 TK527 HS20 H20	HL-93 HS20 H20	ML-80	None	SLL #i (D)	TK527	PHL-93 ML-80 TK527 HS20 H20
Service IIIA	Analysis or Permit	PHL-93 ML-80 TK527 P-82	HL-93	ML-80	P-82	SLL #i (D or P)	TK527	PHL-93 ML-80 TK527 P-82C
	Operating Rating	PHL-93 ML-80 TK527 P-82 HS20 H20	HL-93 HS20 H20	ML-80	P-82	SLL #i (D or P)	TK527	PHL-93 ML-80 TK527 P-82C HS20 H20

Chapter 2 Program Description

Table 2.5-2 Live Loadings for Analysis (continued)

Limit State		Live Load Code for Analysis						
		A	B	C	D	E	F	G
Service IIIB	Analysis or Permit No Rating	PHL-93 ML-80 TK527 P-82	HL-93 HS20 H20	ML-80	P-82	SLL #i (D or P)	TK527	PHL-93 ML-80 TK527 P-82C
Fatigue I	Analysis No Rating	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle
Deflection	Analysis No Rating	PennDOT Deflection Loading	LRFD Deflection Loading	none	none	none	none	PennDOT Deflection Loading

Notes:

1. "none" denotes that the specified live load designation does not apply for the live load code.
2. "SLL #i (D or P)" denotes that all Special Live Loads entered will be used
3. "SLL #i (D)" denotes that all Special Live Loads entered with Vehicle Type D will be used
4. "SLL #i (P)" denotes that all Special Live Loads entered with Vehicle Type P will be used
5. "P-82C" denotes P-82 in one lane and PHL-93 in other lanes

Chapter 2 Program Description

Table 2.5-2 Live Loadings for Analysis (Continued)

Limit State		Live Load Code for Analysis			
		H	I	J	K
Strength I Strength IP	Analysis	None	None	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527
	Inventory Rating	None	None	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20
Strength IA	Analysis	None	None	PHL-93	PHL-93
	Operating Rating	None	None	PHL-93	PHL-93
Strength II	Permit	EV2 EV3 SU6TV	P2016-13	P-82 P2016-13	P-82C P2016-13C
	Operating Rating	EV2 EV3 SU6TV	P2016-13	P-82 P2016-13	P-82C P2016-13
Service I Service IP Service III Service IIIP	Analysis	None	None	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527
	Inventory Rating	None	None	PHL-93 ML-80 TK527 HS20 H20	PHL-93 ML-80 TK527 HS20 H20
Service IIIA	Analysis or Permit	EV2 EV3 SU6TV	P2016-13	PHL-93 ML-80 TK527 P-82 P2016-13	PHL-93 ML-80 TK527 P-82C P2016-13C
	Operating Rating	EV2 EV3 SU6TV	P2016-13	PHL-93 ML-80 TK527 P-82 P2016-13 HS20 H20	PHL-93 ML-80 TK527 P-82C P2016-13C HS20 H20

Chapter 2 Program Description

Table 2.5-2 Live Loadings for Analysis (Continued)

Limit State		Live Load Code for Analysis			
		H	I	J	K
Service IIIB	Analysis or Permit	EV2 EV3 SU6TV	P2016-13	PHL-93 ML-80 TK527 P-82 P2016-13	PHL-93 ML-80 TK527 P-82C P2016-13C
	No Rating				
Fatigue I	Analysis	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle	Fatigue Vehicle
	No Rating				
Deflection	Analysis	None	None	PennDOT Deflection Loading	PennDOT Deflection Loading
	No Rating				

Notes:

1. "none" denotes that the specified live load designation does not apply for the live load code.
2. "P-82C" denotes P-82 in one lane and PHL-93 in other lanes
3. "P2016-13C" denotes P2016-13 in one lane and PHL-93 in other lanes

Chapter 2 Program Description

Table 2.5-3 Live Loadings for Reaction Tables

Design Live Load Code	Design Vehicle	Rating Vehicle	Bearing Reaction Table	Abutment Reaction Table	Pier Reaction Table
A	PHL-93 P-82	PHL-93, P-82 H20, HS20 ML-80, TK527	PHL-93	PHL-93	PHL-93 P-82
B	HL-93 P-82	HL-93, P-82 H20, HS20 ML-80, TK527	HL-93	HL-93	HL-93 P-82
C	HL-93	HL-93 H20, HS20	HL-93	HL-93	HL-93
D	PHL-93 ML-80 P-82	PHL-93, P-82 H20, HS20 ML-80, TK527	PHL-93 ML-80	PHL-93 ML-80	PHL-93 ML-80 P-82
E	PHL-93 ML-80 TK527 P-82	PHL-93, P-82 H20, HS20 ML-80, TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82
F	PHL-93 ML-80 TK527 P-82 P2016-13	PHL-93, P-82 H20, HS20 ML-80, TK527 P2016-13	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82 P2016-13

Chapter 2 Program Description

Table 2.5-3 Live Loadings for Reaction Tables (Continued)

Analysis Live Load Code	Analysis Vehicle	Rating Vehicle	Bearing Reaction Table	Abutment Reaction Table	Pier Reaction Table
A	PHL-93, P-82, H20, HS20, ML-80, TK527	PHL-93, P-82 H20, HS20 ML-80, TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82
B	HL-93, H20, HS20	HL-93 H20, HS20	HL-93	HL-93	HL-93
C	ML-80	ML-80	ML-80	ML-80	ML-80
D	P-82	P-82	P-82	P-82	P-82
E	SLL #i	SLL #i	SLL #i	SLL #i	SLL #i
F	TK527	TK527	TK527	TK527	TK527
G	PHL-93, P-82C, H20, HS20, ML-80, TK527	PHL-93, P-82C H20, HS20 ML-80, TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82
H	EV2 EV3 SU6TV	EV2 EV3 SU6TV	EV2 EV3 SU6TV	EV2 EV3 SU6TV	EV2 EV3 SU6TV
I	P2016-13	P2016-13	P2016-13	P2016-13	P2016-13
J	PHL-93, P-82, H20, HS20, ML-80, TK527, P2016-13	PHL-93, P-82, H20, HS20, ML-80, TK527, P2016-13	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82 P2016-13
K	PHL-93, P-82C, H20, HS20, ML-80, TK527, P2016-13C	PHL-93, P-82C, H20, HS20, ML-80, TK527, P2016-13C	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527	PHL-93 ML-80 TK527 P-82 P2016-13

Chapter 2 Program Description

2.6 RATINGS DEFINITION

The program computes the live load rating factors for service moment, strength moment, and strength shear at all applicable analysis points. The live load rating factor is defined as the ratio of the live load reserve capacity divided by the factored live load effect. The live load reserve capacity is equal to the section capacity minus all dead load and pedestrian load effects.

The program computes inventory and operating ratings for the appropriate live loadings and limit states, as presented in Table 1. The inventory rating is the load that can be carried by the structure for an indefinite period of time. The operating rating is the load that may produce the absolute maximum permissible stress, and it is the maximum load allowed on the structure. By specifying an input value, the program is able to generate ratings with and without Future Wearing Surface loading in a single run of the program for analysis runs with shear analysis.

The Strength I, Strength IP, Service I, Service IP, Service III and Service IIIP limit states are used for the inventory rating. The Strength IA, Strength II, and Service IIIA limit states are used for the operating rating. The live load designations used for each limit state are summarized in Table 1.

The equations used for computing the rating factors are provided in Section 3.16.

Chapter 2 Program Description

Table 2.6-1 Live Load Ratings

Rating Vehicle	Live Load Combination									
	Strength I	Strength IP	Strength IA	Strength II	Service I	Service IP	Service III	Service IIIP	Service IIIA	Service IIIB
PHL-93 / HL-93	I	I	O	--	I	I	I	I	O	--
P-82 / P-82C	--	--	--	O	--	--	--	--	O	--
P2016-13 P2016-13C	--	--	--	O	--	--	--	--	O	--
ML-80	I	I	--	O	I	I	I	I	O	--
TK527	I	I	--	O	I	I	I	I	O	--
EV2	--	--	--	O	--	--	--	--	O	--
EV3	--	--	--	O	--	--	--	--	O	--
SU6TV	--	--	--	O	--	--	--	--	O	--
HS20	I	I	--	O	I	I	I	I	O	--
H20	I	I	--	O	I	I	I	I	O	--
Special Live Load Vehicle Type D	I	I	--	O	I	I	I	I	O	--
Special Live Load Vehicle Type P	--	--	--	O	--	--	--	--	O	--

Notes:

I - Inventory

O - Operating

"P-82C" denotes P-82 in one lane and PHL-93 in other lanes

"P2016-13C" denotes P2016-13 in one lane and PHL-93 in other lanes

Special Live Load Vehicle Type D uses the Dynamic Load Allowance for Design vehicles.

Special Live Load Vehicle Type P uses the Dynamic Load Allowance for Permit vehicles.

Chapter 2 Program Description

2.7 ASSUMPTIONS AND LIMITATIONS

The following is a list of basic assumptions and limitations for PSLRFD:

1. The prestressed concrete beam section can consist of an I-beam, a bulb-tee beam, a Type F or Type D NEXT beam, a plank beam, a box beam with a rectangular void, or a box beam with one, two, or three circular voids.
2. Box beams can be adjacent box beams or spread box beams.
3. The design option can be used for an I-beam, a bulb-tee beam, a Type F NEXT beam, an adjacent plank beam, an adjacent box beam with a rectangular void, or a spread box beam with a rectangular void. It cannot be used for an adjacent box beam with circular voids, a spread box beam with circular voids, a spread plank beam, or a Type D NEXT beam.
4. Spread plank beams cannot be designed or analyzed by the program.
5. The program can design a simple span bridge or a multi-span bridge made continuous for live load having up to twenty spans for all bridge types except for Type F NEXT Beams. The Type F NEXT Beams are limited to single spans.
6. The program automatically places analysis points at twentieth points of each span, at concentrated load points, at drape point locations (if applicable), at the midspan of each simple span, and at 12 inches from the centerline of each bearing. The program uses a tolerance on analysis points of 0.05 inches. That is, if two analysis points are within 0.05 inches of each other, then the program assumes that they are the same point.
7. For a non-standard adjacent box beam, when a shear distribution factor applicability limit for moment of inertia, I , or St. Venant torsional constant, J , is not met (DM-4 Table 4.6.2.2.3a-1), the shear distribution factor is set equal to the moment distribution factor. In addition, the program issues a warning message stating that the applicability limit has not been met and that the moment distribution factor is being used.
8. For both analysis and design runs, a girder must be either composite over its entire length or non-composite over its entire length. It cannot have portions that are composite and other portions that are non-composite.
9. The program makes the following assumptions regarding the haunch:
 - A. In computing the haunch weight for both analysis and design runs, the program assumes that the haunch width is equal to the top flange width. The haunch depth is used in computing the haunch weight. The haunch depth is constant along the entire length of the structure.
 - B. In computing the section properties for an analysis run, the program uses the haunch depth to determine the separation distance between the concrete deck and the girder. Also, the program includes the area of the haunch when computing the section properties. In other words, for an analysis run, the section properties are computed based on the inputted haunch depth and based on a haunch width equal the top width of the girder.

Chapter 2 Program Description

- C. In computing the section properties for a design run, the program assumes that the bottom of the concrete deck is located at the top of the girder. For a design run, the program does not use the inputted haunch depth in any way when computing the section properties. For a design run, the inputted haunch depth is used only to compute the haunch weight.
10. If the user specifies the symmetry option (CTL command, parameter 7), then all input values must be specified for the first half of the bridge length only. For example, for a two-span bridge for which the symmetry option is specified, any input values at the pier must be specified at the end of the first span rather than at the beginning of the second span.
 11. The program does not use maximum moments with concurrent shears or maximum shears with concurrent moments. The program uses maximum moments and maximum shears for all calculations.
 12. The program uses the traditional approach to proportion transverse reinforcement as depicted in AASHTO Figure C5.7.3.3-1. The required stirrup spacing is determined at discrete sections along the member. This spacing is then used up to the next design section out into the span.
 13. The program prints a list of all output tables for which one or more specification checks have failed. This list is printed at the end of the output. Therefore, a good starting point for the user is to look at this list and then refer to each output table that is included in this list to find out the specific location and nature of the specification check failure. This list may include tables that were not selected by the user to be printed.
 14. Throughout this User's Manual, especially in the output descriptions in Chapter 7, the term "end of span" is used. For simple spans and the exterior supports of continuous spans, "end of span" denotes the centerline of bearing at the support. For the interior supports (piers) of continuous spans, "end of span" denotes the centerline of support (pier), not the centerline of simple span bearing.
 15. Input crack control debonding and normal debonding (using the DBS command) for straight and draped strand analysis runs is considered for shear calculations and for stress calculations.
 16. Blast Loading defined in AASHTO Section 3.15 is not considered by the PSLRFD program. Blast Loading is not shown in the DM-4 Load Factor table for Prestressed Concrete Girders which indicates that it should not be considered, even though the AASHTO section for Blast Loading was not deleted in DM-4.
 17. The program assumes only straight strands will be debonded.
 18. The program automatically calculates the beam weight using the beam cross section. However, for box beams the program does not automatically include any weight for diaphragms or box beam end blocks. The user must input all other DC1 loads due to other components using the DIA, CLD and DLD commands.

Additional assumptions and limitations, including parameter lower limits, upper limits, and defaults, are presented with the input descriptions in Chapter 5.

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3

METHOD OF SOLUTION

The primary purpose of this program is to analyze or design, and rate, simple span prestressed concrete girders or multi-span prestressed concrete girders made continuous for live load. The structural analysis and specification checking are performed in accordance with the LRFD Specifications and DM-4. This chapter provides detailed information regarding the method of solution used in the program.

The purpose of this chapter is not to reiterate the countless equations and commentary presented in the LRFD Specifications and DM-4, but rather to supplement them with additional information and details regarding the program's method of solution. Therefore, the user should refer to the LRFD Specifications and to DM-4 for further details. References to the LRFD Specifications and to DM-4 are provided in this chapter, as appropriate.

In the analysis, design, and rating of a girder for a highway bridge, the following steps are generally required:

1. Calculate beam section properties.
2. Calculate dead load effects.
3. Calculate live load effects.
4. Combine dead and live load effects.
5. Calculate beam section resistance.
6. Perform specification checking.
7. Adjust beam section sizes for design.
8. Calculate ratings.

The program performs the above calculations using the classical methods of structural analysis and following the specifications provided in the LRFD Specifications and DM-4. For the purpose of this program, the analysis and design runs are defined as follows:

For an analysis run, the girder sections and bridge geometry are known and the program performs all calculations listed above, except Step 7. For a design run, all calculations listed above are performed.

The following sections describe the above calculations in detail. For Steps 1, 2, 3, and 4 listed above, refer to any standard textbook on structural analysis and the appropriate sections of this manual for further details. For Steps 5 and 6, refer to the LRFD Specifications and DM-4. For Steps 7 and 8, refer to the appropriate sections of this User's Manual.

Chapter 3 Method of Solution

3.1 NOTATIONS

The following are the meanings of equation notations used in various expressions throughout this manual. For each notation, the corresponding units are presented in parentheses. Definitions of abbreviations are presented in Section 1.2.

A	=	beam area (in ²)
a	=	horizontal distance from centerline of pier to concentrated load located between the centerline of pier and centerline of bearing (in)
A_b	=	area of prestressed concrete beam (in ²)
A_{cv}	=	area of concrete section resisting shear transfer (in ²)
A_g	=	gross area of beam (in ²)
A_i	=	area of influence line between two consecutive load intensities
A_{ns}	=	required area of longitudinal reinforcement located in the effective slab width (in ²)
A_p	=	coefficient in stress-strain curve for prestressing strands related to the slope of the second straight line portion of the curve
A_{ps}	=	total area of prestressing steel (in ²)
A_s	=	total area of non-prestressed tension reinforcement (in ²)
$A_{s,min}$	=	minimum total area of non-prestressed tension reinforcement (in ²)
a_{seat2}	=	distance from end of girder to centerline of bearing, first girder seated (in) (Girder Stability)
a_{seat3}	=	distance from end of girder to centerline of bearing, multiple girders seated (in) (Girder Stability)
A_{sr}	=	required area of transverse steel in the girder end zone distance (in ²)
b	=	width of the compression face of the member (in)
b_1	=	a width value, used in computing negative moment capacity, which is a function of the location of the neutral axis (in)
$b_{eff, ext}$	=	effective flange (slab) width for exterior beams (in)
$b_{eff, int}$	=	effective flange (slab) width for interior beams (in)
b_{ft}	=	width of top flange of girder (in)
B_p	=	coefficient in stress-strain curve for prestressing strands related to the intersection of the second straight line portion of the curve with the y-axis
b_s	=	slab width (in)
b_v	=	effective web width (in)
b_w	=	web width (in)
C	=	camber thickness at centerline of beam (in)
c	=	distance from the extreme compression fiber to the neutral axis (in); cohesion factor used to compute nominal interface shear resistance (ksi)
C_1	=	a compressive force used to compute the nominal flexural resistance (kip)
C_2	=	a compressive force used to compute the nominal flexural resistance (kip)
C_{denom}	=	the denominator of the maximum overhang width equation
C_F	=	final camber in a prestressed concrete girder (in)
C_{fact}	=	a factor used to compute the maximum overhang width

Chapter 3 Method of Solution

C_i	=	initial camber in a prestressed concrete girder (in)
C_{IA}	=	initial camber, adjusted for creep, in a prestressed concrete girder (in)
C_{ns}	=	distance from the extreme compression fiber to the neutral axis used in computing the required area of longitudinal reinforcement located in the effective slab width (in)
C_{numer}	=	the numerator of the maximum overhang width equation
$cover_{red}$	=	reduction in concrete cover due to girder rotation (in) (Girder Stability)
C_p	=	coefficient in stress-strain curve for prestressing strands related to the transition curve between the first and second straight lines. A higher value gives a more abrupt transition.
C_r	=	constant to account for creep in camber
d	=	depth of section (in)
d_e	=	effective depth from extreme compression fiber to the centroid of the tensile force in the tensile reinforcement (in)
DFV_1	=	distribution factor for shear at the end of the span to the right of the support (includes skew correction factor)
DFV_2	=	distribution factor for shear at the end of the span to the left of the support (includes skew correction factor)
d_s	=	distance from extreme compression fiber to the centroid of the non-prestressed tensile reinforcement (in)
d_v	=	effective shear depth (in)
E	=	modulus of elasticity (ksi)
e	=	base of Napierian logarithms (2.718281828) (as used in the creep and shrinkage section of this chapter); the eccentricity of the anchorage device or group of devices, with respect to the centroid of the beam cross section (as used in all other sections of this chapter) (in)
e_{brace}	=	imperfection (play) in each brace (in) (Girder Stability)
$e_{brg.seat2}$	=	bearing tolerance from centerline of girder to centerline of support, first girder seated (in) (Girder Stability)
$e_{brg.seat3}$	=	bearing tolerance from centerline of girder to centerline of support, multiple girders seated (in) (Girder Stability)
E_c	=	modulus of elasticity of concrete (ksi)
$E_{c.seat2}$	=	modulus of elasticity of concrete at first girder seated on bearings (ksi) (Girder Stability)
$E_{c.seat3}$	=	modulus of elasticity of concrete at multiple girders seated on bearings (ksi) (Girder Stability)
$ecc_{serv.limit}$	=	eccentricity limit of bearing pad reaction (in) (Girder Stability)
$ecc_{serv.seat3}$	=	eccentricity of bearing pad reaction at service, multiple girders seated (in) (Girder Stability)
E_{ci}	=	modulus of elasticity of concrete at transfer (ksi)
e_{compos}	=	eccentricity of the anchorage device or group of devices with respect to the centroid of the composite cross section (in)
E_{cs}	=	modulus of elasticity of slab concrete (ksi)
$e_{i.seat2}$	=	center of mass eccentricity due to lateral deflection, first girder seated (in) (Girder Stability)
$e_{i.seat3}$	=	center of mass eccentricity due to lateral deflection, multiple girders seated (in) (Girder Stability)
$e_{i.total.seat2}$	=	total lateral deflection over girder length at first girder seated on bearings (in) (Girder Stability)
$e_{i.total.seat3}$	=	total lateral deflection over girder length at multiple girders seated (in) (Girder Stability)

Chapter 3 Method of Solution

e_n	=	eccentricity of the anchorage device or group of devices with respect to the centroid of the cross section at the end of the beam (in)
E_p	=	modulus of elasticity of prestressing tendons (ksi)
E_s	=	modulus of elasticity of reinforcing bars (ksi)
e_s	=	eccentricity of the anchorage device or group of devices with respect to the centroid of the cross section at the midspan of the beam (in)
$e_{total.seat3}$	=	total eccentricity with wind, multiple girders seated (in) (Girder Stability)
$e_{wind.seat3}$	=	girder deflection to center of mass, multiple girders seated (in) (Girder Stability)
$f_{b.seat2}$	=	concrete stress in girder – bottom, first girder seated (ksi) (Girder Stability)
$f_{b.seat3}$	=	concrete stress in girder – bottom, multiple girders seated (ksi) (Girder Stability)
$f_{b.seat3.bracing}$	=	concrete stress in girder – bottom, multiple girders seated with bracing (ksi) (Girder Stability)
f_{bot}	=	bottom fiber stress in the beam (ksi)
$F_{brace.seat3}$	=	horizontal bracing force, multiple girders seated (kip) (Girder Stability)
f_c	=	final compressive stress in the beam (ksi)
$f_{c,bot}$	=	final compressive stress in the bottom fiber of the beam (ksi)
$f_{c,top}$	=	final compressive stress in the top fiber of the beam (ksi)
$f_{c.seat2}$	=	specified compressive strength of concrete at time of first girder seated on bearings (ksi) (Girder Stability)
$f_{c.seat3}$	=	specified compressive strength of concrete at time of multiple girders seated on bearings (ksi) (Girder Stability)
f_c'	=	specified compressive strength of concrete at 28 days (ksi)
f_{cDL}	=	final compressive stress in the beam under design loads (ksi)
f_{cgp}	=	concrete stress at the center of gravity of prestressing tendons, due to the prestressing force at transfer and the self-weight of the member at sections of maximum moment (ksi)
f_{ci}	=	initial compressive stress in the beam (ksi)
f_{ci}'	=	specified compressive strength of concrete at time of initial loading or prestressing (ksi)
f_{cs}'	=	specified compressive strength of slab concrete at 28 days (ksi)
f_{DL}	=	stress due to all dead loads (both non-composite and composite) (ksi)
FEA_{CDL}	=	fixed end action due to dead load creep
$FEA_{CP/S}$	=	fixed end action due to prestress creep
FEA_{CR}	=	fixed end action due to creep
FEA_{SH}	=	fixed end action due to shrinkage
FEA_{SHU}	=	fixed end action due to shrinkage (unfactored)
$f_{eq.b.seat2}$	=	concrete stress in girder at equilibrium – bottom, first girder seated (ksi) (Girder Stability)
$f_{eq.b.seat3}$	=	concrete stress in girder at equilibrium – bottom, multiple girders seated (ksi) (Girder Stability)
$f_{eq.t.seat2}$	=	concrete stress in girder at equilibrium – top, first girder seated (ksi) (Girder Stability)
$f_{eq.t.seat3}$	=	concrete stress in girder at equilibrium – top, multiple girders seated (ksi) (Girder Stability)
f_{IM}	=	dynamic load factor
f_{LL}	=	stress due to vehicular live loading and dynamic load allowance (ksi)
F_{mod}	=	effective resistance of bracing, multiple girders seated (unitless) (Girder Stability)

Chapter 3 Method of Solution

$F_{ot.seat2.brace}$	=	concurrent lateral force to be resisted by bracing, first girder seated (kip) (Girder Stability)
$f_{P/S}$	=	stress due to prestressing steel (ksi)
f_{pe}	=	effective stress in prestressing steel, after total losses (ksi)
f_{pj}	=	stress in the prestressing steel at jacking (ksi)
f_{PL}	=	stress due to pedestrian loading (ksi)
f_{pt}	=	stress in prestressing steel immediately after transfer (ksi)
f_{pu}	=	specified tensile strength of prestressing steel (ksi)
f_{py}	=	yield strength of prestressing steel (ksi)
F_R	=	allowable concrete stress (ksi)
f_r	=	modulus of rupture of concrete (ksi)
$f_{r.seat2}$	=	modulus of rupture of concrete at time of first girder seated on bearings (ksi) (Girder Stability)
$f_{r.seat3}$	=	modulus of rupture of concrete at time of multiple girders seated on bearings (ksi) (Girder Stability)
f_s	=	stress in the prestressing steel (ksi)
f_{s2}	=	stress in the prestressing steel at jacking minus the loss in the prestressing steel stress due to relaxation of steel at transfer (ksi)
$FS_{cr.seat2}$	=	factor of safety against cracking, first girder seated (Girder Stability)
$FS_{cr.seat3}$	=	factor of safety against cracking, multiple girders seated (Girder Stability)
$FS_{overturning}$	=	factor of safety against overturning (Girder Stability)
$FS_{roll.seat2}$	=	factor of safety against rollover, first girder seated (Girder Stability)
$FS_{ult.seat2}$	=	factor of safety against failure, first girder seated (Girder Stability)
$FS_{ult.seat3}$	=	factor of safety against failure, multiple girders seated (Girder Stability)
f_t	=	final tensile stress in the beam (ksi)
$f_{t.seat2}$	=	concrete stress in girder – top, first girder seated (ksi) (Girder Stability)
$f_{t.seat3}$	=	concrete stress in girder – top, multiple girders seated (ksi) (Girder Stability)
$f_{t.seat3.bracing}$	=	concrete stress in girder – top, multiple girders seated with bracing (ksi) (Girder Stability)
$f_{ti,d}$	=	inputted initial tensile stress in the beam (ksi)
f_{ti}	=	initial tensile stress in the beam (ksi)
$f_{ti,new}$	=	revised value of initial tensile stress in the beam (ksi)
f_{top}	=	top fiber stress in the beam (ksi)
F_{ts}	=	total factored flexural stress at the top of the slab (ksi)
f_y	=	specified minimum yield strength of reinforcing bars (ksi)
g_1	=	distance from bottom of beam to first strand row centroid (in)
gDT_{eLR}^1	=	Exterior Moment or Shear DF, Double-Tee Model, One Design Lane Loaded, Lever Rule
gDT_{eLR}^{1P}	=	Exterior Moment or Shear DF, Double-Tee Model, One Design Lane Loaded, Lever Rule (w/ Sidewalks)
gDT_{eLR}^{2+}	=	Exterior Moment or Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Lever Rule
gDT_{eLR}^{2+P}	=	Exterior Moment or Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Lever Rule (w/ Sidewalks)

Chapter 3 Method of Solution

gDT_{eM}	= Exterior Moment DF, Double-Tee Model, Controlling
gDT_{eM}^1	= Exterior Moment DF, Double-Tee Model, One Design Lane Loaded, Equations
gDT_{eM}^{1P}	= Exterior Moment DF, Double-Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gDT_{eM}^{2+}	= Exterior Moment DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations
gDT_{eM}^{2+P}	= Exterior Moment DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gDT_{eM}^{Fat}	= Exterior Moment DF, Double-Tee Model, Fatigue Load, Controlling
gDT_{eM}^P	= Exterior Moment DF, Double-Tee Model, Controlling (w/ Sidewalks)
gDT_{eV}	= Exterior Shear DF, Double-Tee Model, Controlling
gDT_{eV}^1	= Exterior Shear DF, Double-Tee Model, One Design Lane Loaded, Equations
gDT_{eV}^{1P}	= Exterior Shear DF, Double-Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gDT_{eV}^{2+}	= Exterior Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations
gDT_{eV}^{2+P}	= Exterior Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gDT_{eV}^{Fat}	= Exterior Shear DF, Double-Tee Model, Fatigue Load, Controlling
gDT_{eV}^P	= Exterior Shear DF, Double-Tee Model, Controlling (w/ Sidewalks)
gDT_{iLR}^1	= Interior Moment or Shear DF, Double-Tee Model, One Design Lane Loaded, Lever Rule
gDT_{iLR}^{1P}	= Interior Moment or Shear DF, Double-Tee Model, One Design Lane Loaded, Lever Rule (w/ Sidewalks)
gDT_{iLR}^{2+}	= Interior Moment or Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Lever Rule
gDT_{iLR}^{2+P}	= Interior Moment or Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Lever Rule (w/ Sidewalks)
gDT_{iM}	= Interior Moment DF, Double-Tee Model, Controlling
gDT_{iM}^1	= Interior Moment DF, Double-Tee Model, One Design Lane Loaded, Equations
gDT_{iM}^{1P}	= Interior Moment DF, Double-Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gDT_{iM}^{2+}	= Interior Moment DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations
gDT_{iM}^{2+P}	= Interior Moment DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gDT_{iM}^{Fat}	= Interior Moment DF, Double-Tee Model, Fatigue Load, Controlling
gDT_{iM}^P	= Interior Moment DF, Double-Tee Model, Controlling (w/ Sidewalks)
gDT_{iV}	= Interior Shear DF, Double-Tee Model, Controlling
gDT_{iV}^1	= Interior Shear DF, Double-Tee Model, One Design Lane Loaded, Equations
gDT_{iV}^{1P}	= Interior Shear DF, Double-Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gDT_{iV}^{2+}	= Interior Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations
gDT_{iV}^{2+P}	= Interior Shear DF, Double-Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gDT_{iV}^{Fat}	= Interior Shear DF, Double-Tee Model, Fatigue Load, Controlling
gDT_{iV}^P	= Interior Shear DF, Double-Tee Model, Controlling (w/ Sidewalks)

Chapter 3 Method of Solution

g_{eM}	=	Controlling Exterior Moment DF
g_{eM}^1	=	Exterior Moment DF, One Design Lane Loaded, Equations
g_{eM}^{2+}	=	Exterior Moment DF, Two or More Design Lanes Loaded, Equations
g_{eM}^{Fat}	=	Controlling Exterior Moment DF, Fatigue Load
g_{eM}^P	=	Controlling Exterior Moment DF (w/ Sidewalks)
g_{eV}	=	Controlling Exterior Shear DF
g_{eV}^1	=	Exterior Shear DF, One Design Lane Loaded, Equations
g_{eV}^{2+}	=	Exterior Shear DF, Two or More Design Lanes Loaded, Equations
g_{eV}^{Fat}	=	Controlling Exterior Shear DF, Fatigue Load
g_{eV}^P	=	Controlling Exterior Shear DF (w/ Sidewalks)
g_{iM}	=	Controlling Interior Moment DF
g_{iM}^1	=	Interior Moment DF, One Design Lane Loaded, Equations
g_{iM}^{2+}	=	Interior Moment DF, Two or More Design Lanes Loaded, Equations
g_{iM}^{Fat}	=	Controlling Interior Moment DF, Fatigue Load
g_{iM}^P	=	Controlling Interior Moment DF (w/ Sidewalks)
g_{iV}	=	Controlling Interior Shear DF
g_{iV}^1	=	Interior Shear DF, One Design Lane Loaded, Equations
g_{iV}^{2+}	=	Interior Shear DF, Two or More Design Lanes Loaded, Equations
g_{iV}^{Fat}	=	Controlling Interior Shear DF, Fatigue Load
g_{iV}^P	=	Controlling Interior Shear DF (w/ Sidewalks)
gST_{eLR}^1	=	Exterior Moment or Shear DF, Single-Tee Model, One Design Lane Loaded, Lever Rule
gST_{eLR}^{1P}	=	Exterior Moment or Shear DF, Single-Tee Model, One Design Lane Loaded, Lever Rule (w/ Sidewalks)
gST_{eM}	=	Controlling Exterior Moment DF, Single -Tee Model
gST_{eM}^1	=	Exterior Moment DF, Single -Tee Model, One Design Lane Loaded, Equations
gST_{eM}^{1P}	=	Exterior Moment DF, Single -Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gST_{eM}^{2+}	=	Exterior Moment DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations
gST_{eM}^{2+P}	=	Exterior Moment DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gST_{eM}^{Fat}	=	Exterior Moment DF, Single-Tee Model, Fatigue Load, Controlling
gST_{eM}^P	=	Controlling Exterior Moment DF, Single -Tee Model (w/ Sidewalks)
gST_{eV}	=	Controlling Exterior Shear DF, Single -Tee Model
gST_{eV}^1	=	Exterior Shear DF, Single -Tee Model, One Design Lane Loaded, Equations
gST_{eV}^{1P}	=	Exterior Shear DF, Single -Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gST_{eV}^{2+}	=	Exterior Shear DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations
gST_{eV}^{2+P}	=	Exterior Shear DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gST_{eV}^{Fat}	=	Exterior Shear DF, Single-Tee Model, Fatigue Load, Controlling
gST_{eV}^P	=	Controlling Exterior Shear DF, Single -Tee Model (w/ Sidewalks)

Chapter 3 Method of Solution

gST_{iM}	= Controlling Interior Moment DF, Single -Tee Model
gST_{iM}^1	= Interior Moment DF, Single -Tee Model, One Design Lane Loaded, Equations
gST_{iM}^{1P}	= Interior Moment DF, Single -Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gST_{iM}^{2+}	= Interior Moment DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations
gST_{iM}^{2+P}	= Interior Moment DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gST_{iM}^{Fat}	= Interior Moment DF, Single-Tee Model, Fatigue Load, Controlling
gST_{iM}^P	= Controlling Interior Moment DF, Single -Tee Model (w/ Sidewalks)
gST_{iV}	= Interior Shear DF, Single -Tee Model, Controlling
gST_{iV}^1	= Interior Shear DF, Single -Tee Model, One Design Lane Loaded, Equations
gST_{iV}^{1P}	= Interior Shear DF, Single -Tee Model, One Design Lane Loaded, Equations (w/ Sidewalks)
gST_{iV}^{2+}	= Interior Shear DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations
gST_{iV}^{2+P}	= Interior Shear DF, Single -Tee Model, Two or More Design Lanes Loaded, Equations (w/ Sidewalks)
gST_{iV}^{Fat}	= Interior Shear DF, Double-Tee Model, Fatigue Load, Controlling
gST_{iV}^P	= Interior Shear DF, Single -Tee Model, Controlling (w/ Sidewalks)
H	= average annual ambient mean relative humidity, in percent
$h_{brg.seat2}$	= height of the bearing, first girder seated (in) (Girder Stability)
h_f	= compression flange depth (in)
h_{girder}	= height of girder (in) (Girder Stability)
$h_{roll.seat2}$	= height of roll center from bearing pedestal, first girder seated (in) (Girder Stability)
I	= moment of inertia (in ⁴)
I_{beam}	= moment of inertia of prestressed concrete beam (in ⁴)
I_{compos}	= composite, non-transformed, moment of inertia of the section (in ⁴)
I_g	= moment of inertia of the basic beam (in ⁴)
I_y	= vertical axis moment of inertia (in ⁴) (Girder Stability)
IM	= dynamic load allowance
J	= torsional constant (in ⁴)
K_1	= fraction of concrete strength available to resist interface shear; correction factor for source of aggregate, taken as 1.0
K_2	= limiting interface shear resistance (ksi)
k_c	= a factor for the effect of the volume to surface area ratio
k_f	= a factor for the effect of concrete strength
k_h	= humidity factor
k_s	= size factor
$K_{\theta.seat2}$	= transverse bearing rotational stiffness, first girder seated (in-kip/rad) (Girder Stability)
$K_{\theta.seat3}$	= transverse bearing rotational stiffness, multiple girders seated (in-kip/rad) (Girder Stability)
L	= span length (ft)
$L_{1.seat2}$	= distance between centerlines of bearing, first girder seated (ft) (Girder Stability)

Chapter 3 Method of Solution

$L_{1.seat3}$	= distance between centerlines of bearing, multiple girders seated (ft) (Girder Stability)
L_{AA}	= maximum allowable cutoff location from C.L. simple bearing (in)
L_b	= unbraced girder length between braces (ft) (Girder Stability)
L_d	= development length (in)
L_{eff}	= effective span length used in computing the effective flange (slab) width. It is taken as the actual span length for simple span structures or for multi-span structures using the continuous with simple span check analysis option. For multi-span structures using the continuous analysis option, it is taken as the distance between points of permanent load inflection for multi-span girders. (ft)
L_{girder}	= Overall girder length, beam end to beam end (ft) (Girder stability)
L_i	= length of strands to the i'th debonding point (in)
L_t	= transfer length of the strands (in)
L_x	= distance from end of beam to debonding cutoff (in)
M_1	= distributed non-composite dead load at the left end of a range (K/ft)
M_2	= distributed non-composite dead load at the right end of a range (K/ft)
$M_{brace.const}$	= required moment resistance of brace from deck casting (k-ft) (Girder Stability)
M_{CDL}	= dead load creep restraint moment (K-in)
$M_{CP/S}$	= prestressed creep restraint moment (K-in)
M_{CR}	= cracking moment (K-in)
M_D	= unfactored dead load moment at midspan (K-in)
M_{DC1}	= maximum factored flexural moment due to non-composite dead load not already accounted for (K-in)
M_{DC2}	= maximum factored flexural moment due to composite permanent dead load of structural components and nonstructural attachments (K-in)
M_{deck}	= unfactored moment due to the slab at midspan of beam (K-in)
M_{DIA}	= factored flexural moment due to diaphragms (K-in)
M_{DL}	= moment due to all dead loads (both non-composite and composite) (K-in)
M_{DLb}	= service moment due to dead load of beam, including interior diaphragms (K-in)
M_{DNF}	= dead load, non-composite, final moment (K-in)
M_{DNI}	= dead load, non-composite, initial moment (K-in)
$M_{ext\ dia}$	= unfactored moment due to exterior diaphragms at midspan of beam (K-in)
M_{FWS}	= maximum factored flexural moment due to future wearing surfaces (K-in)
M_{fy}	= yield moment capacity (K-in)
M_G	= factored flexural moment due to the girder (K-in)
$M_{g.seat2}$	= moment due to gravity load, first girder seated (k-ft) (Girder Stability)
$M_{g.seat3}$	= moment due to gravity load, multiple girders seated (k-ft) (Girder Stability)
$M_{lat.seat2}$	= lateral moment to cause cracking, first girder seated (k-ft) (Girder Stability)
$M_{lat.seat3}$	= lateral moment to cause cracking, multiple girders seated (k-ft) (Girder Stability)
$M_{LCF,neg}$	= live load, composite, final negative moment (K-in)
M_{LL}	= factored live load moment (K-in)

Chapter 3 Method of Solution

M_{MC2}	=	maximum factored flexural moment due to miscellaneous composite dead load (K-in)
M_{mod}	=	effective moment coefficient due to bracing (Girder Stability)
M_n	=	nominal flexural resistance (K-in)
$M_{ot.seat2}$	=	overturning moment due to wind, first girder seated (k-ft) (Girder Stability)
$M_{ot.seat3}$	=	overturning moment due to wind, multiple girders seated (k-ft) (Girder Stability)
$M_{ot.seat2.brace}$	=	overturning moment to be resisted by bracing, first girder seated (k-ft) (Girder Stability)
$M_{ot.seat3.bracing}$	=	overturning moment to be resisted by bracing, multiple girders seated (k-ft) (Girder Stability)
$M_{P/S}$	=	moment due to prestressing steel (K-in)
M_{PL}	=	moment due to pedestrian loading (K-in)
M_r	=	factored moment resistive capacity of section (K-in)
$M_{r0.9f_{py}}$	=	moment capacity based on a stress of 0.9 f_{py} in the bottom row of the prestressing steel (K-in)
M_{rCR}	=	creep restraint moment (K-in)
$M_{roll.seat2}$	=	overturning moment from wind, first girder seated (k-ft) (Girder Stability)
M_{rSH}	=	shrinkage restraint moment (K-in)
M_s	=	differential shrinkage applied moment (K-in)
M_{sdl}	=	unfactored moment due to superimposed dead load at midspan of beam (K-in)
M_{SLB}	=	factored flexural moment due to the slab (K-in)
M_{SRV}	=	maximum factored moment based on Service IIIB (K-in)
M_U	=	factored moment at the section (K-in)
$M_{uplift.seat3}$	=	uplift moment due to wind, multiple girders seated (k-ft) (Girder Stability)
M_{UT}	=	maximum factored moment based on Service IIIA (K-in)
$M_{UT,max}$	=	maximum factored moment based on Strength I and Strength II (K-in)
$M_{wind.seat2}$	=	lateral moment due to wind, first girder seated (k-ft) (Girder Stability)
$M_{wind.seat3}$	=	lateral moment due to wind, multiple girders seated (k-ft) (Girder Stability)
$M_{wind.seat3.bracing}$	=	modified lateral moment due to wind, multiple girders seated (k-ft) (Girder Stability)
n	=	curve-fitting factor for concrete stress-strain curves
N_{b2}	=	one-half the number of beams in the cross section
n_{braces}	=	number of braces (Girder Stability)
n_{cs}	=	modular ratio of slab concrete to girder concrete
$n_{girders}$	=	number of girders in typical section (Girder Stability)
n_i	=	ratio of the modulus of elasticity of prestressing tendons to the modulus of elasticity of concrete at transfer
n_p	=	modular ratio of prestressing steel to girder concrete
n_s	=	modular ratio of mild steel to girder concrete
$offset_{seat2}$	=	eccentricity reduction factor, first girder seated (Girder Stability)
$offset_{seat3}$	=	eccentricity reduction factor, multiple girders seated (Girder Stability)
P	=	applied load acting on the section (kip)
P_c	=	permanent net compressive force normal to the shear plane (kip)
P_{CLL3}	=	weight of live load on walkway (kip) (Girder Stability)

Chapter 3 Method of Solution

P_e	=	effective force in total prestressing steel after all losses (kip)
$P_{eff.seat2}$	=	effective prestress force at time of first girder seated on bearings (kip) (Girder Stability)
$P_{eff.seat3}$	=	effective prestress force at time of multiple girders seated on bearings (kip) (Girder Stability)
P_i	=	the average of two consecutive load intensities along an influence line (kip)
PPR	=	partial prestressing ratio
P_t	=	force in total prestressing steel immediately after transfer (kip)
Q	=	total factored load
q_i	=	load (unfactored analysis results)
$ratio_{gs,gh}$	=	ratio of girder spacing to girder height (unitless) (Girder Stability)
RF	=	rating factor
S_{ext}	=	overhang of an exterior girder measured from the centerline of girder to the edge of the deck and along a line normal to the girder (in)
S_{int}, S_{girder}	=	spacing of interior girders measured from centerline to centerline of girder and along a line normal to the girder (in)
SSG_{pct}	=	percentage of wind force on simple span girder, multiple girders seated (%) (Girder Stability)
S_{ts}	=	section modulus at top of slab for the composite section (in ³)
$S_{x.b}$	=	horizontal axis section modulus bottom flange (in ³) (Girder Stability)
$S_{x.t}$	=	horizontal axis section modulus top flange (in ³) (Girder Stability)
$S_{y.b}$	=	vertical axis section modulus bottom flange (in ³) (Girder Stability)
$S_{y.t}$	=	vertical axis section modulus top flange (in ³) (Girder Stability)
T	=	tensile force used to compute the nominal flexural resistance (kip)
t	=	time (day)
T_4	=	haunch thickness, excluding the camber thickness (in)
T_5	=	additional overhang thickness (in)
t_{add}	=	additional (sacrificial) slab thickness (in)
$t_{CLL1.0}$	=	uniform torque from live load on concrete deck between girders (ft-k/ft) (Girder Stability)
$t_{CLL1.1}$	=	uniform torque from live load on concrete deck over girders (ft-k/ft) (Girder Stability)
$t_{CLL1.2}$	=	uniform torque from live load on concrete deck cantilever (ft-k/ft) (Girder Stability)
T_{CLL2}	=	concentrated torque from screed machine live load (k-ft) (Girder Stability)
T_{CLL3}	=	concentrated torque from live load on walkway (k-ft) (Girder Stability)
$t_{DC1.0}$	=	uniform torque from concrete deck between flange tips (ft-k/ft) (Girder Stability)
$t_{DC1.1}$	=	uniform torque from concrete deck over girder (ft-k/ft) (Girder Stability)
$t_{DC1.2}$	=	uniform torque from concrete deck cantilever (ft-k/ft) (Girder Stability)
$t_{DC2.0}$	=	uniform torque from stay-in-place forms between girders (ft-k/ft) (Girder Stability)
$t_{DC2.1}$	=	uniform torque from forms over girder (ft-k/ft) (Girder Stability)
$t_{DC2.2}$	=	uniform torque from cantilever forms (ft-k/ft) (Girder Stability)
t_{fws}	=	thickness of future wearing surface (in)
t_h	=	haunch thickness (in)
t_i	=	age of concrete when load is initially applied (day)

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t_s	=	slab thickness (in)
$t_{s, \text{avg}}$	=	average effective thickness of the slab (in)
t_{total}	=	total overturning on girder from uniform torque (ft-k/ft) (Girder Stability)
$total_{CD}$	=	total drag coefficient on girders system, multiple girders seated (unitless) (Girder Stability)
t_w	=	web thickness (in)
V_{DL}	=	shear due to all dead loads (both non-composite and composite) (kip)
V_{LL}	=	shear due to vehicular live loading and dynamic load allowance (kip)
$V_{n\text{-req}}$	=	required nominal shear resistance (kip)
V_p	=	component in the direction of the applied shear of the effective prestressing force (kip)
V_{PL}	=	shear due to pedestrian loading (kip)
V_r	=	factored shear resistance (kip)
V_U	=	factored shear force at section (kip)
W_2	=	beam width at top flange (in)
$W_{brg.seat2}$	=	width of bearing pad measured transverse to the longitudinal axis of the girder, first girder seated (in) (Girder Stability)
$W_{brg.seat3}$	=	width of bearing pad measured transverse to the longitudinal axis of the girder, multiple girders seated (in) (Girder Stability)
w_c	=	unit weight of unreinforced girder concrete (pcf) (Girder Stability)
$w_{CLL1.0}$	=	weight of live load on concrete deck between girders (k/ft) (Girder Stability)
$w_{CLL1.1}$	=	weight of live load on concrete deck over girders (k/ft) (Girder Stability)
$w_{CLL1.2}$	=	weight of live load on concrete deck cantilever (k/ft) (Girder Stability)
$w_{DC1.0}$	=	weight of concrete deck between flange tips (k/ft) (Girder Stability)
$w_{DC1.1}$	=	weight of concrete deck over girder (k/ft) (Girder Stability)
$w_{DC1.2}$	=	weight of concrete deck cantilever (k/ft) (Girder Stability)
$w_{DC2.0}$	=	weight of stay-in-place forms between flange tips (k/ft) (Girder Stability)
$w_{DC2.1}$	=	weight of forms over girder (k/ft) (Girder Stability)
$w_{DC2.2}$	=	weight of cantilever forms (k/ft) (Girder Stability)
$w_{DC.girder}$	=	unit weight of girder (k/ft) (Girder Stability)
W_{girder}	=	weight of girder (kip) (Girder Stability)
$w_{uplift.seat3}$	=	vertical wind uplift force during multiple girders seated (k/ft) (Girder Stability)
$w_{wind.global}$	=	total wind force resisted by all girder (k/ft) (Girder Stability)
$w_{wind.seat2}$	=	lateral wind force at seating the first girder (k/ft) (Girder Stability)
$w_{wind.seat3}$	=	lateral wind force during multiple girders seated (k/ft) (Girder Stability)
X	=	percent of span length for drape point
$X_{anal \text{ pt}}$	=	horizontal distance from the analysis point to the cut-off point of the mild steel over the pier (in)
X_{sr}	=	distribution end zone distance for area of transverse steel (in)
y_b, Y_{bot}	=	vertical distance from non-composite neutral axis of prestressed girder to bottom of girder (in)
$y_{brg.seat2}$	=	height from roll center to bottom of girder, first girder seated (in) (Girder Stability)

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$y_{brg.seat3}$	=	height from roll center to bottom of girder, multiple girders seated (in) (Girder Stability)
$y_{cgs.mid.seat2}$	=	CG of strands at midspan at time of first girder seated on bearings (in) (Girder Stability)
$y_{cgs.mid.seat3}$	=	CG of strands at midspan at time of multiple girders seated on bearings (in) (Girder Stability)
Y_{compos}	=	vertical distance from composite neutral axis of section to bottom of girder (in)
$y_{mid.seat2}$	=	mid-height of cambered girder above roll axis, first girder seated (in) (Girder Stability)
$y_{mid.seat3}$	=	mid-height of cambered girder above roll axis, multiple girders seated (in) (Girder Stability)
$y_{r.seat2}$	=	distance from the center of mass of the cambered arc above the roll axis, first girder seated (in) (Girder Stability)
$y_{r.seat3}$	=	distance from the center of mass of the cambered arc above the roll axis, multiple girders seated (in) (Girder Stability)
Y_s	=	shrinkage restraint moment (K-in)
y_{top}	=	vertical distance from non-composite neutral axis of prestressed girder to top of girder (in)
$z'_{0.seat2}$	=	corresponding center of mass eccentricity due to tilt angle, first girder seated (in) (Girder Stability)
$z_{0.seat2}$	=	lateral deflection due to girder weight on weak axis, first girder seated (in) (Girder Stability)
$z_{0.seat3}$	=	lateral deflection due to girder weight on weak axis, multiple girders seated (in) (Girder Stability)
Z_b	=	section modulus for bottom fiber of girder for non-composite section (in ³)
Z_{bc}	=	section modulus for bottom fiber of girder for composite section (in ³)
Z_{bct}	=	section modulus for bottom fiber of girder for composite section with prestressing strands transformed (in ³)
$z_{max.seat2}$	=	horizontal distance from roll axis to pad kern point, first girder seated (in) (Girder Stability)
Z_t	=	section modulus for top fiber of girder for non-composite section (in ³)
$z_{wind.seat2}$	=	eccentricity due to wind deflection, first girder seated (in) (Girder Stability)
$z_{wind.seat3}$	=	eccentricity due to wind deflection, multiple girders seated (in) (Girder Stability)
α_{seat2}	=	maximum transverse seating tolerance from level, first girder seated (ft/ft) (Girder Stability)
α_{seat3}	=	maximum transverse seating tolerance from level, multiple girders seated (ft/ft) (Girder Stability)
β	=	factor relating effect of longitudinal strain on the shear capacity of concrete, as indicated by the ability of diagonally cracked concrete to transmit tension
β_1	=	ratio of the depth of the equivalent uniformly stressed compression zone assumed in the strength limit state to the depth of the actual compression zone
γ_f	=	unit weight for future wearing surface (kcf)
γ_i	=	load factor
γ_{jack}	=	jacking force load factor for pre-tensioned girder = 1.2
δ	=	maximum allowable parapet overhang (in)
$\Delta_{camber.seat2}$	=	camber at time of first girder seated on bearings (in) (Girder Stability)
$\Delta_{camber.seat3}$	=	camber at time of multiple girders seated on bearings (in) (Girder Stability)
Δf_{cdp}	=	change in concrete stress at center of gravity of prestressing steel due to all dead loads, except dead load acting at the time the prestressing force is applied (ksi)
Δf_{pCR}	=	loss in prestressing steel stress due to creep (ksi)
Δf_{pES}	=	loss in prestressing steel stress due to elastic shortening (ksi)

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Δf_{pLS}	=	loss in prestressing steel stress based on the approximate lump sum method (ksi)
Δf_{pR1}	=	loss in prestressing steel stress due to relaxation of steel at transfer (ksi)
Δf_{pR2}	=	loss in prestressing steel stress due to relaxation of steel after transfer (ksi)
Δf_{pSR}	=	loss in prestressing steel stress due to shrinkage (ksi)
Δf_{pT}	=	total loss in prestressing steel stress (ksi)
$\Delta_{P/S}$	=	camber due to prestressing (in)
Δ_s	=	camber due to slab, form work, and exterior diaphragms (in)
δ_{screed}	=	deflection of screed rail due to girder rotation (in) (Girder Stability)
Δ_{SDL}	=	camber due to superimposed dead load (in)
Δ_{sw}	=	camber due to girder self-weight (including interior diaphragms) (in)
$\delta_{wind.ext.global}$	=	windward exterior girder deflection in the global girder system (in) (Girder Stability)
$\delta_{wind.ext.single}$	=	windward exterior girder deflection without bracing (in) (Girder Stability)
ϵ_0	=	strain in concrete when f_c corresponds to f'_c (in/in)
$\epsilon_{0.9fpy}$	=	strain in prestressing steel that causes a stress of $0.9 f_{py}$
ϵ_c	=	strain in concrete caused by concrete stress, f'_c (in/in)
ϵ_{ce}	=	initial strain due to effective prestressing force at bottom of beam (in/in)
ϵ_{cl}	=	compression-controlled strain limit in the extreme tension steel (in/in)
ϵ_{cr}	=	creep strain (in/in)
ϵ_{crf}	=	final creep strain (in/in)
ϵ_{crm}	=	creep strain at time moment connection is made (in/in)
$\epsilon_{DL(bot)}$	=	strain at bottom of beam from non-composite moment (in/in)
$\epsilon_{DL(g1)}$	=	strain at bottom strand row from non-composite moment (in/in)
$\epsilon_{DL(top)}$	=	strain at top of beam from non-composite moment (in/in)
$\epsilon_{LL(g1)}$	=	strain at bottom strand row from composite moment when the total strain causes a stress of $0.9 f_{py}$ (in/in)
ϵ_p	=	strain in prestressing steel caused by prestressing steel stress, f_s (in/in)
ϵ_{ps}	=	initial strain in prestressing steel caused by effective prestressing (in/in)
ϵ_{sh}	=	concrete shrinkage strain at a given time (in/in)
ϵ_t	=	net tensile strain in the extreme tension steel at nominal resistance (in/in)
ϵ_{te}	=	initial strain due to effective prestressing force at top of beam (in/in)
ϵ_{tl}	=	tension-controlled strain limit in the extreme tension steel (in/in)
η	=	load modifier (final resultant)
η_i	=	load modifier (due to an individual component)
θ	=	angle of inclination of diagonal compressive stresses; angle at corner of the structure; rotation at end of beam; principal angle; prestress slope for set of strands (degrees)
θ_{const}	=	rotation of girder due to torsion of deck casting (rad) (Girder Stability)
$\theta_{cr.seat2}$	=	tilt angle at cracking due to lateral deflection, first girder seated (rad) (Girder Stability)
$\theta_{cr.seat3}$	=	tilt angle at cracking due to lateral deflection, multiple girders seated (rad) (Girder Stability)
$\theta_{eq.seat2}$	=	rotation of girder from vertical at equilibrium, first girder seated (rad) (Girder Stability)

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$\theta_{eq.seat3}$	=	rotation of girder from vertical at equilibrium, multiple girders seated (rad) (Girder Stability)
$\theta'_{max.seat2}$	=	tilt angle at maximum resisting moment arm, first girder seated (rad) (Girder Stability)
$\theta_{max.ult.seat2}$	=	tilt angle at maximum factor of safety, first girder seated (rad) (Girder Stability)
$\theta_{max.ult.seat3}$	=	tilt angle at maximum factor of safety, multiple girders seated (rad) (Girder Stability)
λ	=	concrete density modification factor, taken as 1.00
μ	=	friction factor used to compute nominal interface shear resistance
ρ	=	ratio of the total area of prestressing steel to the area of prestressed concrete beam
ρ_{min}	=	minimum ratio of the total area of prestressing steel to the area of prestressed concrete beam
σ	=	principal stress (ksi)
σ_x	=	normal stress in the x direction (ksi)
σ_y	=	normal stress in the y direction (ksi)
τ_{xy}	=	shearing stress in the x-y plane (ksi)
ϕ	=	ratio of creep strain to elastic strain; resistance factor
ϕ_f	=	resistance factor for flexure
ϕ_v	=	resistance factor for shear
$\Psi(t,t_i)$	=	creep coefficient, equal to the ratio of the strain which exists t days after casting to the elastic strain caused when load p_i is applied t_i days after casting
ω_c	=	density of concrete (kcf)
ω_{cs}	=	density of slab concrete (kcf)

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3.2 CONSTANT INITIALIZATION

The program first initializes all constants used by the program that are dependent on the input parameters. The constants that are initialized by the program include moduli of elasticity, modular ratios, prestress yield stresses, prestress jacking stresses, allowable concrete stresses, modulus of rupture, stress block ratios, load factors, resistance factors, dynamic load allowance, debonding constants, and creep factor for camber. These constants are defined in the following sections.

3.2.1 Moduli of Elasticity

For girder concrete with w_c equal to 0.145 kcf and f'_c less than or equal to 10 ksi, the moduli of elasticity are initialized as follows:

$$E_c = 33,000K_1w_c^{1.5}\sqrt{f'_c}$$

$$E_{ci} = 33,000K_1w_c^{1.5}\sqrt{f'_{ci}}$$

For girder concrete with w_c not equal to 0.145 kcf or f'_c greater than 10 ksi, the moduli of elasticity are initialized as follows:

$$E_c = 120,000K_1w_c^{2.0}(f'_c)^{0.33}$$

$$E_{ci} = 120,000K_1w_c^{2.0}(f'_{ci})^{0.33}$$

For slab concrete with w_{cs} equal to 0.145 kcf (Normal Weight Concrete) or equal to 0.110 kcf (Lightweight Concrete) and f'_c equal to 4.0, 3.5, 3.0, or 2.0 ksi, the modulus of elasticity is initialized as follows:

f'c	Modulus of Elasticity (ksi)	
Structural Design		
Strength (ksi)	Normal Wt.	Lightweight
4.0	3,600	2,300
3.5	3,400	2,200
3.0	3,100	2,100
2.0	2,600	1,800

For slab concrete with w_{cs} equal to 0.145 kcf (Normal Weight Concrete) or equal to 0.110 kcf (Lightweight Concrete) and f'_c between 4.0 ksi and 2.0 ksi, but not equal to a value in the above table, the modulus of elasticity will be interpolated between the values shown and rounded to the nearest 100 ksi.

For slab concrete with w_{cs} equal to 0.145 kcf (Normal Weight Concrete) and f'_c greater than 4.0 ksi and less than or equal to 10.0 ksi, the modulus of elasticity is initialized as follows:

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$$E_{cs} = 33,000K_1w_{cs}^{1.5}\sqrt{f'_c}$$

For slab concrete with w_{cs} not equal to 0.145 kcf (Normal Weight Concrete) or f'_c greater than 10.0 ksi, the modulus of elasticity is initialized as follows:

$$E_{cs} = 120,000K_1w_{cs}^{2.0}(f'_c)^{0.33}$$

For prestressing steel, the modulus of elasticity is initialized as $E_p = 28,500$ ksi.

For mild steel, the modulus of elasticity is initialized as $E_s = 29,000$ ksi.

3.2.2 Modular Ratios

Modular ratios are initialized as follows:

$$n_p = \frac{E_p}{E_c} \geq 2.0$$

$$n_s = \frac{E_s}{E_c} \geq 2.0$$

The program rounds the first two modular ratios presented above, n_p and n_s , to the nearest integer. For example, 8.49 is rounded to 8 and 8.50 is rounded to 9. The program rounds the third modular ratio presented below, n_{cs} , to the nearest tenth.

$$n_{cs} = \frac{E_{cs}}{E_c}$$

3.2.3 Prestress Yield Strength

For stress-relieved strands, the yield strength of prestress is initialized as follows:

$$f_{py} = 0.85 f_{pu}$$

For low-relaxation strands, the yield strength of prestress is initialized as follows:

$$f_{py} = 0.90 f_{pu}$$

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3.2.4 Prestress Jacking Stresses

For stress-relieved strands, the prestress jacking stress is initialized as follows:

$$f_{pj} = 0.70 f_{pu}$$

For low-relaxation strands, the prestress jacking stress is initialized as follows:

$$f_{pj} = 0.75 f_{pu}$$

3.2.5 Allowable Concrete Stresses

The program initializes the allowable concrete stresses for I-beams, box beams based on hollow sections, and adjacent plank beams as presented in DM-4 Article 5.9.2.3, Table 5.9.2.3.4 P-1.

The program uses one set of allowable concrete stresses for the centerline of bearings and another set of allowable concrete stresses for all other locations along the girder.

3.2.6 Modulus of Rupture

The modulus of rupture used to compute the cracking moment for normal-weight concrete is initialized as follows:

$$f_r = 0.24\sqrt{f'_c}$$

The modulus of rupture used to compute the default allowable tension for final stresses with creep and shrinkage is initialized as follows:

$$f_r = 0.24\sqrt{f'_c}$$

3.2.7 Stress Block Ratios

For girder concrete, the stress block ratio is initialized as follows:

$$\beta_1 = 0.85 - \left(\frac{0.05}{1.0} \right) (f'_c - 4.0), \text{ where } 0.65 \leq \beta_1 \leq 0.85$$

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For slab concrete, the stress block ratio is initialized as follows:

$$\beta_1 = 0.85 - \left(\frac{0.05}{1.0} \right) (f_{cs} - 4.0), \text{ where } 0.65 \leq \beta_1 \leq 0.85$$

3.2.8 Load Modifiers

The program computes the factored moments, shears, deflections, reactions, and stresses as required by the LRFD Specifications and DM-4. In accordance with DM-4, the program computes the total factored loads using the following equation:

$$Q = \sum \left[\eta_i \gamma_i q_i \text{ or } \frac{\gamma_i q_i}{\eta_i} \right]$$

Where:

Q	=	total factored load
η_i	=	load modifier (see Table 1)
γ_i	=	load factor (see Table 2)
q_i	=	load (unfactored analysis results)

In the above equation, when the maximum load factor is used for a given load, then $\eta_i \gamma_i q_i$ is used. When the minimum load factor is used with a given load, then $\gamma_i q_i / \eta_i$ is used.

The program computes the load modifier in accordance with LRFD Specifications Article 1.3.2 and the corresponding section of DM-4. The load modifier used for each load combination is summarized in Table 1.

Table 3.2-1 Load Modifier

Load Combination	Load Modifier
All Strength Limit States	η = product of inputted importance factor, ductility factor, and redundancy factor (see CTL command) Minimum η = 1.0 Maximum η = 1.16 As per PennDOT DM-4 Section 1.3.2.1, Eta factors other than 1.0 are not permitted by PennDOT.
All Service Limit States	η = 1.0
Fatigue-I	η = 1.0
Deflection	η = 1.0

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3.2.9 Load Factors

The program computes the factored analysis results by multiplying the unfactored analysis results by the appropriate load factors. The load factor depends on the load type and the limit state, as specified in DM-4. The program considers the Strength I, Strength IP, Strength IA, Strength II, Service I, Service IP, Service III, Service IIIP, Service IIIA, Service IIIB, and Fatigue I limit states. In addition, the program uses load factors for checking deflection.

The load factors used for each load type per limit state are presented in Table 2. In addition, the load factors used for deflection are also presented in Table 2. When two load factors are presented, the first load factor is the maximum load factor and the second load factor is the minimum load factor.

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Table 3.2-2 Load Factors

Load Combinations	Loadings							Design LL Vehicle
	γ_{DC}	γ_{DW}^2	γ_{LL}	γ_{PL}	γ_{SPVH}	$\gamma_{CR, SH}$	γ_{MISC}	
Strength-I	1.25, 0.90	1.50, 0.65	1.75	--	User Def.	0.5	User Def.	PHL-93
Strength-IP	1.25, 0.90	1.50, 0.65	1.35	1.75	User Def.	0.5	User Def.	PHL-93
Strength-IA	1.25, 0.90	1.50, 0.65	1.35	--	--	0.5	User Def.	PHL-93
Strength-II	1.25, 0.90	1.50, 0.65	1.35	--	User Def.	0.5	User Def.	Permit (P-82)
Service-I	1.00	1.00	1.00	--	User Def.	1.00	User Def.	PHL-93
Service-IP	1.00	1.00	0.80	1.00	User Def.	1.00	User Def.	PHL-93
Service-III	1.00	1.00	1.00	--	User Def.	1.00	User Def.	PHL-93
Service-IIIP	1.00	1.00	0.80	1.00	User Def.	1.00	User Def.	PHL-93
Service-IIIA	1.00	1.00	1.00	--	User Def.	--	User Def.	Controlling of PHL-93 or P-82
Service-IIIB	1.00	1.00	1.00	--	User Def.	--	User Def.	Controlling of PHL-93 or P-82
Fatigue-I	--	--	1.75	--	--	--	User Def.	HS20-30
Deflection	--	--	1.00	0.00 ¹ , 1.00	--	--	User Def.	PennDOT Defl. Loading

Notes:

- ¹ For checking live load deflection limit without pedestrian $\gamma = 0.00$. For checking live load deflection limit with pedestrian $\gamma = 1.00$.
- ² DW load factor used for wearing surfaces and utility loads.

The program uses minimum load factors to compute the permanent net compressive force normal to the shear plane, P_c , for horizontal shear design. The permanent net compressive force considers the slab and haunch load, user entered DC2 and MC2 distributed loads, and future wearing surface loads. Conservatively, user entered CW2 and UT2 distributed loads are ignored. For each strength limit state the program computes maximum factored effects using the maximum or minimum load factor for each individual loading such that the factored effects are maximized. Similarly, the program computes minimum factored effects using the maximum or minimum load factor for each individual loading such that the factored effects are minimized.

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Strength-IV limit state does not apply for prestressed concrete girders. This limit state is based on the assumption of very high dead load to live load force effect ratios, exceeding approximately 7.0, which is generally not the case for prestressed concrete girders. Additional information about the applicability of each limit state is presented in LRFD Specifications Article 3.4.1 and the corresponding section of DM-4.

3.2.10 Resistance Factors

For flexure, the resistance factors used by the program for tension-controlled sections are as follows:

$$\phi_f = 1.0 \text{ for prestressed I-beams and solid box beams}$$

$$\phi_f = 0.95 \text{ for prestressed voided box beams}$$

$$\phi_f = 0.90 \text{ for non-prestressed sections}$$

For compression-controlled sections the resistance factor used by the program is as follows:

$$\phi_f = 0.75 \text{ for all beams}$$

For sections between compression-controlled and tension-controlled the resistance factor is linearly increased from the compression-controlled resistance factor to the tension-controlled resistance factor as the net tensile strain increases from the compression-controlled strain limit of 0.002 to the tension-controlled strain limit of 0.005. This results in the following three equations:

$$0.75 \leq \phi = 0.75 + \frac{0.25(\varepsilon_t - \varepsilon_{cl})}{(\varepsilon_{tl} - \varepsilon_{cl})} \leq 1.0 \quad (\text{prestress non-box})$$

$$0.75 \leq \phi = 0.75 + \frac{0.15(\varepsilon_t - \varepsilon_{cl})}{(\varepsilon_{tl} - \varepsilon_{cl})} \leq 0.9 \quad (\text{non-prestressed})$$

$$0.75 \leq \phi = 0.75 + \frac{0.20(\varepsilon_t - \varepsilon_{cl})}{(\varepsilon_{tl} - \varepsilon_{cl})} \leq 0.95 \quad (\text{prestress box})$$

Taking all three equations and generalizing into one equation to make it simpler to program leads to the following equation:

$$0.75 \leq \phi = 0.75 + \frac{(\phi_f - 0.75)(\varepsilon_t - \varepsilon_{cl})}{(\varepsilon_{tl} - \varepsilon_{cl})} \leq \phi_f$$

where:

ε_{cl} = compression-controlled strain limit (in./in.)

all prestressed reinforcement, $\varepsilon_{cl} = 0.002$

non-prestressed reinforcement with $f_y \leq 60.0 \text{ ksi}$, $\varepsilon_{cl} = \min\left(\frac{f_y}{E_s}, 0.002\right)$

non-prestressed reinforcement with $60.0 \text{ ksi} < f_y \leq 100.0 \text{ ksi}$

$$\varepsilon_{cl} = 0.002 + \frac{(f_y - 60)}{40} (0.002)$$

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ϵ_{tl} = tension-controlled strain limit (in./in.)

all prestressed reinforcement, $\epsilon_{tl} = 0.005$

non-prestressed reinforcement with $f_y \leq 75.0 \text{ ksi}$, $\epsilon_{tl} = 0.005$

non-prestressed reinforcement with $75.0 \text{ ksi} < f_y \leq 100.0 \text{ ksi}$

$$\epsilon_{tl} = 0.005 + \frac{(f_y - 75)}{25}(0.003)$$

ϵ_t = net tensile strain (in./in.)

ϕ_r = resistance factor for tension-controlled section

For shear, the resistance factor used by the program is as follows:

$$\phi_v = 0.90 \text{ for all beams}$$

3.2.11 Dynamic Load Allowance

The program initializes the dynamic load allowance (impact) as follows:

$$IM = 33\% \text{ for Strength and Service (non-Permit Vehicle)}$$

$$IM = 20\% \text{ for P-82 Permit Vehicle}$$

$$IM = 15\% \text{ for Fatigue}$$

Based on these initialized values of dynamic load allowance, the dynamic load factor is computed as follows:

$$f_{IM} = \left(1 + \frac{IM}{100} \right)$$

The program does not apply the dynamic load allowance to pedestrian loads or to the design lane load of the PHL-93 and HL-93 loadings. However, the program does apply the dynamic load allowance to the H and HS lane loadings.

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3.2.12 Debonding Constants

The program initializes the debonding constants as presented in Table 3.

Table 3.2-3 Debonding Constants

Debonding Constant	Description of Debonding Constant	Initialized Value
DB1	Maximum allowable strands re-bonded in cutoff section	6 strands
DB2	Minimum allowable strands re-bonded in cutoff section	2 strands
DB3	Maximum allowable debonded strands in girder	30 strands
DB4	Maximum allowable percentage of total debonded strands to total strands in girder	25%
DB5	Maximum allowable debonded cutoffs for one-half girder span	5 cutoffs for design; 8 cutoffs for analysis
DB6	Debonded development length factor for fully-bonded strands	1.0
DB7	Debonded development length factor for debonded strands	1.0
DB8	Constant used in computing the maximum allowable debonded length	0 inches
DB9	Minimum required longitudinal spacing of debonded cutoff lengths	12 inches
DB10	Minimum recommended debonded cutoff length from centerline of bearing	6 inches for I-beams, bulb-tee beams, and NEXT beams; End Block plus 18 inches for box beams
DB11	Increment used to design a debonded cutoff length	6 inches
DB12	Minimum allowable number of debonded strands in girder	2 strands
DB13	First crack control cutoff distance from end of beam	6 inches
DB14	Maximum allowable percentage of the total number of strands that may be debonded for crack control between the end of beam and the first crack control cutoff location	50%
DB15	Second crack control cutoff distance from end of beam	36 inches
DB16	Crack control cutoff distance tolerance	0.5 inches

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3.2.13 Creep Factor for Camber

The program initializes the creep factor for camber as $C_r = 1.60$.

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3.3 GEOMETRY

The span lengths, bridge cross section, and other structure dimensions are input by the user. These dimensions are used to calculate the loads, distribution factors, and the structural analysis solutions. Girder cross sections are defined by their locations and dimensions. Standard PennDOT and AASHTO prestressed concrete girder dimensions are stored in the program. The user enters the beginning and end of each segment of the girder over which the cross section is constant.

For the purposes of analysis, design, and rating, the program establishes analysis points at the following locations:

1. Each support (simple span and continuous)
2. One-twentieth points along each span length (continuous)
3. Midspan of each simple span
4. Concentrated load points
5. Draped point locations (if applicable)
6. 12 inches from the centerline of each bearing
7. Stirrup Change locations (shear analysis runs)

Each of the locations illustrated in Figure 1 is an analysis point that is established by the program. While Figure 1 shows analysis points in only certain spans for simplicity, analysis points listed above are established in each applicable span.

For multi-span girders, span lengths are defined by the centerline of bearing for exterior supports (abutments) and the centerline of pier for interior supports (piers), as shown in Figure 1.

All non-composite dead loads are applied to the simple spans. The moments, shears, and deflections are computed at one-twentieth points that correspond to the continuous span, as well as at the other analysis points listed above.

For multi-span structures, there are two options available for analysis of composite dead load and live load:

1. Continuous analysis option – analyzes the structure as continuously supported.
2. Continuous analysis with simple span check option – analyzes the structure as continuously supported, and then analyzes the structure as series of simple spans. The controlling effect at each analysis is selected as the greater effect from the two analyses. The controlling effects are used for design and specification checking. When the effects are combined for each limit state, continuous analysis effects are combined with continuous analysis effect and simple analysis effects are combined with simple analysis effects.

Moments, shears and deflections are computed at the twentieth points of the continuous span lengths for both analysis options.

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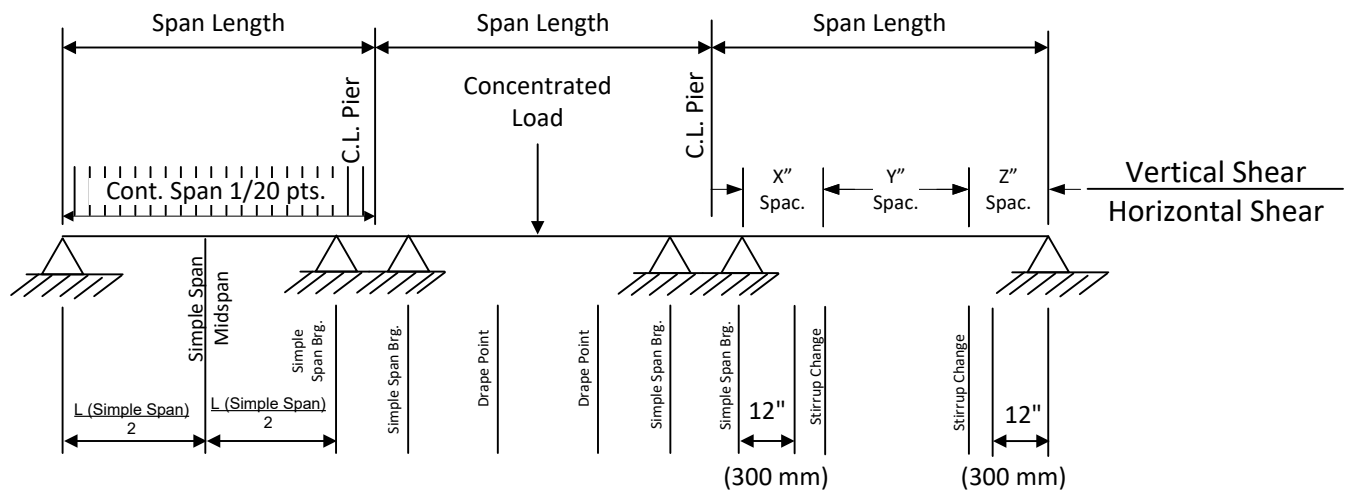


Figure 3.3-1 Analysis Points

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3.4 SECTION PROPERTIES

The program uses the routines of PennDOT's Beam Section Properties (BSP) program to compute the section properties. BSP provides the basic section properties required to analyze prestressed concrete girder sections used in highway bridges. Properties are computed for the following conditions:

1. Basic beam, gross section
2. Basic beam, transformed section
3. Composite beam, gross section
4. Composite beam, transformed section

The basic beam section properties are based on the beam only. The composite beam section properties are based on the beam and the slab acting together as a composite section. The gross section properties do not take into account the transformed effects of the prestressing steel. The transformed section properties take into account the transformed effects of the prestressing steel.

The properties which are computed for the above four conditions include the moment of inertia, location of the neutral axis, and section moduli. In addition, other section properties for the basic beam are computed, as required by the LRFD Specifications. These additional section properties include the beam depth, the area of the basic beam, the weight per unit length, the volume, the surface area, the volume-to-surface area ratio, the longitudinal stiffness parameter, the torsional constant, the half-depth area of concrete containing the positive flexure tension zone, and the half-depth area of concrete containing the negative flexure tension zone. For box beams with voids, an adjusted beam area used to compute the weight per unit length is computed assuming additional concrete of 1/4 inch around the perimeter of the voids.

For analysis points located between the end of the beam and the drape point, the program computes the actual center of gravity of the strand pattern by interpolation and it then computes the actual transformed section properties based on the center of gravity of the strand pattern at that location.

The stiffness of the basic beam, gross section, is used for the dead load analysis of the self-weight of the prestressed concrete girder, the interior diaphragms, the concrete deck, the concrete haunch, the exterior diaphragms, the user-input DC1 dead loads, the user-input utility loads UT1, and the user-input MC1 dead loads. If the section is specified as being composite, the concrete deck is assumed fully effective for the entire girder length, and the composite beam, gross section, stiffness is used for the entire length of the girder. The composite beam, gross section, moment of inertia is used for the superimposed dead load analysis. The superimposed dead loads are the DC2, FWS, UT2, and MC2 loads input by the user. The composite beam, gross section, moment of inertia is used for the pedestrian loading analysis and the live load analysis.

The section properties used for the stress analysis for each load type are shown in Table 1. Transformed section properties are used for the computation of live load stresses. Gross section properties are used for other stress calculations. For example, DC1 loads are applied to the basic beam, gross section, and live loads are applied to the composite beam, transformed section.

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Table 3.4-1 Section Properties for Stress Analysis

Abbreviation	Load Type	Section Properties
DC1	Dead loads of structural components and nonstructural attachments	Basic beam, gross section
DC2	Dead loads of structural components and nonstructural attachments	Composite beam, gross section
MC1	Miscellaneous permanent dead loads applied to the non-composite section	Basic beam, gross section
UT1	Utility loads applied to the non-composite section	Basic beam, gross section
UT2	Utility loads applied to the composite section	Composite beam, gross section
FWS	Dead loads of future wearing surfaces	Composite beam, gross section
MC2	Miscellaneous permanent dead loads applied to the composite section	Composite beam, gross section
LL	Live load of LRFD load, fatigue truck, permit truck, maximum legal loading, HS20, and H20	Composite beam, transformed section
PL	Pedestrian live load	Composite beam, transformed section
SLL #i	Special live load number "i"	Composite beam, transformed section

The section properties used for the stiffness analysis for each load type are shown in Table 2. For example, DC1 loads are applied to the basic beam, gross section, and DC2 loads are applied to the composite beam, gross section.

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Table 3.4-2 Section Properties for Stiffness Analysis

Abbreviation	Load Type	Section Properties
DC1	Dead loads of structural components and nonstructural attachments	Basic beam, gross section
DC2	Dead loads of structural components and nonstructural attachments	Composite beam, gross section
MC1	Miscellaneous permanent dead loads applied to the non-composite section	Basic beam, gross section
UT1	Utility loads applied to the non-composite section	Basic beam, gross section
UT2	Utility loads applied to the composite section	Composite beam, gross section
FWS	Dead loads of future wearing surfaces	Composite beam, gross section
MC2	Miscellaneous permanent dead loads applied to the composite section	Composite beam, gross section
LL	Live load of LRFD load, fatigue truck, permit truck, maximum legal loading, HS20, and H20	Composite beam, gross section
PL	Pedestrian live load	Composite beam, gross section
SLL #i	Special live load number "i"	Composite beam, gross section

The basic beam is used for checking specifications due to non-composite loads. The composite beam is used for checking specifications due to composite loads, including both superimposed dead load and live load.

For box sections, the hollow section properties are used at all locations except for the centerline of pier. At this location, the solid block section properties are used for the continuity moment connection computations. For the design of the continuity moment connection, either hollow section properties or solid block section properties are used, whichever produces the controlling results. The hollow section properties are used for the stiffness analysis and for checking the stresses at all locations, including at the centerline of bearing for simple spans.

The basic formulae used in calculating the section properties can be found in any standard textbook on structural engineering. Source specific formulae used by this program are given in Sections 3.2.1, 3.2.2, and 3.4.1.

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3.4.1 Effective Slab Width

The program computes the effective slab width in accordance with LRFD Specifications Article 4.6.2.6. For interior beams, the effective slab width is the girder spacing:

$$b_{eff,int} = S_{int}$$

For exterior beams, the effective slab width is as follows:

$$b_{eff,ext} = 0.5b_{eff,int} + S_{ext}$$

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3.5 DISTRIBUTION FACTORS

The distribution factors can be either input by the user or computed by the program. Distribution factors are used to compute each of the following:

1. Positive moment in each span.
2. Negative moment in an end span.
3. Negative moment near the interior support.
4. Negative moment near the middle of an interior span.
5. Reaction at an exterior support.
6. Reaction at an interior support.
7. Shear (positive or negative) in any span.
8. Deflections at all analysis points.
- 9. Rotations at supports.**

The distribution factors for moment, shear, and reaction in a girder are a function of several variables, including the span length and the location of the analysis point. The distribution factor for deflection is a function of the number of beams and the number of lanes on the bridge. **The distribution factors for rotation are computed from the moment distribution factors. Refer to section 3.7.17 for details on the rotation distribution factors.**

The program computes the moment, shear, and deflection distribution factors for a design loading (with and without sidewalks) and a fatigue loading. For a design loading, the distribution factor is based on the number of loaded lanes that produces the controlling distribution factor. For bridges with sidewalks, the user enters the number of loaded lanes as if the sidewalks were not present as well as the number of loaded lanes with the sidewalks present (presumably less than or equal to the number of lanes when the sidewalks are not present). For a fatigue loading, the distribution factor is based on one lane loaded, and the resulting distribution factor is then divided by the corresponding multiple presence factor of 1.20, in accordance with LRFD Specifications Article C3.6.1.1.2. Moment and shear skew correction factors are included as appropriate.

For the case of calculating distribution factors when sidewalks are present, the sidewalks are counted as another loaded lane for the purpose of determining the multiple presence factor, as per LRFD Specification Section 3.6.1.1.2. When the distribution factors are calculated using the LRFD Specifications and DM-4 Tables 4.6.2.2.2b-1, 4.6.2.2.2d-1, 4.6.2.2.3a-1, or 4.6.2.2.3b-1, the program only uses the "Two or More Design Lanes Loaded" equations when the sidewalks are present. If the distribution factors are calculated using the lever rule, the distribution factor is calculated with the user input number of loaded lanes (i.e. not including the sidewalk), but the multiple presence factor is computed for one more loaded lane than the number of lanes loaded for the lever rule calculation.

The program uses the lever rule to compute the moment, shear and reaction distribution factors for an exterior girder with one design lane loaded. For an exterior girder with two or more design lanes loaded, the lever rule is applied only for situations described in LRFD Specifications Tables 4.6.2.2.2d-1 and 4.6.2.2.3b-1. For interior girders, the lever rule is applied only for situations described in LRFD Specifications Tables 4.6.2.2.2b-1 and 4.6.2.2.3a-1. LRFD Specifications Article C4.6.2.2.1 defines the lever rule as follows: "the lever rule involves

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summing moments about one support to find the reaction at another support by assuming that the supported component is hinged at interior supports," in which the beams are the supports. When using the lever rule, the program also applies the appropriate multiple presence factor.

The moment of inertia, I , and the torsional constant, J , used for the calculation of distribution factors are the composite beam, gross properties. For the calculation of the shear distribution factors of adjacent box beams, the moment of inertia, I , and the torsional constant, J , are based on the beam sections at the supports. For the calculation of moment and shear distribution factors of exterior adjacent beams (box and plank), the moment of inertia, I , and the torsional constant, J , are also calculated for interior adjacent beams. The exterior adjacent beam distribution factors are computed from the interior moment and shear distribution factors. For the calculation of the moment distribution factor near interior supports, section properties for the adjacent spans are averaged using the span lengths as the weighting factor as follows:

$$p_{avg} = \left(\frac{p_1 \times L_1 + p_2 \times L_2}{L_1 + L_2} \right)$$

Where;

p_{avg} = weighted average cross section property

p_1 = cross section property left span

p_2 = cross section property right span

L_1 = left span length

L_2 = right span length

The following section properties, used in computing the moment distribution factor in the negative dead load moment region, MDF2, for both interior and exterior beams, are averaged:

K_g = longitudinal stiffness parameter

d = depth of member

I = moment of inertia

J = St. Venant torsional inertia

For the continuous analysis with simple span check option, one moment distribution factor, based on the continuous span length, is used for each span. For additional information about distribution factors, refer to Sections 5.8 and 5.9 of this User's Manual. Included in Section 5.9 are two figures, which illustrate the applicable range of the moment and shear distribution factors.

For an exterior beam without sidewalk (either no sidewalk entered or without sidewalk case when sidewalk was entered), when the curb to exterior web of the exterior girder distance, d_e , limit is not within the range of applicability limits, the live load distribution factor is computed using d_e computed from user input. Also, the live load distribution

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factor is computed setting d_e to the violated limit (upper or lower). The larger live load distribution is used for design and an informational message is provided in the output file.

For specific equations used by this program to compute distribution factors, refer to LRFD Specifications Article 4.6.2.2 and the corresponding section of DM-4. For NEXT Beams the method used to compute the distribution factors is detailed in Section 3.5.4 of this Users Manual. Additional information concerning distribution factors for deflection is available in LRFD Specifications Article 2.5.2.6.2, and additional information concerning multiple presence factors for live load is available in LRFD Specifications Article 3.6.1.1.2.

3.5.1 Shear Skew Correction Factors

Shear skew correction factors are computed in accordance with LRFD Specifications Article 4.6.2.2.3 and the corresponding section of DM-4.

For bridges with different skew angles at each support, the skew angle used to compute the shear skew correction factor is determined as follows:

The smallest applicable skew angle (PennDOT skew angle designation) associated with the girder is used to calculate the shear correction factor. For AASHTO skew angle designation, the largest applicable skew angle is used. For both skew angle designations, the absolute value of the skew angle is used to select the controlling skew angle.

The shear skew correction factors are applied to only certain portions of the superstructure, depending on the bridge type.

For spread beams and NEXT beams, the shear skew correction factors are applied only when each of the following three conditions is met, as illustrated in Figure 1:

1. Applied only for exterior girders.
2. Applied only at the obtuse corners of the structure, where obtuse is defined as exceeding 90 degrees but less than 180 degrees and is measured as shown in Figure 1 from the girder towards the centerline of structure to the centerline of abutment or pier.
3. Applied only from the midspan to the support.

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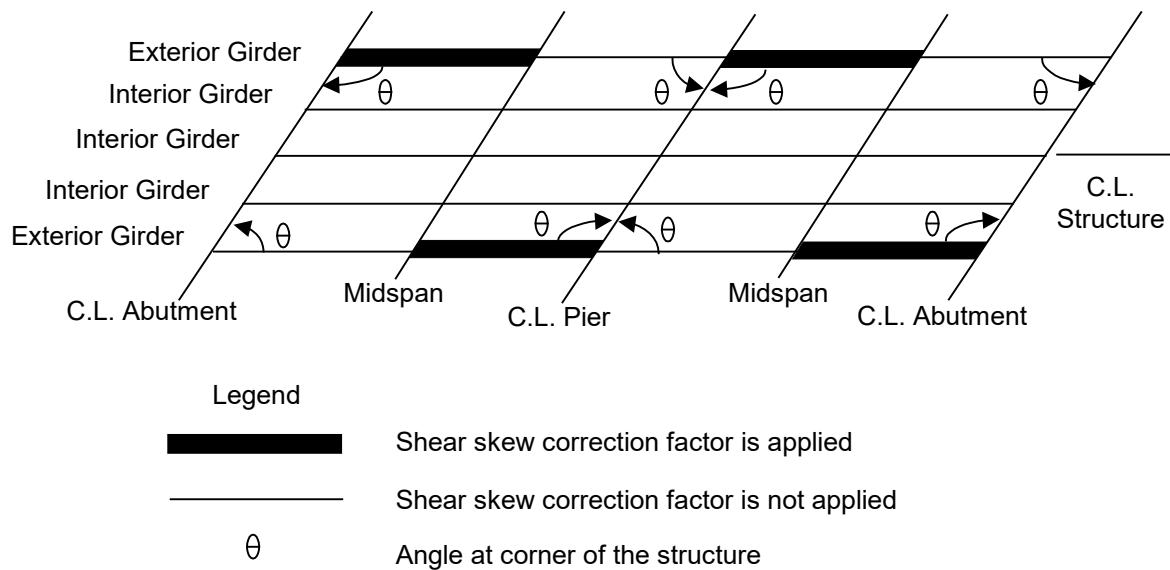


Figure 3.5-1 Application of Shear Skew Correction Factor for Spread Beams and NEXT Beams

For adjacent beams, the shear skew correction factors are applied to the full length of all beams, as illustrated in Figure 2.

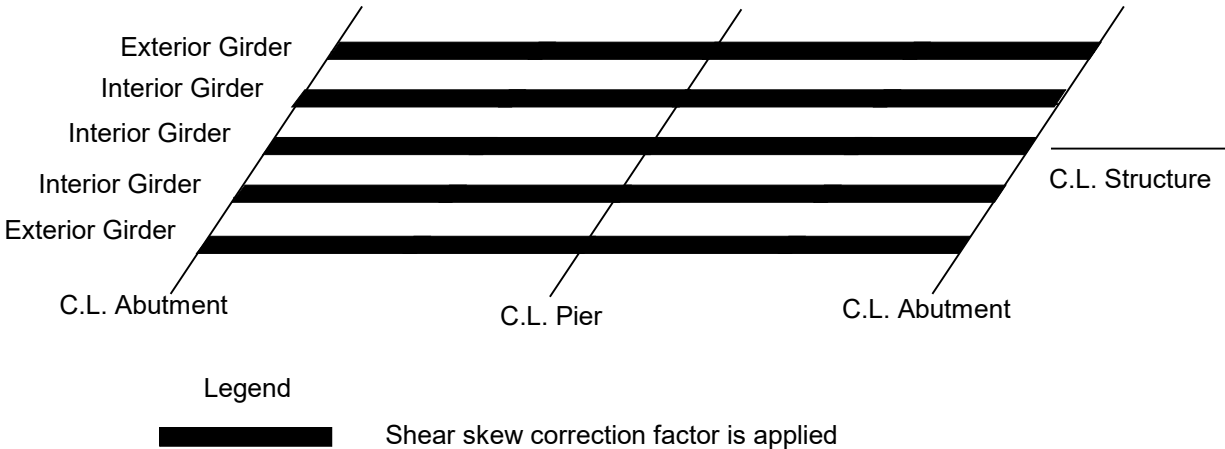


Figure 3.5-2 Application of Shear Skew Correction Factor for Adjacent Beams

3.5.2 Moment Skew Correction Factors

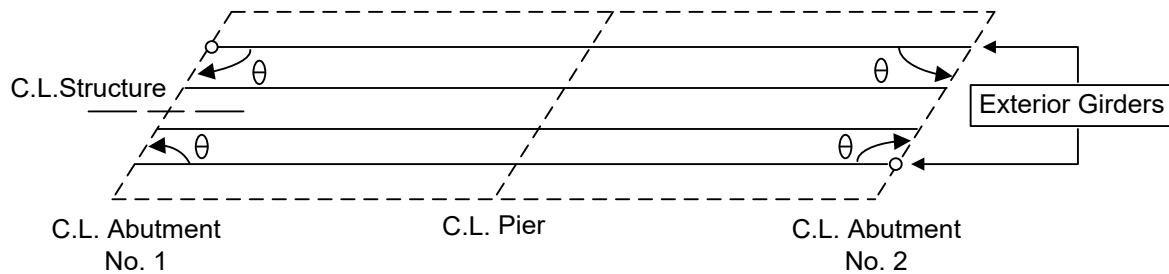
DM-4 states that PennDOT will not take advantage of the moment skew correction factor, thus the program always uses 1.0 for this value. This cannot be revised by the user.

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3.5.3 Reaction Distribution Factors and Application of Shear Skew Correction Factors

The shear skew correction factors are applied to only certain end reactions of the superstructure, depending on the bridge type. For spread beams, the shear skew correction factors are applied only when each of the following three conditions is met, as illustrated in Figure 3:

1. Applied only for exterior girders.
2. Applied only at the obtuse corners of the structure, where obtuse is defined as exceeding 90 degrees but less than 180 degrees and is measured as shown in Figure 3 from the girder towards the C.L. of the structure to the C.L. of the abutment.
3. Applied only at the simple-end reaction of the girders.

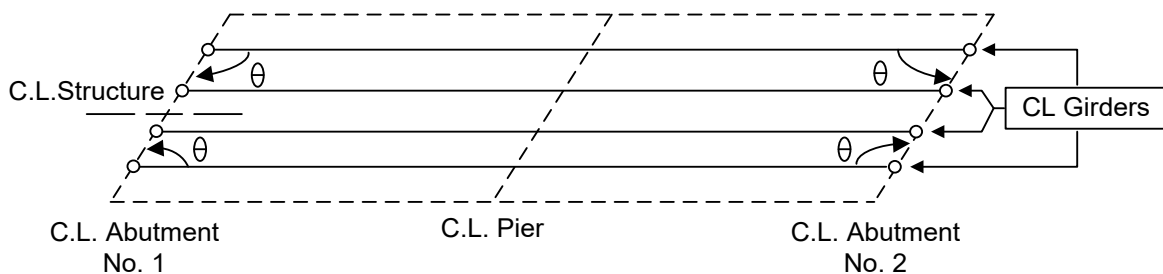


Legend

- Correction factor applied to reaction
- θ Angle at corner of the structure

Figure 3.5-3 Application of Shear Skew Correction Factor for Spread Beam Reactions

For adjacent beams, the shear skew correction factors are applied for all beams which are on a skew, as illustrated in Figure 4.



Legend

- Correction factor applied to reaction
- θ Angle at corner of the structure

Figure 3.5-4 Application of Shear Skew Correction Factor for Adjacent Beam Reactions

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For exterior supports, the program uses the distribution factor for shear adjacent to the support as the reaction distribution factor. For exterior supports the criteria for including the shear skew correction factor in the shear and reaction distribution factor is the same. This allows the exterior support reaction distribution factor to be the same as the corresponding shear distribution factor.

At the First Support:

$$\text{Reaction Distribution Factor} = DFV_1(\text{Span } 1)$$

At the Last Support:

$$\text{Reaction Distribution Factor} = DFV_2(\text{Last Span})$$

At an Interior Support:

$$\text{Reaction Distribution Factor} = DFR$$

Where: DFR = distribution factor for interior support reactions based on equations in Table D4.6.2.2.3a-1 and Table A4.6.2.2.3b-1. Section properties used in calculating the reaction distribution factors are the beam depth (d), the Moment of Intertia (I), and the Torsional Constant (J). The span length and section properties used to calculate the distribution factor are the average values of the span to the left of the support and the span to the right of the support.

3.5.4 NEXT Beam Distribution Factors

Type F NEXT Beams do not explicitly match any cross section type shown in AASHTO Table 4.6.2.2.1-1 but each Type F NEXT beam is considered as cross section type “k” defined in AASHTO Table 4.6.2.2.1-1. Type D NEXT Beams match cross section type “i” with the beams sufficiently connected to act as a unit. Both cross section type “k” and “i” sufficiently connected to act as a unit use the same AASHTO and DM-4 equations to compute distribution factors. For both Type D and Type F NEXT beams the distribution factors are computed based on two different models of the beams. The first model is a Double-Tee Cross Section with beam spacing referenced from the center of each cross section. The second model is a Single-Tee Cross Section with each tee considered a beam. The distance between tees is considered to be half of the beam spacing, which is the average of the spacing between tees, except when using the lever rule for exterior beams the actual spacing of 5 feet is used. For the Single-Tee Model the final interior distribution factor is twice the factor computed for a single tee. For the Single-Tee Model the final exterior distribution factor is the larger of twice the factor computed for the exterior single tee or the sum of the interior single tee factor plus the exterior single tee factor. The final NEXT beam distribution factor to be used is the larger

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of the single-tee model factor and the double-tee model factor. All shear distribution factors include applicable skew correction factors.

Range of Applicability failures result in CBE messages with a description of the violated variable and its current value along with the upper and lower limits on the variable. The CBE messages identify whether the messages apply to the Double-Tee model or the Single-Tee model. PSLRFD continues using the current value to compute the distribution factor.

The Distribution Factors derivations shown below are believed to be conservative, and are being recommended by PCI until AASHTO provides more specific guidance for double-tee distribution factors.

The Figures in this section are shown with Type F NEXT beams, but the same geometry applies to Type D NEXT beams.

3.5.4.1 Moment Interior Beams, Double-Tee Model

3.5.4.1.1 Design Live Load

(DM-4 Table 4.6.2.2b-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

S = Beam Spacing

ts = slab thickness, Type F

= flange thickness, Type D

L = Span Length

$K_g = n(I + A e_s^2)$

I = non-composite moment of inertia of beam, Type F

= moment of inertia of stems, Type D

A = non-composite area of beam, Type F

= area of stems, Type D

n = modulus of elasticity of beam / modulus of elasticity of deck, Type F

= 1, Type D

es = distance between centers of gravity of the basic beam and deck, Type F

= distance between centers of gravity of stems and top flange, Type D

Nb = number of beams

One Design Lane Loaded:

$$gDT_{iM}^1 = 0.06 + \left(\frac{S}{9.6}\right)^{1.0} \left(\frac{S}{L}\right)^{0.2} \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

Two or More Design Lanes Loaded:

$$gDT_{iM}^{2+} = 0.075 + \left(\frac{S}{11}\right)^{1.0} \left(\frac{S}{L}\right)^{0.08} \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

Nb = 3, Use lesser of the above or Lever Rule, gDT_{iLR}^{2+}

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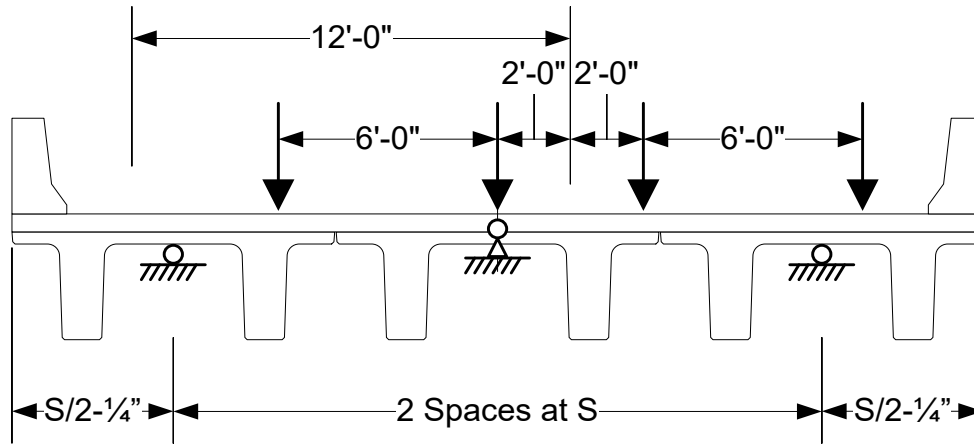


Figure 3.5-5 Notional Double-Tee Model for Applying Lever Rule

If $N_b = 3$ then $gDT_{iM} = \text{Max}[\min(gDT_{iM}^1, gDT_{iLR}^1), \min(gDT_{iM}^{2+}, gDT_{iLR}^{2+})]$

Else $gDT_{iM} = \text{max}(gDT_{iM}^1, gDT_{iM}^{2+})$ $\{N_b = 2 \text{ or } N_b \geq 4\}$

3.5.4.1.2 Fatigue Load

If $N_b = 3$ then

$$gDT_{iM}^{Fat} = \frac{\text{Min}(gDT_{iM}^1, gDT_{iLR}^1)}{1.2}$$

Else

$$gDT_{iM}^{Fat} = \frac{gDT_{iM}^1}{1.2}$$

3.5.4.2 Moment Interior Beams, Single-Tee Model

3.5.4.2.1 Design Live Load

(DM-4 Table 4.6.2.2.2b-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

S = Beam Spacing / 2

t_s = slab thickness, Type F

= flange thickness, Type D

L = Span Length

$K_g = n(I + A e_s^2)$

I = non-composite moment of inertia of beam / 2, Type F

= moment of inertia of stems / 2, Type D

A = non-composite area of beam / 2, Type F

= area of stems / 2, Type D

n = modulus of elasticity of beam / modulus of elasticity of deck, Type F

= 1, Type D

e_s = distance between centers of gravity of the basic beam and deck, Type F

= distance between centers of gravity of stems and top flange, Type D

N_b = number of beams * 2 (each beam has 2 tees)

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One Design Lane Loaded:

$$gST_{iM}^1 = 0.06 + \left(\frac{S}{9.6}\right)^{1.0} \left(\frac{S}{L}\right)^{0.2} \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

Two or More Design Lanes Loaded:

$$gST_{iM}^{2+} = 0.075 + \left(\frac{S}{11}\right)^{1.0} \left(\frac{S}{L}\right)^{0.08} \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

Nb $\neq$ 3, Lever Rule does not apply (minimum number of beams is 2 on CTL command; Nb $\geq$ 4 when each tee is counted)

Controlling:

$$gST_{iM} = 2 * \text{Max}(gST_{iM}^1, gST_{iM}^{2+})$$

3.5.4.2.2 Fatigue Load

$$gST_{iM}^{Fat} = \frac{2 * gST_{iM}^1}{1.2}$$

3.5.4.3 Controlling Interior Moment Distribution Factor

3.5.4.3.1 Design Live Load

$$g_{iM} = \text{Max}(gST_{iM}, gDT_{iM})$$

3.5.4.3.2 Fatigue Load

$$g_{iM}^{Fat} = \text{Max}(gST_{iM}^{Fat}, gDT_{iM}^{Fat})$$

3.5.4.4 Shear Interior Beams, Double-Tee Model

3.5.4.4.1 Design Live Load

(DM-4 Table 4.6.2.2.3a-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit; Note: Nb $\geq$ 3 for NEXT beams)

S = Beam Spacing

One Design Lane Loaded:

$$gDT_{iV}^1 = 0.36 + \frac{S}{25}$$

Nb = 3, Use Lever Rule, gDT_{iLR}^1

Two or More Design Lanes Loaded:

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$$gDT_{iv}^{2+} = 0.2 + \frac{S}{12} - \left(\frac{S}{35}\right)^2$$

Nb = 3, Use Lever Rule, gDT_{iLR}^{2+}

Controlling:

$$gDT_{iv} = \text{Max}(gDT_{iv}^1, gDT_{iv}^{2+})$$

3.5.4.4.2 Fatigue Load

$$gDT_{iv}^{Fat} = \frac{gDT_{iv}^1}{1.2}$$

3.5.4.5 Shear Interior Beams, Single-Tee Model

3.5.4.5.1 Design Live Load

(DM-4 Table 4.6.2.2.3a-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

S = Beam Spacing / 2

One Design Lane Loaded:

$$gST_{iv}^1 = 0.36 + \frac{S}{25}$$

Two or More Design Lanes Loaded:

$$gST_{iv}^{2+} = 0.2 + \frac{S}{12} - \left(\frac{S}{35}\right)^2$$

Controlling:

$$gST_{iv} = 2 * \text{Max}(gST_{iv}^1, gST_{iv}^{2+})$$

3.5.4.5.2 Fatigue Load

$$gST_{iv}^{Fat} = \frac{2 * gST_{iv}^1}{1.2}$$

3.5.4.6 Controlling Interior Shear Distribution Factor

3.5.4.6.1 Design Live Load

$$g_{iv} = \text{Max}(gST_{iv}, gDT_{iv})$$

3.5.4.6.2 Fatigue Load

$$g_{iv}^{Fat} = \text{Max}(gST_{iv}^{Fat}, gDT_{iv}^{Fat})$$

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3.5.4.7 Moment Exterior Beams, Double-Tee Model

3.5.4.7.1 Design Live Load

(AASHTO Table 4.6.2.2d-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

d_e = horizontal distance from the centerline of the exterior tee of exterior beam at deck level to the interior edge of curb or traffic barrier

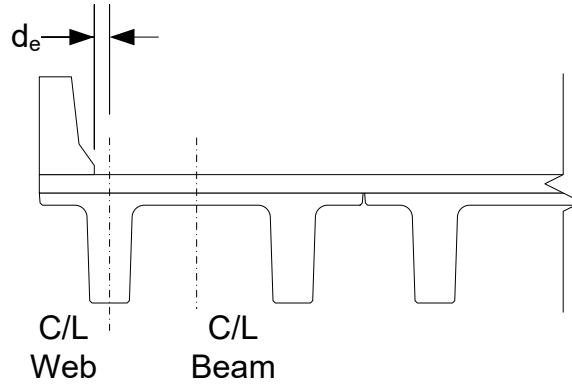


Figure 3.5-6 Distance d_e

One Design Lane Loaded:

$$gDT_{eM}^1 = \text{Lever Rule, } gDT_{eLR}^1$$

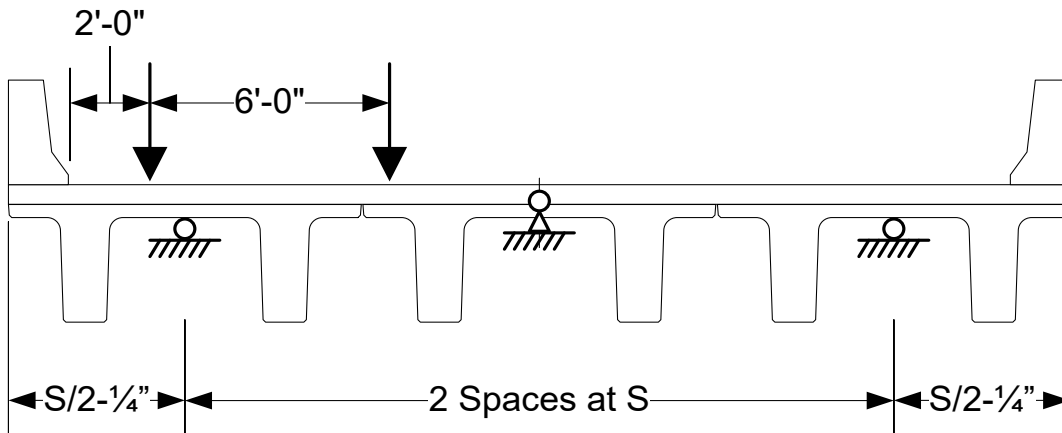


Figure 3.5-7 Notional Double-Tee Model for Applying Lever Rule to Exterior Beam (One Lane)

Two or More Design Lanes Loaded:

$$gDT_{eM}^{2+} = e gDT_{iM}$$

$$e = 0.77 + \frac{d_e}{9.1}$$

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Nb = 3, Use lesser of the above or Lever Rule, gDT_{eLR}^{2+}

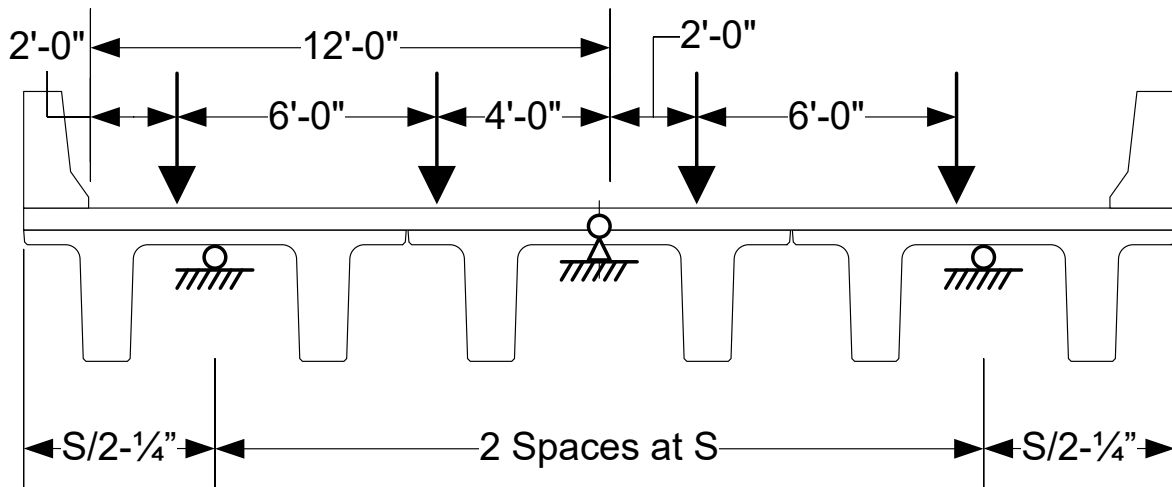


Figure 3.5-8 Notional Double-Tee Model for Applying Lever Rule to Exterior Beam (Two or more Lanes)

If Nb = 3 then $gDT_{eM} = \max[(gDT_{eLR}^1, \min(gDT_{eM}^{2+}, gDT_{eLR}^{2+})]$

Else $gDT_{eM} = \max(gDT_{eLR}^1, gDT_{eM}^{2+})$ {Nb = 2 or Nb ≥ 4}

3.5.4.7.2 Fatigue Load

$$gDT_{eM}^{Fat} = \frac{gDT_{eLR}^1}{1.2}$$

3.5.4.8 Moment Exterior Beams, Single-Tee Model

3.5.4.8.1 Design Live Load

(AASHTO Table 4.6.2.2d-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

d_e = horizontal distance from the centerline of the exterior tee of exterior beam at deck level to the interior edge of curb or traffic barrier (same definition as Double-Tee Model)

One Design Lane Loaded:

$$gST_{eM}^1 = \text{Lever Rule, } gST_{eLR}^1$$

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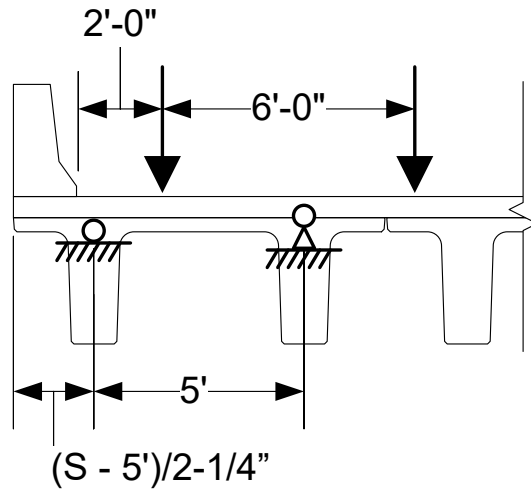


Figure 3.5-9 Notional Single-Tee Model for Applying Lever Rule to Exterior Beam (One Lane)

Two or More Design Lanes Loaded:

$$gST_{eM}^{2+} = e gST_{iM}$$

$$e = 0.77 + \frac{d_e}{9.1}$$

“Twice the single exterior tee DF, but not less than the sum of the interior tee plus the exterior tee”

$$gST_{eM} = \text{MAX}[2 * gST_{eLR}^1, 2 * gST_{eM}^{2+}, gST_{eLR}^1 + gST_{iM}^1, gST_{eM}^{2+} + gST_{iM}^{2+}]$$

3.5.4.8.2 Fatigue Load

$$gST_{eM}^{Fat} = \frac{\text{Max}(2 * gST_{eLR}^1, gST_{eLR}^1 + gST_{iM}^1)}{1.2}$$

3.5.4.9 Controlling Exterior Moment Distribution Factor

3.5.4.9.1 Design Live Load

$$g_{eM} = \text{Max}(gST_{eM}, gDT_{eM})$$

3.5.4.9.2 Fatigue Load

$$g_{eM}^{Fat} = \text{Max}(gST_{eM}^{Fat}, gDT_{eM}^{Fat})$$

3.5.4.10 Shear Exterior Beams, Double-Tee Model

3.5.4.10.1 Design Live Load

(AASHTO Table 4.6.2.2.3b-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

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One Design Lane Loaded:

$$gDT_{eV}^1 = \text{Lever Rule, } gDT_{eLR}^1 \text{ (Same as Exterior Moment)}$$

Two or More Design Lanes Loaded:

$$gDT_{eV}^{2+} = e \ gDT_{iV}$$

$$e = 0.6 + \frac{d_e}{10}$$

Nb = 3, Use Lever Rule, gDT_{eLR}^{2+}

If $Nb \geq 4$ then $gDT_{eV} = \max(gDT_{eLR}^1, gDT_{eV}^{2+})$

Else $gDT_{eV} = gDT_{eLR}^{2+}$

3.5.4.10.2 Fatigue Load

$$gDT_{eV}^{Fat} = \frac{gDT_{eLR}^1}{1.2}$$

3.5.4.11 Shear Exterior Beams, Single-Tee Model

3.5.4.11.1 Design Live Load

(AASHTO Table 4.6.2.2.3b-1 cross-section type a,e,k and i, j if sufficiently connected to act as a unit)

One Design Lane Loaded:

$$gST_{eV}^1 = \text{Lever Rule, } gST_{eLR}^1 \text{ (Same as Exterior Moment)}$$

Two or More Design Lanes Loaded:

$$gST_{eV}^{2+} = e \ gST_{iV}$$

$$e = 0.6 + \frac{d_e}{10}$$

“Twice the single exterior tee Df, but not less than the sum of the interior tee plus the exterior tee”

$$gST_{eV} = \text{MAX}[2 * gST_{eLR}^1, 2 * gST_{eV}^{2+}, gST_{eLR}^1 + gST_{iV}^1, gST_{eV}^{2+} + gST_{iV}^{2+}]$$

3.5.4.11.2 Fatigue Load

$$gST_{eV}^{Fat} = \frac{\text{Max}(2 * gST_{eLR}^1, gST_{eLR}^1 + gST_{iV}^1)}{1.2}$$

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3.5.4.12 Controlling Exterior Shear Distribution Factor

3.5.4.12.1 Design Live Load

$$g_{eV} = \text{Max}(gDT_{eV}, gST_{eV})$$

3.5.4.12.2 Fatigue Load

$$g_{eV}^{Fat} = \text{Max}(gDT_{eV}^{Fat}, gST_{eV}^{Fat})$$

3.5.4.13 Pedestrian Load

When pedestrian load has been specified, an additional set of distribution factors are computed using the variables specific to sidewalks. On the CDF command these variables are Distance to Outermost Wheel with Sidewalks and Centerline Exterior Beam to Curb with Sidewalks. On the GEO command the corresponding variable is Number of Design Lanes with Sidewalks. The procedure for computing the distribution factors with sidewalks is the same as the procedure for the design live load. The variable names include a "P" to distinguish the "with Sidewalk" distribution factors from the design live load distribution factors without sidewalk.

3.5.5 Composite and Non-Composite Adjacent Beam Distribution Factors

Composite adjacent beams include both adjacent plank beams and adjacent box beams with a composite concrete slab. Composite adjacent beams are considered as cross section type "f" (shown in Figure 10) as defined in AASHTO Table 4.6.2.2.1-1 for the purpose of computing distribution factors. (Note: Transverse post-tensioning is required by BD-651M but is not shown in this distribution factor figure.)

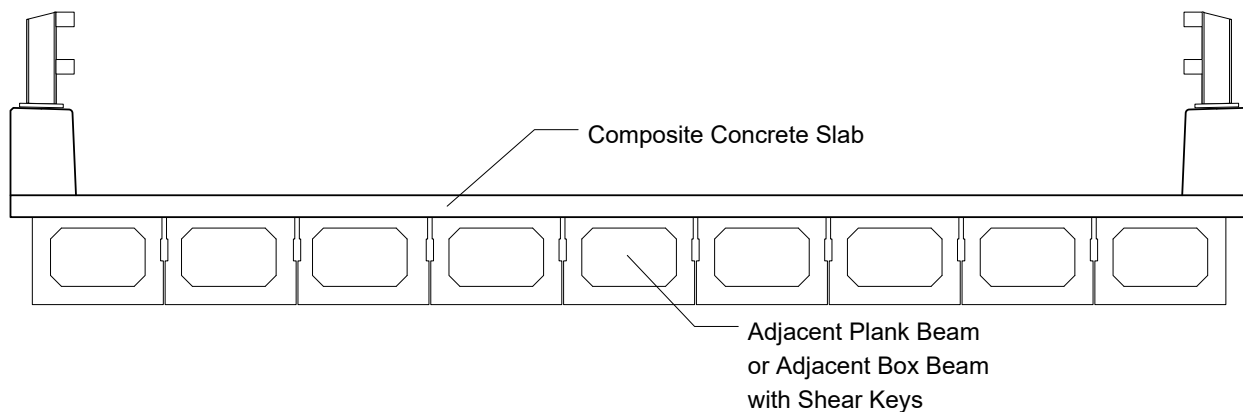


Figure 3.5-10 AASHTO Distribution Factor Cross Section Type "f"

Non-composite adjacent beams include both adjacent plank beams and adjacent box beams without a composite deck slab. (Note: Strike-Off-Letter 431-06-01 placed a moratorium on the construction of new bridges of this type.) Non-composite adjacent beams are considered as cross section type "g" (shown in Figure 11) as defined in AASHTO Table 4.6.2.2.1-1. For the purpose of computing distribution factors the

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cross section type is further defined to be connected only enough to prevent relative vertical displacement at the interface and not assumed to be sufficiently connected to act as a unit.

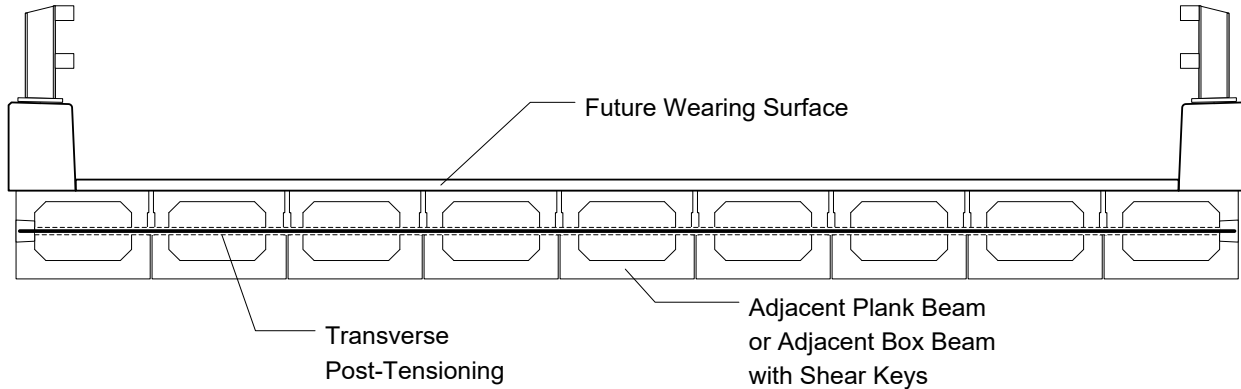


Figure 3.5-11 AASHTO Distribution Factor Cross Section Type "g"

3.5.5.1 Moment Interior Composite Adjacent Beams

The following equations are used to compute the distribution factor for moment for interior composite adjacent box beams and adjacent plank beams.

Design Live Load

One Design Lane Loaded:

$$g_{iM}^1 = k \left(\frac{b}{33.3L} \right)^{0.5} \left(\frac{l}{j} \right)^{0.25} \quad \text{If } L > 120', \text{ Use } L = 120'$$

Two of More Design Lanes Loaded:

$$g_{iM}^{2+} = k \left(\frac{b}{305} \right)^{0.6} \left(\frac{b}{12.0L} \right)^{0.2} \left(\frac{l}{j} \right)^{0.06} \left(\frac{2.4}{L^{0.15}} \right)^{\frac{N_b}{15}} \quad \text{If } N_b > 12, \text{ Use } N_b = 12$$

where: $k = 2.5(N_b)^{-0.2} \geq 1.5$

Controlling:

$$g_{iM} = \text{Max}(g_{iM}^1, g_{iM}^{2+})$$

Fatigue Load

$$g_{iM}^{Fat} = \frac{g_{iM}^1}{1.2}$$

3.5.5.2 Moment Interior Non-Composite Adjacent Beams

The following equations are used to compute the distribution factor for moment for interior non-composite adjacent box beams and adjacent plank beams.

Design Live Load

Regardless of Number of Loaded Lanes:

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$$g_{iM} = S/D$$

where:

$$C = K(W/L) \leq K$$

$$D = 11.5 - N_L + 1.4N_L(1 - 0.2C)^2 \text{ when } C \leq 5$$

$$D = 11.5 - N_L \text{ when } C > 5$$

$$K = \sqrt{\frac{(1 + \mu)I}{J}}$$

Fatigue Load

$$g_{iM}^{Fat} = g_{iM}$$

3.5.5.3 Moment Exterior Composite and Non-Composite Adjacent Beams

The following equations are used to compute the distribution factor for moment for exterior composite and non-composite adjacent box beams and adjacent plank beams.

Design Live Load

One Design Lane Loaded:

$$g_{eM}^1 = e \times g_{iM}^1 \quad (\text{composite})$$

$$g_{eM}^1 = e \times g_{iM} \quad (\text{non-composite})$$

$$e = 1.125 + \frac{d_e}{30} \geq 1.0$$

Two of More Design Lanes Loaded:

$$g_{eM}^{2+} = e \times g_{iM}^{2+} \quad (\text{composite})$$

$$g_{eM}^{2+} = e \times g_{iM} \quad (\text{non-composite})$$

$$e = 1.04 + \frac{d_e}{25} \geq 1.0$$

Controlling:

$$g_{eM} = \text{Max}(g_{eM}^1, g_{eM}^{2+})$$

Fatigue Load

$$g_{eM}^{Fat} = \frac{g_{eM}^1}{1.2} \quad (\text{composite})$$

$$g_{eM}^{Fat} = g_{eM}^1 \quad (\text{non-composite})$$

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3.5.5.4 Shear Interior Composite and Non-Composite Adjacent Beams

The following equations are used to compute the distribution factor for shear for interior composite and non-composite adjacent box beams and adjacent plank beams.

Design Live Load

One Design Lane Loaded:

$$g_{iv}^1 = \left(\frac{b}{130L}\right)^{0.15} \left(\frac{I}{J}\right)^{0.05}$$

Two of More Design Lanes Loaded:

$$g_{iv}^{2+} = \left(\frac{b}{156}\right)^{0.4} \left(\frac{b}{12L}\right)^{0.1} \left(\frac{I}{J}\right)^{0.05}$$

Controlling:

$$g_{iv} = \text{Max}(g_{iv}^1, g_{iv}^{2+})$$

Fatigue Load

$$g_{iv}^{Fat} = \frac{g_{iv}^1}{1.2}$$

3.5.5.5 Shear Exterior Composite and Non-Composite Adjacent Beams

The following equations are used to compute the distribution factor for shear for exterior composite and non-composite adjacent box beams and adjacent plank beams.

Design Live Load

One Design Lane Loaded:

$$g_{ev}^1 = e \times g_{iv}^1$$

$$e = 1.25 + \frac{d_e}{20} \geq 1.0$$

Two of More Design Lanes Loaded:

$$g_{ev}^{2+} = e \times g_{iv}^{2+} \left(\frac{48}{b}\right)$$

$$\frac{48}{b} \leq 1.0$$

$$e = 1 + \left(\frac{d_e + \frac{b}{12} - 2.0}{40}\right)^{0.5} \geq 1.0$$

Controlling:

$$g_{ev} = \text{Max}(g_{ev}^1, g_{ev}^{2+})$$

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Fatigue Load

$$g_{ev}^{Fat} = \frac{g_{ev}^1}{1.2}$$

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3.6 LOADS

3.6.1 Dead Loads

Loads used by the program include girder weight, slab and haunch weight, interior diaphragm weight, exterior diaphragm weight, non-composite and composite counterweight load, additional DC1 weight, additional DC2 weight, miscellaneous non-composite dead load weight, miscellaneous composite dead load weight, utility loads and future wearing surface weight.

Permanent loads consist of the dead load of structural components and nonstructural attachments (DC), Utility loads and the dead load of future wearing surfaces (FWS). The DC loads consist of the DC1 loads applied to the non-composite section properties and the DC2 loads applied to the composite section properties. The FWS loads are also applied to the composite section properties but have different load factors than the DC2 loads, as specified in the LRFD Specifications. The Utility loads consist of the UT1 loads applied to the non-composite section properties and the UT2 loads applied to the composite section properties. The Utility loads have the same load factors as FWS loads. Utility loads are separated from FWS to allow rating to be computed with and without FWS.

DC1 loads automatically computed by the program include the self-weight of the prestressed concrete girder, the concrete haunch, and the concrete deck. The user must input all other DC1 loads due to other components (such as, the end block weight for box beams) using the DIA, CLD, and DLD commands.

See Figure 1 for a typical deck cross-section (with I-beams) and haunch detail. When computing dead loads, the program uses the actual slab thickness for t_s ; when computing section properties, the program uses the effective slab thickness for t_s .

For exterior girders, the DC1 load due to the concrete slab is:

$$DC1_{slab} = \left(S_{ext} + \frac{S_{int}}{2} \right) (t_s) (\text{Concrete Density})$$

For interior girders, the DC1 load due to the concrete slab is:

$$DC1_{slab} = (S_{int})(t_s)(\text{Concrete Density})$$

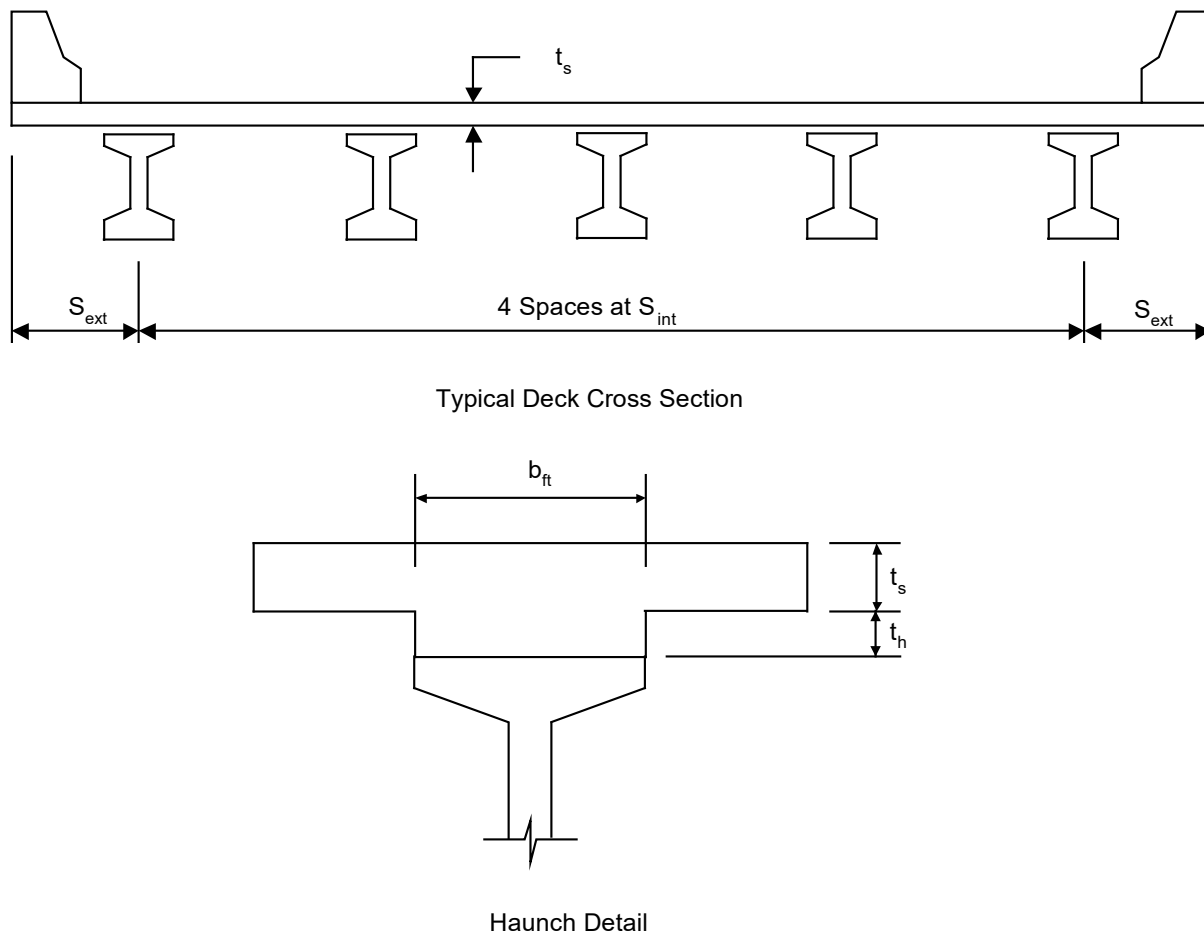


Figure 3.6-1 Typical Section and Haunch

For both the interior and exterior girder, the DC1 load due to the haunch is:

$$DC1_{haunch} = (b_{ft})(t_h)(Concrete\ Density)$$

The DC2 loads, such as parapets, are not computed by the program and must be input by the user. The DC2 input should include the loads that are applied to the composite section. Parapet loads should be distributed according to DM-4 Article 3.5.1.1P. The DC1 and DC2 loads are multiplied by the same DC load factor. The FWS load consists of the future wearing surface, which should be distributed equally to all girders and is applied to the composite section. This load must also be input by the user. The FWS loads are multiplied by the DW load factors, which are different from the DC load factors.

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The user can also input two types of utility loads – UT1 and UT2. The non-composite utility load (UT1) is applied to the basic beam. The composite utility load (UT2) is applied to the composite beam. The utility loads are multiplied by the DW load factors. The utility loads are separated from the FWS loads to allow rating to be computed for both with FWS and without FWS.

In addition to the DC1, DC2, UT1, UT2, and FWS loads, the user can also input two miscellaneous load types - MC1 and MC2. The miscellaneous non-composite load (MC1) is applied to the basic beam, and the miscellaneous permanent composite load (MC2) is applied to the composite beam. For the miscellaneous load types (MC1 and MC2), the user must input the load factors, which are to be used for each load combination and each miscellaneous load type.

The program computes a separate table of moment, shear, and deflection results and a separate table of reactions for each of the following dead load cases:

1. Girder weight
2. Slab and haunch weight
3. Interior diaphragm weight
4. Exterior diaphragm weight
5. Additional DC1 weight
6. Non-Comp. Counter-Wt weight
7. Misc. Noncomp. weight
8. Non-Comp. Utility Load weight
9. DC2 weight
10. Comp. Counter-Wt weight
11. Future wearing surf weight
12. Misc. Composite weight
13. Comp. Utility Load weight

3.6.1.1 Bearing Reactions

If the continuous analysis with simple span check option is selected, non-composite dead loads are applied to the beams acting as simple spans. Composite dead loads are applied to both the beams acting as continuous spans and the beams acting as simple spans, and the maximum result is used. For non-composite dead loads, the application of a user-input distributed load across more than one span would be placed as shown in Figure 2. By doing this, a section of load between the centerline of bearings at the piers is not applied to the structure in the usual manner. The program computes this load between the centerline of bearings and applies it as concentrated loads at the centerline of bearings.

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The program applies the non-composite load as a reaction to the bearing corresponding to the span in which the load is located. For the example shown in Figure 3, the program applies load P as a concentrated load acting entirely at Support 2.

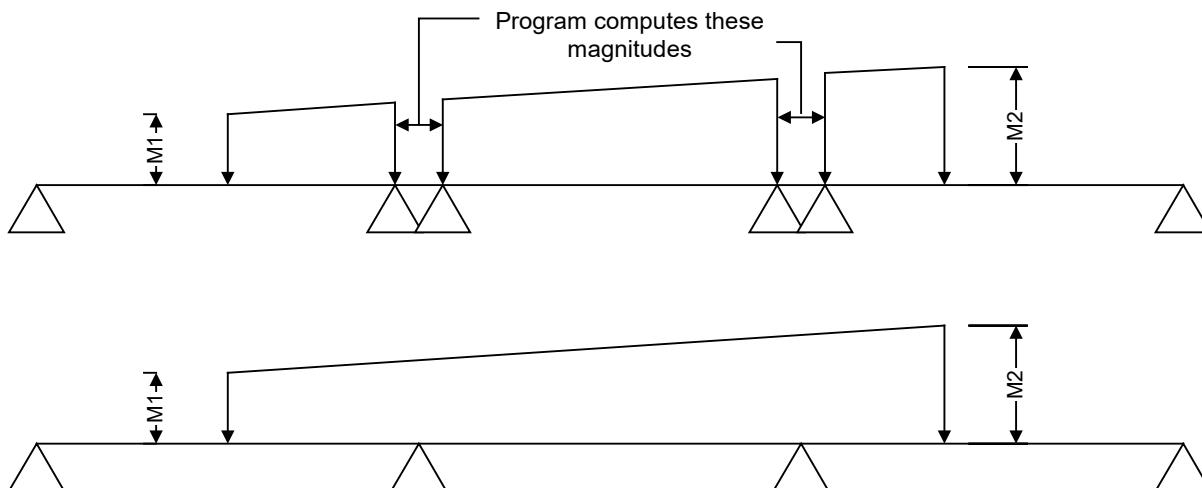


Figure 3.6-2 Distributed Non-composite Dead Load at Piers

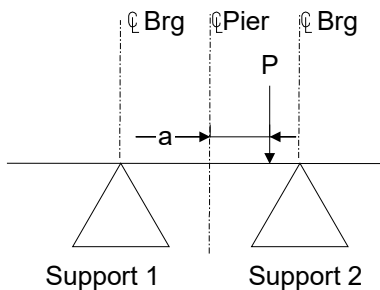


Figure 3.6-3 Distribution of Concentrated Non-composite Dead Load at Piers

For the example shown in Figure 4, the program applies the distributed load located between Support 1 and the centerline of the pier as a concentrated load acting entirely at Support 1. The program applies the distributed load located between the centerline of the pier and Support 2 as a concentrated load acting entirely at Support 2.

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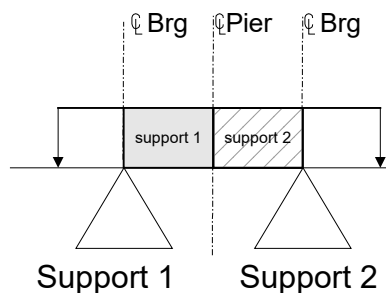


Figure 3.6-4 Distribution of Distributed Non-composite Dead Load at Piers

3.6.1.2 Bearing Reactions

If the program encounters an uplift condition at any support for the Service-I Minimum limit state a counterweight load can be utilized to counteract the uplift. The required counterweight force is equal to the Strength-I Minimum limit state reaction at the support where uplift is detected.

3.6.2 Live Loads

In addition to the dead loads previously described, the user has several live load options for performing an analysis or design. The available live load designations are:

PHL-93	- PennDOT LRFD live loading
HL-93	- AASHTO LRFD live loading
P-82	- PennDOT permit live loading
ML-80	- PennDOT maximum legal live loading
TK527	- PennDOT new legal live loading
HS20	- AASHTO HS20 live loading
H20	- AASHTO H20 live loading
SLL #i	- User-defined special live loading
P-82C	- P-82 load in one lane with PHL-93 in other lanes
EV2	- PennDOT single rear axle emergency vehicle
EV3	- PennDOT tandem rear axle emergency vehicle
SU6TV	- PennDOT heavy-duty tow and recovery vehicle
P2016-13	- PennDOT 13 axle permit design vehicle
P2016-13C	- P2016-13 in one lane with PHL-93 in other lanes

The HL-93 loading is the vehicular live load consisting of the Design Truck, Design Tandem, and Design Lane Load as defined in the LRFD Specifications.

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The PHL-93 loading is the same as the HL-93 loading except that the axle loads on the Design Tandem for the PHL-93 loading are multiplied by a factor of 1.25. In addition, for negative moment between points of dead load contraflexure, the factor for the effect of two Design Trucks combined with the Design Lane Load is 100% for the PHL-93 loading and 90% for the HL-93 loading. The 1.25 factor is not applied to the Design Tandem Pair for the PHL-93 loading.

The PennDOT maximum legal live loading (ML-80) is the maximum legal truck allowed in Pennsylvania prior to Strike-Off-Letter 431-01-15. The new PennDOT legal load (TK527) controlled by the FHWA-approved Bridge Formula for the Interstate System.

The PennDOT Design Permit Vehicle (P-82) is a 102 tons, 8-axle notional load used to check Strength II, Service IIIA, and Service IIIB limit states.

The PennDOT Design Permit Vehicle (P2016-13) is a 165 tons, 13-axle non-notional load used to check Strength II, Service IIIA, and Service IIIB limit states.

The EV2, EV3, and SU6TV vehicles are load rating vehicles from FHWA's memo, "Load Rating for the FAST Act's Emergency Vehicles", dated November 3, 2016.

The AASHTO HS20 live loading and AASHTO H20 live loading are in accordance with the AASHTO Standard Specifications for Highway Bridges.

For each special live loading (SLL #i), the user can input the axle loads, the axle spacings, uniform lane loading, and the corresponding load factors for each limit state. This can be used to analyze permit loads or to analyze more than one truck unit on the structure. Each special live load may have up to a maximum of 80 axles.

The axle loads and axle spacings for the HL-93 and PHL-93 design truck, HL-93 design tandem, PHL-93 design tandem, HL-93 and PHL-93 design tandem pair, ML-80 rating truck, and TK527 rating truck are presented in Figure 2.5-1. The P-82 permit truck, HS20 truck, H20 truck, and HS20 and H20 lane loading are presented in Figure 2.5-2.

For the ML-80 live loading, the TK527 live loading, and the P-82 live loading, only one truck unit is considered longitudinally on the structure. In calculating the effect of a design truck, design tandem, fatigue load, design truck pair, or design tandem pair for the LRFD loading, only the axle loads which contribute to the effect being sought are considered.

The P-82C and P2016-13C live loadings are a combination of the P-82 (or P2016-13) live loading in one lane with PHL-93 live loading in the other lanes as defined in DM-4 by equation 3.4.1-3P as follows:

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$$FR_T = FR_{DPV} \left(\frac{g_1}{Z} \right) + FR_{PHL-93} \left(g - \frac{g_1}{Z} \right)$$

where:

FR_T	=	total force response, moment or shear
FR_{DPV}	=	Design Permit Vehicle (P-82 or P2016-13) force response, moment or shear
FR_{PHL-93}	=	PHL-93 force response, moment or shear
g_1	=	single lane distribution factor, moment or shear
g	=	multi-lane distribution factor, moment or shear
Z	=	a factor taken as 1.20 where the lever rule was not utilized and 1.0 where the lever rule was used for a single lane live load distribution factor

FR_T need not be taken greater than $FR_{DPV}(g)$.

The “Z” factor is taken as 1.20 or 1.0 and is used to remove the multiple presence factor when the approximate equations are used to compute distribution factors for a single lane. In PSLRFD, single and multiple lane distribution factors are calculated specifically or user input for the P-82C or P2016-13C combinations, and are denoted as $g_{DPVC,single}$ and $g_{DPVC,multi}$. When computing $g_{DPVC,single}$ the multiple presence factor of 1.2 is not include.

The equation can be rewritten using the DPVC distribution factors and other program-output values as follows:

$$FR_T = FR_{DPV} + FR_{PHL-93} \left(\frac{g_{DPVC,multi} - g_{DPVC,single}}{g} \right) \leq FR_{DPV} \left(\frac{g}{g_{DPVC,single}} \right)$$

where:

FR_T	=	total force response, moment or shear
FR_{DPV}	=	Design Permit Vehicle (P-82 or P2016-13) force response, moment or shear (note that the program output for the P-82 or P2016-13 force response is multiplied by $g_{DPVC,single}$)
FR_{PHL-93}	=	PHL-93 force response, moment or shear (note that the program output for PHL-93 force response is multiplied by g)
$g_{DPVC,single}$	=	single lane distribution factor for the Design Permit Vehicle Combination, moment or shear, calculated subject to the restrictions of AASHTO Article 4.6.2.2.5.

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$g_{DPVC, multi}$ = multi-lane distribution factor for the Design Permit Vehicle Combination, moment or shear, calculated subject to the restrictions of AASHTO Article 4.6.2.2.5.

g = multi-lane distribution factor, moment or shear, calculated without the restrictions of AASHTO Article 4.6.2.2.5.

This combination loading may be used for the rating of existing bridges with the Strength II and Service IIIA Limit States.

AASHTO LRFD equation 4.6.2.2.5-1 provides the same equations with different nomenclature and provides restrictions on the application of the equation. The following restrictions are applied by the program:

- The equation is not allowed when both the multi-lane and the single lane distribution factors are computed using the lever rule. If both $g_{PDVC, single}$ and $g_{PDVC, multi}$ are governed by the lever rule, the program will stop with an error.
- The equation is not allowed when the bridge has only a single design lane. If the P-82C or P2016-13C load combination is specified for a single lane bridge, the program will stop with an error.

For roadway widths varying from 18 to 24 feet, the program uses two design lanes, each equal to one-half the roadway width. For all other roadway widths, the program determines the number of design lanes and the design lane width in accordance with LRFD Specifications Article 3.6.1.1.1.

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3.7 STRUCTURAL ANALYSIS

The program uses the routines of the PennDOT Continuous Beam Analysis (CBA) program to compute the moments, shears, reactions, rotations, and deflections for the permanent loads and transient loads at each analysis point defined in Section 3.3. For analysis, the user-input beam sections are used. For design, the analysis program iterates the beam section dimensions until the LRFD Specifications and DM-4 Specifications, including live load deflections, are satisfied and an optimal design is obtained. Permanent loads are dead loads of structural components and nonstructural attachments (DC), Utility loads, and dead loads of future wearing surfaces (FWS). DC loads applied to the non-composite section are referred to as DC1 loads, and DC loads applied to the composite section are referred to as DC2 loads. In addition, miscellaneous loads, which act on the non-composite section, are referred to as MC1 loads, and miscellaneous loads, which act on the composite section, are referred to as MC2 loads. Utility loads applied to the non-composite section are referred to as UT1 loads, and Utility loads applied to the composite section are referred to as UT2 loads. Transient loads consist of the vehicular live load (LL), the vehicular dynamic load allowance (IM), and the pedestrian load (PL).

The program calculates the results at each analysis point for the following loads:

1. Self-weight of the prestressed concrete girder.
2. Concrete slab and haunch dead loads.
3. User-input non-composite interior diaphragm dead loads.
4. User-input non-composite exterior diaphragm dead loads.
5. User-input non-composite additional DC1 dead loads.
6. User-input non-composite miscellaneous MC1 dead loads.
7. User-input non-composite Utility loads.
8. User-input composite additional DC2 dead loads.
9. User-input composite future wearing surface FWS dead loads.
10. User-input composite miscellaneous MC2 dead loads.
11. User-input composite Utility loads.
12. Each live loading.

CBA analyzes the girder for a given loading condition and calculates the load effects at various analysis points. CBA uses the Modified Flexibility Method for the solution of the unknown reactions for a given loading condition.

3.7.1 Modified Flexibility Method

CBA begins by dividing each span into twenty segments and setting up an analysis point at the end of each segment. For multi-span girders made continuous for live load, the span ends are defined as the centerline of bearing for the exterior supports (abutments) and the centerline of piers for the interior supports (piers), and an additional analysis point is defined at the midspan of the simple span. The unknowns in the solution

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of a continuous beam are assumed to be the reactions at support points. The following conditions give a set of simultaneous equations for the solution of unknown reactions. The first condition is that the sum of reactions must be equal to the sum of applied loads. The second condition is that the sum of moments due to reactions must be equal to the sum of moments due to applied loads at the right most support. The remaining conditions (if the beam is statically indeterminate) are that the deflection at each support due to applied loads is zero. The formulation of these equations and their solution by matrix algebra is the essence of the Modified Flexibility Method. The deflections and rotations are by-products of this process.

A typical loading condition is a unit load applied at an analysis point. The effects (such as reaction, rotation, deflection, etc.) are then calculated at all analysis points for this loading condition. Applying this unit load at each analysis point in succession and then calculating the effects at all analysis points produces the ordinates of an influence line for a given effect. CBA generates and stores the influence lines for support reactions, support rotations, and the deflections at analysis points. The influence lines for moments and shears at analysis points are generated from the reaction influence lines when needed for analysis of a given loading.

3.7.2 Dead Load Analysis

The dead load effect at a given analysis point is calculated by placing the loads on the appropriate influence line and then adding the effect of each load as follows. If the dead load is a series of concentrated loads, the effect is the algebraic sum of the product of the load value and the influence line ordinate value under each concentrated load. If the dead load is a uniform load, the effect is the product of the area of the influence line under the load and the intensity of the uniform load. If the dead load is trapezoidal, the effect is the summation of A_i times P_i over the length of the trapezoid, where A_i is the area of influence line between two consecutive load intensities, P_i is the average of two consecutive load intensities, and i is the segment number of the trapezoidal load. The trapezoidal load is divided into the segments that correspond to the influence line ordinates.

3.7.3 Multi-span Analysis Options

The program provides two options for the analysis of multi-span structures. One option considers multi-span structures to be continuously supported for composite dead loads and live loads. The other option analyzes the structures as both continuously supported and simply supported for composite dead loads and live loads. The effects of both the continuous and simple analyses are considered with the maximum from either analysis being used for further analysis and design. The purpose of the second analysis option is to account for the condition where the true fixity at each interior support is somewhere between simply supported and fully continuously supported. This analysis option is referred to as the continuous analysis with simple span check option by the program.

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When the continuous analysis with simple span check option is used several other changes are made in the analysis and design as follows:

Distribution Factors – One set of distribution factors, based on the simple span lengths, is used for both the simply supported analysis and the continuously supported analysis. For the moment distribution factor, this results in only one value for each span rather than one value for positive moments and another value for negative moments.

Section Properties – One set of section properties, based on the effective span length defined as the simple span lengths for each span, is used for both the simply supported analysis and the continuously supported analysis.

Creep and Shrinkage – The effects of creep and shrinkage are not considered for the continuous analysis with simple span check analysis option. Therefore, creep and shrinkage loads and moments are not computed and not included in the program output.

Positive Moment Connection – The required area of steel for the positive moment connection at each interior support is not computed for the continuous analysis with simple span check analysis option.

Ultimate Moment Check – Locations from the end of the beam to the end of the transfer length are excluded when searching for the maximum strength moment in the span. For very odd span arrangements (i.e. 31 ft – 80 ft – 130 ft) the maximum positive strength moment can occur at the interior support.

Analysis Output Tables – Output tables for composite dead loads and live loads identify which analysis (simple supports or continuous supports) produced the reported value. Only output tables that are reporting a single load type have the identification. The output table reporting the total composite dead load does not include the identifications since the total could be a summation of effects from both simple and continuous analysis.

3.7.4 Creep and Shrinkage Analysis

The effects of creep and shrinkage on a continuous beam are calculated by entering the fixed end actions due to these conditions. The program calculates the moments and reactions generated at each end of the span due to creep and shrinkage assuming one (for end spans) or both (for interior spans) ends of the span being fixed. The program converts these fixed end actions into equivalent joint loads acting at each support. At a given support, the equivalent joint moment is the moment required to balance the algebraic sum of the entered fixed end moments at that support.

The effects of equivalent joint loads are then calculated in the same manner as explained in the section entitled "Modified Flexibility Method", except that the equivalent joint moments are treated as concentrated couples acting on the beam. The following conditions are used to set up the simultaneous equations for

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the solution of the unknown reactions. The first condition is that the sum of reactions must be equal to the sum of equivalent vertical joint loads. The second condition is that the sum of moments due to reactions at the right most support must be equal to the sum of moments due to equivalent joint loads applied to the beam. The remaining conditions (if the beam is statically indeterminate) are that the deflection at each support is equal to zero. The equations are formulated according to the above conditions and then are solved by matrix algebra to determine the unknown reactions at supports. The moments, shears, deflections, and rotations at analysis points are then computed in the same manner as the unit load condition except that the fixed end actions are added to get the final actions.

The creep and shrinkage analysis is not performed if the continuous analysis with simple span check option is selected.

If the “Shrinkage Only Analysis” parameter of the CTL Command is entered as ‘Y’, the creep analysis is not performed. This feature may be used for a redecking analysis.

3.7.5 HL-93 Loading and PHL-93 Loading

For the purpose of this program, the vehicular live load consisting of the Design Truck, Design Tandem, and Design Lane Load, as defined in the LRFD Specifications, is referred to as the HL-93 loading. For the design of its bridges, PennDOT has modified the HL-93 loading, and it is referred to as the PHL-93 loading. Refer to Figures 2.5-1 and 2.5-2 for a summary of the live loads that are stored in the program. The PHL-93 loading is the same as the HL-93 loading except that the axle loads on the Design Tandem for the PHL-93 loading are multiplied by a factor of 1.25. The Design Tandem Pair is the same for the HL-93 and PHL-93 loading since the 1.25 factor is not applied to the PHL-93 Design Tandem Pair. H20 and HS20 loadings are as defined in the current AASHTO Standard Specifications for Highway Bridges. Refer to Table 1 for load combinations that are used to calculate various effects due to HL-93 and PHL-93 loadings.

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Table 3.7-1 Live Load Effects due to HL-93 and PHL-93 Loadings

Effects	Loading	Tandem + Lane	Truck + Lane	Tandem Pair + Lane	Truck Pair + Lane	Truck Alone	25% Truck + Lane
Mom +	HL-93	X	X			X	
	PHL-93	X ¹	X			X	
Mom -	HL-93			X	0.90X	X	
	PHL-93			X ¹	X	X	
End React +	HL-93	X	X			X	
	PHL-93	X ¹	X			X	
End React -	HL-93	X	X			X	
	PHL-93	X ¹	X			X	
Pier React +	HL-93			X	0.90X	X	
	PHL-93			X ¹	0.90X	X	
Pier React -	HL-93	X	X			X	
	PHL-93	X ¹	X			X	
Deflection	HL-93					X	X
	PHL-93					X	1.25X

¹ The axle loads for Design Tandem and Design Tandem Pair for PHL-93 loading are different as shown in Figure 2.5-1.

3.7.6 Truck Load Effect

The effect of a truck load is calculated by placing the load at various locations on the influence line. For this, the influence line is divided into regions of positive and negative ordinates. For each region, the location of the maximum (peak) ordinate is found. If the influence line has more than two regions, the locations of the two largest positive and the two largest negative (if they exist) peaks are stored. For each peak of the influence line, the first axle of the truck is placed over the peak and other axles that follow are placed in their respective positions. The effect of this load position is computed by multiplying the axle load with the influence line ordinate under the load.

For axle loads that fall between two known influence line ordinates, the influence line ordinate under the load is computed by straight-line interpolation. The sum of the product of the axle load and influence line ordinate represents the effect of the load in that position. The effect is stored, and the load is moved such that now the second axle is placed over the peak. The effect of this load position is computed again, and it is compared with the previously stored effect. The greater of the two effects is stored again. This procedure is repeated until the last axle is placed over the peak. Next, the load is placed such that the center of gravity of the load is over the peak. This effect is calculated and saved if it is greater than the previously stored effect. The above procedure is repeated for each saved peak. The load is then reversed and the same procedure is repeated. When this process is completed, the absolute maximum positive and the absolute maximum negative truck load effects are obtained.

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In calculating the effect of a Design Truck, Design Tandem, Fatigue Load, Design Truck Pair, or Design Tandem Pair for LRFD loadings, the axle loads, which do not contribute to the effect being sought, are neglected. That is, for a positive effect, the axles that fall on the negative region of the influence line are neglected, and for a negative effect, the axles that fall on the positive region of the influence line are neglected.

3.7.7 Variable Axle Spacing of Design Truck

The LRFD Specifications require that in calculating the effect of the design truck, the spacing between the two 32 kip axles (rear axles) may vary from 14 to 30 feet. A schematic drawing showing the variable axle spacing of the LRFD design truck is presented at the top of Figure 2.5-1.

To compute the effect of the design truck, the program starts with a design truck with 14 feet between the rear axles, and analyzes the influence line as explained in the section entitled "Truck Load Effect." The effect of the design truck so defined is stored. Next, a new design truck is defined by adding 0.5 feet to the spacing between the rear axles. The effect of this new design truck is calculated again. The effect of the new design truck is compared with the previously stored effect, and the greater effect is stored. The above procedure is repeated until the spacing between the rear axles becomes 30 feet. The spacing between the rear axles is not varied if the lengths of the influence line regions adjacent to the region where the design truck is placed are greater than 30 feet.

3.7.8 Variable Spacing of Truck or Tandem Pair

The LRFD Specifications require that in calculating the negative moment at any section between the point of dead load contraflexure and the interior support, and in calculating the reaction at the interior support, the spacing between the two trucks of the design truck pair may vary from 50 feet to any distance that will produce the maximum effect. For this, the program replaces the truck pair with a single truck of six axles. The first three and the last three axles of this single truck are the same as the axles of the design truck. Initially the distance between the third axle and the fourth axle is set equal to 50 feet. The influence line is analyzed for so defined single truck as explained in the section entitled "Truck Load Effect." The effect of this load is stored. Next, the single truck is modified by increasing the distance between the third axle and the fourth axle by 0.5 feet, and its effect is calculated. The above procedure is repeated until the distance between the third axle and the fourth axle of the single truck becomes larger than the distance between two consecutive peak ordinates having the same sign. The spacing between the third axle and the fourth axle is not varied if the distance between two consecutive peak ordinates having the same sign is less than 50 feet or if the effect being sought is a reaction at the interior support. The design tandem pair is analyzed in the same manner as the design truck pair. The single truck defined to represent a design tandem pair has four axles and the distance between the second and the third axle is varied from 26 to 40 feet.

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3.7.9 Lane Load Effect

The effect of a lane load is calculated by loading the appropriate regions of the influence line with the uniform lane load. If the positive lane load effect is being sought, the sum of the positive areas of the influence line is multiplied by the value of the uniform lane load, and the result is stored as the positive lane load effect. The negative lane load effect is calculated similarly using the negative areas of the influence line. In calculating the lane load effect, the load is placed only over the positive or negative areas of the influence line.

3.7.10 Positive Moments, Shears, and End Reactions due to HL-93 or PHL-93 Loading

In calculating the positive moment, the positive area of the influence line is multiplied by the design lane load and it is stored as the design lane load effect. Next the maximum positive effect of the design truck is calculated by moving the load across the influence line as explained in the section entitled “Truck Load Effect.” The design truck effect is multiplied by the impact factor, then added to the design lane load effect and is stored as the combined design truck and lane load effect. Next the same procedure is repeated for the design tandem and the design lane load. The larger of these two effects is stored as the positive moment. The positive and negative shears at a section, the negative reaction at an interior support, the positive and negative reaction at an exterior support are calculated in the same manner as the positive moment except, in calculating the negative shear and reaction due to the design lane load, the negative area of the influence line is used.

3.7.11 Negative Moments and Pier Reactions due to HL-93 or PHL-93 Loading

In calculating the negative moment at any section between the point of dead load contraflexure and the interior support, and in calculating the positive reaction at the pier, the influence line is analyzed for the following conditions:

1. Effect 1: One design tandem plus design lane load
2. Effect 2: One design truck plus design lane load
3. Effect 3: Design tandem pair plus design lane load
4. Effect 4: Design truck pair plus design lane load

Effects 1 and 2 are calculated in the same manner explained in the section entitled “Positive Moments, Shears, and End Reactions due to HL-93 or PHL-93 Loading.” Effects 3 and 4 are calculated as follows. The maximum effect of the design tandem pair is calculated as explained in the section entitled “Variable Spacing of Truck or Tandem Pair.” The negative area of the influence line is multiplied by the design lane load, and it is stored as the design lane load effect. The design tandem pair effect is multiplied by the impact factor and is added to the design lane load effect to get Effect 3. Similarly Effect 4 is calculated using the design truck pair.

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For the HL-93 loading, the larger of Effect 1, Effect 2, 100% of Effect 3, and 90% of Effect 4 is stored as the governing effect.

For the PHL-93 loading, the governing effect is computed in a similar manner except that the two-truck plus lane factor is 100% rather than 90% for the negative moment. Therefore, for the PHL-93 loading, the larger of Effect 1, Effect 2, 100% of Effect 3, and 100% of Effect 4 is stored as the governing effect for negative moment and the larger of Effect 1, Effect 2, 100% of Effect 3, and 90% of Effect 4 is stored as the governing effect for the positive reaction at the pier.

3.7.12 Deflections due to HL-93 and PHL-93 Loading

The live load deflection due to the HL-93 loading is computed by analyzing the influence line for deflection for a design truck alone and a combination of 25% of the design truck and 100% of the design lane load. The larger of these two effects is stored as the live load plus impact deflection due to one lane. In calculating the above effect, the impact factor is applied to the design truck effect only. The actual live load plus impact deflection is then determined by multiplying the distribution factor for deflection and the live load plus impact deflection due to one lane calculated before.

The live load deflection due to the PHL-93 loading is computed in the same manner as the live load deflection due to the HL-93 loading except that the deflection due to HL-93 loading is multiplied by a factor of 1.25 to obtain the deflection due to the PHL-93 loading as per DM-4 Article 3.6.1.3.2.

3.7.13 Fatigue Load

The effects of a Fatigue Load are calculated in the same manner as explained in the section entitled "Truck Load Effect." The distance between the rear axles of the Fatigue Load is kept constant at 30 feet.

3.7.14 Special Live Load

The effects of each Special Live Load are calculated in the same manner as explained in the section entitled "Truck Load Effect." The effects of all axles are considered unless the user has specified to neglect the effects of those axles that do not produce the same effect as the effect being sought. Also, if the combined effect of a Special Lane Load and the Special Live Load is requested, the program computes these effects in a similar manner as the LRFD loading.

In calculating the effect of each Special Live Load, the effects of all axle loads are considered only if the user specifies to include the effects of all axles.

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3.7.15 Influence Line Analysis for H20 and HS20 Loadings

As described earlier, the influence lines are generated for various effects at analysis points on the beam. Each influence line is then analyzed as described here to find the maximum live load effect. For this, the influence line is divided into a number of regions. Each region consists of either all positive or all negative ordinates. The area of each region, the absolute maximum (peak) ordinate in each region and its location are found. For each peak of the influence line, the following is done. First, the axle number one is placed over the peak and the other axles are placed to the left in their respective positions. The ordinates under other axles are computed by interpolation assuming a straight-line variation of the influence line between two consecutive ordinates. Each axle load is then multiplied by the ordinate under it. All positive values are added and stored as a positive effect. Likewise, all negative values are added and stored as a negative effect. The absolute maximum positive effect and the absolute maximum negative effect are stored. Next, the second axle is placed over the peak and the above procedure is repeated. After the last axle is placed over the peak, the axles are then placed such that the center of gravity of the load coincides with the location of the peak. The positive and negative effects are found again and the maximum effects are stored. The axle loads are then reversed (to consider the effect of the live load moving across the bridge in the other direction) and the procedure described above is repeated. When this process is completed, the absolute maximum positive and the absolute maximum negative live load effects are obtained. These are then multiplied by the distribution factor, reduction in live load intensity factor, and impact factor to get the actual live load plus impact effects. Schematic drawings of the HS20 truck and H20 truck are presented in Figure 2.5-2.

The procedure described above is applicable for a truck load. However, for H or HS loading, the effects of equivalent lane loading must also be investigated. To find the effects of lane loading (uniform load plus a floating concentrated load), the sum of all positive and the sum of all negative areas of the influence line are computed. Also, the absolute maximum positive ordinate and the absolute maximum negative ordinate are found. To find the positive lane loading effect, the sum of positive areas is multiplied by the uniform load and added to the product of the maximum positive ordinate and the applicable (moment or shear) concentrated load. The negative lane loading effect is found in the same manner. The governing effects are stored. A schematic drawing of the HS20 and H20 lane load is presented in Figure 2.5-2.

The above procedures are illustrated in Figures 1 and 2. Figure 1 illustrates the procedure for computing the governing moment at a given analysis point ($0.4L_1$). Similarly, Figure 2 illustrates the procedure for computing the governing shear at that same analysis point.

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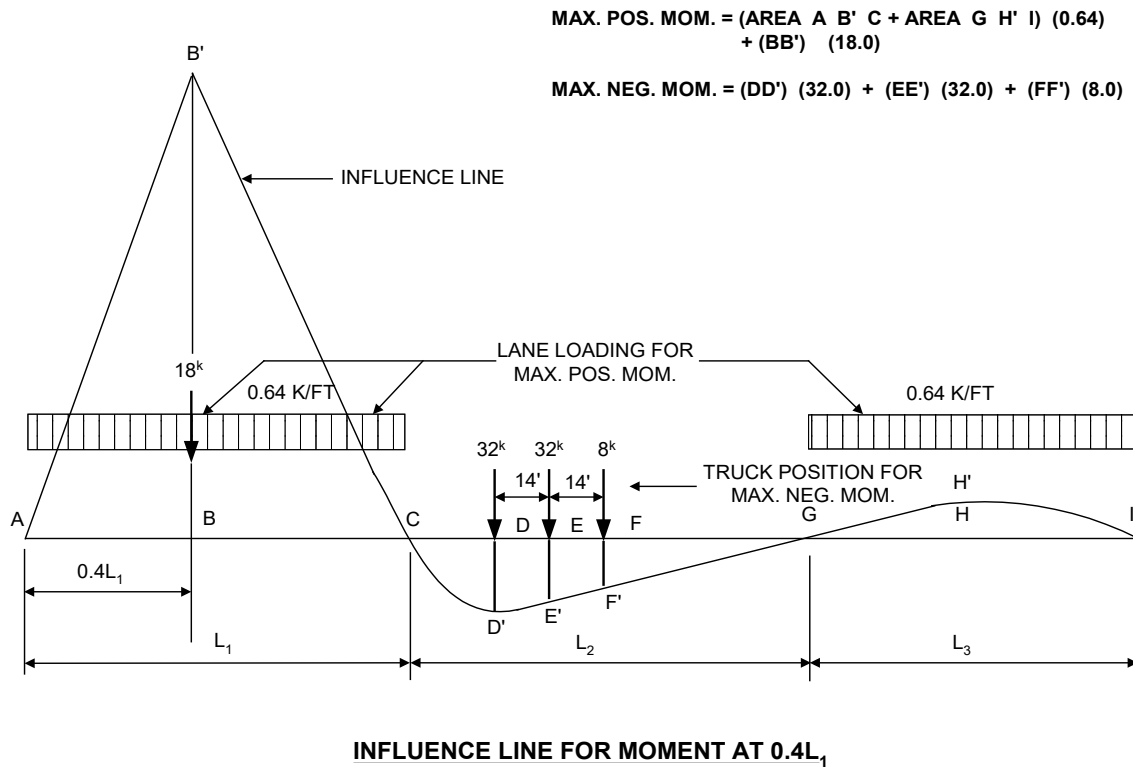


Figure 3.7-1 Moment Influence Line

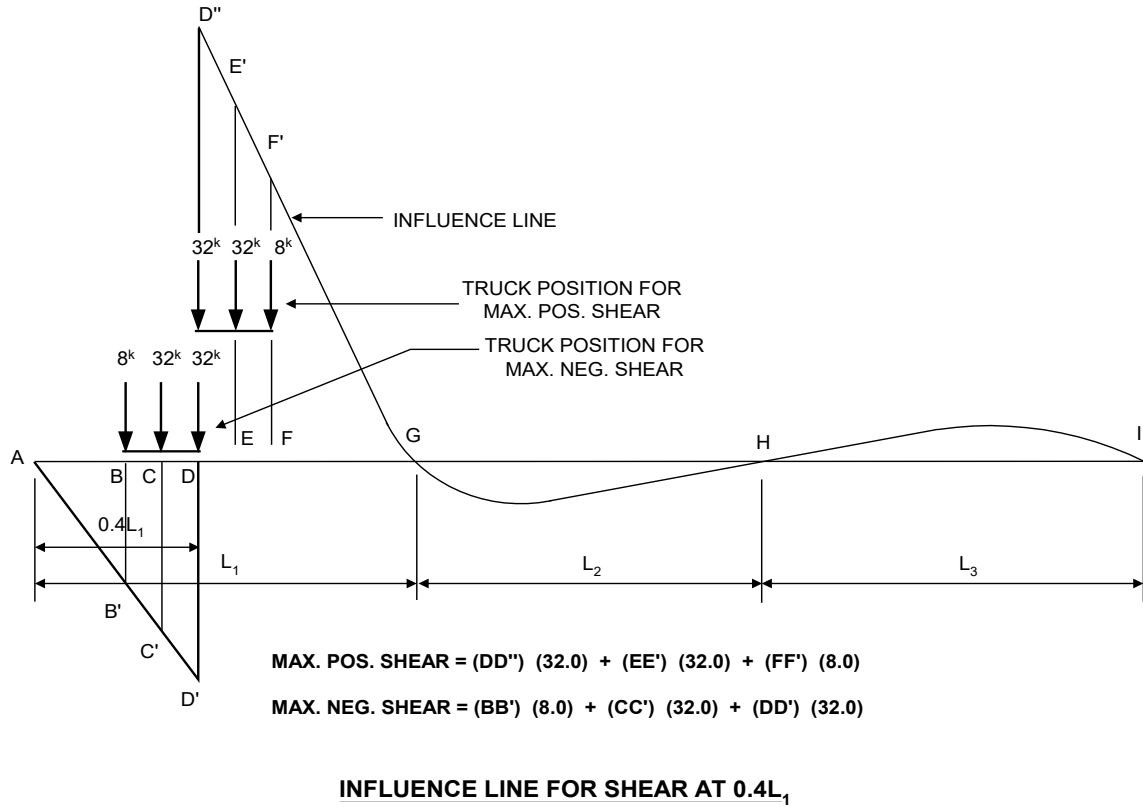


Figure 3.7-2 Shear Influence Line

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3.7.16 Pedestrian Load

The effect of a pedestrian load is calculated in the same manner as explained in the section entitled "Lane Load Effect", except that the uniform lane load is replaced by the uniform pedestrian load.

3.7.17 Live Load Rotations

The live load rotations at the ends of each span are calculated by CBA by analyzing the influence lines for rotations at these points. The Distribution Factor for Moment, DF1, is used to calculate the positive and negative rotations at the end support of an exterior span. The Distribution Factor for Moment, DF2, is used to calculate the positive and negative rotations at an interior support. For HL93 and PHL93 loadings, the program checks all load cases that are used for calculating the live load moments.

Please note that the distribution factors used for the calculation of live load rotations may be different from the distribution factor used for the calculation of live load deflections. In addition, for HL93 and PHL93 loadings, the program only checks Truck Alone and 25% Truck plus Lane cases. Thus, there may not be a correlation between the live load rotations and deflections values reported by the program.

3.7.18 Summary of Reactions

Reactions at the supports required for bearing, abutment, and pier designs are provided. Reactions, without impact but with distribution factors, are computed and provided for elastomeric bearing design. Reactions, with impact and with distribution factors, are provided for pot, disc, and steel bearing design. Reactions, without impact and without distribution factors, are provided for abutment and pier design.

The following procedure is used to determine the controlling live load and dead load combinations to obtain the reaction components for elastomeric, pot, steel, and disc bearing design. The load combination that governs the elastomeric bearing design is used to obtain the reaction components for the abutment and pier designs.

The reactions are computed using the following generalized equation:

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$$\begin{aligned} \text{Reaction} = & \gamma_{DC} * (DC1 + DC2) + \gamma_{MC1} * MC1 + \gamma_{MC2} * MC2 + \gamma_{FWS} * FWS \\ & + \gamma_{SWDL} * SWDL + \gamma_{AFWS} * AFWS + \gamma_{LL} * LL + \gamma_{PDL} * PDL \end{aligned}$$

Where;

γ_{DC} = Dead Load Factor

γ_{MC1} = Miscellaneous Noncomposite Load Factor

γ_{MC2} = Miscellaneous Composite Load Factor

γ_{FWS} = Future Wearing Surface Load Factor

γ_{SWDL} = Sidewalk Dead Load Factor

γ_{AFWS} = Additional Future Wearing Surface Load Factor

γ_{LL} = Live Load Factor

γ_{PDL} = Pedestrian Load Factor

This equation is evaluated for 3 different combinations as follows:

- 1) Maximum load versus Minimum load
- 2) Continuous Span live load model versus Simple Span live load model
- 3) Service I Limit State versus Service IP Limit State

The first combination always applies. The second combination only applies for multiple spans with the simple span check option. The third combination only applies when pedestrian loading is be considered. When all three combination apply, the generalized equation results in a total of 8 equations. The load combination from all valid equations that gives the smallest algebraic reaction is the minimum reaction. Likewise, the largest algebraic reaction from the valid equations is the maximum reaction.

Future wearing surface is not used in computing the rotation. The absolute maximum of the computed minimum and maximum rotation is reported for dead and live loads. Rotations are required and reported for bearing designs.

Live load and dead load reactions per girder are reported for the use in bearing pad design. For abutment and pier designs dead load reactions are reported per girder while the live load reactions are reported per lane. Frequently, the first interior beam may have the largest dead load reaction because of the beam spacing and loads from parapets. It is the responsibility of the user to chose the correct dead load reaction for use in the design and anlysis of abutments. The user is expected to sum the dead load reactions for all the girders in the bridge cross section obtained from different runs for interior and exterior girders. The resulting value should than be divided by the skewed abutment width to obtain the total dead load reaction per unit width of the abutment for use in the abutment design.

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$$RXDL_{DESIGN} = \frac{\sum_{i=1}^{N_{BEAMS}} RXDL_i}{ABW}$$

where;

$RXDL_{DESIGN}$ = Dead load reaction per unit width of abutment

$RXDL_i$ = Dead load reaction for beam i

N_{BEAMS} = Number of beams in bridge cross section

ABW = Abutment width measured along the skew

The user should multiply the live load reaction value given in the output table by the number of lanes and the multiple presence factor. The resulting value should then be divided by the abutment width to obtain the live load reaction per unit width of the abutment for use in the abutment design.

$$RXLL_{DESIGN} = \frac{RXLL_{OUTPUT} * N_{LANES} * MPF}{ABW}$$

where;

$RXLL_{DESIGN}$ = Live load reaction per unit width of abutment

$RXLL_{DESIGN}$ = Live load reaction for single lane (no impact or distribution factor)

N_{LANES} = Number of design lanes

MPF = Multiple presence factor

ABW = Abutment width measured along the skew

The PAPIER program requires that live load reactions be entered as a single bearing point. Therefore, the left and right bearing reactions at interior supports must be added together and entered as a single value in PAPIER.

$$RXLL_{PAPIER} = RXLL_{INT(L)} + RXLL_{INT(R)}$$

where;

$RXLL_{PAPIER}$ = Live Load reaction for PAPIER

$RXLL_{INT(L)}$ = Live Load reaction at left of interior support

$RXLL_{INT(R)}$ = Live Load reaction at right of interior support

The PAPIER program requires that the pedestrian load be entered as a load per area. PAPIER computes the pedestrian reactions internally assuming simple beams between piers. For continuous superstructures this will under estimate the pedestrian reactions for piers. This can be corrected for by entering an "adjusted" pedestrian load into PAPIER. The ratio of continuous pedestrian reaction over the simple pedestrian reaction should be multiplied by the actual pedestrian load per area to compute and "adjusted" pedestrian load per area.

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$$RATIO = \frac{RX\_PED_{Cont}}{RX\_PED_{Simple}}$$

where;

$RATIO$ = Adjustment ratio

RX_PED_{Cont} = Pedestrian reaction from continuous superstructure

RX_PED_{Simple} = Pedestrian reaction from simple superstructure

$$PED_{ADJ} = PED * RATIO$$

where;

PED_{ADJ} = Adjusted Pedestrian load

PED = Actual Pedestrian load

When the simplified span check is not made only the continuous reactions will be printed. The simple span pedestrian reactions may be computed by using the actual pedestrian load per area times the pedestrian width times the span length times one-half and the above procedure used to get the “adjusted” pedestrian load per area.

$$RX\_PED_{Simple} = PED * W * L * 0.5$$

where;

W = Width of pedestrian load

L = Length of span

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3.8 STRAND DESIGN/ANALYSIS

The program checks the user-defined strand pattern for an analysis problem and determines a feasible strand pattern for a design problem's optimal prestress force and eccentricity. Strand design and analysis also includes the computation of prestress losses, prestress eccentricities, prestress transfer lengths, prestress development length, girder cracking moments, girder flexural capacities, initial concrete stresses, and final concrete stresses.

For an analysis run, the program analyzes the prestressed concrete girder based on the user-defined strand pattern and section properties, and it compares the actual analysis values with allowable values, determining if the user-defined configuration satisfies each of the applicable specifications.

For a design run, the program performs an iterative design of the prestressed concrete girders. The program can perform a design of a simple span bridge or a multi-span bridge made continuous for live load. It can design a multi-span bridge made continuous for live load having up to twenty spans for all bridge types except for Type F NEXT Beams. The Type F NEXT Beams are limited to single spans.

The cross sections, which can be designed by the program, are an I-beam, a bulb-tee beam, a Type F NEXT beam, an adjacent plank beam, an adjacent box beam with a rectangular void, and a spread box beam with a rectangular void. The design option cannot be used for an adjacent box beam with circular voids, a spread box beam with circular voids, a spread plank beam, or a Type D NEXT beam.

The first step that the program performs in the strand pattern design process is to estimate the required initial prestressing force. This force is estimated by solving two equations for stresses. The first equation is for the initial tensile stress in the top fiber at the end of the beam, and the other equation is for the final tensile stress in the bottom fiber at the location of maximum moment. These two equations for stresses are solved using the allowable stress values, using only the gross section properties, and assuming a prestress loss and a beam size. Based on this estimated initial prestressing force, the program then estimates the required number of strands.

The next step that the program performs is to compute the required design eccentricity. Similar to the required initial prestressing force, the required design eccentricity is estimated by solving several equations for stresses. The minimum eccentricity is computed as the maximum of the following:

1. Eccentricity based on compressive stress, top fiber of girder, maximum moment, and a negative value of f_c .
2. Eccentricity based on tensile stress, bottom fiber, and maximum moment.
3. Eccentricity based on compressive stress due to dead load and prestressing force, top fiber of girder, maximum moment, and a negative value of f_{cDL} .

The maximum eccentricity is computed as the minimum of the following:

1. Eccentricity based on compressive stress, bottom fiber, and at the drap point or L_t .
2. Eccentricity based on tensile stress, top fiber of girder, and at the drap point or L_t .
3. Eccentricity based on compressive stress, bottom fiber, at the drap point or L_t , and negative moment.

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4. Eccentricity based on compressive stress due to one-half of the sum of dead load and prestressing force, plus live load, bottom fiber, and negative moment.

The preliminary eccentricity is then taken as either the maximum eccentricity or the average of the minimum and maximum eccentricities, depending on the design criteria.

Using the preliminary number of strands and eccentricity, the factored flexural resistance and the cracking moment are computed at the midspan. If the ratio of the factored flexural resistance to the cracking moment at the midspan is less than 1.0, then the design is found to be controlled by cracking moment, strands are added, and the previous steps are repeated.

However, if the ratio of the factored flexural resistance to the cracking moment at the midspan is greater than or equal to 1.0, then the design is not controlled by cracking moment. In that case, the moment capacity based on a stress of $0.9f_{py}$ in the bottom row of the prestressing steel is computed. If the moment due to unfactored dead load plus unfactored live load is greater than the moment capacity based on a stress of $0.9f_{py}$ in the bottom row of the prestressing steel, or if the total factored moment for strength design is greater than the factored flexural resistance, then the design is found to be controlled by strength and, again, strands are added and the previous steps are repeated.

However, if the design is not controlled by either the cracking moment or strength, then the final stresses at the location of maximum moment are computed and compared with the allowable values. If any allowable stress values are exceeded, then strands are added and the previous steps are repeated.

After the cracking moment check, the strength check, and final allowable stress check are each met, an actual feasible strand pattern is established based on the required number of strands and eccentricity. For I-beam cross sections (PA I-beams, AASHTO I-beams, PA Bulb Tee beams), the feasible strand pattern will have strand rows in the bottom flange where each higher row has at most one more strand than the previous row for rows with an odd number of available strands (at most two more strands for even strands rows).

Based on the actual strand pattern, the following stress checks are made:

1. Stresses due to initial prestressing force at the drape points for draped strands or at 1 foot from the centerline of bearing for straight strands. This check is not performed for debonded design.
2. Stresses due to final prestressing force at the location of maximum moment.

If any allowable stress is exceeded in either of the two checks above, then strands are added and the previous steps are repeated. In addition, losses are computed and checked with the assumed loss against a given tolerance level. If the tolerance is exceeded, then the number of strands is recomputed and the previous steps are repeated with the computed loss as the assumed loss for the next iteration.

For a draped strand design that has previously been found to be controlled by either cracking moment or strength, the tensile stresses at the top of the girder at the drape point are checked for both initial prestressing force and final prestressing force. If any of these allowable stresses are exceeded, then the eccentricity is reduced and the above check is repeated until the allowable stresses are satisfied. The required end eccentricity is then computed by solving certain stress formulas.

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The transfer length, L_t , is then computed, as well as the cracking moment at that location. If the moment due to unfactored dead load plus unfactored live load at L_t exceeds the cracking moment at L_t , then the design is found to be controlled by cracking moment and, again, strands are added and the previous steps are repeated.

Finally, for straight and draped strands, the positive moment capacities and the cracking moments are computed at each analysis point and the end block stresses are computed based on solid section.

The iterative calculation for strand design starts with user-defined allowable stresses in concrete, and a tentative strand pattern is developed for each span in the girder. Creep and shrinkage analysis is then performed, and stresses due to creep and shrinkage are combined with those due to dead loads and live loads. If, at any location on the girder, this combined stress exceeds the corresponding allowable value, then allowable stresses (particularly the allowable tensile stresses) are reduced by an amount equal to the difference between the total combined stress and the current allowable stress. The strand design is repeated, and this cycle continues until all combined stresses are within current allowable limits.

When checking the cracking in the transfer zone, the program uses the Service-III limit state with either the PHL-93 vehicle or the P-82 vehicle, whichever vehicle controls. For analysis runs using the P-82C live loading, the P-82 vehicle is replaced by the P-82C live loading.

For a design run, the program also designs for the optimal beam size and the optimal beam concrete strength. Additional details concerning these computations are presented in the following sections.

3.8.1 Prestress Losses

The total prestress loss is the sum of the loss due to elastic shortening plus the losses due to long-term shrinkage and creep of concrete, and relaxation of the steel. The total losses are computed using the following equation:

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$$

where:

Δf_{pT} = total loss in prestressing steel (ksi)

Δf_{pES} = loss in prestressing steel due to elastic shortening (ksi)

Δf_{pLT} = losses in prestressing steel due to long-term shrinkage and creep of concrete, and relaxation of the steel (ksi)

The long-term losses are computed using the Refined Estimates of Time-Dependent Losses as follows:

$$\Delta f_{pLT} = (\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1})_{id} + (\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR2} + \Delta f_{pSS})_{df}$$

where:

Δf_{pSR} = prestress loss due to shrinkage of girder concrete between transfer and deck placement (ksi)

Δf_{pCR} = prestress loss due to creep of girder concrete between transfer and deck placement (ksi)

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Δf_{pR1} = prestress loss due to relaxation of prestressing strands between time of transfer and deck placement (ksi)

Δf_{pR2} = prestress loss due to relaxation of prestressing strands in composite section between time of transfer and deck placement (ksi)

Δf_{pSD} = prestress loss due to shrinkage of girder concrete between time of deck placement and final time (ksi)

Δf_{pCD} = prestress loss due to creep of girder concrete between time of deck placement and final time (ksi)

Δf_{pSS} = prestress gain due to shrinkage of deck in composite section (ksi)

$(\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1})_{id}$ = sum of time-dependent prestress losses between transfer and deck placement (ksi)

$(\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR2} + \Delta f_{pSS})_{df}$ = sum of time-dependent prestress losses after deck placement (ksi)

For the specific equations used by this program to compute the individual components of the total prestress loss, refer to LRFD Specifications Article 5.9.3.4 and the corresponding section of DM-4. The total loss, Δf_{pT} , has a minimum loss of 20% per DM-4. The time dependent losses vary based on the concrete age at three events; 1) Transfer, 2) Deck Placement, and 3) Final Stage. The transfer and deck placement age are specified on the CTL input command. The final stage age is a system parameter set to 7300 days (~20 years). DM-4 requires the total prestress loss due to relaxation, $\Delta f_{pR1} + \Delta f_{pR2}$, to be a minimum of 3 ksi. AASHTO assumes Δf_{pR2} is equal to Δf_{pR1} which results in both losses have a minimum of 1.5 ksi.

3.8.2 Beam Size

The program can design the optimal beam size for each span based on the design parameters specified by the user in the DES command. These design parameters include the minimum depth of the beam, the maximum depth of the beam, the maximum difference in depth of beams between two adjacent spans, and the width of box beams. The program first optimizes the beam size of the first span, and it then proceeds through each subsequent span until all spans have been optimized.

The first step that the program performs in the beam size optimization process is to select the beam with the minimum moment of inertia, while satisfying all of the user-input design parameters. Using this beam in all spans, the program optimizes the various design features of the beam in the first span including the strand pattern, shear stirrups and debonding.

If all design specifications can be satisfied in the first span for all design features, then the program uses this beam for the first span, and it then proceeds to the design of the next span. If any design specifications cannot be satisfied in the first span, then the program selects the next largest beam, based on moment of inertia, while satisfying all of the user-input design parameters. It then reanalyzes the entire structure, using the new beam size in the first span and the original beam size for the other spans. The beam sizes in the

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other spans are changed only if required based on the user-input value of depth difference, where the depth difference is the maximum difference in depth of beams between two adjacent spans.

The above procedure is continued for each span until all spans have been designed. When the beam size changes in any given span, the entire bridge length is reanalyzed since the applied loads in any given span affect all other spans. Therefore, the program reoptimizes previously designed spans due to required beam size changes in subsequent spans.

If the symmetry option is selected by the user, then the program generates a symmetrical design.

3.8.3 Beam Concrete Strength

Using the DES command, the user can specify whether or not the program is to optimize for f'_c . If the user specifies that the program should optimize for f'_c , then the user must also specify the increment by which f'_c is to be decreased.

If the user specifies that the program is not to optimize for f'_c , then the user-input value of maximum f'_c is used and the beam concrete strength is not optimized.

However, if the user specifies that the program is to optimize for f'_c , then the program first finds the optimal beam sizes and the optimal strand patterns using the user-input value of maximum f'_c . All output requested by the user is reported for the current f'_c value followed by the f'_c OPTIMIZATION MESSAGES output table. This table reports the new f'_c value being attempted. Then, using the same beam sizes that were designed using the user-input value of maximum f'_c , the program designs these beam sizes using the new f'_c , where the new f'_c is equal to the maximum f'_c minus the f'_c increment. If all design specifications are met using this new f'_c , then all requested output is reported again with the new f'_c value followed by the next f'_c OPTIMIZATION MESSAGES output table. The program continues to reduce f'_c until any design specifications are not met or the new f'_c value is less than 5.0 ksi. The optimal beam concrete strength is then taken as the lowest f'_c for which all design specifications are met using the original beam sizes. The beam sizes are optimized using only the maximum f'_c ; they are not reoptimized using the reduced f'_c .

3.8.4 Strength Cracking Moment Check

The program checks the cracking moment and the ultimate moment for the minimum reinforcement criteria, as presented in DM-4 Article 5.6.3.3, for all analysis points excluding the ends of the beam in the development zone.

3.8.5 Service Cracking Moment Check

The program checks the service cracking moment within the transfer length at each end of the span (this includes the debonded region plus the transfer length). The Service IIIB moment is compared to the $1.0 \cdot M_{cr}$ at relevant analysis points within the transfer length/debonded region.

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3.9 CREEP AND SHRINKAGE

The program computes the restraint moments due to creep and shrinkage. The program uses the routines of the PennDOT Continuous Beam Analysis (CBA) program to compute the restraint moments due to dead load creep and prestress creep, and the differential shrinkage between the beam and slab for the computed values of fixed end actions. These moments, along with the factored positive live load moment, are used to design the positive moment steel at the interior supports. If the creep and shrinkage moments at the interior supports are negative, they are used in the design or analysis of the negative moment steel.

When the continuous analysis with simple span check option is selected, the creep and shrinkage analysis is not performed and the positive moment steel at the interior supports is not designed.

The program computes the effects of creep and shrinkage based on the 1969 PCA Bulletin entitled "Design of Continuous Highway Bridges with Precast, Prestressed Concrete Girders". The effects of creep due to both dead load and prestressing are taken into account. By default, the time of the moment connection is a minimum of 30 days and a maximum of 450 days. An envelope of values generated from this minimum and maximum is computed and stored.

The fixed end action due to creep is computed as follows:

$$FEA_{CR} = (FEA_{CP/S} + FEA_{CDL})(1 - e^{-\Phi})$$

Where: $(1 - e^{-\Phi})$ = Correction factor for creep

$$\Phi = (\varepsilon_{crf} - \varepsilon_{crm}) E_{ci} / f_{cgp}$$

The fixed end action due to shrinkage is computed as follows:

$$FEA_{SH} = FEA_{SHU} \left(\frac{1 - e^{-\Phi}}{\Phi} \right)$$

Where: $\left(\frac{1 - e^{-\Phi}}{\Phi} \right)$ = Correction factor for shrinkage

The fixed end equations for creep and shrinkage are presented in Table 1. The sign convention for fixed end action values presented in this table is as follows:

1. Upward reactions are positive.
2. Counterclockwise moments are positive.

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Table 3.9-1 Creep and Shrinkage Fixed End Action

Type of Restraint Moments	Fixed End Action	Location of Member		
		Left Exterior Member	Interior Member	Right Exterior Member
Dead Load Creep (FEA _{CDL})	Left End Reaction	$-M_D/L$	0.0	M_D/L
	Left End Moment	0.0	$2M_D/3$	M_D
	Right End Reaction	M_D/L	0.0	$-M_D/L$
	Right End Moment	$-M_D$	$-2M_D/3$	0.0
Prestress Creep (FEA _{CP/S})	Left End Reaction	$-3EI\theta/L^2$	0.0	$3EI\theta/L^2$
	Left End Moment	0.0	$2EI\theta/L$	$3EI\theta/L$
	Right End Reaction	$3EI\theta/L^2$	0.0	$-3EI\theta/L^2$
	Right End Moment	$-3EI\theta/L$	$-2EI\theta/L$	0.0
Shrinkage (FEA _{SHU})	Left End Reaction	0.0	0.0	0.0
	Left End Moment	M_s	M_s	M_s
	Right End Reaction	0.0	0.0	0.0
	Right End Moment	$-M_s$	$-M_s$	$-M_s$

For pedestrian load runs the value of M_D always includes the sidewalk and additional future wearing surface. For creep and shrinkage effects, the program computes section properties, such as composite area and composite moment of inertia, based on the beam spacing.

The program reduces the value of f_t if the creep and shrinkage tensile stresses exceed a given tolerance. However, in the case of a multi-span girder in which some spans pass this check but others do not, the reduced f_t applies only to those spans in which the tolerance stress is exceeded.

For additional information concerning analysis for the creep and shrinkage effects, refer to Section 3.7.4, entitled "Creep and Shrinkage Analysis."

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3.10 DEBONDING DESIGN/ANALYSIS

The program computes a debonded solution to an existing fully-bonded girder configuration in accordance with LRFD Specifications Articles 5.6.3, 5.9.2.3, and 5.9.4.3, and the corresponding section of DM-4. The design and analysis of debonding in this program includes the following:

1. Check of the debonded strand configuration (designed or user-defined) against specified limits.
2. Calculation and check of the final and initial, compressive and tensile, concrete service stresses.
3. Calculation and check of the ultimate capacities against positive, maximum effect, applied moment loads.
4. Calculation and check of the yield capacities against positive, maximum effect, applied moment loads.
5. Calculation and check of the cracking ratios against specified limits.

The following criteria, taken from DM-4, are used by the program to control the number and location of debonding cutoffs. The purpose is to prevent a bond failure and to meet the strength and service requirements at cutoff locations. The equations are for design and analysis only and are not for rating. The following calculations are made:

1. For a design problem, the program selects a strand pattern so that the calculated practical eccentricity is as close as possible, but not less than, the design eccentricity. The program uses the input values of R1, R2, etc., as the maximum number of strands allowed per row. This is the initial bonded strand pattern used to start debonding computations.
2. The transfer length, L_t , and the development length, L_d , are computed next. The transfer length is computed in accordance with AASHTO Article 5.9.4.3.1, and the development length is computed in accordance with AASHTO Article 5.9.4.3.2 for bonded strands and with DM-4 Article 5.9.4.3.3 for debonded strands. The total member depth is conservatively used to determine the K multiplier factor for bonded strands. The total member depth includes the beam depth, the haunch thickness for section properties, and the effective slab thickness. These lengths include the beam projection beyond the centerline of bearing. Presented in Figure 1 is a girder elevation view showing debonded strand design details.
3. For a design problem, the program assumes that at least two strands are to be debonded.
4. For a design problem, a trial pattern is selected at the centerline of bearing so that the initial tensile stress in the concrete is less than or equal to the allowable. The debonding pattern and the number of debonding lengths are selected based on the following criteria and by the suggested number of strands presented in Table 1.
 - a. The maximum number of debonded strands is limited to 25% of the total number of strands, not to exceed 30 strands. Strands are always debonded in pairs.
 - b. For rows containing 3 or more strands, the maximum number of debonded strands in a row is 50% and the number of debonded strands is rounded up to the next higher number in the case of an odd number of strands in a row. For example, for a row of 13 strands, the maximum number of strands available for debonding is 7, except this would result in an odd number of debonded

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- strands, so the limit is 6. For a row of 11 strands, the maximum number of strands available for debonding is 6.
- For rows having 2 strands, the program debonds 0 or 2 strands. For a row having 1 strand, it debonds 0 strands.
 - The number of debonded strands cut off at a section is limited to a minimum of two and a maximum of six.
 - The number of debonding points is limited to a maximum of five, excluding the section at the end of the beam.
 - Selection of debonding of strands is from the bottom up successively.
 - The program makes provisions to avoid debonding the outer-most strands in all rows located within the full-width section of the flange for I-beams (PennDOT I-Beams, AASHTO I-Beams, or PA Bulb Tee Beams) or the bottom slab of box beams.
 - The program makes provisions to debond all strands symmetrically about the vertical axis of the beam. Debonding of adjacent strands in the same row and/or column not allowed and is avoided. For Type F NEXT Beams the strands are debonded symmetrically about the vertical axis of each stem.
 - For I-beams, all strands within the horizontal limits of the web are bonded.

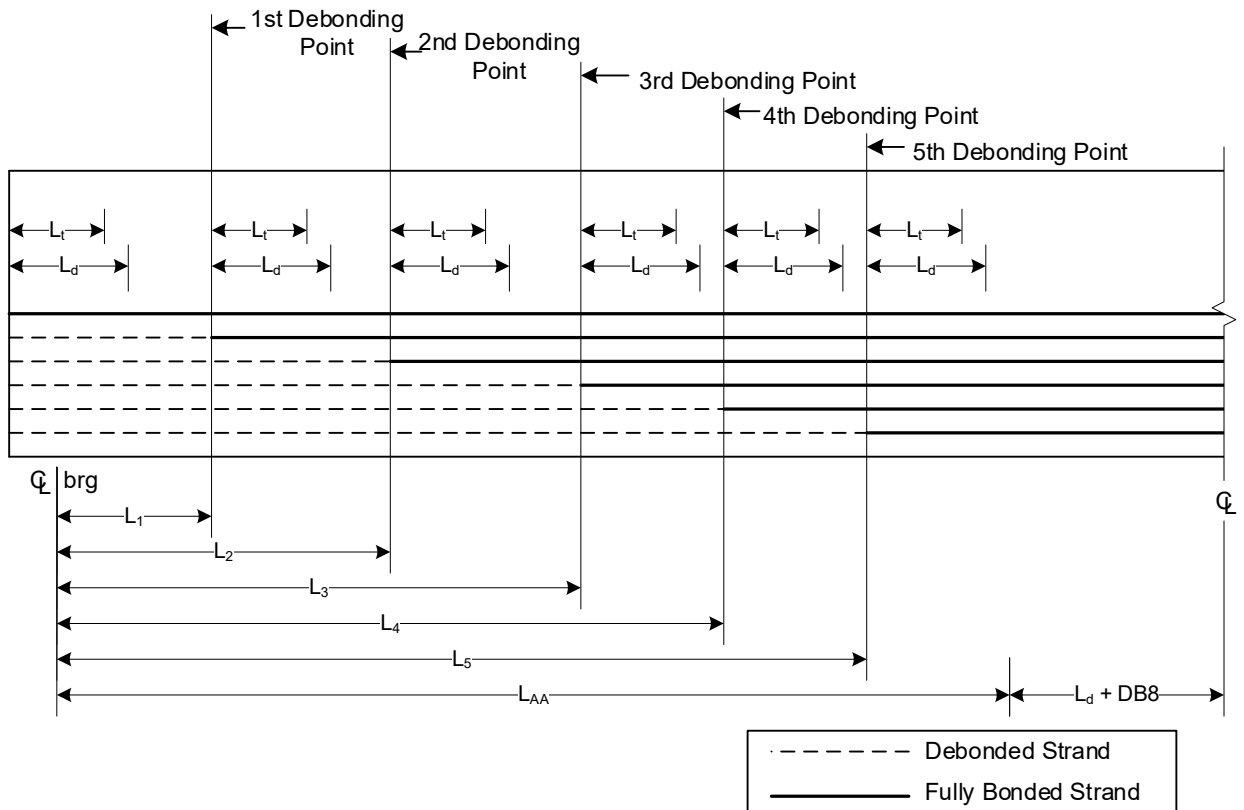


Figure 3.10-1 Debonded Strand Design Details

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Table 3.10-1 Suggested Number of Strands per Debonding

Total Number of Debonded Strands	Suggested Number of Strands per Debonding				
	1st Debonding Point	2nd Debonding Point	3rd Debonding Point	4th Debonding Point	5th Debonding Point
2 *	2				
4	4				
6	6				
8	2	6			
10	4	6			
12	6	6			
14	2	6	6		
16	4	6	6		
18	6	6	6		
20	2	6	6	6	
22	4	6	6	6	
24	6	6	6	6	
26	2	6	6	6	6
28	4	6	6	6	6
30**	6	6	6	6	6
* Minimum number of strands debonded is 2. ** Maximum number of strands debonded is 30.					

- P_i and e are computed from the input (analysis problem) or selected (design problem) strand pattern at each cutoff location.
- For a design problem, the top and bottom fiber stresses in the beam at the centerline of bearing are computed and compared with the input f_{tf,d} and f_{cl} values, respectively.

$$f_{top} = -\frac{P_i}{A_b} + \frac{P_i e}{Z_t} - \frac{M_{DNI}}{Z_t}$$

$$f_{bot} = -\frac{P_i}{A_b} - \frac{P_i e}{Z_b} + \frac{M_{DNI}}{Z_b}$$

If the calculated stresses exceed the allowable stresses, then two strands are added to the total number of debonded strands and computations are repeated beginning with Step 4. If the requirements of Step

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4a are not satisfied, then the entire design process is repeated using a revised value of f_{ti} . The revised value of f_{ti} is calculated as follows:

$$f_{ti,new} = \left[\frac{f_{ti}}{\sqrt{f'_{ci}}} - 0.03 \right] \sqrt{f'_{ci}}, \text{ but not less than } 0.095 \sqrt{f'_{ci}}$$

7. If required debonded lengths are not input, the program assumes the first debonded length, L_x , is 6 inches for I-beams, bulb-tee beams, or Type F NEXT beams and 30 inches for box or adjacent plank beams, measured from the centerline of bearing.
8. The initial top tension and final bottom compression stresses in the beam under design loads at L_x and at $[L_x + L_t]$ are computed and compared to the user-defined f_t and f_c values.

$$f_{t,top} = -\frac{P_i}{A_b} + \frac{P_i e}{Z_t} - \frac{M_{DNI}}{Z_t}$$

$$f_{c,bot} = -\frac{P}{A_b} - \frac{Pe}{Z_b} + \frac{M_G + M_{DIA} + M_{SLB} + M_{DC1}}{Z_b} + \frac{M_{FWS} + M_{DC2} + M_{PL}}{Z_{bc}} + \frac{M_{LCF,neg}}{Z_{bct}}$$

If the calculated stresses exceed the allowable stresses, then 6 inches is added to the assumed debonded length and $f_{t,top}$ and $f_{c,bot}$ are computed again.

If the assumed L_x exceeds the maximum allowable length, L_{AA} , then the program will select the next beam size and begin the design process again.

9. The next cutoff location is assumed to be located 1 foot beyond the previous cutoff location, and the computations in Step 8 are repeated for each cutoff location.
10. At each cutoff location, the theoretical debonded lengths and the critical sections are computed. The theoretical debonded length is equal to the required debonded length, L_x plus L_t . The critical section is assumed to be located at a distance equal to the debonded length, L_x plus L_d .
11. At each critical section, the ultimate moment capacity, M_{UC} , is computed, and at each theoretical debonded section, the cracking moment, M_{CR} , and the yield moment capacity, M_{fy} , are computed.

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12. For a design problem, the following conditions are checked:

$$M_{SRV} < M_{CR}$$

$$M_{UT} < M_{fy}$$

$$M_{UT,max} < M_r$$

In the above equations, M_{SRV} is the maximum factored moment based on Service IIIB, M_{UT} is the maximum factored moment based on Service IIIA, and $M_{UT,max}$ is the maximum factored moment based on Strength I and Strength II.

If this first condition is not met, the entire design process is repeated using a revised value of f_{ti} . The revised value of f_{ti} is calculated as follows:

$$f_{ti,new} = \left[\frac{f_{ti}}{\sqrt{f'_{ci}}} - 0.03 \right] \sqrt{f'_{ci}}, \text{ but not less than } 0.095 \sqrt{f'_{ci}}$$

NOTE: If $f_{ti,new}$ is less than $0.095 \sqrt{f'_{ci}}$, the program will change the strand pattern from debonded to straight for the design span.

If the second or third condition is not met, then the program will select the next beam size and begin the design process again.

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3.11 NEGATIVE MOMENT CAPACITY

For the case in which the longitudinal slab reinforcement is to be designed, the program calculates the required area of longitudinal slab reinforcement to resist the applied composite negative flexure loads. For the case in which the longitudinal slab reinforcement is not to be designed but is entered by the user, the program computes the negative moment capacity of the composite prestressed concrete beam based on the area of longitudinal slab reinforcement specified. In the positive moment region, a negative moment capacity is still computed using nominal longitudinal slab reinforcement.

Since the program uses the same section properties for both negative and positive flexure, forces and stresses at points of reversal of moments are computed using the same equations as for all other points. The procedure for computing forces and stresses at and near the contraflexure points is not unique in any way.

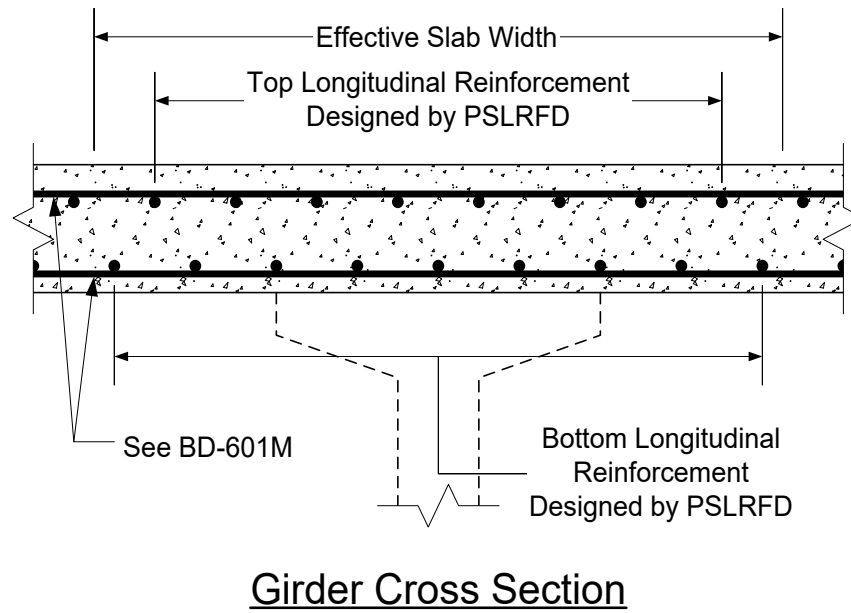


Figure 3.11-1 Longitudinal Slab Reinforcement

3.11.1 Required Longitudinal Slab Reinforcement for Design

For the case in which the longitudinal slab reinforcement is to be designed, the program calculates the required area of longitudinal slab reinforcement to resist the applied composite negative flexure loads as follows:

$$A_{ns} = -\sqrt{0.85f'_c} \left[\frac{\sqrt{b_1}(RAD1) - (RAD2)}{f_y} \right]$$

Where:

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$$RAD1 = \sqrt{0.85f'_c h_f (2d_e - h_f)(b - b_1) + 0.85f'_c b_1 d_e^2 - \left(\frac{2M_u}{\phi}\right)}$$

$$RAD2 = \sqrt{0.85f'_c} [h_f(b - b_1) + b_1 d_e]$$

The above equations are derived from LRFD Specifications Equations 5.6.3.1.1-3 and 5.6.3.2.2-1 with the area of prestressing steel and the area of compression reinforcement considered to be zero and the stress in the longitudinal slab reinforcement, f_s , is replaced by f_y , the yield strength of the longitudinal slab reinforcement (this assumes the ratio c/d_s meets the criteria of LRFD Specification Article 5.6.2.1). The compression flange is the bottom flange of the beam. T-section behavior is assumed, $\beta_1 c > h_f$, and b_1 is equal to the web width. Using the initially computed value of A_{ns} the value of $\beta_1 c$ is computed and compared to h_f and if not greater, the area is recomputed with b_1 equal to the bottom flange width.

The term, M_u , used in the previous equation is computed as follows:

$$M_u = \text{Maximum} \left[M_{UD}, \text{Minimum} \left(M_{cr}, \frac{4}{3} M_{UD} \right) \right]$$

Where: M_{UD} = factored negative moment based on the controlling combination of dead load, live load, and creep and shrinkage at the support being considered.

M_{cr} = cracking moment of the section.

For box sections, these computations are performed twice for each connection, once using the hollow box section and again using the solid box section. The design area of reinforcement is then taken as the maximum required for the solid or hollow box section.

3.11.2 Negative Moment Capacity for Analysis

For the case in which the longitudinal slab reinforcement is not to be designed, the program computes the negative moment capacity of the prestressed concrete beam as follows:

$$M_r = \phi_f M_n$$

Where: ϕ_f = resistance factor for flexure for reinforced concrete

$$M_n = A_s f_y \left(d_e - \frac{a}{2} \right) + 0.85f'_c (b - b_1) h_f \left(\frac{a}{2} - \frac{h_f}{2} \right)$$

$$a = \beta_1 c$$

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$$c = \frac{A_s f_y - 0.85 f'_c (b - b_1) h_f}{0.85 \beta_1 f'_c b_1}$$

3.11.3 Development Length

For longitudinal slab reinforcement, the development length is measured from the end of the bar towards the centerline of the pier, as shown in Figure 1. For definition of left and right cutoff points, see Sections 0 and 6.20.

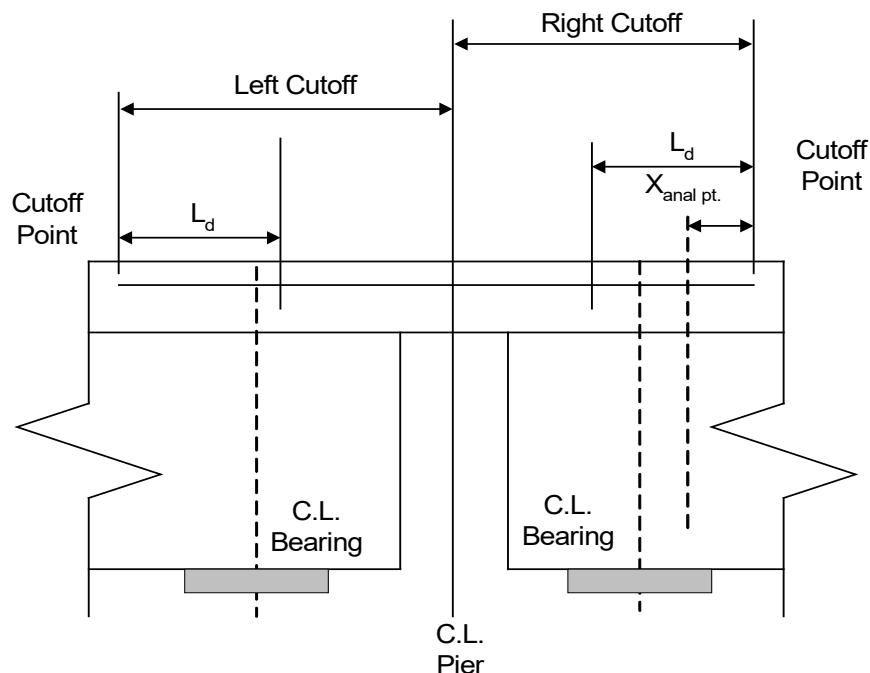


Figure 3.11-2 Development Length for Longitudinal Slab Reinforcement

3.11.4 Crack Control By Distribution of Longitudinal Slab Reinforcement (Serviceability)

For analysis problems the longitudinal slab reinforcement is checked at each analysis point that has negative moment for Service I Limit State. The user enters the CGS on the SLB command for the negative moment region and the bar size and area of reinforcement per effective slab width for the top and bottom layers on the SST command. The program computes the effective bar spacing and compares it to the allowable spacing. The requirements of DM-4 5.12.3.3.8 which refers to 6.10.1.7 are not checked.

For design problems various combinations of bar sizes and bar spacing are given that satisfy the distribution of reinforcement for control of cracking at each interior support.

For spread beams with a double mat of reinforcement, the top longitudinal bars are selected to provide a minimum of 2/3 of the minimum reinforcement area. The bottom longitudinal bars are selected to provide a minimum of 1/3 of the minimum reinforcement area. The minimum reinforcement area is 1% of the total

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slab area. Bar sizes #4 through #8 are analyzed for top longitudinal bars. Bar sizes #4 through #6 are analyzed for the bottom longitudinal bars. The bottom longitudinal bar size will never be larger than the top bar size. The bottom transverse bar is always a #5 bar. The top transverse bar is entered by the user on the SLB command. The following clear covers and clear distance are used when checking maximum bar limits within the effective deck thickness:

Top clear cover:	2"
Clear spacing between longitudinal bars in top and bottom mats:	2"
Clear spacing between transverse bars in top and bottom mats:	2"
Bottom clear cover:	1"

The transverse bar in the top mat can be located either above the longitudinal top mat bar or below the longitudinal top mat bar. When the longitudinal top bar is below the transverse top bar, only the clear distance between the longitudinal bars needs to be considered. Figure 3.11-3 shows a 7.5" effective deck thickness with a #6 top transverse bar below the longitudinal bar, a #6 bottom longitudinal bar, and a #8 top longitudinal bar.

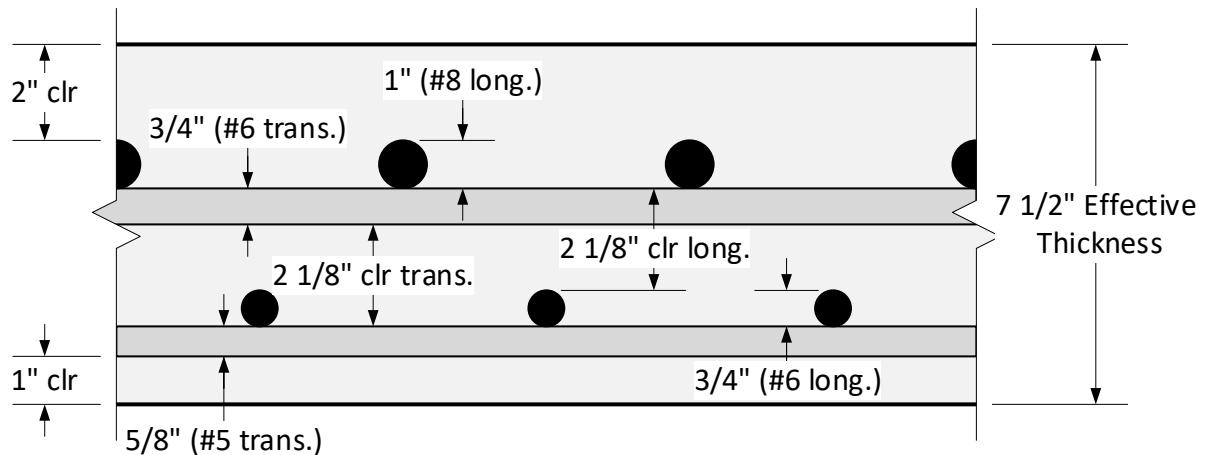


Figure 3.11-3 Clear Distance of Longitudinal and Transverse Bars

The following calculates the clear distance for the longitudinal and transverse bars in the mats.

Longitudinal clear distance

Effective Deck Thickness	7.5"
- Top clear cover	2.0"
- Top longitudinal bar	1.0" (#8 bar)
- Bottom longitudinal bar	0.75" (#6 bar)
- Bottom transverse bar	0.625" (#5 bar)
- Bottom clear cover	1.0"
= Longitudinal clear distance	2.125"

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Transverse clear distance

Effective Deck Thickness	7.5"
- Top clear cover	2.0"
- Top longitudinal bar	1.0" (#8 bar)
- Top transverse bar	0.75" (#6 bar)
- Bottom transverse bar	0.625" (#5 bar)
- Bottom clear cover	1.0"
= Transverse clear distance	2.125"

For adjacent box or plank beams with a single mat of reinforcement, the spacing of the longitudinal bars are given that satisfies distribution of reinforcement and provides the required area of reinforcement. Also, the area of reinforcement is a minimum of 1% of the total slab area.

The user should use the design output only as a guide. The designer should come up with a practical bar size and spacing and rerun the program as an analysis run.

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3.12 SHEAR DESIGN/ANALYSIS

The program designs and analyzes for shear in a prestressed concrete beam in accordance with LRFD Specifications Article 5.7, Appendix B5, and the corresponding section of DM-4. The program determines the critical section for shear and then calculates the shear resistance due to concrete, prestressing, and mild reinforcing stirrup steel for each analysis point including the critical section for shear. The program computes the values of θ and β by interpolating the data presented in LRFD Specifications Table B5.2-1 based on the total developed longitudinal steel, which includes all the prestress steel and all the mild steel in the slab and beam, with the appropriate reduction of each steel for its development. The actual factored tension and the tensile resistance of the total developed longitudinal steel are also calculated by the program. The equations for the shear design and analysis computations are presented in the above referenced section of the LRFD Specifications and DM-4. Horizontal shear requirements are also checked. The critical section is located at the maximum of the effective shear depth, d_v , or $0.5*d_v*\cot \theta$ from the simple bearing.

The critical sections for shear are based upon a variety of beam, strand, and geometrical properties. The following assumptions are made for this program in computing the critical section for shear.

The program gets the section properties, number of strands, and the CGS for the strands at the left end of the beam based on the following: for straight strand beam design or analysis problems and draped strand beam design problems, all strands are assumed to be fully bonded and are considered with no reduction for development; for debonded strand beam design problems, all the bonded strands required only for flexural design (i.e. ignoring crack control debonding) are assumed to be effective and are considered with no reduction for development; for debonded or draped strand beam analysis problems, all the bonded strands input by the user are assumed to be effective and are considered with no reduction for development. The critical section for shear is then evaluated as to whether it is located within the positive or negative moment region by assuming a trial value of critical distance equal to $0.72h$ from the left centerline of the simple bearing. For composite beams, h equals the depth of the beam plus the effective slab thickness and haunch. For non-composite beams, h equals the depth of the beam. The program then determines the mild steel areas in slab and beam (as applicable) based on the assumed location of the critical section and on the problem type, either beam design or beam analysis.

The effective shear depth in a **positive moment region** is computed by the program as the greater of the following:

1. 0.72 times the total girder depth.
2. 0.9 times the effective depth, d_e , from the extreme compression fiber to the centroid of the tensile force in the tensile reinforcement.
3. The vertical distance between the compressive resultant in the girder cross-section and the tensile resultant in the girder cross-section. This value is determined by the quantity $d_e - d_{CR}$, where d_{CR} is the distance from the top fiber to the centroid of the compression block.

The value of d_e is equal to d_p , the distance to the centroid of the prestressing steel, in positive moment regions and is equal to d_s , the distance to centroid of the mild steel in the slab, in negative moment regions. The beam mild steel is ignored when determining d_e . For beam analysis problems, the beam mild steel is based on the user-input

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values reduced for development appropriately based on the location of the critical section. If the user does not specify beam mild steel and selects a beam designation from the BD standards, the area of beam mild steel is read from the beam table. For beam analysis problems, the CGS of the beam positive mild steel measured from the bottom of the beam (see Figures 5.21-1 through 5.21-14) defaults to the following:

Positive (Bottom) Steel:

<u>Beam Type</u>	<u>CGS</u>
PA I-Beam	T1 + B1
AASHTO I-Beam	D/4
PA Bulb-Tee Beam	D/4

Note: The area of positive steel for box beams, NEXT beams and adjacent plank beams is zero.

Negative (Top) Steel:

<u>Beam Type</u>	<u>CGS</u>
PA I-Beam	D - (T2 + B3)
AASHTO I-Beam	D - (T2 + D1 + B3)
PA Bulb-Tee Beam	D - (T2 + D1 + B3)
Box Beam	D - (T2/2)
Adjacent Plank Beam	D - 4"

Note: The area of negative steel for NEXT beams is zero.

When computing the distance to the centroid of the compression block, d_{CR} , the program only considers the prestressing steel in a positive moment region. Beam mild steel is not considered. Slab mild steel is not considered when computing the critical section for shear in a positive moment region.

The effective shear depth in a **negative moment region** is computed by the program as the greater of the following:

1. 0.72 times the total girder depth.
2. 0.9 times the effective depth, d_e , from the extreme compression fiber to the centroid of the tensile force in the slab reinforcement.
3. The vertical distance between the compressive resultant in the girder cross-section and the tensile resultant in the girder cross-section. This value is determined by the quantity $d_e - C_{res}$, where C_{res} is the distance from the bottom fiber to the centroid of the compression block.

The value of d_e is computed as the distance from the bottom fiber to the center of gravity of the longitudinal slab reinforcement reduced for development appropriately based on the location of the critical section. For beam analysis problems, the longitudinal slab reinforcement is based on the user-input values. For beam design problems, the longitudinal slab reinforcement is designed. For both beam design and beam analysis, the beam mild reinforcement is not considered when computing d_e in a negative moment region.

For a shear design problem, the program designs the shear reinforcement stirrup spacing. Based upon the computed values of V_u , V_c , and V_p at each analysis point within the shear design region, a value of required V_s is

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computed. For the calculation of V_c , the total developed longitudinal reinforcement is considered. Based upon the user inputted shear reinforcement stirrup area, the required shear reinforcement stirrup spacing is then computed. The shear reinforcement stirrup spacing must be within a given range of minimum and maximum values base on the LRFD Specifications and DM-4. The maximum stirrup spacing is limited by the maximum spacing of transverse reinforcement (LRFD Article 5.7.2.6). Additionally, when V_u is greater than $0.5\phi_v(V_c+V_p)$ the maximum stirrup spacing must meet the minimum transverse reinforcement (LRFD Article 5.7.2.5) for the user entered stirrup area. If such a design is not possible and the problem is a beam design, it may be necessary to increase the beam size.

The beam size may also need to be increased for a beam design problem if any of the following conditions exist:

1. If $[(V_u / \phi_v) - V_p] > 0.25f'_c b_v d_v$. (vertical shear)
2. If $V_{n\text{-req}} > K_1 f'_c A_{cv}$. (horizontal shear)
3. If $V_{n\text{-req}} > K_2 A_{cv}$. (horizontal shear)

For a shear analysis problem, the program checks the user inputted shear reinforcement stirrups. Based upon the computed values of V_u , V_c , V_p and the user inputted stirrup area and spacing at each analysis point, the shear strength of the stirrups, V_s , the maximum allowed spacing of the stirrups, $s_{\max}$, and the total shear resistance of the section, V_r , are computed. The value of V_r is then compared with V_u and the value of s is then compared with $s_{\max}$. If the value of V_r is less than the value of V_u or if the value of s is greater than $s_{\max}$, then a warning message is printed in the output, and the program run continues.

3.12.1 Tensile Resistance Provided by Longitudinal Reinforcement

For shear design, the program checks the actual tension versus the tensile resistance provided by the total developed longitudinal reinforcement. The equations used for this check are presented in LRFD Specifications Article 5.7.3.5 and the corresponding section of DM-4. If this check is not satisfied, then the program makes the following revisions:

In the positive moment region:

1. The program reduces the shear stirrup spacing.
2. For a beam design problem, if reducing the shear stirrup spacing fails to provide a satisfactory design, then the program adds prestressing stands to the previously determined strand pattern, returns to the analysis section of the Strand Design/Analysis portion of the program, and continues the design process as outlined in Chapter 2 of this manual.

For a beam analysis problem, if reducing the shear stirrup spacing fails to provide a satisfactory design, then the program prints a warning message and the analysis process continues as outlined in Chapter 2 of this manual.

3. For a beam design problem, if adding prestressing strands fails to provide a satisfactory design, then the program increases the beam size and the design process begins again as outlined in Chapter 2 of this manual.

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In the negative moment region:

1. The program reduces the shear stirrup spacing.
2. For a beam design problem, if reducing the shear stirrup spacing fails to provide a satisfactory design, then the program adds longitudinal mild reinforcement in the slab to the previously determined negative moment longitudinal mild reinforcement in the slab, returns to the capacity calculation section of the Negative Moment Capacity portion of the program, and continues the design process as outlined in Chapter 2 of this manual. If the specified longitudinal slab reinforcement is not sufficient, the design stirrup spacing can be substantially low.

For a beam analysis problem, if reducing the shear stirrup spacing fails to provide a satisfactory design, then the program prints a warning message and the analysis process continues as outlined in Chapter 2 of this manual.

3. For a beam design problem, if adding longitudinal mild reinforcement in the slab fails to provide a satisfactory design, then the program increases the beam size and the design process begins again as outlined in Chapter 2 of this manual.

For shear analysis, the program checks the required tensile resistance versus the actual tensile resistance provided by the total developed longitudinal slab reinforcement and beam mild reinforcement. If this check is not satisfied, then a warning message is printed in the output, and the program run continues.

3.12.2 Accounting for Crack Control Debonding in Shear Design and Shear Analysis

Both shear design and shear analysis are affected by the presence of debonded strand due to the change in effective prestress force. Thus, the program conservatively performs all the required shear calculations for both shear design and shear analysis based on the assumed crack control debonding presented in Table 1.

Table 3.12-1 Assumed Crack Control Debonding for Shear Calculations

Strand Configuration	Beam Design	Beam Analysis
Straight (fully bonded)	Maximum crack control debonding inserted	Input crack control debonding inserted
Debonded (Straight)	Maximum crack control debonding inserted	Input crack control debonding inserted
Draped	Maximum crack control debonding inserted	Input crack control debonding inserted

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For beam design, the program assumes the maximum crack control debonding allowed by Publication 408, Section 1107.01. Thus, for all strand configuration types, the program assumes the following: that from the end of the beam to 6 inches along the beam, 50% of all prestressing strands are debonded for crack control; that from 6 inches to 3 feet along the beam from the end of the beam, 25% of all prestressing strands are debonded for crack control; and that beyond 3 feet from the end of the beam there is no crack control debonding.

For beam analysis, the program uses the crack control debonding information provided by the user. For straight and draped strand beam analysis, the program issues a warning message if the user has not inputted crack control debonding using the DBS command (Section 5.26). In such a case, the program performs all required shear calculations assuming that there is no crack control debonding. For debonded strand beam analysis, the program performs all required shear calculations based on the user inputted debonded strand pattern using the DBS command. For this case, the program makes no distinction between the typical debonded strands and the crack control debonding (if any). Thus, the user is responsible for ensuring that any and all crack control debonding has been entered along with the typical debonded strands in the DBS command.

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3.13 END ZONE

The program calculates the required area of transverse stirrup steel and the distribution distance to resist end zone splitting stresses in the girder. The required area of transverse steel in the girder end zone is computed in accordance with LRFD Specifications Article 5.9.4.4.1, as follows:

$$Req'd A_{sr} = \frac{0.04 P_{Transfer}}{f_s}$$

Where: $f_s = 20ksi$

The required distribution end zone distance for area of transverse steel is computed as follows:

$$Req'd X_{sr} = \frac{d}{4}$$

Solid block section properties are used for box beams when performing end zone computations. The paving notch is determined in accordance with PennDOT Standards BD-661M and BD-662M. Initial tensile stresses are computed using the full depth section and the section reduced by the paving notch, and the program prints the results for both.

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3.14 POSITIVE MOMENT CONNECTION

When the continuous analysis option is selected, the program determines the required area of reinforcement for the positive moment connection at each interior support.

The program determines the required area of steel for the positive moment connection at each support. This computation is required only for prestressed concrete beams made continuous for live load.

The nominal flexural resistance, M_n , for the positive moment connection is computed as follows:

$$M_n = T \left(d_s - \frac{t_s}{2} \right) - C_1 \frac{h_f}{2} - C_2 \left(\frac{\beta_1 c}{2} - \frac{t_s}{2} \right)$$

where:

$$C_1 = 0.85 f'_c (b - b_w) (t_s + h_f)$$

$$C_2 = 0.85 f'_c b_w \beta_1 c$$

$$T = A_s f_y$$

In the above equations, the values for b and b_w depend on the location of the neutral axis, as presented in Table 1.

Table 3.14-1 Width Values

Location of Neutral Axis	Value for b	Value for b_w
Neutral axis in slab	Effective slab width	Effective slab width
Neutral axis in flange	$(\text{Flange width}) \left(\frac{\text{Beam } f'_c}{\text{Slab } f'_c} \right)$	$(\text{Flange width}) \left(\frac{\text{Beam } f'_c}{\text{Slab } f'_c} \right)$
Neutral axis in web	$(\text{Flange width}) \left(\frac{\text{Beam } f'_c}{\text{Slab } f'_c} \right)$	$(\text{Web width}) \left(\frac{\text{Beam } f'_c}{\text{Slab } f'_c} \right)$

For checking the positive moment connection, the program uses the effective slab width.

The program initially assumes an infinitesimally small value for area to proceed with the computation for positive moment connection steel and evaluates it using an iterative procedure. The required flexural capacity to be provided by the positive moment connection steel is computed as follows:

$$M_u = \text{Maximum} \left[M_{UD}, \text{Minimum} \left(M_{cr}, \frac{4}{3} M_{UD} \right) \right]$$

Where: M_{UD} = factored positive moment based on the controlling combination of dead load, live load, and creep and shrinkage at the support being considered. Future wearing surface (FWS) moments will be included only if the FWS moment is positive.

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M_{cr} = cracking moment of the section.

The program then uses the above equations and an assumed value of A_s , 0.001 in², to check if the moment provided by the positive moment connection exceeds the required moment at the positive moment connection. If the positive moment connection meets the requirements, then the assumed value of A_s is used for the steel area. However, if the positive moment connection does not meet the requirements, then the assumed value of A_s is gradually increased. The iterative procedure is then repeated until the positive moment connection requirements are satisfied.

For positive mild steel reinforcement, the development length is measured from the end of the girder towards the midspan.

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3.15 FATIGUE STRESS CHECK IN PRESTRESSED STRANDS

The program checks the fatigue stress range in the prestressing steel at the location of maximum fatigue live load and at drape points if draped strands are used. The effective fatigue stress range is checked against allowable limits.

In regions of compressive stress due to permanent loads and prestress, the fatigue stress check is performed only if the compressive stress is less than the maximum tensile live load stress resulting from the Fatigue I load combination.

For problems in which the fatigue stress check is required, the program uses the equations (including the use of dead load) as presented in LRFD Specifications Article 5.5.3 and the corresponding section of DM-4.

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3.16 RATINGS

For both analysis and design runs, the program computes ratings for service moment, strength moment, and strength shear at all applicable analysis points. Rating factors are computed for each applicable live load vehicle. Rating summary tables are developed which present the controlling rating factors for each vehicle, as well as the corresponding location and rating tonnage. The program prints a warning for any rating factor that is less than 1.0.

The rating tonnage is computed as the product of the rating factor and the corresponding vehicle weight in tons.

For both the H and HS live loadings, the controlling rating factor from either the truck loading or the lane loading is multiplied by the truck loading weight to compute the rating tonnage.

Since HL-93 and PHL-93 live loadings are based on a combination of various effects, there is no unique corresponding vehicle weight. Therefore, for HL-93 and PHL-93, no rating tonnage is computed. In addition, for special live loadings, which can include a uniform lane load component, no rating tonnage is computed.

The Strength I, Strength IP, Service I, Service IP, Service III and Service IIIP limit states are used for the inventory rating. The Strength IA, Strength II, and Service IIIA limit states are used for the operating rating. The live load designations used for each limit state are summarized in Table 2.6-1.

For design runs and analysis runs with shear design (stirrups not specified), the program always includes FWS (future wearing surface) loading in the live load rating computations. For analysis runs with shear analysis, if the user does not want FWS loading to be included in the live load rating computations, then FWS loading should be omitted from the input commands or both ratings with and without FWS should be requested.

3.16.1 Service Moment Ratings

For Service I, Service IP, Service III and Service IIIP moment, the rating factor is defined by the following general equation:

$$RF = \frac{F_R - (f_{P/S} + f_{DL} + f_{PL} + f_{C\&S})}{f_{LL}}$$

Where: RF	=	rating factor
F_R	=	allowable concrete stress
$f_{P/S}$	=	stress due to prestressing steel
f_{DL}	=	stress due to all dead loads (both non-composite and composite)
f_{PL}	=	stress due to pedestrian loading
$f_{C\&S}$	=	stress due to creep and shrinkage loading
f_{LL}	=	stress due to vehicular live loading and dynamic load allowance

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For Service IIIA moment, the rating factor is defined by the following general equation:

$$RF = \frac{Mr_{0.9f_{py}} - [M_{DL}]}{M_{LL}}$$

Where: RF = rating factor

$Mr_{0.9f_{py}}$ = moment capacity based on a stress of $0.9f_{py}$ in the bottom row of the prestressing steel

M_{DL} = moment due to all dead loads (both non-composite and composite)

M_{LL} = moment due to vehicular live loading and dynamic load allowance

The above general equations are used to compute each of the following rating factors:

1. Compression at the top of the girder.
2. Compression at the top of the slab.
3. Compression at the bottom of the girder.
4. Tension at the bottom of the girder.
5. Tension at the top of the girder.

The signs used in the above general equation vary with each of the above computations, depending on whether compression or tension is being considered and whether the top or bottom is being investigated.

If the live load vehicle does not produce the desired effect, then that particular rating factor is set to 100.0. For example, if the rating factor based on compression at the top of the girder is being computed and the live load vehicle is found to produce tension at the top of the girder for the analysis point being considered, then the rating factor based on compression at the top of the girder is set to 100.0 for that particular analysis point.

Stresses due to prestressing steel are computed based on basic beam, gross section, section properties. Stresses due to non-composite dead loads are computed based on basic beam, gross section, section properties. Stresses due to composite dead loads are computed based on composite beam, gross section, and section properties. Stresses due to pedestrian loading are computed based on composite beam, gross section, section properties. Stresses due to vehicular live loading and dynamic load allowance are computed based on composite beam, transformed section, section properties.

For service moment, inventory rating factors are computed for Service I and Service III limit states and operating rating factors are computed for Service IIIA limit state.

3.16.2 Strength Moment Ratings

For strength moment, the rating factor is defined by the following general equation:

$$RF = \frac{M_r - (M_{DL} + M_{PL} + M_{C\&S})}{M_{LL}}$$

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where: RF	=	rating factor
M_r	=	strength moment resistive capacity of section
M_{DL}	=	moment due to all dead loads (both non-composite and composite)
M_{PL}	=	moment due to pedestrian loading
$M_{C\&S}$	=	moment due to creep and shrinkage loading
M_{LL}	=	moment due to vehicular live loading and dynamic load allowance

The above general equation is used to compute rating factors for both positive flexure and negative flexure.

If the live load vehicle does not produce the flexure being considered, then that particular rating factor is set to 100.0. For example, if the rating factor based on positive flexure is being computed and the live load vehicle is found to produce negative flexure for the analysis point being considered, then the rating factor based on positive flexure is set to 100.0 for that particular analysis point.

For strength moment, inventory rating factors are computed for Strength I and Strength IP limit states and operating rating factors are computed for Strength IA and Strength II limit states.

3.16.3 Strength Shear Ratings

For strength shear, the rating factor is defined by the following general equation:

$$RF = \frac{V_r - (V_{DL} + V_{PL})}{V_{LL}}$$

Where: RF	=	rating factor
V_r	=	strength shear resistive capacity of section
V_{DL}	=	shear due to all dead loads (both non-composite and composite)
V_{PL}	=	shear due to pedestrian loading
V_{LL}	=	shear due to vehicular live loading and dynamic load allowance

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The above general equation is used to compute rating factors for both positive shear and negative shear.

In computing the strength shear rating factor, the program uses both the positive value of live load shear and the negative value of live load shear and reports the live load shear with the smaller rating factor. If the sign of the shear due to all dead loads and pedestrian loading is opposite the sign of the live load shear, then the shear due to all dead loads and pedestrian loading is added rather than subtracted in the above equation and the absolute value of live load shear is used.

The program must perform an iterative process to compute the strength shear rating factors for prestressed concrete girders. The shear strength at any given section is a function of the maximum factored shear force and the maximum factored moment acting at that point, which are dependent on the live load. Therefore, an iterative process is required to ensure that the shear strength used in the rating factor computation corresponds correctly with the computed rating factor.

When the numerator in the expression for the rating factor is negative, the iterative process is skipped and the shear resistance computed from the applied loads is used to compute the rating factor. The rating factor will be negative since the numerator is negative. Also, the longitudinal tension (see below) is skipped since the reduction factor could be negative.

Next, the program checks the actual and required tensile resistance using the live loads increased by the computed rating factor. If the actual longitudinal tension is less than the required tension then the rating factor is reduced by the following factor:

$$RF_T = \frac{T_{act} - T_{req-dl}}{T_{req-ll}}$$

Where: RF_T = Reduction factor for tensile resistance

T_{act} = Actual tensile resistance

T_{req-dl} = Required tensile resistance for dead load

T_{req-ll} = Required tensile resistance for live load

Shear rating factors that have been reduced are flagged in the detailed rating factor output report.

For strength shear, inventory rating factors are computed for Strength I and Strength IP limit states and operating rating factors are computed for Strength IA and Strength II limit states.

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3.17 DEFLECTION AND CAMBER

The program also computes the deflection and camber for prestressed concrete beams. Deflection values are computed based on prestressing; girder self-weight, including interior diaphragm weight; slab, formwork, and exterior diaphragm weight; and superimposed dead load weight. Camber values are computed based on initial camber; initial camber, adjusted for creep; and final camber.

3.17.1 Deflection

The program computes the deflection due to prestressing steel as follows:

$$\Delta_{P/S} = \frac{P e_s L^2}{8 E_{ci} I} \quad \text{for straight bonded strands}$$

$$\Delta_{P/S} = \frac{P L^2 [4 X^2 (e_n - e_s) + 3 e_s]}{24 E_{ci} I} \quad \text{for draped strands}$$

$$\Delta_{P/S} = \frac{P e_s [L^2 - (L_t + 2 L_x)^2]}{8 E_{ci} I} \quad \text{for debonded strands}$$

The prestressing force, P, is the jacking force reduced by the assumed prestress losses or the loss entered for parameter 5, "Estimated % P/S Loss", of the MPS command. For beams containing prestressing strands of more than one type or debonded length, the deflection due to prestressing steel is computed for each set of strands of the same type or debonded length using the P and e corresponding to that set of strands. The final deflection due to prestressing steel is determined by the sum of the deflections for each set.

The program computes the following deflections using the routines of the CBA program:

1. Δ_{SW} = deflection due to girder self-weight, including interior diaphragm weight
2. Δ_s = deflection due to slab, formwork, and exterior diaphragm weight
3. Δ_{SDL} = deflection due to superimposed dead load weight
4. Δ_{LL+I} = deflection due to live load including dynamic load allowance

3.17.2 Camber

Camber values are then computed based on the above deflection values. The program computes the initial camber as follows:

$$C_I = \Delta_{P/S} - \Delta_{SW}$$

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The program computes the initial camber, adjusted for creep, as follows:

$$C_{IA} = C_I C_r$$

Finally, the program computes the final camber as follows:

$$C_F = C_{IA} - \Delta_S - \Delta_{SDL}$$

The program calculates two sets of camber values. One set of values should be used for establishing the beam seat elevations, and the other set of values should be used for checking for probable beam sag.

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3.18 MAXIMUM PARAPET OVERHANG

The program computes an approximation for the maximum overhang width such that the final stress in the interior and exterior girders is the same. The program assumes that the interior and exterior girders have the same section properties.

The maximum parapet overhang is not computed if any of the following three conditions exist:

1. The girder is noncomposite.
2. The girder is an adjacent box beam, a Type F NEXT beam, or a Type D NEXT beam.
3. The girder is an exterior girder.

If none of the above three conditions exists, then the program computes the maximum parapet overhang using an iterative process. Initially the allowable overhang, δ , is assumed to be one-half of the girder spacing. If the calculated value is within 3 inches of this assumed value, then the procedure is finished and the resulting δ value is the allowable parapet overhang. However, if the calculated value is not within 3 inches, then the average of the assumed value and the calculated value is taken as the new assumed value and δ is recalculated. This iterative process continues until the calculated and assumed values are within 3 inches of one another.

The program calculates the allowable overhang, δ , as follows:

$$\delta = \frac{C_{numer}}{C_{denom}}$$

Where:

$$C_{numer} = A[CL^2 N_{b2} W_2 Z_{bc} Z_{bct} Y_c - 3C_{fact}] + 48N_{b2} PZ_b Z_{bc} Z_{bct}$$

$$C_{denom} = 6AL^2 N_{b2} Z_{bct} [CZ_{bc} Y_c + T_4 Z_{bc} Y_c + T_5 Z_{bc} Y_c + Z_b Y_f t_{fws} + Z_{bc} Y_c (t_{add} + t_s)]$$

In performing the above computations, the program must compute the single lane distribution factor, based on the lever rule, multiplied by the single lane presence factor. It also computes the correction factor to be applied to the interior girder distribution factor to obtain the exterior girder distribution factor.

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3.19 STRAND CODE DETAIL CHECKS

The program checks the vertical and horizontal minimum strand spacings. These strand code detail checks are performed using the equations presented in LRFD Specifications Article 5.9.4.1 and the corresponding section of DM-4.

If any of these conditions are not satisfied, the program prints an error message for design and a warning message for analysis.

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3.20 PRINCIPAL STRESSES

The program is also capable of computing the approximate principal stresses at significant locations along the girder.

The program computes principal stresses for each analysis point and at points immediately before and after the drape point for beams with draped strands. They are computed at selected vertical positions within the beam.

Principal stresses are computed based on unfactored loads. They are then computed based on the controlling factored strength limit state loads.

As with all other computations, the program uses maximum shears and maximum moments for each live loading for principal stress computations.

The general equations for principal stresses are as follows:

$$\sigma = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left[\frac{\sigma_x - \sigma_y}{2} \right]^2 + \tau_{xy}^2}$$

$$\tan 2\theta = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

Note:

Principal Stresses are not usually needed for design calculations. This option has been provided for research purposes.

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3.21 CALCULATION OF MR @ 0.9 F_{py}

Service IIIA Limit State requires the checking of the factored flexural resistance of a section in bending with the bottom prestressing strands having a stress of 0.9 of the yield strength of the prestressing steel. A moment-curvature analysis is used to determine the applied moment that will result in a stress of 0.9f_{py} in prestressing strands in the bottom row of the beam cross section. The moment-curvature analysis is based on equilibrium and compatibility conditions along with the material stress-strain relationships.

3.21.1 Stress-Strain Curves for Concrete

The stress-strain relationship for concrete compression is represented by a parabola as shown in Figure 1 and given by the following equations from *Prestressed Concrete Structures*, Michael P. Collins, Denis Mitchell, Prentice-Hall, 1991:

$$\frac{f_c}{f'_c} = 2 \frac{\epsilon_c}{\epsilon_0} - \left(\frac{\epsilon_c}{\epsilon_0} \right)^2 \quad (\text{Eq. 3-7 Collins \& Mitchell, 1991})$$

$$\epsilon_0 = \frac{f'_c}{E_c} \left(\frac{n}{n-1} \right) \quad (\text{Eq. 3-5 Collins \& Mitchell, 1991})$$

$$n = 0.8 + \frac{f'_c}{2.5} \quad (\text{Eqs. 3-4 Collins \& Mitchell, 1991})$$

where;

f_c = stress in concrete

ϵ_c = strain in concrete caused by concrete stress, f_c

f'_c = peak stress obtained from a cylinder test

ϵ_0 = strain when f_c corresponds to f'_c

n = curve-fitting factor

E_c = modulus of elasticity of concrete

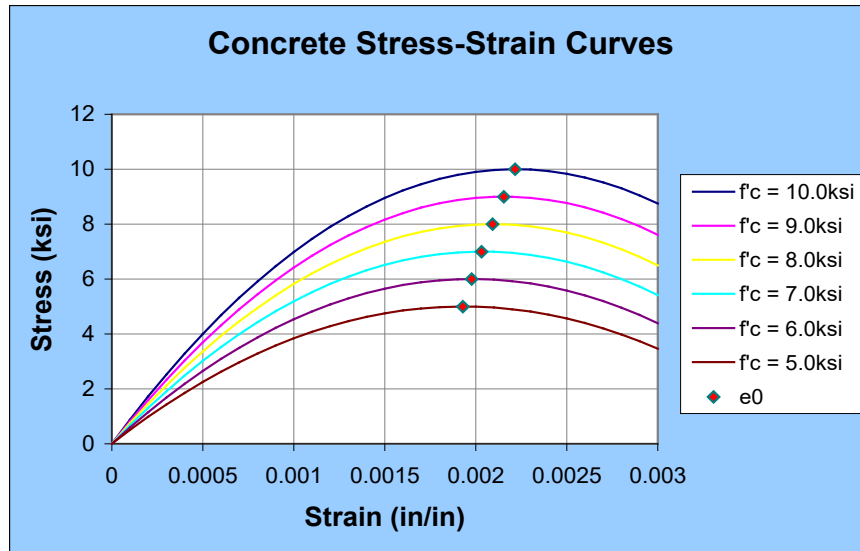


Figure 3.21-1 Concrete Compressive Stress-Strain Response

3.21.2 Stress-Strain Curves for Prestressing Steel

The stress-strain relationship for prestressing strands is represented by the modified Ramberg-Osgood function.

Modified Ramberg – Osgood Function

$$f_s = E_p \epsilon_p \left\{ A_p + \frac{1 - A_p}{\left[1 + (B_p \epsilon_p)^{C_p} \right]^{1/C_p}} \right\} \leq f_{pu} \quad (\text{Eq. 3-25 Collins \& Mitchell, 1991})$$

with; (EQ 3 – 26, 3 – 27 Collins and Mitchell)

$A_p = 0.025$ (low – relaxation) 0.03 (stress – relieved)

$B_p = 118$ (low – relaxation) 121 (stress – relieved)

$C_p = 10$ (low – relaxation) 6 (stress – relieved)

This function consists of two straight lines joined by a curve. The coefficients A_p , B_p , C_p of the function for both low-relaxation strands and stress-relieved strands are used to plot the curves in Figure 2. The first straight line passes through the plot origin and has a slope of E_p . The second straight line has a slope of $A_p * E_p$ and intersects the y-axis at:

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$$\text{Point 1} = \left[0, \left(\frac{1 - A_p}{B_p} \right) E_p \right]$$

This gives the equation of the second line as:

$$y = A_p E_p x + \left(\frac{1 - A_p}{B_p} \right) E_p \quad (y = mx + b \text{ form})$$

The strains in the concrete are assumed uniform over the width of the section and vary linearly over the depth of the section. The strain in the prestressing strands is equal to the strain in the surrounding concrete plus the strain difference in the prestressing strands. The equilibrium conditions require that the sum of all forces acting over the section equal zero and the moment of these forces acting over the section equal the applied moment.

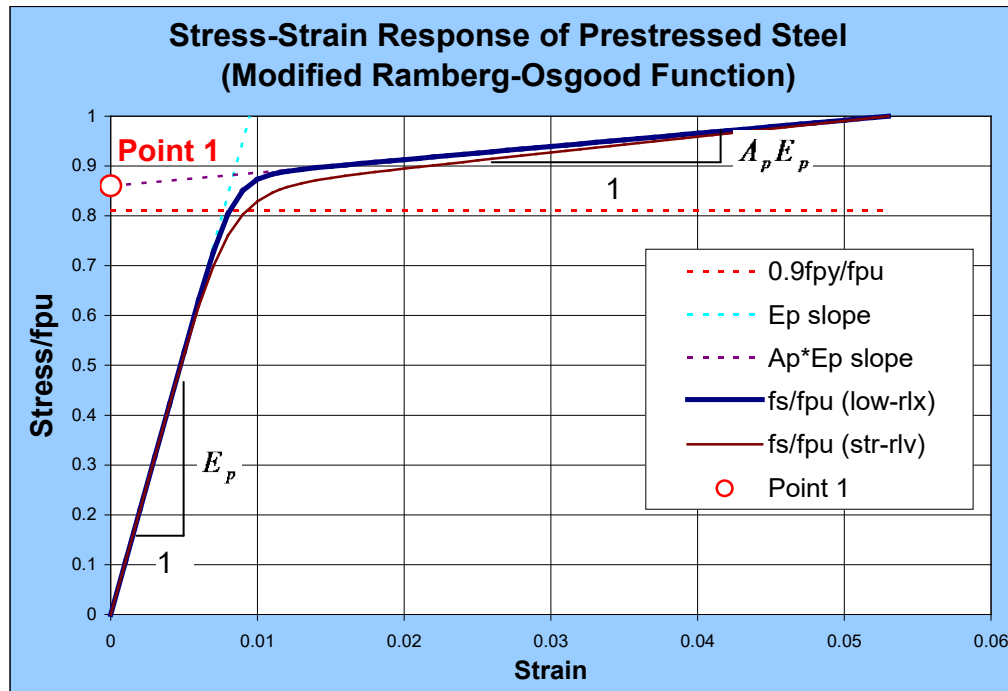


Figure 3.21-2 Modified Ramberg-Osgood Function

3.21.3 Composite Construction Effects on Strain Distributions

Composite construction will cause a strain discontinuity at the interface of the concrete in the beam and the concrete in the composite slab. At the time when the slab concrete is placed there will be existing strains in the precast beam while the strains in the slab will be zero. After the slab concrete has hardened, the two concretes at the interface will undergo the same changes in strain and hence the strain discontinuity will remain constant throughout the life of the member. The total concrete strain can be expressed as the sum of the initial strain and the additional strains. The initial strain in the concrete is the sum of the strains

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caused by the effective prestressing force and the applied non-composite dead loads. The initial strain in the prestressing strands is computed from the effective prestress force. The Initial, Non-Composite, Composite, and Final Strains are shown in Figure 3.

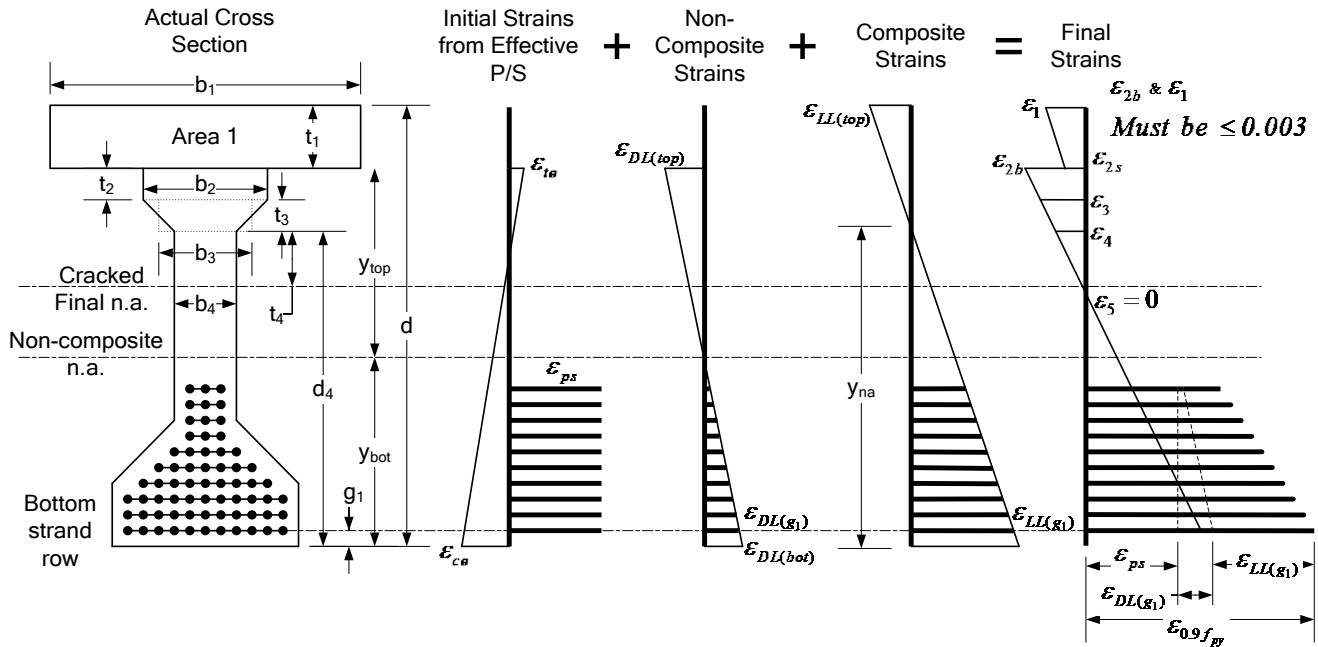


Figure 3.21.3 Concrete and Prestressing Strain Distributions

The initial strain in the concrete due to the effective prestressing force at the top and bottom of the precast beam is computed by the following equations. Note: For the initial strains the beam is assumed to be elastic and strains can be computed from stresses using a constant modulus of elasticity.

$$\epsilon_{ce} = \frac{\left(\frac{-P}{A_g} + \frac{Pe(-y_{bot})}{I_g} \right)}{E_c} \quad \epsilon_{te} = \frac{\left(\frac{-P}{A_g} + \frac{Pe(y_{top})}{I_g} \right)}{E_c}$$

The initial strain in the prestressing strands due to the effective prestressing force is computed by:

$$\epsilon_{ps} = \frac{\left(\frac{P}{A_{ps}} \right)}{E_p}$$

The additional strains on the non-composite section are computed from the applied non-composite moment using the following equations:

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$$\varepsilon_{DL(bot)} = \left(\frac{M_{DNF}(-y_{bot})}{I_g} \right) \frac{1}{E_c} \quad \varepsilon_{DL(top)} = \left(\frac{M_{DNF}(y_{top})}{I_g} \right) \frac{1}{E_c} \quad \varepsilon_{DL(g_1)} = \left(\frac{M_{DNF}(-y_{bot} + g_1)}{I_g} \right) \frac{1}{E_c}$$

If the non-composite strain and the initial prestressing strain is larger than the concrete tension rupture strain then the applied non-composite load will cause the concrete beam to crack and the assumed elastic behavior is not valid. In this case, the non-composite moment is ignored by setting the non-composite dead load strains to zero and the analysis proceeds considering all of the moments applied to the cracked composite section.

The total strain in the bottom row of the prestressing strands is set to cause a stress of $0.9f_{py}$. For Low Relax strands, if the yield stress is $0.9f_{pu}$ then this stress would be $0.81f_{pu}$. For Stress Relieved strands, if the yield stress is $0.85f_{pu}$ then this stress would be $0.765f_{pu}$. Referring to Figure 2 for the modified Ramberg-Osgood curve this stress corresponds to the beginning of the transition from the first straight line to the curved line. An iterative procedure is used to find the strain that results in a stress of $0.9f_{py}$. This strain value is noted as $\varepsilon_{0.9f_{py}}$ and must be equal to the sum of all strains in the bottom row of prestressing strands:

$$\varepsilon_{0.9f_{py}} = \varepsilon_{ps} + \varepsilon_{DL(g_1)} + \varepsilon_{LL(g_1)}$$

where;

$$\varepsilon_{LL(g_1)} = \text{Strain in prestressing steel from composite moments}$$

The moment-curvature analysis proceeds by setting the strain in the bottom row of prestressed strands and iterating the location of the neutral axis so that the net force from the final strains is zero.

The compressive force in the concrete section is computed from the average stress on each rectangular layer of the cross section (see Figure 4) where the average stress is the average of the stress at the top and bottom of the rectangular layer. The location of the resultant compressive force for each layer corresponds to calculating the centroid for a trapezoid.

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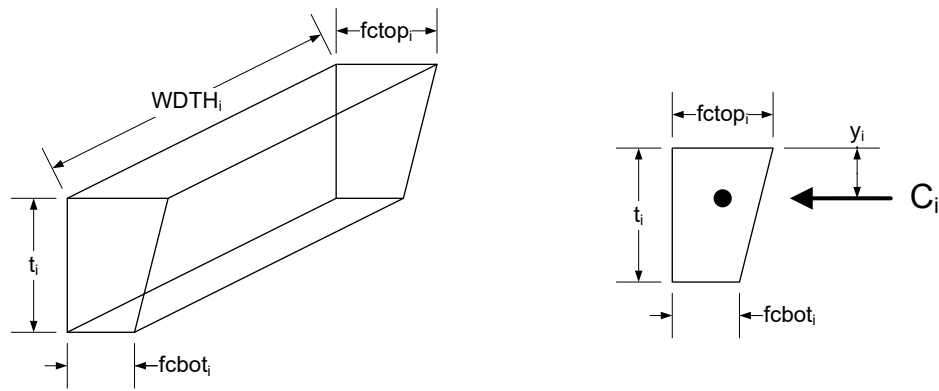


Figure 3.21-4 Stress on Rectangular Layer of the Cross Section

The strain in each row of prestressing strands is determined. From the strain in each row the stress is computed using the modified Ramberg-Osgood function shown in Figure 2. From the stress, the force for each row is determined from the number of strands per row and the area of one strand.

Finally, the moment capacity is determined by computing the moments of the tension and compression forces about a point as shown in Figure 5.

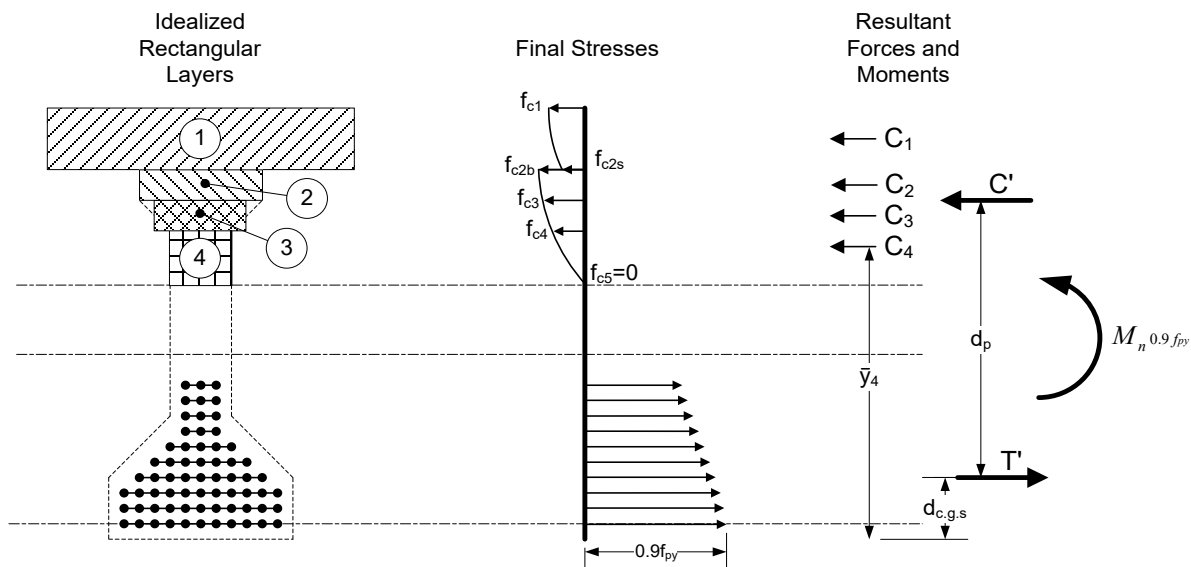


Figure 3.21.5 Calculation of Sectional Forces and Moments

The procedure followed by the program is summarized in Figure 6 along with the equations used to compute the strains, stresses, forces, and moments.

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PROCEDURE 1. Compute initial strains for the concrete and P/S strands from the effective P/S force. 2. Compute additional strains for the non composite moment 3. Compute the composite strain req'd to produce stress of 0.9f_{py} in the bottom row of strands 4. Assume location of NA. 5. Compute final strains in the concrete and the P/S strands. 6. Compute the compressive stress in the concrete and the tensile stress in the P/S strands. 7. Compute the total compressive force (C') in the concrete and the total tensile force (T') in the P/S strands. 8. Compare C' and T'. If (C' - T')/T' > 0.01%, then choose new n .a. and go to step 5. 9. Compute moment arm(d_p). 10. Compute moment capacity(M_{0.9fpy}).	STRAIN EQUATIONS Initial strain in concrete due to P and e: $\epsilon_{ce} = \frac{\left(\frac{-P}{A_g} + \frac{Pe(-y_{bot})}{I_g} \right)}{E_c}$ $\epsilon_{te} = \frac{\left(\frac{-P}{A_g} + \frac{Pe(y_{top})}{I_g} \right)}{E_c}$ Non-Composite Strains $\epsilon_{DL(bot)} = \frac{\frac{M_{DNF}(-y_{bot})}{I_g}}{E_c}$ $\epsilon_{DL(top)} = \frac{\frac{M_{DNF}(y_{top})}{I_g}}{E_c}$ $\epsilon_{DL(g_1)} = \frac{\frac{M_{DNF}(-y_{bot} + g_1)}{I_g}}{E_c}$	Initial Strain in strands $\epsilon_{ps} = \frac{\left(\frac{P}{A_{ps}} \right)}{E_p}$ Strain req'd to produce stress 0.9 f_{py} in bot. row of strands: $\epsilon_{LL(g_1)} = \epsilon_{0.9 f_{py}} - \epsilon_{ps} - \epsilon_{DL(g_1)}$ $\epsilon_{LL(top)} = \frac{\epsilon_{LL(g_1)}(d - y_{na})}{y_{na} - g_1}$ Strain at fc: $\epsilon_0 = \frac{f'_c}{E_c} \left(\frac{n}{n-1} \right)$ Where: $n = 0.8 + f'_c / 2.5$
STRESS EQUATIONS Compressive concrete stress at strain ε_c: $f_c(\epsilon_c) = f'_c \left[\frac{2\epsilon_c}{\epsilon_0} - \left(\frac{\epsilon_c}{\epsilon_0} \right)^2 \right]$ Tensile stress in P/S strands at strain : $f_s(\epsilon_p) = E_p \epsilon_p \left\{ A_p + \frac{1 - A_p}{\left[1 + (B_p \epsilon_p)^{C_p} \right]^{1/C_p}} \right\} \leq f_{pu}$ Where: A_p = 0.025, B_p = 118, C_p = 10 (low-relaxation strands) A_p = 0.030, B_p = 121, C_p = 6 (stress-relieved strands)	FORCE EQUATIONS Compressive Force in concrete section : $C_i = \frac{(f_{c(i)} + f_{c(i+1)})}{2} b_i t_i$ Total compressive force $C' = \sum C_i$ Tensile Force in P/S strand row j: $T_j = f_{s(j)} A_{ps} N_j$ Total tensile force $T' = \sum T_j$	
MOMENT ARM Distance from C₁ to bottom of beam: $\bar{y}_i = d_i - \frac{(f_{c(i)} + 2 f_{c(i+1)})}{(f_{c(i)} + f_{c(i+1)})} \left(\frac{t_i}{3} \right)$ $d_{c.g.s.} = \sum T_j g_j / \sum T_j$ $d_p = \frac{\sum C_i \bar{y}_i}{\sum C_i} - d_{c.g.s.}$	MOMENT CAPACITY $\sum M_{c.g.s.} = 0$ $M_{n\ 0.9\ f_{py}} = 0.5\ (T' + C') d_p$ $M_{r\ 0.9\ f_{py}} = \phi\ M_{n\ 0.9\ f_{py}}$ $\phi = 1.0$	

Figure 3.21.6 Summary of Procedure and Equations

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3.21.4 Solving For the Location of the Neutral Axis (N.A.)

The location of the neutral axis must be determined so that the sum of the forces acting on the cross section is zero. Compression forces exist in the concrete above the neutral axis. Starting with an assumed location of the N.A. the net forces acting on the cross section are computed. The location of the N.A. is iterated until the resultant force is within a tolerance of zero. The iteration process is started with an assumed N.A. location of 25% of the total depth (measured from the top of the cross section). Newton's Method is used to compute the next N.A. location using the following equation:

$$X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)}$$

where;

$$X_{n+1} = \text{next iteration value}$$

$$X_n = \text{previous iteration value}$$

$$f(X_n) = \text{previous function value (Net Force)}$$

$$f'(X_n) = \text{derivative (slope) at previous function value}$$

The derivate is determined by changing the previous iteration value by a small delta amount and re-computing the function value as follows:

$$f'(X_n) = \frac{f(X_n + \Delta X) - f(X_n)}{\Delta X}$$

Since this procedure divides by the derivative, numerical problems will arise if the minimum of the function is not less than zero and the derivative starts to approach zero. To prevent this condition, an iteration is made with the maximum concrete strain set to 0.003 and the net compressive force is compared to the net tension force. If the net compressive force is less than the net tension force this means the specified tension in the bottom strands can not be met and does not represent a feasible stress condition for the given section. The specified bottom strand tension is reduced until the net compressive force is larger than the net tension force. This ensures the iterations will converge without numerical difficulties.

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The following example illustrates the process. The initial trial location is based on 25% of the total depth of 54 inches, 13.5 inches. This results in a net force of 913.5 kips tension on the cross section. From this starting point the next iteration is computed to be 20.607 inches. The iteration quickly converges and stops with the N.A. location being 22.308 inches and a net force of 0.018 kips on the section. Graphically, in Figure 7, from the starting value of 13.5 inches at the net force of 913.5 kips a line tangent to the curve is extended to the intersection of the x axis to get the next value for the iteration process. This process is repeated until the net force approaches zero.

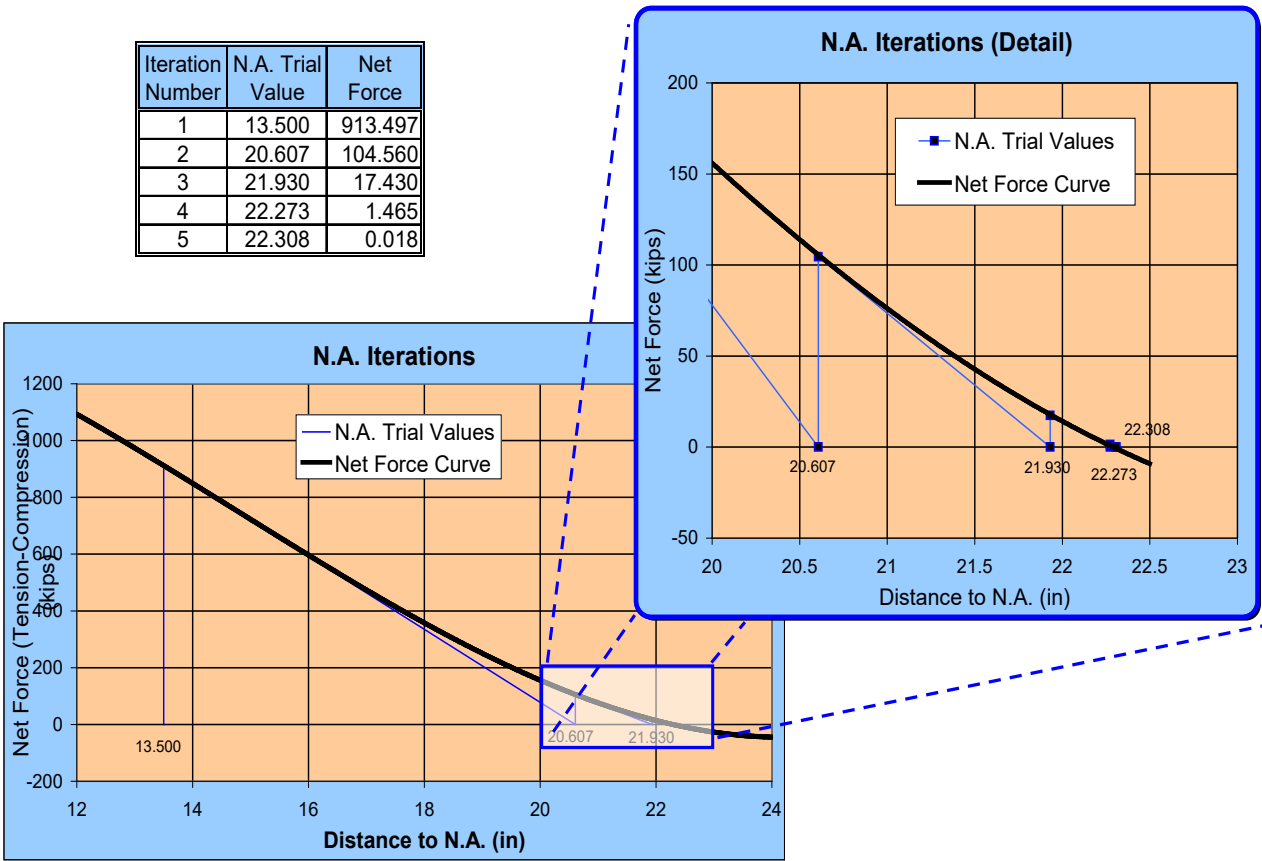


Figure 3.21-7 Neutral Axis Iterations

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3.22 DAPPING

An elastomeric bearing pad (plain or reinforced) requires that the planes formed by the bottom of the beam bearing area and the top of the beam seat are parallel unless the bearing pad is specifically designed to accommodate the slope differential. One of the acceptable methods for modifying the bottom of beam bearing area is to cast a beveled notch in the underside of the beam. This is referred to as *dapping*. See Figure 3.22-1 for Typical P/S Concrete Beam Dap Detail.

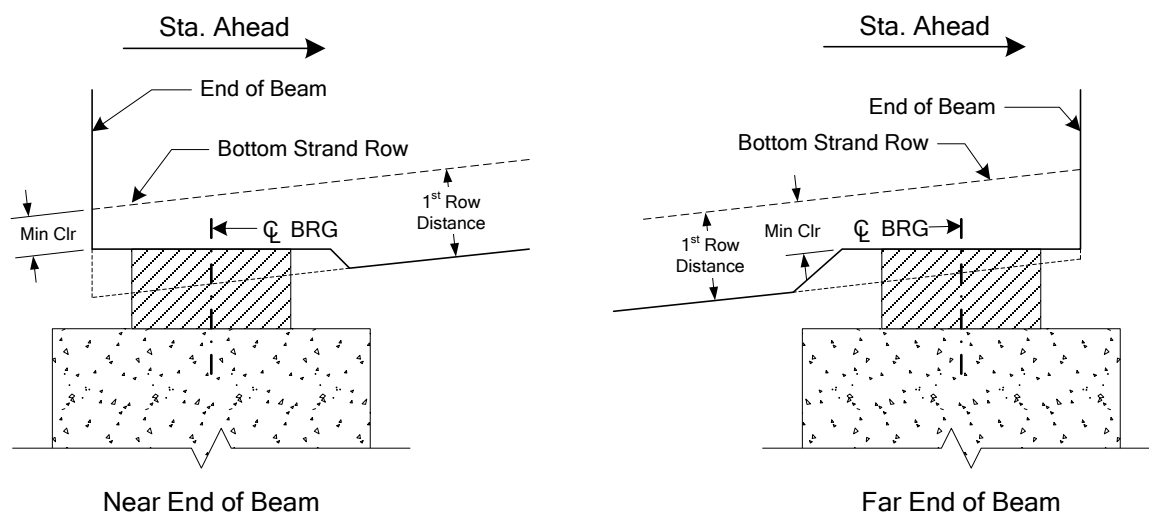


Figure 3.22-1 Typical P/S Concrete Beam Dap Detail

To maintain the minimum concrete cover on the bottom row of prestressing strands, the distance from the bottom of the beam to the centerline of the prestressing strand bottom row must be increased by an amount equal to the maximum dapping distance. The distance to the bottom row of prestressing strands can be entered by the user.

When dapping is used on spread and adjacent box beams, the program increases the thickness of the bottom flange to ensure that the minimum concrete cover is provided on the prestressing strands adjacent to the inner void of the box beam. The thickness is based on the distance to the first row of prestressing strands and the bottom flange thickness given in the table for Box Beam Dap Design Parameters on BD-661M sheet 3 of 8.

When dapping adjacent box beams or adjacent plank beams, the program adjusts the number of allowable strands in each row to avoid interference with transverse tendons.

When dapping I-Beams (PENNDOT or AASHTO) or Bulb Tees beams, the program adjusts the number of allowable strands in each row to maintain the minimum concrete covers on prestressing strands and the confinement reinforcement bars. Based on the distance to the first strand row entered by the user, a strand pattern is selected so that the entered distance is less than or equal to the distance for that pattern. A complete list of available strand patterns for each beam contained in the beam tables is given in Tables 3.22-1 to Tables 3.22-8.

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Table 3.22-1 Spread Box Beam Strand Patterns

Designation	Number of Strands per Row										Last Row
	1	2	3	4	5	6	7	8	9	...	
3617	14	16	2	2	2	2	2	7			
3621	14	16	2	2	2	2	2	2	2	9	
3624	14	16	2	2	2	2	2	2	2	... 11	
3627	14	16	2	2	2	2	2	2	2	... 12	
3630	14	16	2	2	2	2	2	2	2	... 14	
3633	14	16	2	2	2	2	2	2	2	... 15	
3636	14	16	2	2	2	2	2	2	2	... 17	
3639	14	16	2	2	2	2	2	2	2	... 18	
3642	14	16	2	2	2	2	2	2	2	... 20	
3645	14	16	2	2	2	2	2	2	2	... 20	
3648	14	16	2	2	2	2	2	2	2	... 22	
3654	14	16	2	2	2	2	2	2	2	... 24	
3660	14	16	2	2	2	2	2	2	2	... 26	
3666	14	16	2	2	2	2	2	2	2	... 28	
4817	20	22	2	2	2	2	2	7			
4821	20	22	2	2	2	2	2	2	2	9	
4824	20	22	2	2	2	2	2	2	2	... 11	
4827	20	22	2	2	2	2	2	2	2	... 12	
4830	20	22	2	2	2	2	2	2	2	... 14	
4833	20	22	2	2	2	2	2	2	2	... 15	
4836	20	22	2	2	2	2	2	2	2	... 17	
4839	20	22	2	2	2	2	2	2	2	... 18	
4842	20	22	2	2	2	2	2	2	2	... 20	
4845	20	22	2	2	2	2	2	2	2	... 20	
4848	20	22	2	2	2	2	2	2	2	... 22	
4854	20	22	2	2	2	2	2	2	2	... 24	
4860	20	22	2	2	2	2	2	2	2	... 26	
4866	20	22	2	2	2	2	2	2	2	... 28	

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Table 3.22-2 Adjacent Box Beam Strand Patterns

Designation	Number of Strands per Row*																								Last Row
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	...	
3617	14	16	0	0	0	0	2																		7
3621	14	16	2	0	0	0	0	2	2																9
3624	14	16	2	2	0	0	0	0	2	2	2														11
3627	14	16	2	2	0	0	0	0	2	2	2	2													12
3630	14	16	2	2	2	0	0	0	0	2	2	2	2	2											14
3633	14	16	2	2	2	2	0	0	0	0	2	2	2	2	2										15
3636	14	16	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2								17
3639	14	16	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2							18
3642	14	16	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2					20
3645	14	16	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2				20
3648	14	16	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2			22
3654	14	16	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2	...	24
3660	14	16	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	...	26
3666	14	16	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	...	28
4817	20	22	0	0	0	0	2																		7
4821	20	22	2	0	0	0	0	2	2																9
4824	20	22	2	2	0	0	0	0	2	2	2														11
4827	20	22	2	2	0	0	0	0	2	2	2	2													12
4830	20	22	2	2	2	0	0	0	0	2	2	2	2	2											14
4833	20	22	2	2	2	2	0	0	0	0	2	2	2	2	2										15
4836	20	22	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2								17
4839	20	22	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2							18
4842	20	22	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2					20
4845	20	22	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2				20
4848	20	22	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2			22
4854	20	22	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	2	2	...	24
4860	20	22	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	2	...	26
4866	20	22	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	2	2	2	2	2	...	28

*Note: The number of strands per row shown is based on the default tendon height and a 2" distance to the first strand row. Changes to the tendon height and/or changes to the distance to the first strand row could result in different number of strands per row.

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Table 3.22-3 Adjacent Plank Beam Strand Patterns

Designation	Number of Strands per Row*	
	1	2
3612	14	10
4812	20	16

*Note: The number of strands per row shown is based on the default strands row spacing.

Table 3.22-4 AASHTO Type I-Beam Strand Patterns

Designation	Distance to 1 st Row (in)	Number of Strands per Row										Last Row
		1	2	3	4	5	6	7	8	9	...	
2863	≤ 3.00	11	13	13	11	9	7	5	3	3	...	27
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2866	≤ 3.00	11	13	13	11	9	7	5	3	3	...	28
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2872	≤ 3.00	11	13	13	11	9	7	5	3	3	...	30
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2878	≤ 3.00	11	13	13	11	9	7	5	3	3	...	32
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2884	≤ 3.00	11	13	13	11	9	7	5	3	3	...	34
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2890	≤ 3.00	11	13	13	11	9	7	5	3	3	...	36
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	
2896	≤ 3.00	11	13	13	11	9	7	5	3	3	...	38
	≤ 3.75	11	13	11	9	7	5	3	3	3	...	

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Table 3.22-5 PennDOT Standard I-Beam Strand Patterns

Designation	Distance to 1 st Row (in)	Number of Strands per Row													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1830	≤ 2.00	6	6	6	4	2	0	2	2						
	≤ 2.25	6	6	4	4	2	0	2	2						
	≤ 2.50	6	6	4	4	2	0	2	2						
	≤ 2.75	6	6	4	2	2	0	2	2						
	≤ 3.00	6	6	4	2	2	0	2	2						
1833	≤ 2.00	6	8	6	6	4	2	0	2	2					
	≤ 2.25	6	8	6	4	4	2	0	2	2					
	≤ 2.50	6	8	6	4	4	2	0	2	2					
	≤ 2.75	6	8	6	4	2	2	0	2	2					
	≤ 3.00	6	8	6	4	2	2	0	2	2					
1836	≤ 2.00	6	8	8	6	6	4	2	0	2	2				
	≤ 2.25	6	8	8	6	4	4	2	0	2	2				
	≤ 2.50	6	8	8	6	4	4	2	0	2	2				
	≤ 2.75	6	8	8	6	4	2	2	0	2	2				
	≤ 3.00	6	8	8	6	4	2	2	0	2	2				
2030	≤ 2.00	7	7	7	5	3	1	3	3						
	≤ 2.25	7	7	5	5	3	1	2	3						
	≤ 2.50	7	7	5	5	3	1	2	3						
	≤ 2.75	7	7	5	3	3	1	2	3						
	≤ 3.00	7	7	5	3	3	1	2	3						
2033	≤ 2.00	7	9	7	7	5	3	1	3	3					
	≤ 2.25	7	9	7	5	5	3	1	2	3					
	≤ 2.50	7	9	7	5	5	3	1	2	3					
	≤ 2.75	7	9	7	5	3	3	1	2	3					
	≤ 3.00	7	9	7	5	3	3	1	2	3					
2036	≤ 2.00	7	9	9	7	7	5	3	1	3	3				
	≤ 2.25	7	9	9	7	5	5	3	1	2	3				
	≤ 2.50	7	9	9	7	5	5	3	1	2	3				
	≤ 2.75	7	9	9	7	5	3	3	1	2	3				
	≤ 3.00	7	9	9	7	5	3	3	1	2	3				
2039	≤ 2.00	7	9	9	7	7	5	3	1	3	3				
	≤ 2.25	7	9	9	7	5	5	3	1	2	3				
	≤ 2.50	7	9	9	7	5	5	3	1	2	3				
	≤ 2.75	7	9	9	7	5	3	3	1	2	3				
	≤ 3.00	7	9	9	7	5	3	3	1	2	3				
2433	≤ 2.00	9	11	9	9	7	5	3	3	3	4	5	5		
	≤ 2.25	9	11	9	7	7	5	3	3	3	4	5	5		
	≤ 2.50	9	11	9	7	7	5	3	3	3	5	5	5		
	≤ 2.75	9	11	9	7	5	5	3	3	4	5	5	5		
	≤ 3.00	9	11	9	7	5	5	3	3	4	5	5	5		

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Table 3.22-5 PennDOT Standard I-Beam Strand Patterns (Cont.)

Designation	Distance to 1 st Row (in)	Number of Strands per Row													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
2436	≤ 2.00	9	11	11	9	9	7	5	3	3	3	4	5	5	
	≤ 2.25	9	11	11	9	7	7	5	3	3	3	4	5	5	
	≤ 2.50	9	11	11	9	7	7	5	3	3	3	5	5	5	
	≤ 2.75	9	11	11	9	7	5	5	3	3	4	5	5	5	
	≤ 3.00	9	11	11	9	7	5	5	3	3	4	5	5	5	
2633	≤ 2.00	10	12	10	10	8	6	4	2	4	4	6	6		
	≤ 2.25	10	12	10	8	8	6	4	2	4	4	6	6		
	≤ 2.50	10	12	10	8	8	6	4	4	4	6	6	6		
	≤ 2.75	10	12	10	8	6	6	4	4	4	6	6	6		
	≤ 3.00	10	12	10	8	6	6	4	4	4	6	6	6		
2636	≤ 2.00	10	12	12	10	10	8	6	4	2	4	4	6	6	
	≤ 2.25	10	12	12	10	8	8	6	4	2	4	4	6	6	
	≤ 2.50	10	12	12	10	8	8	6	4	4	4	6	6	6	
	≤ 2.75	10	12	12	10	8	6	6	4	4	4	6	6	6	
	≤ 3.00	10	12	12	10	8	6	6	4	4	4	6	6	6	
2442	≤ 2.00	9	11	11	9	7	5	3	3	1	2	3	3	3	
	≤ 2.25	9	11	9	9	7	5	3	3	1	2	3	3	3	
	≤ 2.50	9	11	9	9	7	5	3	1	1	3	3	3	3	
	≤ 2.75	9	11	9	9	7	5	3	1	1	3	3	3	3	
	≤ 3.00	9	11	9	9	7	5	3	1	2	3	3	3	3	
2445	≤ 2.00	9	11	11	9	7	5	3	3	1	2	3	3	3	
	≤ 2.25	9	11	9	9	7	5	3	3	1	2	3	3	3	
	≤ 2.50	9	11	9	9	7	5	3	1	1	3	3	3	3	
	≤ 2.75	9	11	9	9	7	5	3	1	1	3	3	3	3	
	≤ 3.00	9	11	9	9	7	5	3	1	2	3	3	3	3	
2448	≤ 2.00	9	11	11	11	9	7	5	3	3	1	2	3	3	3
	≤ 2.25	9	11	11	9	9	7	5	3	3	1	2	3	3	3
	≤ 2.50	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 2.75	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 3.00	9	11	11	9	9	7	5	3	1	2	3	3	3	3
2451	≤ 2.00	9	11	11	11	9	7	5	3	3	1	2	3	3	3
	≤ 2.25	9	11	11	9	9	7	5	3	3	1	2	3	3	3
	≤ 2.50	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 2.75	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 3.00	9	11	11	9	9	7	5	3	1	2	3	3	3	3
2454	≤ 2.00	9	11	11	11	9	7	5	3	3	1	2	3	3	3
	≤ 2.25	9	11	11	9	9	7	5	3	3	1	2	3	3	3
	≤ 2.50	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 2.75	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 3.00	9	11	11	9	9	7	5	3	1	2	3	3	3	3

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Table 3.22-5 PennDOT Standard I-Beam Strand Patterns (Cont.)

Designation	Distance to 1 st Row (in)	Number of Strands per Row													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
2460	≤ 2.00	9	11	11	11	9	7	5	3	3	1	2	3	3	3
	≤ 2.25	9	11	11	9	9	7	5	3	3	1	2	3	3	3
	≤ 2.50	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 2.75	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 3.00	9	11	11	9	9	7	5	3	1	2	3	3	3	3
2463	≤ 2.00	9	11	11	11	9	7	5	3	3	1	2	3	3	3
	≤ 2.25	9	11	11	9	9	7	5	3	3	1	2	3	3	3
	≤ 2.50	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 2.75	9	11	11	9	9	7	5	3	1	1	3	3	3	3
	≤ 3.00	9	11	11	9	9	7	5	3	1	2	3	3	3	3
2654	≤ 2.00	11	11	11	11	9	7	5	3	1	3	3	3	3	
	≤ 2.25	11	11	11	9	7	5	3	1	0	3	3	3	3	
	≤ 2.50	11	11	11	9	7	5	3	1	0	3	3	3	3	
	≤ 2.75	11	11	11	9	7	5	3	1	0	3	3	3	3	
	≤ 3.00	11	11	11	9	7	5	3	1	2	3	3	3	3	
2660	≤ 2.00	10	12	12	10	8	6	4	4	2	2	4	4	4	
	≤ 2.25	10	12	10	10	8	6	4	4	2	2	4	4	4	
	≤ 2.50	10	12	10	10	8	6	4	2	2	2	4	4	4	
	≤ 2.75	10	12	10	10	8	6	4	2	2	2	4	4	4	
	≤ 3.00	10	12	10	8	8	6	4	2	0	4	4	4	4	
2663	≤ 2.00	10	12	12	10	8	6	4	4	2	2	4	4	4	
	≤ 2.25	10	12	10	10	8	6	4	4	2	2	4	4	4	
	≤ 2.50	10	12	10	10	8	6	4	2	2	2	4	4	4	
	≤ 2.75	10	12	10	10	8	6	4	2	2	2	4	4	4	
	≤ 3.00	10	12	10	8	8	6	4	2	0	4	4	4	4	

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Table 3.22-6 PA Bulb Tee Beam Strand Patterns (9 in Bulb – 36, 42, or 48 in Top Flange)

Designation	Distance to 1 st Row (in)	Number of Strands per Row										Last Row
		1	2	3	4	5	6	7	8	9	...	
3331 3331.25 3331.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	10
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3339 3339.25 3339.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	14
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3347 3347.25 3347.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	18
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3355 3355.25 3355.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	22
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3363 3363.25 3363.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	26
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3371 3371.25 3371.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	30
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3379 3379.25 3379.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	34
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3387 3387.25 3387.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	38
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	
3395 3395.25 3395.5	≤ 2.25	13	15	15	13	7	3	3	3	3	...	42
	≤ 3.00	13	15	15	11	5	3	3	3	3	...	
	≤ 3.75	13	15	15	9	3	3	3	3	3	...	

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Table 3.22-7 PA Bulb Tee Beam Strand Patterns (7 in Bulb – 36, 42, or 48 in Top Flange)

Designation	Distance to 1 st Row (in)	Number of Strands per Row										Last Row
		1	2	3	4	5	6	7	8	9	...	
3329	≤ 2.25	13	15	13	7	3	3	3	3	3		9
3329.25	≤ 3.00	13	15	11	5	3	3	3	3	3		
3329.5	≤ 3.75	13	15	9	3	3	3	3	3	3		
3337	≤ 2.25	13	15	13	7	3	3	3	3	3	...	13
3337.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3337.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3345	≤ 2.25	13	15	13	7	3	3	3	3	3	...	17
3345.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3345.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3353	≤ 2.25	13	15	13	7	3	3	3	3	3	...	21
3353.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3353.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3361	≤ 2.25	13	15	13	7	3	3	3	3	3	...	25
3361.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3361.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3369	≤ 2.25	13	15	13	7	3	3	3	3	3	...	29
3369.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3369.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3377	≤ 2.25	13	15	13	7	3	3	3	3	3	...	33
3377.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3377.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3385	≤ 2.25	13	15	13	7	3	3	3	3	3	...	37
3385.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3385.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	
3393	≤ 2.25	13	15	13	7	3	3	3	3	3	...	41
3393.25	≤ 3.00	13	15	11	5	3	3	3	3	3	...	
3393.5	≤ 3.75	13	15	9	3	3	3	3	3	3	...	

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Table 3.22-8 NEXT Beam Strand Patterns

Designation	Number of Strands per Row					
	1	2	3	4	5	Last*
NEXT36F	6	10	10	10	10	4*
NEXT32F	6	10	10	10	10	4*
NEXT28F	6	10	10	10	10	4*
NEXT24F	6	10	10	10	10	4*
NEXT40D	6	10	10	10	10	4*
NEXT36D	6	10	10	10	10	4*
NEXT32D	6	10	10	10	10	4*
NEXT28D	6	10	10	10	10	4*

* - The last strand row, 6 for PennDOT Standard beams, is located in the top flange and can have either zero or four strands to allow for symmetrical strand patterns based on standard NEXT Beam forms. If the last row is less than 6 the number of available strands will be 4 in that row.

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3.23 TRANSVERSE TENDONS IN ADJACENT BEAMS

Transverse tendons are located vertically near the mid-depth of adjacent box beams and adjacent plank beams per standard drawing BD-651M, Sheet 2 and BC-775M, Sheet 2. For PennDOT standard beams the tendon is located at the mid-point between strands that are closest to the mid-height of the beam to minimize the number of strand rows that interfere with the tendon. The available strands per row are adjusted by PSLRFD to avoid interference between the tendon and the prestress strands. The adjustment to the available strands per row is the same for both exterior and interior beams.

3.23.1 Straight and Debonded Strands

The number of available strands for in each row is defined in the beam table text file (AABEAMUS.TAB) for each of the standard adjacent beams. Any row that interferes with the tendon location has the number of available strands adjusted to avoid any possible interference.

The strand rows that interfere with the tendon depends on the diameter of the hole for the tendon, any clearance between the tendon and the prestressing strand and the tendon pocket located on the outside face of the fascia beam. The tendon pocket and clearances from the pocket to the prestressing strand will control the required changes to the strand rows. The tendon pocket has a maximum width and height of 6" and a typical depth of 5". The center of prestressing strands are located 2" from the edge of concrete faces. This same 2" dimension will be used to determine interference between the pocket and the prestress strands. Adding 2" clearance to the top and bottom of the 6" pocket gives a total height of 10" and a total of 4 rows that would interfere with the tendon pocket. See Figure 3.23-1 below.

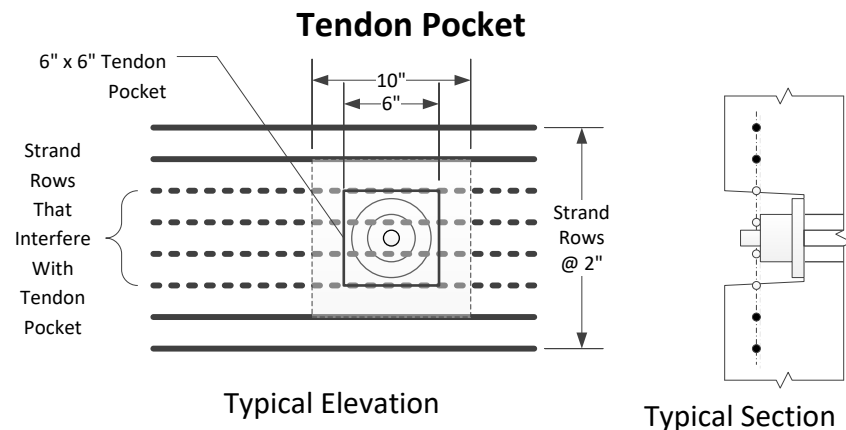


Figure 3.23-3-1 Typical Tendon Detail

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3.23.2 Draped Strands

The following Figure 3.23-2 shows a possible interference between the tendon pocket and draped strands.

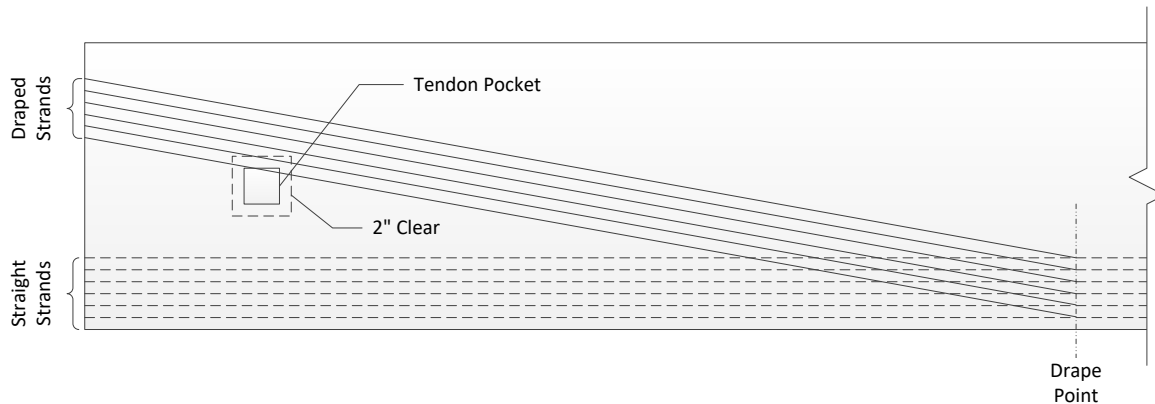


Figure 3.23-3-2 Typical Beam Elevation with Draped Strands

The program determines if the draped strands interfere with the tendon pocket by using the vertical and horizontal location of the tendon pocket(s) that are specified by the TND command. If interference is detected a warning message will appear in the output file.

3.23.3 Dapped Beams

Dapping requires the bottom flange thickness to be increased by the dap amount and that all of the strand rows to be moved up to maintain the minimum concrete cover on the bottom row of prestressing strands. Depending on the depth of the dapping the strand rows that interfere with the tendon pocket will change. For the adjacent box beams and adjacent plank beams the dapping thickness is considered when determining which strand rows need to be adjusted to avoid interference.

3.23.4 Adjacent Plank Beams

Adjacent plank beams are 12" deep and have two rows of strands located 2" and 4" from the bottom of the beam. The tendon location is shown in Figure 3.23-3 below.

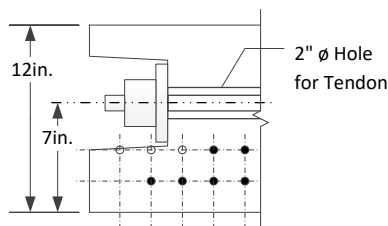


Figure 3.23-3-3 Adjacent Plank Beam Typical Section

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Based on Figure 3.23-3, three strands in the second row interfere with the tendon pocket and need to be eliminated. Three additional strands need to be eliminated for strand symmetry for a total of six strands being removed from the second row.

PennDOT Standard BC-775M allows a 2" to 3" hole for the tendon for adjacent box beams but only allows a 2" hole for the tendon for adjacent plank beams. For adjacent plank beams the diameter of the hole for the tendon is assumed to be a maximum of 2" to provide 2" from the center line of the strand to the edge of the hole.

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3.24 SHEAR REINFORCEMENT FOR DRAWINGS

3.24.1 General Description

The Shear Reinforcement for Drawings output table combines the stirrup requirements from other PSLRFD output tables, DM-4 and AASHTO LRFD Specifications, and PennDOT BD Standards to provide stirrup spacing that incorporates all of this data. The Shear Reinforcement and Resistance output table provides stirrup spacing requirements between the left and right critical shear locations. The Shear Reinforcement and Resistance output table does not provide stirrup spacing information from the beam ends to the critical shear locations. The End Zone Splitting Stresses output table provides stirrup spacing information from the beam ends to the end of the distribution end zone. The requirements for the stirrup spacing from the end of the end zone to the critical shear location is detailed in the PennDOT BD Standards by BD-661M and BD-662M. BD-661M covers adjacent box beams, spread box beams, and adjacent plank beams. BD-662M covers PA I-Beams, AASHTO I-Beams, and PA Bulb-Tee Beams. Generally, the stirrup spacing requirements in DM-4 agree with the requirements in the BD Standards. The one known exception is the reference point used to define the region for confinement reinforcement. DM-4 uses 1/3 of the span length from the beam end. The BD Standards use 1/3 of the span length from the first stirrup. The Shear Reinforcement for Drawings output report uses the DM-4 reference of the beam end. The distance between simple bearings is used for the span length to define the confinement region.

The stirrup spacing is provided at 20th points plus key points. The key points start at the left beam end. The next key point is the first stirrup location from the beam end. All distances are from the left continuous support of the current span measuring to the right. This distance reference is the same as references in other output tables. The key points depend on the type of beam shape as defined on the CTL command.

The stirrup spacings provided in the output table are the required spacing at the given distance. The spacings are measured along the centerline of the beam. When stirrups are placed parallel to the skew, the spacing along beam centerline will be larger than the spacing measured perpendicular to the stirrup bars. When stirrups are placed parallel to the skew in the splitting zone, the stirrups after the splitting zone are placed flared by having different spacing along the left and right sides of the beam. At the end of the flaring the stirrups are perpendicular to the centerline of the beam. The flared spacing may increase as the design / provided spacing increases. This can result in varying flared spacing. For flared stirrups the spacing along beam centerline is reported in the output table. The maximum and minimum spacing is given in the Key Points at the bottom of the table. Flared stirrups are used for boxes and plank beams with a skew. The information in the output table can be used to develop the actual stirrup spacing to be shown on the drawings.

The stirrup configuration at the ends of the beams depends on the dimensions of the beam notch. For box beam cross sections, the stirrup configuration also depends on the length of the end block. Therefore, the Beam Details command must be given for the Shear Reinforcement for Drawings output table to be printed.

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3.24.2 Detailed Example of Multiple Flared Regions

The following adjacent box beam example shows the Shear Reinforcement for Drawings output report for an extreme example with a total of four flared stirrup regions. This example was created to demonstrate multiple flared regions with variable spacing. The following select output shows the new Shear Reinforcement for Drawing table (only points to Mid-Span are shown).

SHEAR REINFORCEMENT FOR DRAWINGS

(All distances and spacings measured along the centerline of the beam.)

Span No.	Distance (ft)	Design / Provided Stirrup Vertical		Horizontal		A1 Pairs Stirrup	A2 Top	A3 Bottom
		Spacing (in)	Area (in ²)	Spacing (in)	Area (in ²)	Spacing (in)	Spacing (in)	Spacing (in)
1	-0.866	n/a	0.40	n/a	0.40	n/a	n/a	n/a
	-0.577	3.46	0.40	6.93	0.40	n/a	3.46	3.46&
	1.299	3.46	0.40	6.93	0.40	n/a	3.46	3.46&
	1.443	3.46	0.40	6.93	0.40	n/a	3.46	3.46&
	1.702	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	1.729<	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	1.734	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	2.186	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	4.373	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	4.800	3.10	0.40	6.20	0.40	6.20f	6.20f	3.10%
	5.088	3.45	0.40	6.90	0.40	6.90f	6.90f	3.45%
	6.559	3.45	0.40	6.90	0.40	6.90f	6.90f	3.45%
	6.813	3.45	0.40	6.90	0.40	6.90f	6.90f	3.45%
	7.136	3.87	0.40	7.74	0.40	7.74f	7.74f	3.87%
	8.746	3.87	0.40	7.74	0.40	7.74f	7.74f	3.87%
	8.749	3.87	0.40	7.74	0.40	7.74f	7.74f	3.87%
	9.167	5.01	0.40	10.02	0.40	10.02f	10.02f	5.01%
	10.002	5.01	0.40	10.02	0.40	10.02f	10.02f	5.01%
	10.932	12.50	0.40	16.38	0.40	16.38	12.50	12.50&
	13.119	12.50	0.40	21.00	0.40	21.00	12.50	12.50&
	15.305	12.50	0.40	21.00	0.40	21.00	12.50	12.50&
	17.492	12.50	0.40	21.00	0.40	21.00	12.50	12.50&
	19.678	12.50	0.40	21.00	0.40	21.00	12.50	12.50&
	21.865	12.50	0.40	21.00	0.40	21.00	12.50	12.50&

. . . (points omitted)

NOTE:

& - Match A3 with A2

% - Match A3 with A1 pairs & Match A3 with A2

A "f" next to a spacing indicates flared bar placement. Max. and min. spacing measured parallel to beam C.L. between bars at clear cover from edge of beam. A1 pairs matched with A3; alt. with A2 & A3.

See Key Points for max. and min. spacing.

A "<" next to a distance indicates the critical distance.

A "v" next to a distance indicates a draping point.

A "x" next to a distance indicates a diaphragm location.

Actual End Block Length (Obtuse corner to Void) = 2.948 (ft) Left Beam End

Actual End Block Length (Obtuse corner to Void) = 2.948 (ft) Right Beam End

Key Points:

-0.866 ft - Left Beam End

-0.577 ft - start splitting zone reinforcement parallel to skew, left beam end

1.299 ft - **3" min beyond Beam Notch, left beam end**

1.443 ft - stop splitting zone reinforcement, left beam end

1.702 ft - start 1st flared spacing, A3 max 3.20 (in), A3 min 3.00 (in), left beam end

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3.237 ft - end block ends, left beam end
 4.737 ft - stop end block A3 max 6" spacing, start design spacing, left beam end
 4.800 ft - Stop 1st flared spacing, left beam end
 5.088 ft - start 2nd flared spacing, A3 max 3.90 (in), A3 min 3.00 (in), left beam end
 6.813 ft - Stop 2nd flared spacing, left beam end
 7.136 ft - start 3rd flared spacing, A3 max 4.74 (in), A3 min 3.00 (in), left beam end
 8.749 ft - Stop 3rd flared spacing, left beam end
 9.167 ft - start 4th flared spacing, A3 max 6.02 (in), A3 min 4.00 (in), left beam end
 10.002 ft - Stop 4th flared spacing, left beam end

. . . (points omitted)

3.24.3 Verification

The following hand calculations verify the minimum and maximum spacing in the flared regions.

[Note: Some of the values used in the hand calculations have more significant digits than shown in the program output. Those values are from special debug output.]

The minimum and maximum spacing in the flared region is given on Sheet 2 of 6 of BD-661M in the Adjacent Box Beam End Block Reinforcement detail (shown below).

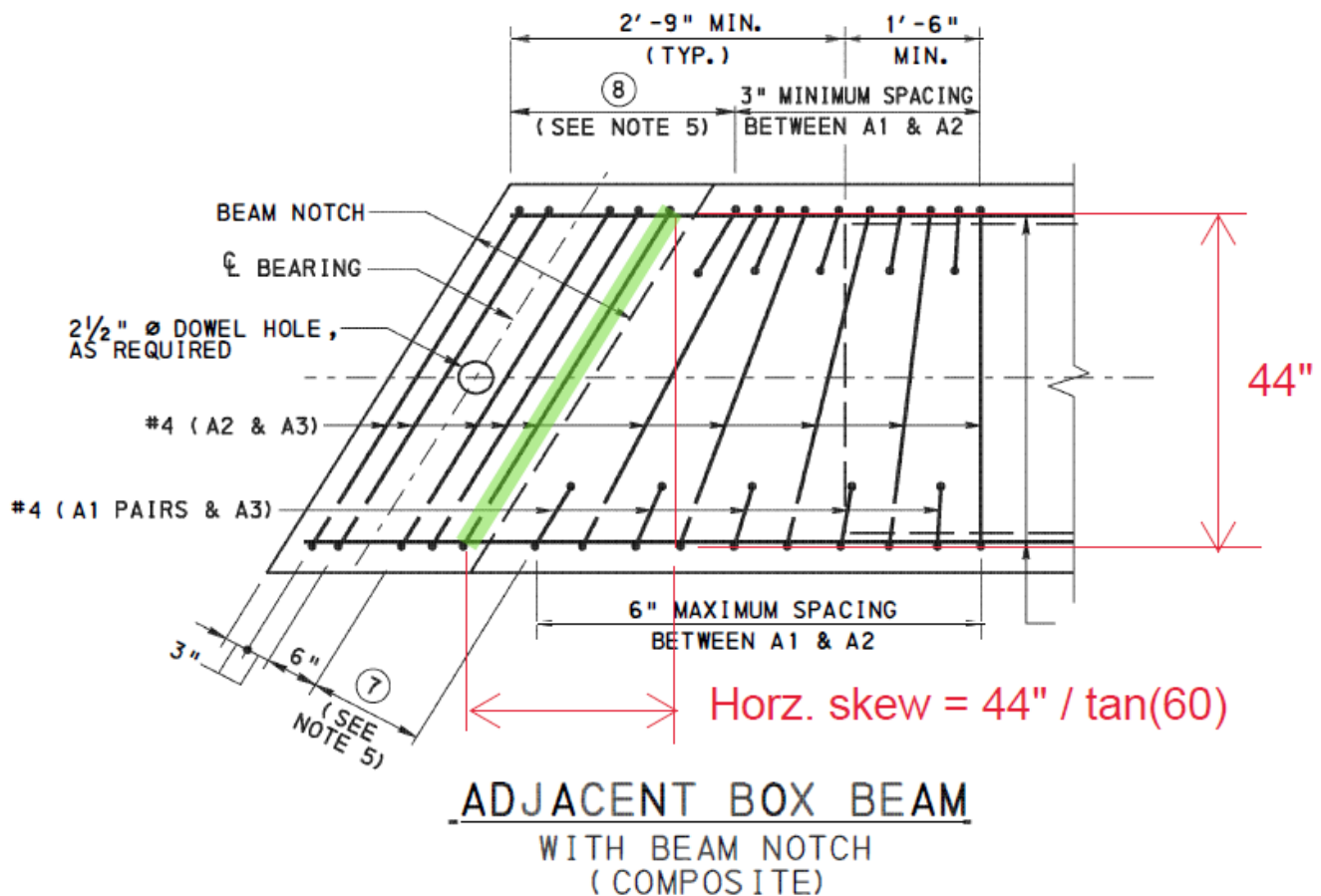


Figure 3.24-1 Adjacent Beam End Block Reinforcement

Chapter 3 Method of Solution

The MinSpac, 3", is between the A1 & A2 bars. This implies the minimum A3 bar spacing is 3" and the minimum A1 & A2 bar spacing is 6". The MaxSpac, 6", is also between the A1 & A2 bars. Again, implying the maximum A3 bar spacing is 6" and the maximum A1 & A2 bar spacing in 12". **The design spacing will control the maximum spacing at the end of the End Block Area Reinforcement which ends at 1 ft 6 in beyond the end block. The end block ends at 3.237 ft and the end block reinforcement ends at 4.737 ft. For this example, the skew angle is 60 degrees. The box beam is 48" wide and the stirrup bars have 2" of clear cover from the exterior walls. The horizontal projection of a skewed stirrup is computed as $(48" - 2 \times 2") / \tan(60^\circ) = 25.403"$. As each flared stirrup is placed the horizontal projection is reduced by the difference between the maximum and minimum spacing of the stirrup. When the horizontal projection is zero, the stirrup is normal to the beam centerline.**

End Zone Splitting Reinforcement

The first End Zone Splitting reinforcement is placed parallel to the skew at 3" from the beam end, or -0.577 feet from the centerline of bearing. These bars are parallel on the skew at 3" until the required area is met, and the bars are a minimum of 3" beyond the beam notch, if present. The 3" skew distance measured along the beam centerline is 3.46". The number of bars is controlled by the 3" minimum beyond the beam notch which is located at 1.299 feet along beam centerline. The location of the last splitting bar is determined as follows:

First splitting bar location	=	-0.577 ft
Min last splitting bar location	=	1.299 ft
Min number of spaces	=	$(1.299 - -0.577) \text{ ft} \times 12 \text{ in/ft} / 3.46 \text{ in} = 6.506 \Rightarrow 7 \text{ spc}$
Last splitting bar location	=	$-0.577 \text{ ft} + 7 \times 3.46 \text{ in} / 12 \text{ in/ft} = 1.443 \text{ ft}$

First Flared Region

This flared region starts within the End Block Reinforcement so the maximum end block spacing applies. The maximum and minimum spacings are computed as shown below.

Vertical Design Spacing, DVSPAC	=	8.50"
Horizontal Design Spacing, DHSPAC	=	6.4"
Max Spacing between A1 & A2	=	$\min (\text{DVSPAC}, \text{DHSPAC}/2, \text{MaxSpac})$
	=	$\min (8.50, 6.4/2, 6) = 3.20"$
Min Spacing between A1 & A2	=	MinSpac = 3.00"
Spacing @ C.L.	=	$(\max + \min)/2 = (3.20 + 3.00)/2 = 3.10"$
First flared bar location	=	$1.443 \text{ ft} + 3.10 \text{ in} / 12 \text{ in/ft} = 1.702 \text{ ft}$
Min last End Block bar location	=	4.737 ft
Min number of spaces	=	$(4.737 - 1.443) \text{ ft} \times 12 \text{ in/ft} / 3.10 \text{ in} = 12.75$
	=	$\Rightarrow 13 \text{ spc}$
Last flared bar (1 st Region)	=	$1.443 \text{ ft} + 13 \times 3.10 \text{ in} / 12 \text{ in/ft} = 4.800 \text{ ft}$
Horz. change in skew per space	=	$\max - \min = 3.20 - 3.00 = 0.197"$
Skew last flared bar	=	$\text{atan}[(44 \times \tan(60)) / (44 - 0.197 \times 13 \times \tan(60))]$
	=	$\text{atan}[76.210 / 39.564] = 62.56 \text{ degrees}$
New Horz. projection	=	$25.403" - 13 \times 0.197" = 22.842"$

Chapter 3 Method of Solution

Flaring starts at 1.702 feet as noted in the Key Points and continues to 4.800 feet where the bars are beyond the End Block Reinforcement maximum 6" spacing which ended at 4.737 feet and the design spacing starts.

Second Flared Region

The flared region is beyond the End Block Reinforcement so the design spacing controls the maximums.

Vertical Design Spacing, DVSPAC	=	10.00"
Horizontal Design Spacing, DHSPAC	=	7.8"
Max Spacing between A1 & A2	=	min (DVSPAC, DHSPAC/2)
	=	min (10.00, 7.8/2) = 3.90"
Min Spacing between A1 & A2	=	MinSpac = 3.00"
Spacing @ C.L.	=	(max + min)/2 = (3.90 + 3.00)/2 = 3.45"
First flared bar location	=	4.800 ft + 3.45 in / 12 in/ft = 5.088 ft
Min next design location	=	6.559 ft (3 rd 20 th point)
Min number of spaces	=	(6.559 – 4.800) ft * 12 in/ft / 3.45 in = 6.12
	=>	7 spc
Last flared bar (2 nd Region)	=	4.800 ft + 7 * 3.45 in / 12 in/ft = 6.813 ft
Horz. change in skew	=	max – min = 3.90 – 3.00 = 0.902"
Skew last flared bar	=	atan[(44 x tan(62.56)) / (44 – 0.902 x 7 x tan(62.56))]
	=	atan[84.740 / 31.840] = 69.41 degrees
New Horz. projection	=	22.842" – 7 x 0.902" = 16.528"

Flaring starts at 5.088 feet and continues to 6.813 feet which is beyond the third 20th point (6.559 feet).

Third Flared Region

The design spacing at the third 20th point.

Vertical Design Spacing, DVSPAC	=	11.50"
Horizontal Design Spacing, DHSPAC	=	9.5"
Max Spacing between A1 & A2	=	min (DVSPAC, DHSPAC/2)
	=	min (11.50, 9.5/2) = 4.74"
Min Spacing between A1 & A2	=	MinSpac = 3.00"
Spacing @ C.L.	=	(max + min)/2 = (4.74 + 3.00)/2 = 3.87"
First flared bar location	=	6.813 ft + 3.87 in / 12 in/ft = 7.136 ft
Min next design location	=	8.746 ft (4 th 20 th point)
Min number of spaces	=	(8.746 – 6.813) ft * 12 in/ft / 3.87 in = 5.99
	=>	6 spc
Last flared bar (3 rd Region)	=	6.813 ft + 6 * 3.87 in / 12 in/ft = 8.749 ft
Horz. change in skew	=	max – min = 4.74 – 3.00 = 1.745"
Skew last flared bar	=	atan[(44 x tan(69.41)) / (44 – 1.745 x 6 x tan(69.41))]
	=	atan[117.122 / 16.130] = 82.16 degrees
New Horz. projection	=	16.528" – 6 x 1.745" = 6.058"

Flaring starts at 6.813 feet and continues to 8.748 feet which is beyond the fourth 20th point (8.746 feet).

Fourth Flared Region

The design spacing at the fourth 20th point.

Vertical Design Spacing, DVSPAC	=	12.50"
Horizontal Design Spacing, DHSPAC	=	12.04"
Max Spacing between A1 & A2	=	min (DVSPAC, DHSPAC/2)
	=	min (12.50, 12.04/2) = 6.02"
Min Spacing between A1 & A2	=	MinSpac = 3.00"
Spacing @ C.L.	=	(max + min)/2 = (6.02 + 3.00)/2 = 4.51"
First flared bar location	=	8.749 ft + 4.51 in / 12 in/ft = 9.125 ft
Min next design location	=	10.932 ft (5th 20th point)
Min number of spaces	=	(10.932 – 8.749) ft * 12 in/ft / 4.51 in = 5.81
	=	=> 6 spc
Horz. change in skew	=	max – min = 6.02" – 3.00 = 3.018"
New Horz. projection	=	6.058" – 6 x 3.018" = -12.049" ← N.G.
Re-compute spaces	=	6.059 / 3.018 = 2.008 => 3 spc
Re-compute Horz change in skew	=	6.059 / 3 = 2.02"
Re-compute Min Spacing	=	6.02 – 2.02 = 4.00"
Re-compute Spa @ C.L.	=	(6.02 + 4.00) = 5.01"
Re-compute 1st bar location	=	8.748 ft + 5.01 in / 12 in/ft = 9.167 ft
Last flared bar (4th Region)	=	8.748 ft + 3 * 5.01 in / 12 in/ft = 10.002 ft
Horz. change in skew	=	max – min = 6.02 – 4.00 = 2.02"
Compute skew last bar	=	atan[(44 x tan(82.16)) / (44 – 2.02 x 3 x tan(82.16))]
	=	atan[319.55 / -0.0105] = 90.002 degrees

Flaring starts at 9.167 feet and continues to 10.002 feet where the flared bars become perpendicular to the C.L. of beam

The four flared regions are **shown** in Figure 3.24-2 **below**:

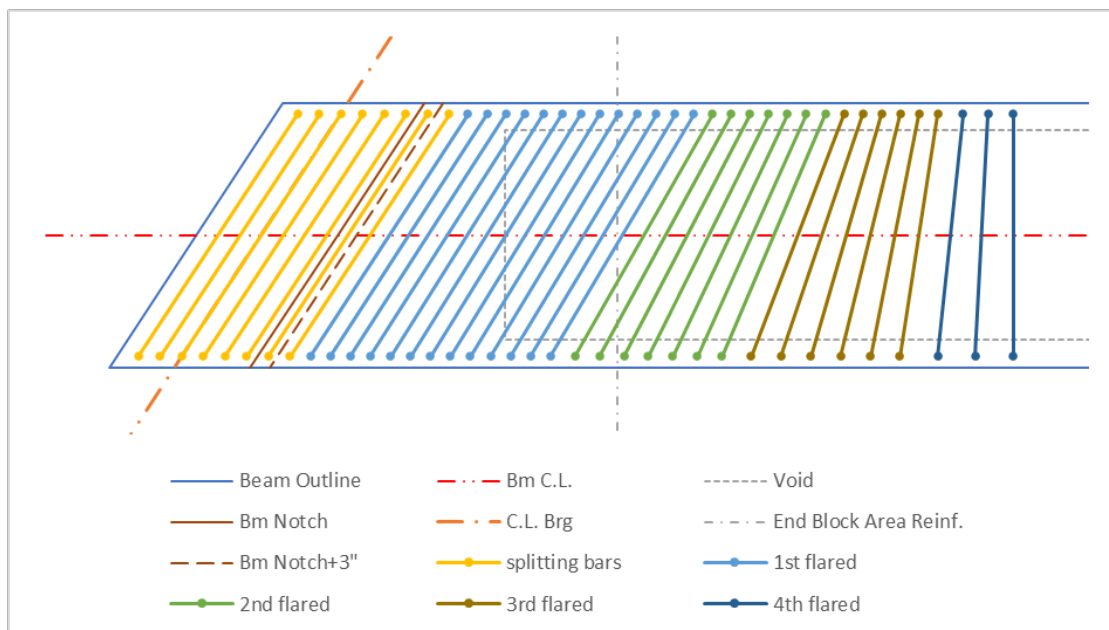


Figure 3.24-2 Flared Stirrup Regions

Chapter 3 Method of Solution

3.25 GIRDER STABILITY CHECKS

The requirements for girder stability are defined in AASHTO LRFD Article 5.5.4.3, Stability, as follows:

Buckling of precast members during handling, transportation, and erection shall be investigated.

The Precast/Prestressed Concrete Institute, PCI, established the Girder Stability Subcommittee to provide recommendations about lateral stability of prestressed concrete girders during all stages of construction. The subcommittee produced the report, *Recommended Practices for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*. This report will be used as the basis of the stability checks in PS LRFD. The following discussion is taken in part from that report.

As girders have become longer and more slender, lateral stability during handling, transport, and erection is a safety concern. There are two basic support conditions for a girder. A girder is typically lifted with the aid of devices attached to its web or embedded in its top near each end. A girder suspended from the top is commonly referred to as a **hanging girder**. A girder can also be supported from beneath during lifting, storage, transport, and then set into position on the bridge. A girder supported from below is commonly referred to as a **seated girder**.

3.25.1 Hanging Girder Stability

Hanging girder stability is based on the resolution of internal and external loads that are eccentric to an imaginary line connecting the support points, referred to as the **roll axis**. Fabrication tolerances, including permissible deviation in member geometry and prestressing eccentricity, cause the girder to have built-in transverse deformation, defined as **sweep**, which causes the center of mass of the girder to fall to one side or the other of the roll axis, as shown in the figure below.

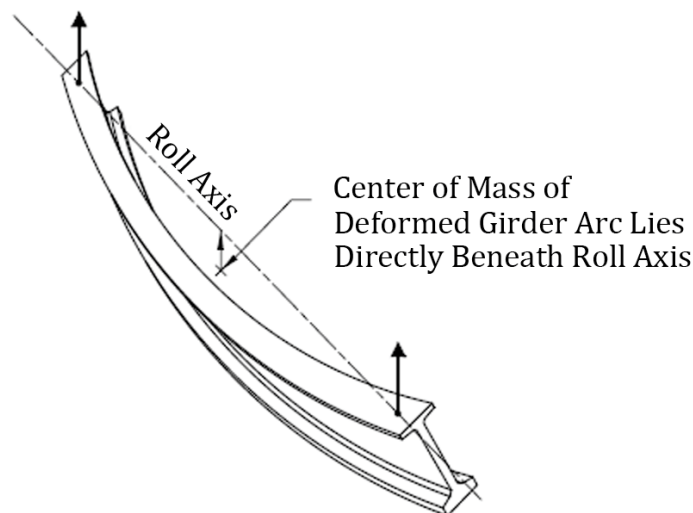


Figure 3.25-1 Perspective View of a Hanging Girder

3.25.1.1 Girder Equilibrium

The figure consists of two diagrams illustrating the effect of roll on the weight distribution of a ship's hull.

Left Diagram (Undeformed Girder): Shows a cross-section of a ship's hull. A vertical dashed line represents the undeformed girder. The roll axis is at the lift point. The center of mass is located at a distance $z + e_i$ from the roll axis. The weight W acts vertically through the center of mass. The roll angle is θ . The vertical distance from the lift point to the center of mass is y_{cm} . The vertical distance from the lift point to the center of buoyancy is y_{cb} .

Right Diagram (Deformed Girder): Shows the same cross-section of a ship's hull, but the weight W is now acting vertically through the center of mass, which has shifted horizontally due to roll. The weight W is decomposed into a horizontal component $W \sin \theta$ and a vertical component $W \cos \theta$. The roll angle is θ . The vertical distance from the lift point to the center of mass is y_{cm} . The vertical distance from the lift point to the center of buoyancy is y_{cb} .

The following variables are shown in the figure:

- The initial lateral eccentricity of the center of mass of the girder caused by the girder sweep is not equal to the girder sweep. The girder sweep is assumed to vary parabolic along the length of the girder. The center of mass of a parabolic arc is approximately one-third of the sweep from the centerline of the arc. The sweep measured from the roll axis is equal to the original sweep times the square of the ratio of the length between lifting loops and the total beam length as shown in the Figure 3.25-3.

Eccentricity of CG cause by Transverse Deformation (Sweep)

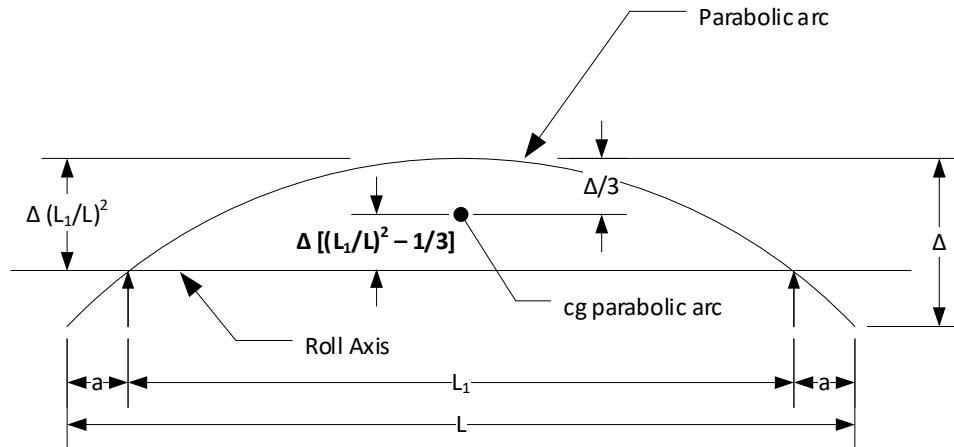


Figure 3.25-3 Eccentricity of Center of Mass due to Sweep, Δ

As the girder rotates, the self-weight of the girder causes a lateral deflection of the girder. This lateral deflection causes the eccentricity of the center of mass to increase. Again, the eccentricity of the center of mass is not the maximum lateral deflection of the girder. This is shown in the figure below.

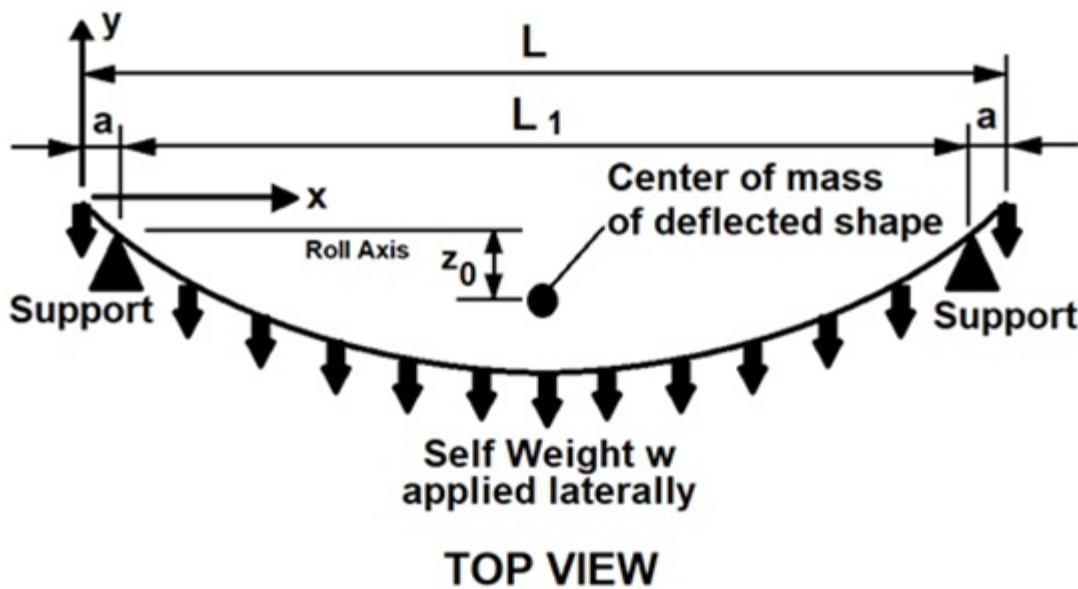


Figure 3.25-4 Definition of z_0

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The equation for the eccentricity of the center of mass is obtained by integrating the shape of the deflection curve to find its centroid and is given by the following equation:

$$z_0 = \frac{w}{12EIL} \left(\frac{1}{10} l_1^5 - a^2 l_1^3 + 3a^4 l_1 + \frac{6}{5} a^5 \right)$$

Where;

- z_0 = lateral eccentricity, measured from the roll axis, of the center of mass of the deflected shape of the girder subjected to its own self weight, W , applied as a lateral load (in)
- w = weight of beam per unit length (k/in)
- E = concrete modulus of elasticity (ksi)
- I = moment of inertia (in⁴)
- L = total length of girder (in)
- a = overhang distance (in)
- l_1 = $L - 2a$ (in)

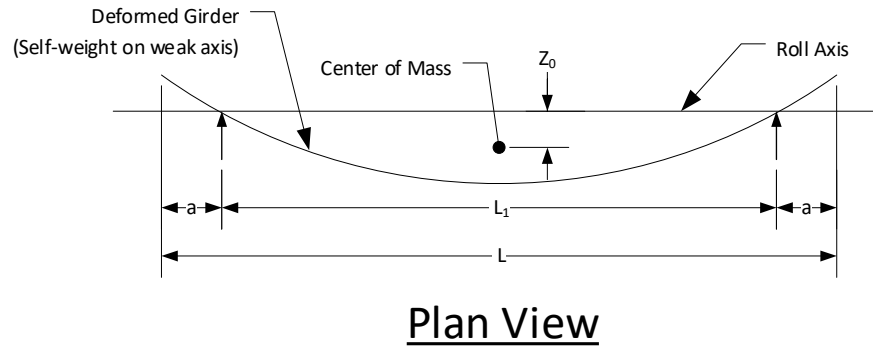


Figure 3.25-5 Eccentricity of Center of Mass due to Self-Weight

The lateral eccentricity of the deflected shape of the girder, z , is caused by the deflection from force $W \sin(\theta)$. The lateral deflection, z , can be redefined as:

$$z = z_0 \sin \theta$$

To satisfy the condition of equilibrium, moments are taken about the roll center at the lifting point. For a given rotation, the resisting moment is:

$$M_r = W \sin \theta * y_r$$

For a given rotation, the acting moment is:

$$M_a = W \cos \theta (z + e_i) = W \cos \theta (z_0 \sin \theta + e_i)$$

Using small deflection theory, $\cos \theta = 1$ and $\sin \theta = \theta$, these equations become:

$$M_r = W y_r \theta$$

And

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$$M_a = W(z_0\theta + e_i)$$

The equilibrium condition is defined where the resisting and acting moments are equal.

$$W y_r \theta = W(z_0\theta + e_i)$$

Solving for the rotation at equilibrium, where the acting and resisting moments are equal,

$$\theta_{eq} = \frac{e_i}{y_r - z_0}$$

This angle is utilized to calculate the lateral moment in the girder due to self-weight. The lateral moment is combined with the load effects from girder dead load weight and prestressing to determine the stresses in the girder. These stresses are compared to allowable compressive stresses and may require an increased 28-day design compressive strength.

For straight strands the stresses are computed at midspan. For draped strands the stresses are computed at midspan and at the drape point. For debonded strands the stresses are computed at midspan and at each debonding cutoff location. Additionally, for all strand types, stresses are computed at the lifting loops. Stresses are computed from prestressing, gravity, wind, and the rotation or tilt of the girder. The general equation to compute stresses due to prestressing, gravity, and wind is given by:

$$f_c = \frac{P}{A} \mp \frac{Pe}{S_x} \pm \frac{M_g}{S_x} \mp \frac{M_w}{S_y}$$

Where:

- f_c = concrete stress at flange tip (either top or bottom flange and right or left tip) (ksi)
- P = prestress force at the location being checked (kip)
- A = cross sectional area of girder (in²)
- e = eccentricity of strands at the location being checked (in)
- S_x = horizontal axis section modulus (either top or bottom flange) (in³)
- M_g = gravity moment at the location being checked (k-in)
- M_w = wind moment at the location being checked (k-in)
- S_y = vertical axis section modulus (either top or bottom flange) (in³)

The stresses due to the girder tilt are added to the previously calculated stresses to get the final stresses at equilibrium.

$$f_{c.eq} = f_c \pm \frac{M_g \theta_{eq}}{S_y}$$

Where:

- θ_{eq} = rotation angle at equilibrium (rad)
- $f_{c.eq}$ = concrete stress at flange tip at equilibrium (ksi)

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3.25.1.2 Factor of Safety

A key concept in ensuring girder stability is the notion of factor of safety, which is a measure to provide a resisting moment that is sufficiently larger than the acting moment. The factor of safety is defined as:

$$FS = \frac{M_r}{M_a} = \frac{y_r \theta}{z_0 \theta + e_i}$$

The factor of safety is computed for two cases:

- 1) to provide an uncracked section,
- 2) against failure using cracked sections.

For the uncracked section, the rotation at which the section cracks, θ_{cr} , is defined as:

$$\theta_{cr} = \frac{M_{y.crack}}{M_z}$$

Where:

$$\begin{aligned} M_{y.crack} &= \text{lateral moment applied to the girder that causes tensile cracking in the most critical flange} \\ M_z &= \text{gravity moment of the girder} \end{aligned}$$

The factor of safety against cracking is recommended to be at least 1.0.

For the cracked section, the lateral stiffness of the girder is reduced, so it will deflect more under the same load. The effective stiffness is defined as:

$$E_c I_{eff} = \frac{E_c I_g}{(1 + 2.5\theta)}$$

The effective stiffness is applied to the lateral deflection of the girder only, as the initial lateral eccentricity is not affected by the softening of the girder. With the effective stiffness, the factor of safety becomes:

$$FS = \frac{M_r}{M_a} = \frac{y_r \theta}{z_0 \theta (1 + 2.5\theta) + e_i}$$

The angle of rotation in the above formula is varied to find the maximum factor of safety by setting the derivative of the function to zero and solving for theta at the maximum factor of safety, θ'_{max} . The resulting formula becomes:

$$\theta'_{max} = \sqrt{\frac{e_i}{2.5z_0}}$$

The factor of safety against failure must be at least 1.5:

$$FS_{ult} = \frac{M_r}{M_a} = \frac{y_r \theta'_{max}}{z_0 \theta'_{max} (1 + 2.5\theta'_{max}) + e_i} \geq 1.5$$

Section checks should be performed to assure that the girder has adequate lateral moment capacity to resist $1.5M_a$.

Chapter 3 Method of Solution

3.25.1.3 Effect of Wind and Inclined Cables

The introduction of wind into the equilibrium equations requires consideration of both added rotation of the girder and added lateral deflection of the girder. Since the girder is supported from the top, this rotation and deflection results in opposing contributions to the lateral stability factor of safety.

For a case where the girder bottom rotates to the right due to the applied eccentricities described in Section 3.25.1.1, the girder rotation will increase due to the wind load as shown in the left diagram of Figure 3.25-6, increasing the lateral self-weight deflection, z . However, the lateral deflection of the girder due to wind load acts in the opposite direction, reducing the lateral deflection. The opposite occurs with wind from the opposite direction, the rotation lessens while the deflection increases. Therefore, it is necessary to check wind from both directions to establish the critical factors of safety.

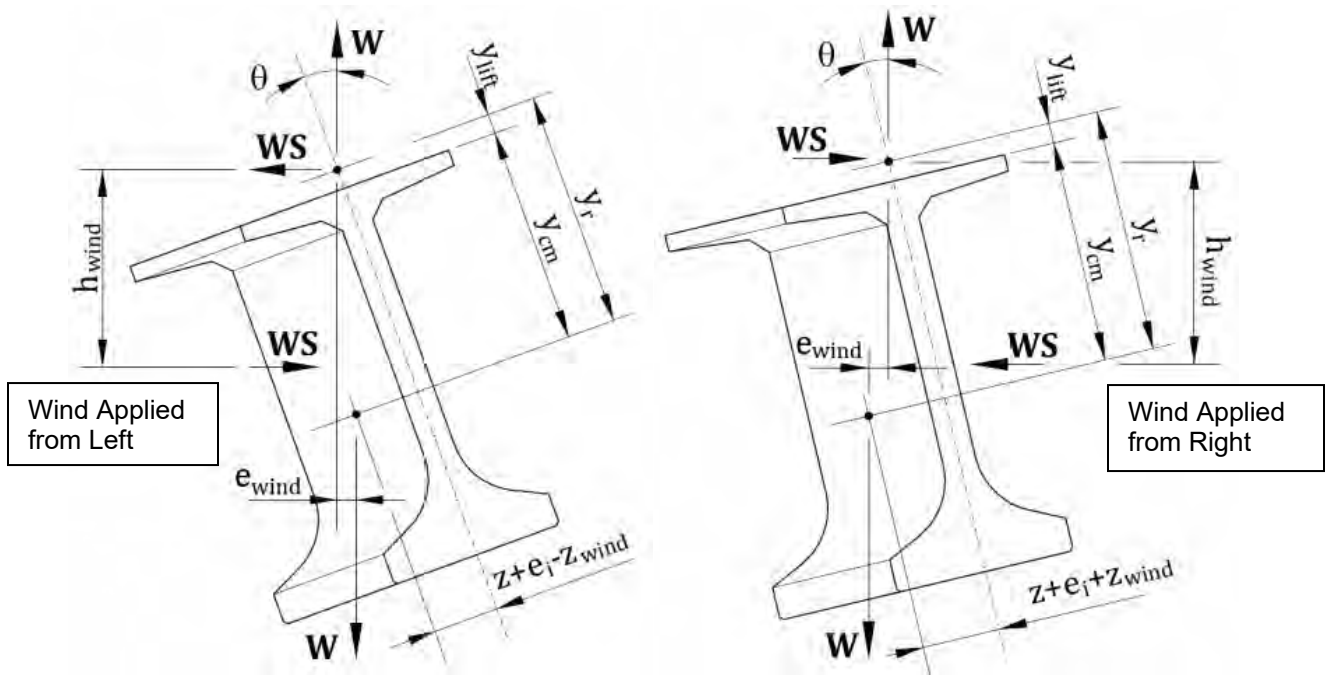


Figure 3.25-6 Geometric Condition and Free Body Diagram of Rotated Girder Subject to Wind from Both Directions

Where wind acts to increase girder rotation, the equilibrium equations described in Section 3.25.1.1 are modified to include the wind effects. The lateral movement of the girder due to wind is defined as:

$$e_{wind} = \frac{WS \times h_{wind}}{W}$$

The resisting and acting moments become:

$$M_r = W y_r \theta$$

$$M_a = W(z_0 \theta + e_i - z_{wind} + e_{wind})$$

Solving for the rotation at equilibrium, where the acting and resisting moments are equal,

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$$\theta_{eq} = \frac{e_i - z_{wind} + e_{wind}}{y_r - z_0}$$

This angle is utilized to calculate the lateral moment in the girder due to self-weight and other loads such as wind force, to determine the concrete compressive strength requirements.

The factor of safety against cracking and against failure are as follows:

$$FS_{cr} = \frac{M_r}{M_a} = \frac{y_r \theta_{cr}}{z_0 \theta_{cr} + e_{conn} - z_{wind} + e_{wind} + e_i} \geq 1.0$$

$$FS_{ult} = \frac{M_r}{M_a} = \frac{y_r \theta}{(z_0 \theta - z_{wind})(1 + 2.5\theta) + e_{wind} + e_{conn} + e_i} \geq 1.5$$

Where wind acts to decrease girder rotations, the equilibrium equations described in Section 3.25.1.1 are modified to include the wind effects as follows:

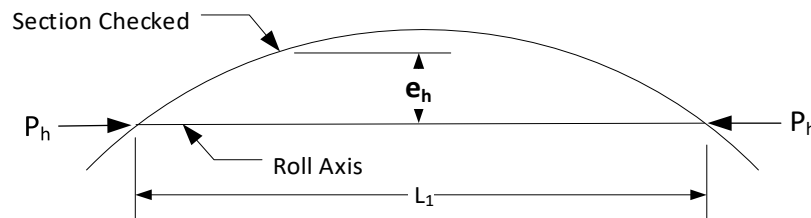
$$M_a = W(z_0 \theta + e_i + z_{wind} - e_{wind})$$

$$\theta_{eq} = \frac{e_i + z_{wind} - e_{wind}}{y_r - z_0}$$

$$FS_{cr} = \frac{M_r}{M_a} = \frac{y_r \theta_{cr}}{z_0 \theta_{cr} + e_{conn} + z_{wind} - e_{wind} + e_i} \geq 1.0$$

$$FS_{ult} = \frac{M_r}{M_a} = \frac{y_r \theta}{(z_0 \theta + z_{wind})(1 + 2.5\theta) - e_{wind} + e_{conn} + e_i} \geq 1.5$$

Girders are sometimes lifted with inclined slings from a single crane hook. The horizontal component of the tensile force in these cables, when applied directly to the girder roll center, introduces an eccentric compressive force in the girder section along the roll axis. This force results in compression in the top of the girder and a constant moment between lifting points due to the eccentricity of the roll center to the center of mass of the girder. Increased lateral moment occurs from the eccentricity due to the lateral deflection of the girder as shown in Figure 3.25-7. These forces should be considered when determining the stability of the girder.



Plan View

Figure 3.25-7 Lateral Eccentricity of Horizontal Force

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Where:

e_h = lateral eccentricity of the horizontal component of the tension force from the roll axis to the section under consideration (in)

P_h = horizontal component of the tension force in the inclined cable (kip)

The calculation of the lateral moment caused by the eccentricity should be adjusted for P-Delta effects by magnifying the eccentricity by the quantity:

$$\frac{1}{1 - \frac{P_h}{P_{cr}}}$$

Where;

P_{cr} = critical buckling load = $\frac{\pi^2 E_c I_y}{L_1^2}$ (kip)

E_c = modulus of elasticity of the girder (ksi)

I_y = weak axis moment of inertia of the girder (in⁴)

L_1 = span length between lifting points (in)

The lateral eccentricity, e_h , is composed of all the deformations defined by the initial eccentricity, the deflection caused by external lateral forces, such as wind, and the self-weight lateral deflection of the girder due to rotation. All these eccentricities are magnified for P-Delta effects.

The calculation for rotation causing cracking is redefined to address the P-Delta effect as follows:

$$\theta_{cr} = \frac{M_{y.crack}}{M_z + P_h z_0}$$

Where $M_{y.crack}$ = lateral moment applied to the girder that causes tensile cracking in the most critical flange after consideration of all lateral eccentricities that are not affected by girder rotation.

3.25.2 First Girder Seated – Girder Equilibrium on Elastomeric Bearings

Stability must be checked for the condition of seating of the first girder at the bridge site. The rotational stiffness of the bearings and the cross slope of the bearing surface greatly influence the stability of the girder. The relationship between the girder and its bearings is illustrated in Figure 3.25-7. The roll center is defined at the center of the elastomeric bearing. The accompanying free body diagram indicates the direct relation between the acting girder weight and the restoring force caused by the torsional resistance of the bearings. The spring constant of the bearings, K_θ , must be sufficient to resist the overturning tendency of the tilted girder.

The rotational stiffness of the bearing, K_θ , is highly dependent on the conditions of the mating surfaces. As the girder rotates, liftoff can occur. When this liftoff occurs, the rotational stiffness of the bearings is reduced dramatically. The equations presented herein depend on a linear relationship between the moment resistance of the bearing and the rotation. To maintain the applicability of these equations, the reaction

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eccentricity must not exceed the kern point of the bearing. A factor of safety of 1.2 for this bearing check is recommended based on overturning resistance requirements in Section 2.2.3 of the *AASHTO Guide Design Specification for Bridge Temporary Works* (2008).

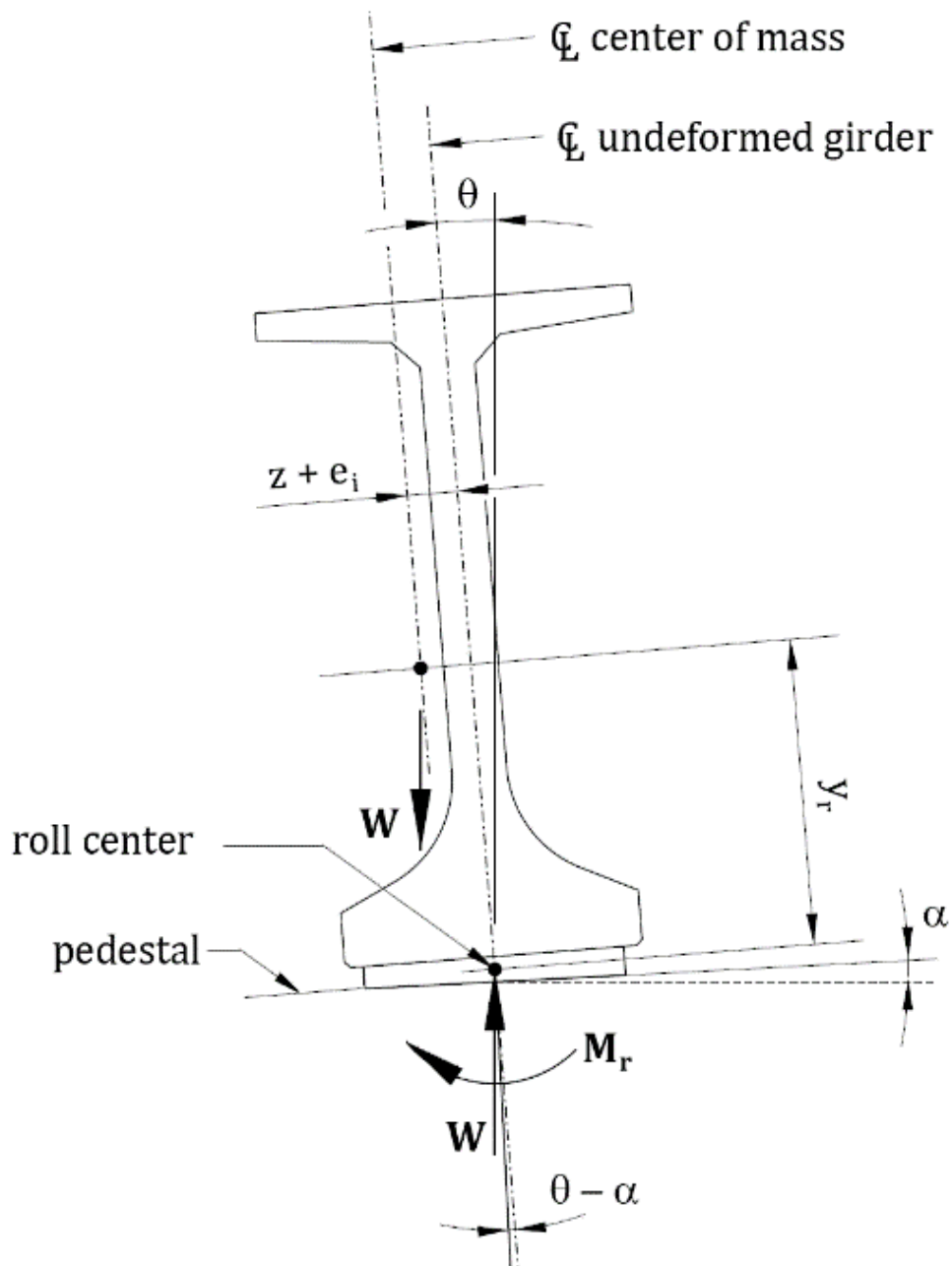


Figure 3.25-8 Geometric Condition and Free Body Diagram of Rotated Girder on Bearings

Three different checks are performed to verify the stability of a supported girder:

- 1) the potential for cracking resulting from lateral deformation,
- 2) the potential for the cracked girder to fail prior to rolling over, and
- 3) the potential for the girder rolling over due to failure.

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This takes the form of computing the safety factor against cracking, the factor of safety against failure, and the factor of safety against girder rollover.

Factor of Safety Against Cracking

First, the equilibrium angle is computed by:

$$\theta_{eq.seat2} = \frac{K_{\theta.seat2} \times \alpha_{seat2} + W_{girder}(z_{wind.seat2} + e_{i.seat2} + e_{brg.seat2}) + M_{ot.seat2}}{K_{\theta.seat2} - W_{girder}(y_{r.seat2} + z_{0.seat2})}$$

This angle is utilized to calculate the lateral moment in the girder due to self-weight and lateral wind. This lateral moment is combined with load effects from girder dead weight and prestressing to determine the stresses in the girder. These stresses are compared to the allowable concrete stresses.

Then the lateral moment to cause cracking is computed as:

$$M_{lat.seat2} = (f_{t.seat2} - f_{r.seat2})S_{y,t}$$

Where:

$$\begin{aligned} f_{t.seat2} &= \text{concrete stress in girder top flange (ksi)} \\ f_{r.seat2} &= \text{girder concrete modulus of rupture (ksi)} \\ S_{y,t} &= \text{vertical axis section modulus top flange (in}^3\text{)} \end{aligned}$$

The overturning moment due to the wind is computed as:

$$M_{ot.seat2} = L_{girder} \times w_{wind.seat2} \times y_{mid.seat2}$$

Where:

$$\begin{aligned} L_{girder} &= \text{total length of girder (ft)} \\ w_{wind.seat2} &= \text{lateral wind force at seating (klf)} \\ y_{mid.seat2} &= \text{mid-height of cambered girder above roll axis (in)} \end{aligned}$$

The tilt angle at cracking, $\theta_{cr.seat2}$, is found by dividing the lateral cracking moment by the gravity moment:

$$\theta_{cr.seat2} = \frac{M_{lat.seat2}}{M_{g.seat2}}$$

The factor of safety against cracking is determined and compared to the recommended factor of at least 1.0:

$$FS_{cr.seat2} = \frac{K_{\theta.seat2}(\theta_{cr.seat2} - \alpha_{seat2})}{W_{girder}[(z_{0.seat2} + y_{r.seat2})\theta_{cr.seat2} + z_{wind.seat2} + e_{i.seat2} + e_{brg.seat2}] + M_{ot.seat2}} \geq 1.0$$

Where:

$$\begin{aligned} K_{\theta.seat2} &= \text{rotational constant of the bearings (in-k/rad)} \\ \theta_{cr.seat2} &= \text{tilt angle at cracking due to lateral deflection (rad)} \end{aligned}$$

Chapter 3 Method of Solution

- α_{seat2} = maximum transverse seating tolerance from level (ft/ft)
 W_{girder} = weight of the girder (kip)
 $z_{0.seat2}$ = center of mass eccentricity due to girder weight on weak axis (in)
 $y_{r.seat2}$ = distance from the roll center to the center of mass of the girder (in)
 $e_{i.seat2}$ = initial lateral eccentricity of center of mass of girder with respect to roll axis caused by girder sweep (in)
 $e_{brg.seat2}$ = eccentricity of bearing pad centerline from centerline of girder (in) (see Figure 3.25-9)
 $z_{wind.seat2}$ = lateral deflection of the girder subjected to wind force on girder (in)

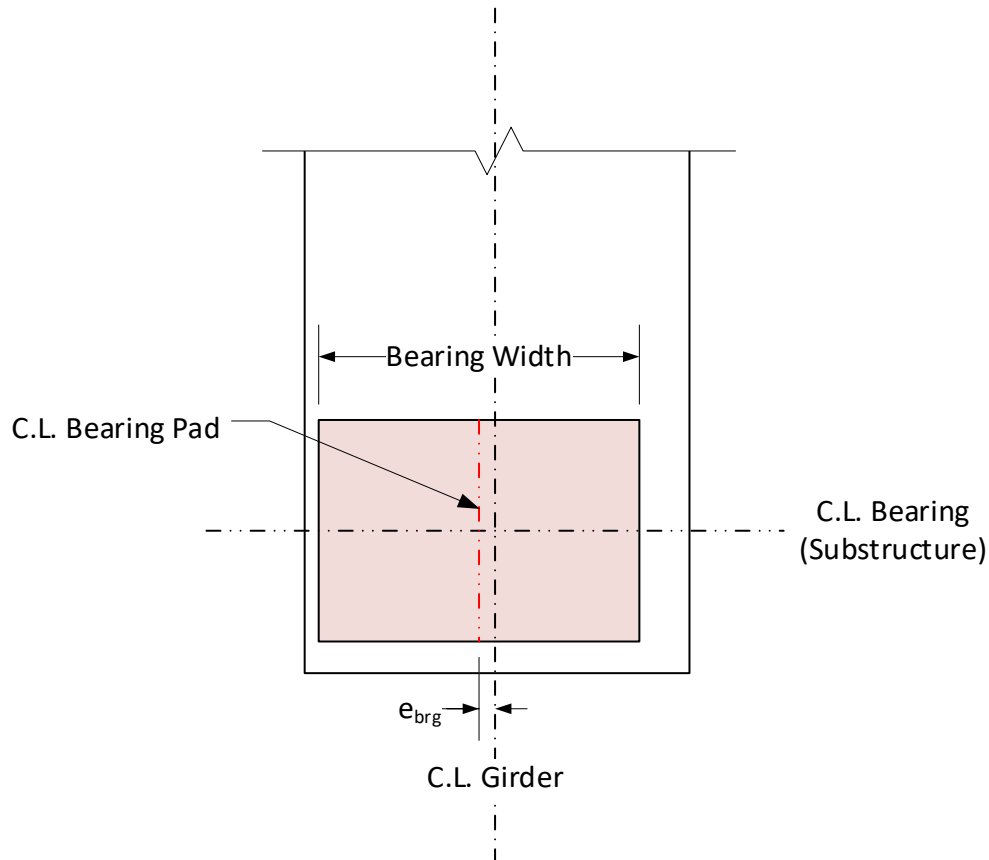


Figure 3.25-9 Plan View of Bearing Pad and Girder End

Factor of Safety Against Failure (Cracked section)

For cracked sections, the lateral stiffness of the girder is reduced, so it will deflect more under the same load. The effective stiffness is defined as:

$$E_c I_{eff} = \frac{E_c I_g}{(1 + 2.5\theta)}$$

Where:

- E_c = concrete girder modulus of elasticity (ksi)

Chapter 3 Method of Solution

$$\begin{aligned}
 I_{eff} &= \text{effective horizontal axis moment of inertia (in}^4\text{)} \\
 I_g &= \text{horizontal axis moment of inertia of girder (in}^4\text{)} \\
 \theta &= \text{tilt angle of girder (rad)}
 \end{aligned}$$

The effective stiffness is applied to the lateral deflection of the girder only, as the initial lateral eccentricity is not affected by the softening of the girder. Incorporating this effective stiffness, the factor of safety against failure becomes:

$$FS_{ult.seat2} = \frac{K_{\theta.seat2}(\theta - \alpha_{seat2})}{W_{girder}[(z_{0.seat2} \times \theta + z_{wind.seat2})(1 + 2.5\theta) + y_{r.seat2} \times \theta + e_{i.seat2} + e_{brg.seat2}] + M_{ot.seat2}} \geq 1.5$$

The angle of rotation, theta, in this formula for the factor of safety against failure is varied between 0. and 0.4 radians to find the maximum factor of safety. The rotation angle at the maximum factor of safety is designated, $\theta_{max.ult.seat2}$.

The factor of safety against failure must be at least 1.5.

Girder Equilibrium -- Beam Rollover (Cracked)

Factor of safety against rollover is the factor of safety calculated at a girder rotation angle at which the girder is expected to rollover. Equilibrium of the girder at rollover is presented in Figure 3.25-10. On the left of the Figure 3.25-10, the girder with lateral forces on the bearing pad is shown. On the right is the free body diagram of the bearing pad on a surface with angle of α . The girder angle at which the girder rolls over is given by:

$$\begin{aligned}
 z_{max.seat2} &= \frac{W_{brg.seat2}}{6} \\
 M_{roll.seat2} &= L_{girder} \times w_{wind.seat2} \times h_{roll.seat2} \\
 \theta'_{max.seat2} &= \frac{W_{girder}(z_{max.seat2} - h_{roll.seat2} \times \alpha_{seat2} - e_{brg.seat2}) + M_{roll.seat2}}{K_{\theta.seat2}} + \alpha_{seat2}
 \end{aligned}$$

Where:

$$\begin{aligned}
 z_{max.seat2} &= \text{horizontal distance from roll axis to the kern point of the pad (in)} \\
 W_{brg.seat2} &= \text{plan dimension of bearing parallel to transverse axis of the girder (in)} \\
 h_{roll.seat2} &= \text{height of roll center above bearing pedestal (in)} \\
 e_{brg.seat2} &= \text{bearing tolerance from centerline of girder to centerline of support (in)} \\
 M_{roll.seat2} &= \text{overturning moment from wind (in-k)}
 \end{aligned}$$

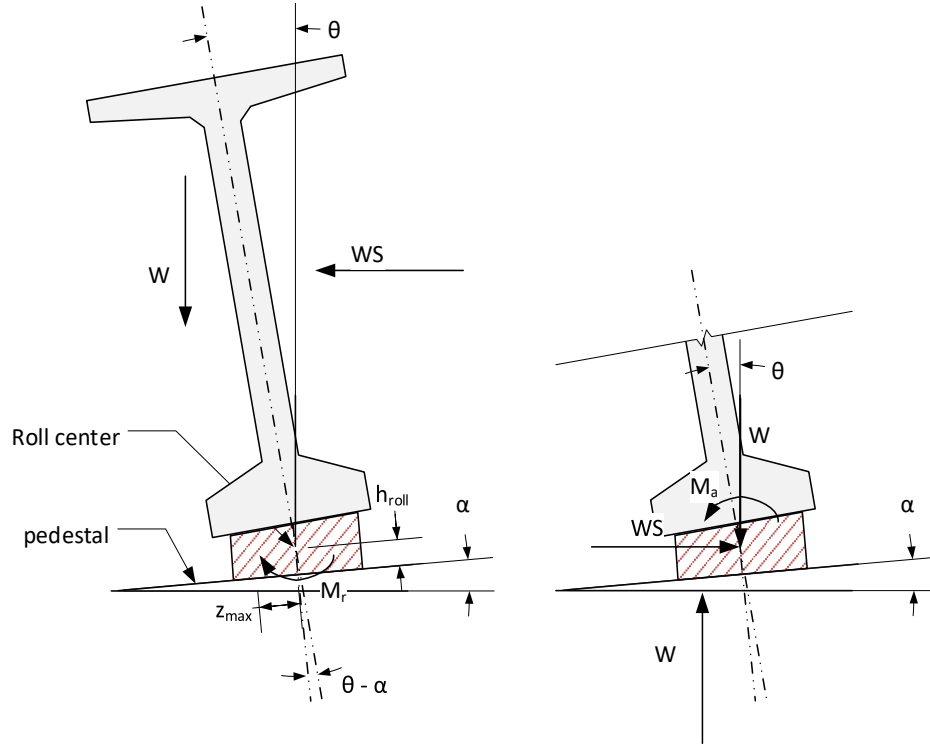


Figure 3.25-10 Geometric Condition and Free Body Diagram of Girder Rollover on Bearings

The corresponding Center of Mass Eccentricity due to the tilt angle is given by:

$$z'_{0.seat2} = z_{0.seat2}(1 + 2.5\theta'_{max.seat2})$$

The Factor of Safety against Rollover is given by:

$$FS_{roll.seat2} = \frac{K_{\theta.seat2}(\theta'_{max.seat2} - \alpha_{seat2})}{W_{girder}[(z'_{0.seat2} + y_{r.seat2}) \times \theta'_{max.seat2} + z_{wind.seat2}(1 + 2.5\theta'_{max.seat2}) + e_{i.seat2} + e_{brg.seat2}] + M_{roll.seat2}} \geq 1.5$$

When the user specifies that End Braces are Provided (GS2 Command), the Factor of Safety against Rollover is not considered due to the bracing.

The overturning to be resisted by bracing is given by:

$$M_{ot.seat2.brace} = \frac{W_{girder}[z'_{0.seat2} \times \theta'_{max.seat2} + y_{r.seat2} \times \theta'_{max.seat2} + e_{i.seat2} + e_{brg.seat2}] + M_{ot.seat2}}{2}$$

The concurrent lateral force for each brace is given by:

$$F_{ot.seat2.brace} = \frac{L_{girder} \times W_{wind.seat2}}{2}$$

Chapter 3 Method of Solution

The following brief descriptions provides the additional equations used to compute the stability checks made for the first girder seated on bearings for active construction.

NOTE: These equations compute concrete stresses with compression being positive and tension being negative. The output of concrete stresses reverses the sign of the stresses to be consistence with other stress output of the program.

Concrete Modulus of Elasticity:

$$E_{c.seat2} = 120000K_1 \times w_c^2 \times (f_{c.seat2})^{0.33}$$

Modulus of rupture:

$$f_{r.seat2} = -0.24\lambda\sqrt{f_{c.seat2}}$$

Eccentricity reduction factor:

$$offset_{seat2} = \left(\frac{L_{1.seat2}}{L_{girder}}\right)^2 - \frac{1}{3}$$

Where;

$$L_{1.seat2} = L_{girder} - 2a_{seat2}$$

Center of mass eccentricity due to lateral deflection:

$$e_{i.seat2} = e_{i.total.seat2} \times offset_{seat2}$$

Distance from the center of mass of the cambered arc above roll axis:

$$y_{r.seat2} = y_{brg.seat2} + y_b + offset_{seat2} \times \Delta_{camber.seat2}$$

Mid-height of cambered girder above roll axis:

$$y_{mid.seat3} = \frac{h_{girder}}{2} + y_{brg.seat2} + offset_{seat2} \times \Delta_{camber.seat2}$$

Eccentricity due to wind deflection:

$$z_{wind.seat2} = \frac{w_{wind.seat2}}{12E_{c.seat2} \times I_y \times L_{girder}} \left[\frac{(L_{1.seat2})^5}{10} - (a_{seat2})^2(L_{1.seat2})^3 + 3(a_{seat2})^4(L_{1.seat2}) + \frac{6}{5}(a_{seat2})^5 \right]$$

Lateral deflection due to girder weight on weak axis:

$$z_{0.seat2} = \frac{w_{DC.girder}}{12E_{c.seat2} \times I_y \times L_{girder}} \left[\frac{(L_{1.seat2})^5}{10} - (a_{seat2})^2(L_{1.seat2})^3 + 3(a_{seat2})^4(L_{1.seat2}) + \frac{6}{5}(a_{seat2})^5 \right]$$

Chapter 3 Method of Solution

Moment due to gravity load at x :

$$M_{g.seat2} = \frac{w_{DC.girder} \times L_{girder}}{2} (x - a_{seat2}) - \frac{w_{DC.girder} \times x^2}{2}$$

Lateral moment due to wind on girder at x :

$$M_{wind.seat2} = \frac{w_{wind.seat2} \times L_{girder}}{2} (x - a_{seat2}) - \frac{w_{wind.seat2} \times x^2}{2}$$

Concrete stresses in girder:

$$f_{t.seat2} = P_{eff.seat2} \left(\frac{1}{A} - \frac{y_b - y_{cgs.mid.seat2}}{S_{x,t}} \right) + \frac{M_{g.seat2}}{S_{x,t}} - \frac{M_{wind.seat2}}{S_{y,t}}$$

$$f_{b.seat2} = P_{eff.seat2} \left(\frac{1}{A} + \frac{y_b - y_{cgs.mid.seat2}}{S_{x,b}} \right) - \frac{M_{g.seat2}}{S_{x,b}} + \frac{M_{wind.seat2}}{S_{y,b}}$$

Concrete stresses in girder at equilibrium:

$$f_{eq.t.seat2} = f_{t.seat2} - \frac{M_{g.seat2} \times \theta_{eq.seat2}}{S_{y,t}}$$

$$f_{eq.b.seat2} = f_{b.seat2} + \frac{M_{g.seat2} \times \theta_{eq.seat2}}{S_{y,b}}$$

3.25.3 Multiple Girders Seated – Inactive Construction

The next stability check is for all girders seated with construction inactive wind conditions. These wind conditions would typically correspond to 90 mph 3-second gust. During these wind conditions, a corresponding vertical wind causing an uplift pressure would be considered. First stresses are checked with bracing only at the bearings using the construction inactive wind loads. As with the first girder seated, the factor of safety against cracking and the factor of safety against failure are computed and compared to the required factor of safety. Also, the eccentricity of the bearing pad reaction is compared to the eccentricity limit for the reaction. If any of these checks fail, intermediate bracing will be added, and the concrete stresses rechecked. The number of required braces will be increased until the concrete stresses are less than the allowable or the number of braces exceeds 11. With braces in place, only the concrete stresses need to be checked. Therefore, if the user has specified the number of intermediate braces (GS2 Command) to be greater than zero, only the concrete stresses are checked.

The following brief descriptions provides the detailed equations used to compute the stability checks made for multiple girders seated for inactive construction.

Chapter 3 Method of Solution

NOTE: These equations compute concrete stresses with compression being positive and tension being negative. The output of concrete stresses reverses the sign of the stresses to be consistence with other stress output of the program.

Concrete Modulus of Elasticity:

$$E_{c.seat3} = 120000K_1 \times w_c^2 \times (f_{c.seat3})^{0.33}$$

Modulus of rupture:

$$f_{r.seat3} = -0.24\lambda\sqrt{f_{c.seat3}}$$

Eccentricity reduction factor:

$$offset_{seat3} = \left(\frac{L_{1.seat3}}{L_{girder}}\right)^2 - \frac{1}{3}$$

Where;

$$L_{1.seat3} = L_{girder} - 2a_{seat3}$$

Center of mass eccentricity due to lateral deflection:

$$e_{i.seat3} = e_{i.total.seat3} \times offset_{seat3}$$

Distance from the center of mass of the cambered arc above roll axis:

$$y_{r.seat3} = y_{brg.seat3} + y_b + offset_{seat3} \times \Delta_{camber.seat3}$$

Mid-height of cambered girder above roll axis:

$$y_{mid.seat3} = \frac{h_{girder}}{2} + y_{brg.seat3} + offset_{seat3} \times \Delta_{camber.seat3}$$

Eccentricity due to wind deflection:

$$z_{wind.seat3} = \frac{w_{wind.seat3}}{12E_{c.seat3} \times I_y \times L_{girder}} \left[\frac{(L_{1.seat3})^5}{10} - (a_{seat3})^2(L_{1.seat3})^3 + 3(a_{seat3})^4(L_{1.seat3}) + \frac{6}{5}(a_{seat3})^5 \right]$$

Lateral deflection due to girder weight on weak axis:

$$z_{0.seat3} = \frac{w_{DC.girder}}{12E_{c.seat3} \times I_y \times L_{girder}} \left[\frac{(L_{1.seat3})^5}{10} - (a_{seat3})^2(L_{1.seat3})^3 + 3(a_{seat3})^4(L_{1.seat3}) + \frac{6}{5}(a_{seat3})^5 \right]$$

Moment due to gravity load at x :

$$M_{g.seat3} = \frac{w_{DC.girder} \times L_{girder}}{2} (x - a_{seat3}) - \frac{w_{DC.girder} \times x^2}{2}$$

Chapter 3 Method of Solution

Lateral moment due to wind on girder at x :

$$M_{wind.seat3} = \frac{w_{wind.seat3} \times L_{girder}}{2} (x - a_{seat3}) - \frac{w_{wind.seat3} \times x^2}{2}$$

Uplift moment due to wind:

$$M_{uplift.seat3} = \frac{w_{uplift.seat3} \times L_{girder}}{2} (x - a_{seat3}) - \frac{w_{uplift.seat3} \times x^2}{2}$$

Overturning moment due to wind:

$$M_{ot.seat3} = L_{girder} \times w_{wind.seat3} \times y_{mid.seat3}$$

Concrete stresses in girder:

$$f_{t.seat3} = P_{eff.seat3} \left(\frac{1}{A} - \frac{y_b - y_{cgs.mid.seat3}}{S_{x.t}} \right) + \frac{M_{g.seat3} - M_{uplift.seat3}}{S_{x.t}} - \frac{M_{wind.seat3}}{S_{y.t}}$$

$$f_{b.seat3} = P_{eff.seat3} \left(\frac{1}{A} + \frac{y_b - y_{cgs.mid.seat3}}{S_{x.b}} \right) - \frac{M_{g.seat3} - M_{uplift.seat3}}{S_{x.b}} + \frac{M_{wind.seat3}}{S_{y.b}}$$

Tilt angle at equilibrium:

$$\theta_{eq.seat3} = \frac{K_{\theta.seat3} \times \alpha_{seat3} + W_{girder}(z_{wind.seat3} + e_{i.seat3}) + M_{ot.seat3}}{K_{\theta.seat3} - W_{girder}(y_{r.seat3} + z_{0.seat3})}$$

Concrete stresses in girder at equilibrium:

$$f_{eq.t.seat3} = f_{t.seat3} - \frac{M_{g.seat3} \times \theta_{eq.seat3}}{S_{y.t}}$$

$$f_{eq.b.seat3} = f_{b.seat3} + \frac{M_{g.seat3} \times \theta_{eq.seat3}}{S_{y.b}}$$

Lateral moment to cause cracking:

$$M_{lat.seat3} = (f_{t.seat3} - f_{r.seat3})S_{y.t}$$

Tilt angle at cracking due to lateral deflection:

$$\theta_{cr.seat3} = \frac{M_{lat.seat3}}{M_{g.seat3}}$$

Factor of safety against cracking:

$$FS_{cr.seat3} = \frac{K_{\theta.seat3}(\theta_{cr.seat3} - \alpha_{seat3})}{W_{girder}[(y_{r.seat3} + z_{0.seat3})\theta_{cr.seat3} + z_{wind.seat3} + e_{i.seat3} + e_{brg.seat3}] + M_{ot.seat3}}$$

Chapter 3 Method of Solution

Factor of Safety against failure:

$$FS_{ult.seat3} = \frac{K_{\theta.seat3}(\theta - \alpha_{seat3})}{W_{girder}[(z_{0.seat3} \times \theta + z_{wind.seat3})(1 + 2.5\theta) + y_{r.seat3} \times \theta + e_{i.seat3} + e_{brg.seat3}] + M_{ot.seat3}}$$

Maximize factor of safety by varying $\theta = \theta_{max.ult.seat3} \leq 0.4$ rad

Bearing pad effectiveness under service loads:

Eccentricity at service:

$$ecc_{serv.seat3} = \frac{W_{girder}[(z_{0.seat3} + y_{r.seat3})\theta_{eq.seat3} + z_{wind.seat3} + e_{i.seat3} + e_{brg.seat3}] + M_{ot.seat3}}{W_{girder}}$$

Eccentricity limit:

$$ecc_{serv.limit} = \frac{W_{brg.seat3}}{6(FS_{overturning})}$$

Where;

$$FS_{overturning} = 1.5$$

Ratio of girder spacing to girder height:

$$ratio_{gs.gh} = \frac{s_{girder}}{h_{girder}}$$

The total drag coefficient on the girder system is the sum of the drag coefficients on each girder. For the third through the fifth girder the drag coefficient depends on the ratio of the girder spacing to the girder height as shown below (if the girder does not exist the drag coefficient is 0.0):

Drag coefficients on girders:

First Girder	= 1.00 C_D
Second Girder	= 0.00 C_D
Third Girder	= 0.25 C_D if $ratio_{gs.gh} \leq 3$, otherwise 0.50 C_D
Fourth Girder	= 0.25 C_D if $ratio_{gs.gh} \leq 3$, otherwise 0.50 C_D
Fifth Girder	= 0.25 C_D if $ratio_{gs.gh} \leq 3$, otherwise 0.50 C_D
Remainder Total	= 0.50 C_D times ($n_{girders} - 5$)

Total drag coefficient on girders system:

$$total_{CD} = \sum_{i=1, n_{girders}} (C_D)_i$$

Total wind force resisted by all girders:

$$w_{wind.global} = w_{wind.seat3} \times total_{CD}$$

Chapter 3 Method of Solution

Windward exterior girder deflection in global girder system:

$$\delta_{wind.ext.global} = \frac{w_{wind.global} \times L_{1.seat3}}{384E_{c.seat3} \times I_y \times n_{girders}} [5(L_{1.seat3})^3 - 24(a_{seat3})^2(L_{1.seat3})] + \frac{n_{girders} - 1}{2} e_{brace}$$

Windward exterior girder deflection without bracing:

$$\delta_{wind.ext.single} = \frac{w_{wind.seat3} \times L_{1.seat3}}{384E_{c.seat3} \times I_y} [5(L_{1.seat3})^3 - 24(a_{seat3})^2(L_{1.seat3})]$$

Percentage of wind force on simple span girder:

$$SSG_{pct} = \frac{\delta_{wind.ext.global}}{\delta_{wind.ext.single}}$$

Effective moment coefficient due to bracing:

Note: Assumes girder has bracing at equal spacing. M_{mod} is the factor that is used to calculate critical moment due to uniform load.

$$M_{mod} = \begin{cases} 0.125 & \text{if } n_{braces} < 4 \\ 0.100 & \text{if } n_{braces} = 4 \\ 0.107 & \text{if } n_{braces} = 5 \\ 0.105 & \text{if } n_{braces} = 6 \\ 0.106 & \text{otherwise} \end{cases}$$

Modified lateral moment due to wind:

$$M_{wind.seat3.bracing} = SSG_{pct} \times M_{wind.seat3} + M_{mod} \times w_{wind.seat3} \left(\frac{L_{1.seat3}}{n_{braces} - 1} \right)^2$$

Concrete stresses in girder with bracing:

$$f_{t.seat3.bracing} = P_{eff.seat3} \left(\frac{1}{A} - \frac{y_b - y_{cgs.mid.seat3}}{S_{x.t}} \right) + \frac{M_{g.seat3} - M_{uplift.seat3}}{S_{x.t}} - \frac{M_{wind.seat3.bracing}}{S_{y.t}}$$

$$f_{b.seat3.bracing} = P_{eff.seat3} \left(\frac{1}{A} - \frac{y_b - y_{cgs.mid.seat3}}{S_{x.b}} \right) - \frac{M_{g.seat3} - M_{uplift.seat3}}{S_{x.b}} + \frac{M_{wind.seat3.bracing}}{S_{y.b}}$$

Girder deflection to center of mass:

$$e_{wind.seat3} = offset_{seat3} \times \delta_{wind.ext.global}$$

Total eccentricity with wind:

$$e_{total.seat3} = e_{wind.seat3} + e_{i.seat3} + e_{brg.seat3}$$

Chapter 3 Method of Solution

Effective resistance of bracing:

Note: Assumes girder has bracing at equal spacing. F_{mod} is the factor that is used to calculate critical reaction due to uniform load.

$$F_{mod} = \begin{cases} 0.50 & \text{if } n_{braces} = 2 \\ 1.25 & \text{if } n_{braces} = 3 \\ 1.15 & \text{otherwise} \end{cases}$$

Overturning moment to be resisted by each brace:

$$M_{ot.seat3.bracing} = \frac{F_{mod} [W_{girder} (z_{0.seat3} \times \theta_{eq.seat3} + y_{r.seat3} \times \theta_{eq.seat3} + e_{total.seat3}) + M_{ot.seat3}]}{n_{braces} - 1}$$

Horizontal bracing force:

$$F_{brace.seat3} = \frac{F_{mod} \times w_{wind.seat3} \times L_{girder}}{n_{braces} - 1}$$

3.25.4 Deck (Active) Construction – Deck Casting

The exterior girder is checked for deck casting with construction active wind condition. This wind corresponds to a 20 mph 3-second gust. The exterior girder is checked for rotation caused by the torque loads applied to the exterior girder during the casting of the deck. These torque loads are caused by the deck concrete, the weight of the forms, construction dead loads, and construction live loads. For a typical configuration, these loads will cause a net torque on the exterior girder that will tend to cause the girder to rotate away from the bridge centerline (see Figure 3.25-11). This rotation will have the effect of reducing the concrete cover over the deck reinforcement. Figure 3.25-11 shows the original position of the exterior girder at the mid-point between bracing locations and the position of the girder after being twisted by the net torque on the girder. This Figure shows the two sources of the reduction in the concrete cover. The long red dashed line shows the change in the top of the deck due to the screed rail deflection, δ . The red circle highlights the rotation of the tip of the top flange which also reduces the concrete cover. Increasing the number of bracing points reduces the amount of girder rotation, which in turn, reduces the loss of concrete cover. The number of braces starts with two, one at each support. The number of braces is increased until the cover reduction is less than 1/4 inch or the number of braces is 11.

The twist angle, ϕ , is computed as follows:

$$G = \frac{E}{2(1 + \nu)}$$

$$\phi = \frac{0.25TL}{GJ}$$

Where;

G = modulus of rigidity (ksi)

E = modulus of elasticity (ksi)

Chapter 3 Method of Solution

- ν = Poisson's ratio (0.2 for concrete)
 L = girder length between bracing points (ft)
 T = the applied torque (k-ft)
 J = the torsional constant (computed by AASHTO Eq. C4.6.2.2.1-2) (in⁴)

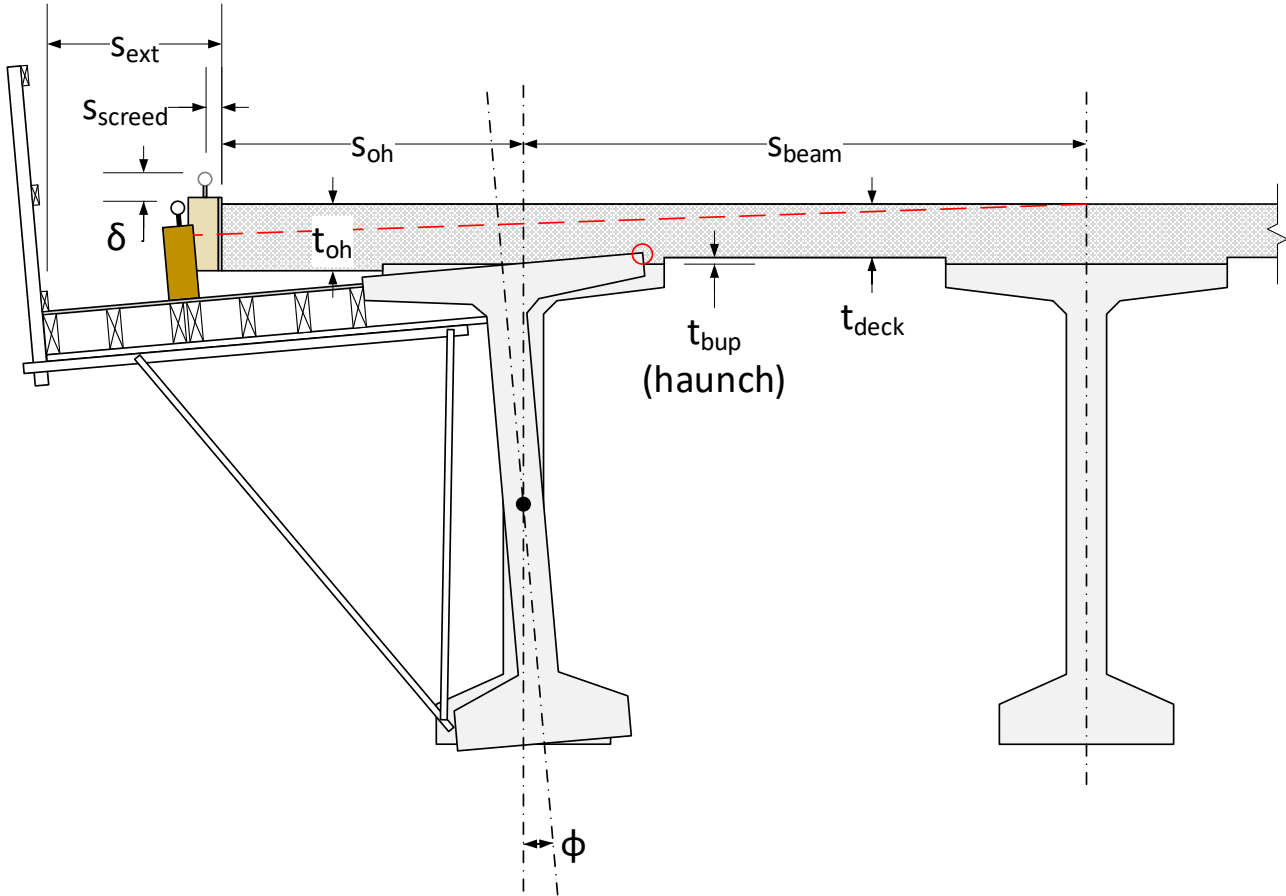


Figure 3.25-11 Geometric Condition of Exterior Girder During Deck Casting

Weight and Torque Calculations

Positive torque causes overturning towards the cantilever.

Weight and torque of concrete deck between girder flange tips per foot:

$$w_{DC1.0} = \left(\frac{S_{beam} - b_{top.flange}}{2} \right) t_{deck} w_{conc.deck}$$

$$t_{DC1.0} = w_{DC1.0} \left(\frac{-b_{top.flange}}{2} \right)$$

Weight and torque of concrete deck over girder per foot:

$$w_{DC1.1} = b_{top.flange} (t_{deck} + t_{bup}) w_{conc.deck}$$

$$t_{DC1.1} = 0.0$$

Chapter 3 Method of Solution

Weight and torque of concrete deck on cantilever per foot.

$$w_{DC1.2} = \left(s_{oh} - \frac{b_{top.flange}}{2} \right) t_{oh} w_{conc.deck}$$

$$t_{DC1.2} = w_{DC1.2} \left(\frac{b_{top.flange}}{4} + \frac{s_{oh}}{2} \right)$$

Weight and torque of stay-in-place forms per foot.

$$w_{DC2.0} = \left(\frac{s_{beam} - b_{top.flange}}{2} \right) w_{sip}$$

$$t_{DC2.0} = w_{DC2.0} \left(\frac{-b_{top.flange}}{2} \right)$$

No forms over girders.

$$w_{DC2.1} = 0.0$$

$$t_{DC2.1} = 0.0$$

Weight and torque of forms on cantilever per foot.

$$w_{DC2.2} = \left(s_{oh} + s_{ext} - \frac{b_{top.flange}}{2} \right) w_{form.cant}$$

$$t_{DC2.2} = w_{DC2.2} \left(\frac{b_{top.flange}}{4} + \frac{s_{oh}}{2} + \frac{s_{ext}}{2} \right)$$

Pattern live load over Cantilever.

Live load weight and torque on concrete deck between girders assumed to be zero for maximum overturning.

$$w_{CCL1.0} = 0.0$$

$$t_{CCL1.0} = 0.0$$

Live load weight and torque on concrete deck over half of girder per foot.

$$w_{CCL1.1} = \left(\frac{b_{top.flange}}{2} \right) w_{CCL1}$$

$$t_{CCL1.1} = w_{CCL1.1} \left(\frac{b_{top.flange}}{4} \right)$$

Live load weight and torque on concrete deck cantilever per foot.

$$w_{CCL1.2} = \left(s_{oh} - \frac{b_{top.flange}}{2} \right) w_{CCL1}$$

$$t_{CCL1.2} = w_{CCL1.2} \left(\frac{b_{top.flange}}{4} - \frac{s_{oh}}{2} \right)$$

Chapter 3 Method of Solution

Concentrated torque due to screed machine live loads.

$$T_{CLL2} = P_{CLL2}(s_{oh} + s_{screed})$$

Live load on walkway.

$$P_{CLL3} = W_{CLL3}L_{CLL3}$$

$$T_{CLL3} = \left(s_{oh} + \frac{s_{ext}}{2}\right)P_{CLL3}$$

Chapter 3 Method of Solution

3.26 END BLOCK LENGTH

For adjacent and spread box beams the interior void of the box beam starts after the end block concrete as shown in Figure 3.26.1. The end block length is measured from the obtuse corner of the box to the beginning of the void.

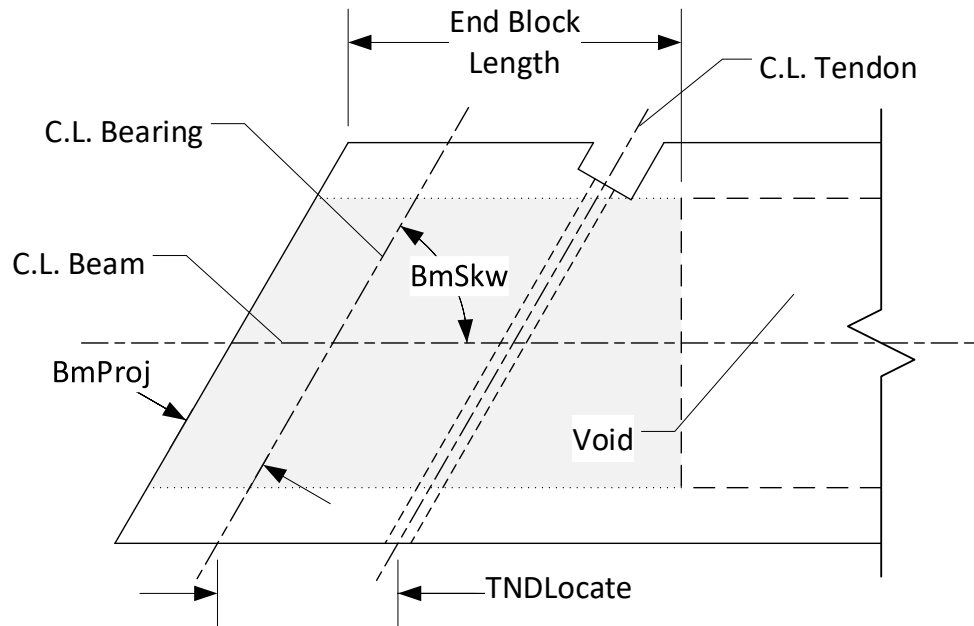


Figure 3.26-1 Plan View of Box Beam End

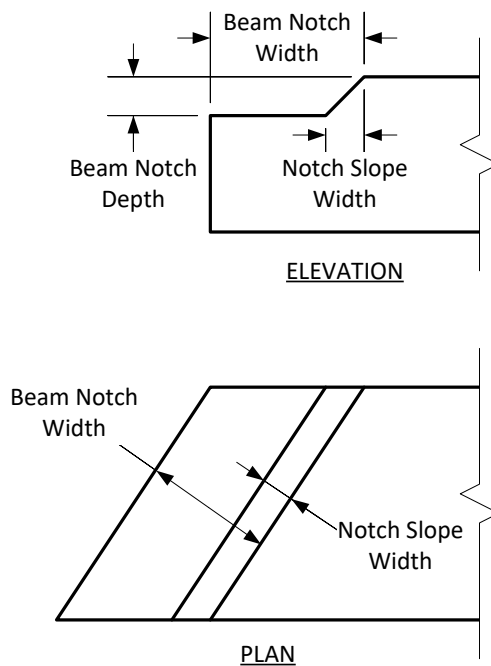


Figure 3.26-2 Plan and Elevation Views of Beam Notch

Chapter 3 Method of Solution

The End Block Length criteria are dependent upon the skew angle, beam notch dimensions, beam end projection, abutment configuration, and transverse tendon locations (adjacent boxes only). The following sections give the criteria to compute the minimum end block length. The following variables (see Figures 1 and 2) are used to make these calculations:

BmProj	=	distance from CL Brg to beam end measured perpendicular to CL Brg, parameter 5 on GEO command multiplied by $\sin(\text{BmSkw})$
BmSkw	=	angle between CL Beam and CL Brg measured counterclockwise from CL Beam to CL Brg
BmWall	=	thickness of beam wall, variable W3 on the BDM command (typ. 5") BD-652M Sheet 1
BmNotchW	=	Beam Notch Width, parameter 3 on the BDT command
NotchSlopeW	=	Beam Notch Slope Width, parameter 5 on the BDT command
TNDLocate	=	Location of transverse tendon, parameters 3 through 7 on the TND command

3.26.1 Spread Box Beams with Integral Abutments

Figure 3.26-3 shows a plan view of the end block geometry for spread boxes on integral abutments from BD-667M Sheet 8.

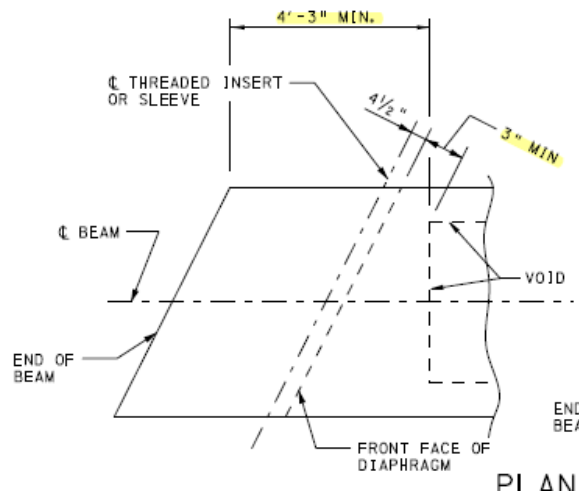


Figure 3.26-3 Plan View of Spread Box with Integral Abutment

Equations to determine minimum end block length.

- 1) 4'-3"
- 2) Maintain a 3" minimum from front face of diaphragm to the corner of the void.

$$= (\text{BmProj} + 24") / \sin(\text{BmSkw}) + 3" / \sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw}))$$

Note: 24" from C.L. Brgs to Front Face of abutment is from BD-667M, Sheet 1, Typical Plan

Chapter 3 Method of Solution

3.26.2 Spread Box with Beam Notch, with Traditional Abutments

Figure 3.26-4 shows a plan view and an elevation view of the end block geometry for spread boxes with beam notches with traditional abutments from BD-661M Sheet 6.

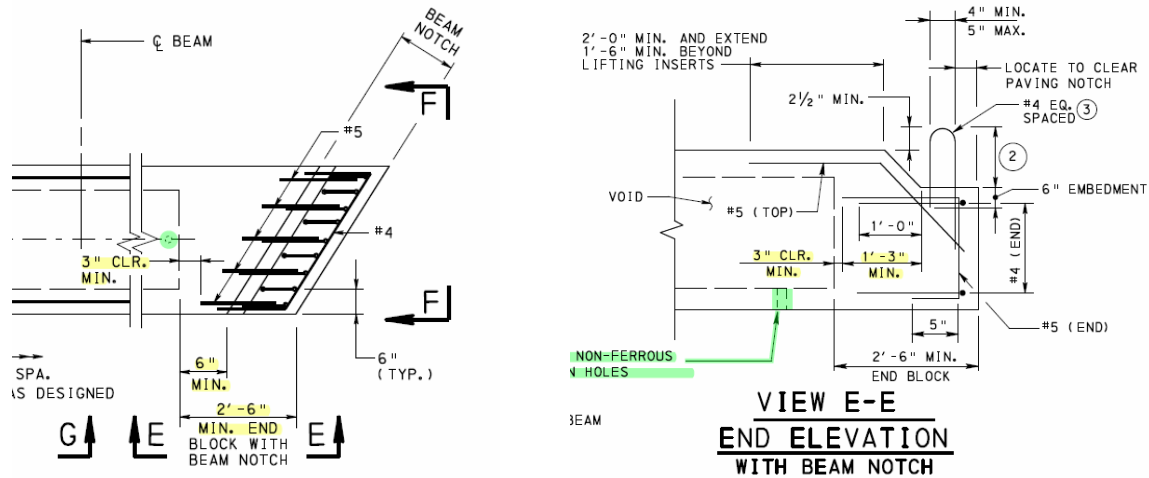


Figure 3.26-4 Plan and Elevation Views of Spread Box with Beam Notch

Equations to determine minimum end block length.

- 1) 2'-6"
- 2) Maintain a 6" minimum from Beam Notch to corner of void

$$= \text{BmNotchW} / \sin(\text{BmSkw}) + 6"$$
- 3) Maintain a 3" clear of rebar (rebar length 1'-3" from toe of beam notch)

$$= (\text{BmNotchW} - \text{NotchSlopeW}) / \sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw})) + 1'-3" + 3"$$

3.26.3 Adjacent Box with Beam Notch, with Traditional Abutments

Figure 3.26-5 shows a plan view of the end block geometry for adjacent boxes with beam notches with traditional abutments from BD-661M Sheet 1. Figure 3.26-6 shows the details of the tendon pocket geometry.

Chapter 3 Method of Solution

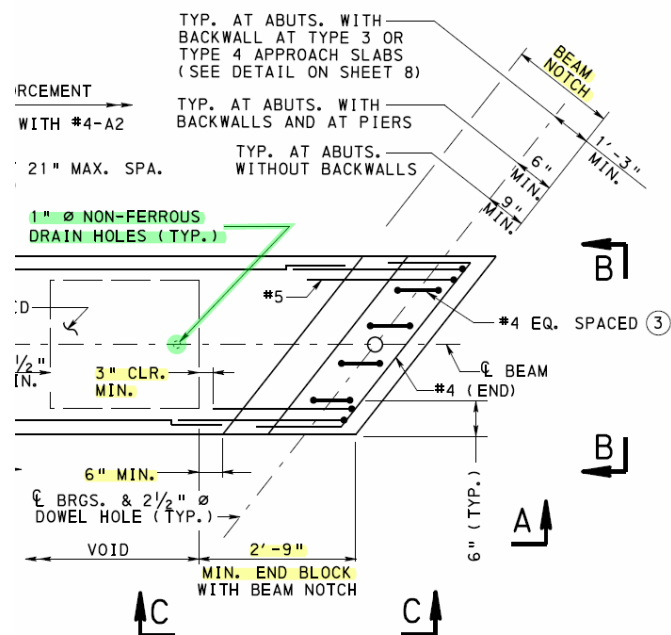


Figure 3.26-5 Plan View of Adjacent Box with Beam Notch

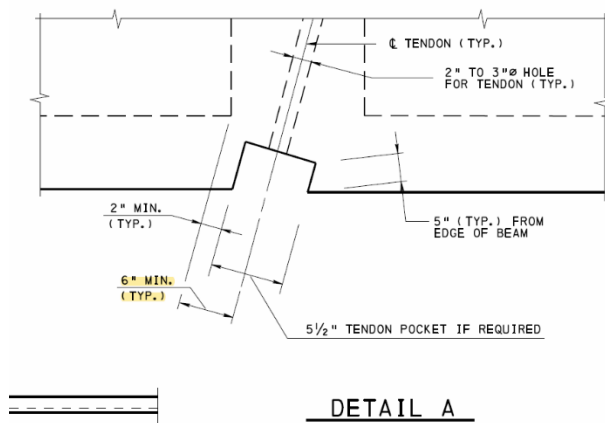


Figure 3.26-6 Tendon Pocket Detail

Chapter 3 Method of Solution

Equations to determine minimum end block length.

- 1) 2'-9"
- 2) Maintain a 6" minimum from Beam Notch to corner of void

$$= \text{BmNotchW} / \sin(\text{BmSkw}) + 6"$$
- 3) Maintain a 3" clear for rebar (rebar length 1'-3" from toe of beam notch)

$$= (\text{BmNotchW} - \text{NotchSlopeW}) / \sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw})) + 1'-3" + 3"$$
- 4) Maintain a 6" minimum clear between C.L. Tendon and corner of void (BC-775M, Sheet 2, Detail A)

$$= \text{BmProj} / \sin(\text{BmSkw}) + \text{TNDLocate} + 6"/\sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw}))$$

3.26.4 Adjacent Box without Beam Notch, with Traditional Abutments

Figure 3.26-7 shows an elevation view of the end block geometry for adjacent boxes without beam notches with traditional abutments from BD-661M Sheet 1.

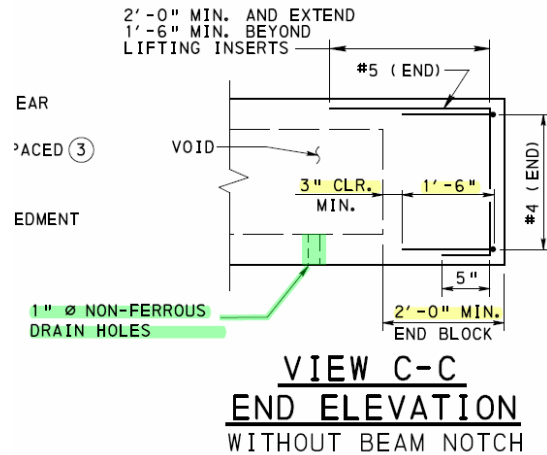


Figure 3.26-7 End Elevation View

Equations to determine minimum end block length.

- 1) 2'-0"
- 2) Maintain a 3" clear for rebar (rebar length 1'-6" with 2" clear cover)

$$= 2" / \sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw})) + 1'-6" + 3"$$
- 3) Maintain a 6" minimum clear between C.L. Tendon and corner of void (BC-775M, Sheet 2, Detail A)

$$= \text{BmProj} / \sin(\text{BmSkw}) + \text{TNDLocate} + 6"/\sin(\text{BmSkw}) - \text{BmWall} * \text{abs}(\cot(\text{BmSkw}))$$

3.26.5 Spread Box without Beam Notch, with Traditional Abutments

Figure 3.26-8 shows an elevation view of the end block geometry for spread boxes without beam notches with traditional abutments from BD-661M Sheet 6. Figure 3.26-9 shows a plan view of the end block geometry.

Chapter 3 Method of Solution

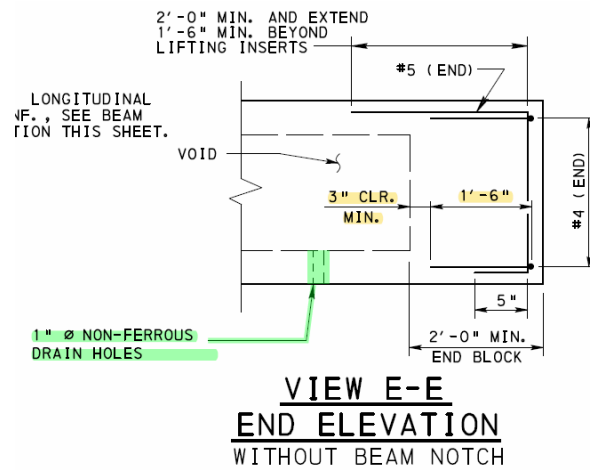


Figure 3.26-8 End Elevation View

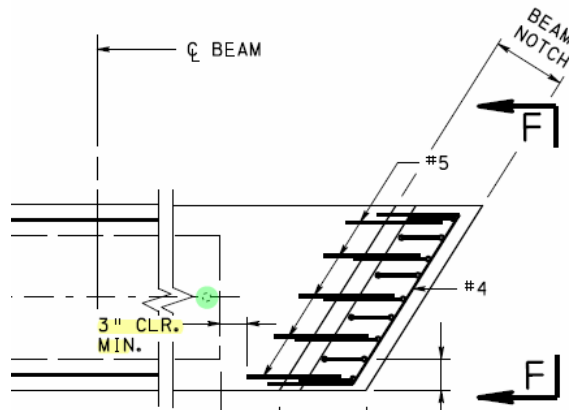


Figure 3.26-9 Plan View

Equations to determine minimum end block length.

- 1) 2'-0"
- 2) Maintain a 3" clear for rebar (rebar length 1'-6" with 2" clear cover)

$$= 2" / \sin(\text{BmSkw}) + \text{BmWall} * \cot(\text{BmSkw}) + 1'-6" + 3"$$

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GETTING STARTED

4.1 INSTALLATION

This program is delivered via download from the Department's website. Once payment has been received by PennDOT you will receive a confirmation e-mail with instructions on how to download the software. The download file is a self-extracting installation file for the licensed PennDOT engineering software. The engineering program runs as a 32-bit application and is supported on Windows 10 operating systems (32-bit and 64-bit versions) and Windows 11.

Your license number, license key and registered company name, found in the e-mail received from the Department, are required to be entered when installing the program and must be entered exactly as shown in the e-mail. The license number, license key and registered company name will also be needed when requesting future versions of the program (i.e., enhancements, modifications, or error corrections), and requesting program support. A backup copy of the program download and e-mail instructions should be made and used for future installations. You may want to print the software license agreement, record the license number, license key and registered company name and keep it in a safe place.

To install the program, follow the installation instructions provided with the original e-mail from the Department.

The following files will be installed in the program destination folder, which defaults to "C:\Program Files\PennDOT\PSLRFD v<version_number>" or "C:\Program Files (x86)\PennDOT\PSLRFD v<version_number>" for 64-bit operating systems:

1. Pslrfd.exe, PSLRFD_DLL.dll	- Executable program and Dynamic Link Library.
2. Pslrfd.pd	- Parameter definition file.
3. AABEAMUS.TAB	- Standard Beam Table file.
4. Pslrfd Users Manual.pdf	- Program User's Manual (PDF Format).
5. PslrfdRevReq.dot	- Revision Request form (MS Word template).
6. GettingStarted.pdf	- A document describing installation and running of the program
7. LicenseAgreement.pdf	- The program license agreement
8. MSVCR71.dll	- Runtime Dynamic Link Library.

Chapter 4 Getting Started

The program example problem files (ex*.dat) will be installed in the program example folder, which defaults to "C:\PennDOT\PSLRFD v<version_number> Examples\". Users must have write access to this folder in order to run the input files from this folder.

Chapter 4 Getting Started

4.2 PREPARING INPUT

The program requires an ASCII input file. The input file consists of a series of command lines. Each command line defines a set of input parameters that are associated with that command. A description of the input commands can be found in Chapter 5 of the User's Manual. The input can be created using Engineering Assistant, described below or any text editor.

Chapter 4 Getting Started

4.3 ENGINEERING ASSISTANT

The Engineering Assistant (EngAsst) is a Windows application developed by the Pennsylvania Department of Transportation (PENNDOT) to provide a graphical user interface (GUI) for PENNDOT's engineering programs. The data for the input to the engineering program is presented in a user-friendly format, reflecting the implied structure of the data, showing each record type on a separate tab page in the display and showing each field on each record with a defining label.

With EngAsst the user can create a new input file, modify an existing input file, import input files, run the associated engineering program and view the output in a Windows environment. The help and documentation are provided, including text descriptions of each field, relevant images, and extended help text at both the record/tab level and the field level. Access to all parts of the Engineering Program User's Manual, where available, is also provided within EngAsst.

EngAsst is not included with this software. It requires a separate license that can be obtained through the Department's standard Engineering Software licensing procedures. Order forms can be obtained from program support website at <http://penndot.engrprograms.com>.

Chapter 4 Getting Started

4.4 RUNNING THE PROGRAM WITHOUT ENGASST

PSLRFD is a FORTRAN console application program. It may be run from a command window, by double-clicking on the program icon from Windows Explorer, by selecting the shortcut from the Start menu under Programs\PennDOT PSLRFD <version number>, or by double-clicking the shortcut icon on the desktop. To run the program in a command window, the user must specify the directory in which the program has been installed or change to the directory.

The program will prompt for an input file name, and the user should then enter the appropriate input file name. The input file must be created before running the program. The program will then prompt for whether the output should be reviewed on the screen. The user should enter Y if the output is to be reviewed on the screen after execution or N if the output is not to be reviewed on the screen. The program will then prompt for the name of the output file in which the output is to be stored, and the user should then enter the desired output file name. If a file with the specified output file name already exists, the program will ask the user whether to overwrite the existing file. The user should enter Y if the existing file is to be overwritten or N if the existing file is not to be overwritten. If the user enters N to specify that the existing file is not to be overwritten, the program will prompt the user for another output file name. The program will then execute.

To cancel the program during execution, press <Ctrl C> or <Ctrl Break>, and then press <Enter>.

When the program completes execution, the user is prompted to "Press <ENTER> to exit program." This allows the user to view the last messages written to the screen when the program was started by double-clicking on the program icon from Windows Explorer.

The user can view the *.OUT output file with a text editor and the *.PDF output file with Adobe Acrobat or any other PDF viewing program.

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5

INPUT DESCRIPTION

5.1 INPUT DATA REQUIREMENTS

Before running PSLRFD, the user must create an input file. The input file consists of a series of command lines. Each command line defines a set of input parameters that are associated with that command. The program interprets each command line and checks the input parameters to insure that the input data is of the correct type and within the allowable ranges set by the program.

The syntax of a command line is given as:

KWD parm1, parm2, , , parm5, ,

where, KWD is a 3 character keyword representing a command, and
parm1, parm2.... are the parameter values associated with the KWD.

If a command line begins with an exclamation point (!), then it is treated as a comment line that is not used by the program. Comment lines can be inserted by the user to provide descriptions and clarifications. The following are two examples of a comment line:

! THE FOLLOWING COMMAND LINE INCLUDES THE DIAPHRAGM WEIGHT.
! PENNDOT SKEW ANGLE DESIGNATION IS USED IN THIS INPUT.

To temporarily make a command line void, the user can use an exclamation point (!) to transform the command line into a comment line. For an input line to be treated as a comment line, the exclamation point must be put in column 1 of the input line. For example, in the following case, the program will use the input data on the second line but will not use the input data on the first line:

! UDF 1, D, 0.649, , 0.815, 0.815
UDF 1, D, 0.750, , 0.815, 0.815

A command line must not exceed 256 characters in length. Command lines can be continued on any number of data lines in the input file by placing a hyphen (-) at the end of each data line to be continued, and by placing any remaining parameters on the following lines starting in column 4 of each continuation line. The limit of 256

Chapter 5 Input Description

characters includes all characters and parameters on all continuation lines of a given command line. Some commands are repeatable and some commands have parameters or groups of parameters that are repeatable. When parameters are repeatable, the user has the option of repeating the parameters in a single command or repeating the command. For example, the SPL (span length) command has Span Number and Span Length as repeatable parameters. The user could enter the Span Number and Span Length three times on one command line and four times on another command line, or seven times on a single command line.

```
SPL    1, 100, 2, 110, 3, 120
SPL    4, 130, 5, 140, 6, 150, 7, 160
```

or

```
SPL    1, 100, 2, 110, 3, 120, 4, 130, 5, 140, 6, 150, 7, 160
```

Groups of repeatable parameters, such as Span Number and Span Length, must stay together in a command line unless a continuation character (-) is used. That is, a command can not end with a Span Number input and continue using another SPL command having the Span Length input. When a continuation character is used, the repeatable data can be separated on two lines. The program reads all continuation lines as one command. For example,

Incorrect input:

```
SPL    1, 100, 2, 110, 3
SPL    120, 4, 130, 5, 140, 6, 150, 7, 160
```

Correct input:

```
SPL    1, 100, 2, 110, 3 -
        120, 4, 130, 5, 140, 6, 150, 7, 160
```

The first three columns of each command line are reserved for keywords that define the command type. Columns 4 through 256 are to be used to input the parameters associated with a command. One or more spaces are recommended between the keyword and the input parameters to improve readability.

The parameters associated with each command must be entered in the order they appear in the command description tables. The user must place commas to separate the parameters on the command line. Blank spaces can not be used to separate parameters. The parameter field width is not restricted; however, the total number of characters can not exceed 256.

The default value for a parameter is assigned by the program by placing a comma without any value for the parameter. For example, in the command syntax example shown below, the default values will be assigned to parameters parm3 and parm4.

Chapter 5 Input Description

KWD parm1, parm2, , , parm5

If the user places a comma and there is no default value, the program will return an error status. If a comma is entered after the command keyword, the program will assign the default value to the first parameter. If the user does not enter all parameters for a command, the program will assign default values for those parameters not entered. That is, the user is not required to place commas at the end of a command line. If the above example required seven parameters, parm6 and parm7 would also be assigned default values by the program.

The default values are stored in a parameter file which can be changed only by the Department's system manager. The parameter file stores the parameter description, type of data, units, upper limit, lower limit, error or warning status if the upper or lower limits are exceeded, and the default value for each parameter.

Any numerical value, within the upper and lower limits, can be entered for a parameter. The status codes, shown in parentheses below the lower and upper limits, indicate the status if an input item exceeds the lower or upper limits. The status code, (E), indicates an error. The status code, (W), indicates a warning. The status code, (C), indicates a warning that can be accepted/ignored only upon the approval of the Department's Chief Bridge Engineer. The status code, (D), indicates a warning that can be accepted/ignored only upon the approval of the District Bridge Engineer.

In the following sections, all available commands and associated parameters are described with two tables for each command. The first table contains the keyword for a particular command along with a description of the command. The second table gives all the parameters associated with the given command, parameter description, units, limits, and default values.

The program will process all input and will check for errors and warnings. If the number of errors exceeds 25 during input processing, the program will terminate immediately. After all input is processed, the program checks if any errors were found. If an error was found, the program will terminate. If warnings are found, the program will continue to process. There is no limit on the number of warnings in a single run. The user should review all warnings in the output file to insure that the input data is correct. Warnings are an indication that the input value has exceeded normally acceptable limits for that parameter.

Chapter 5 Input Description

5.2 ORDER OF COMMANDS

If the user wants to control the number of lines printed on a page or the number of lines to be left blank at the top of each page, the CFG (configuration) command should be used. The CFG command is optional and the program will use default values if the CFG command is not entered. As many as ten TTL (title) commands may be entered by the user. The first TTL command is printed in the header at the top of each output page. A maximum of ten TTL commands are printed on the first page of the output. The first required command is the CTL (control) command. The CTL command includes major control parameters such as Design/Analysis, Number of Beams, and Number of Spans which is required for checking other input data.

The remaining commands can be entered in any order, provided certain required parameters for a given command have been entered previously. For example, the span lengths are defined using the SPL (span length) command. Since span distances are used in other commands, such as the CLD and DLD commands, the SPL command must precede these commands which include span distance. The program will return an error status if a command requires data that has not been previously entered.

The user need not enter any of the output commands (OIN, OAN, OSC, and ORF commands) to produce the output tables that are designated as the default output tables. The default output tables, as presented in Sections 6.42 through 6.46, are produced if no output commands are entered.

The recommended order of the commands is shown in Table 1. The commands are shown in alphabetical order in Table 2. The section heading in these tables refers to the section number of this chapter where these commands are described. Figure 1 shows the overall view of a typical input file with these commands.

Chapter 5 Input Description

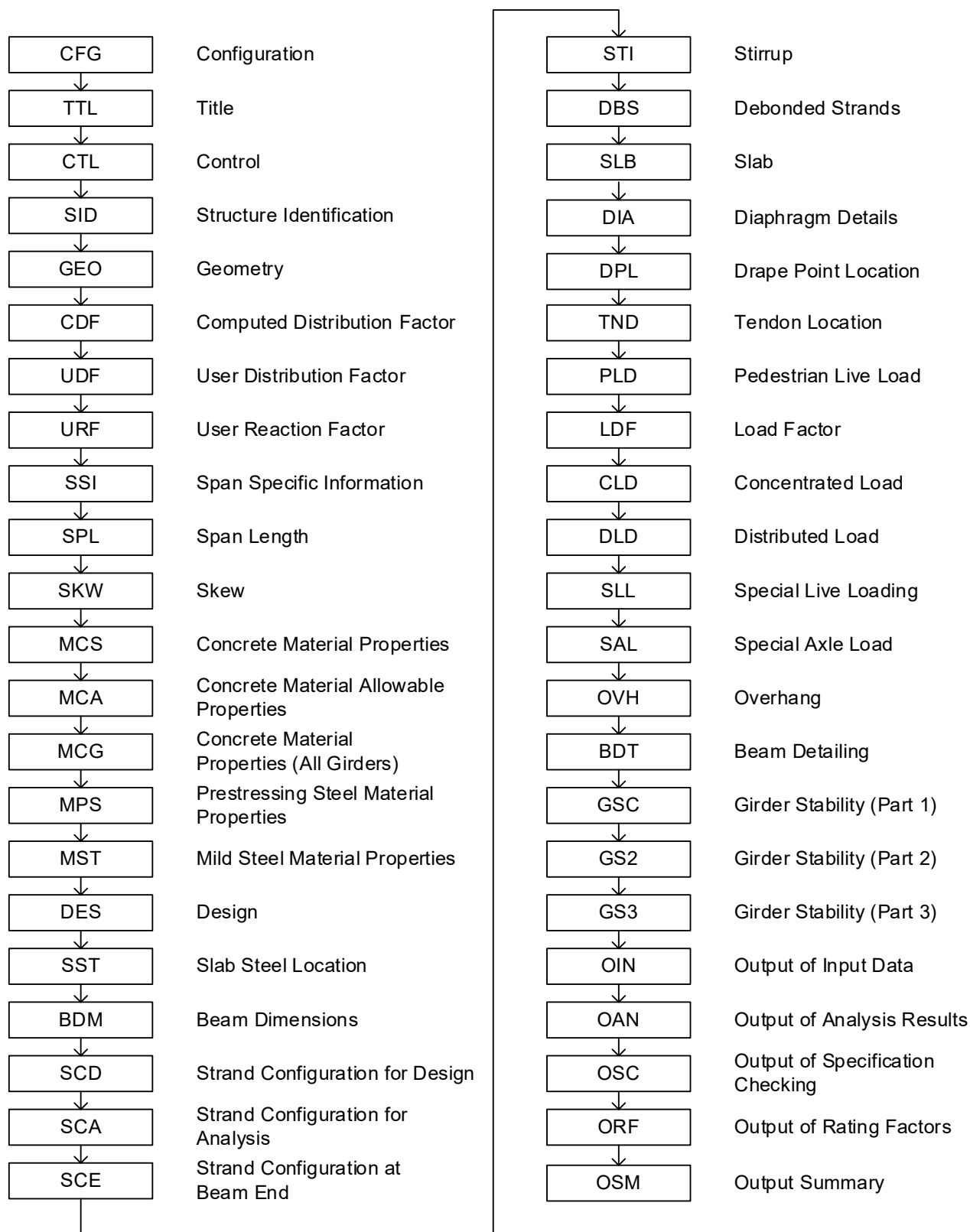


Figure 5.2-1 Overall View of Input File

Chapter 5 Input Description

Table 5.2-1 Recommended Order of Commands

Keyword	Command Description	Comments	Section
CFG	Configuration	Optional for both design and analysis	5.3
TTL	Title	At least one TTL command is required for both design and analysis	5.4
CTL	Control	Required before other structure commands (other than CFG and TTL commands) for both design and analysis	5.5
SID	Structure Identification	Required only for APRAS runs	5.6
GEO	Geometry	Required for both design and analysis	5.7
CDF	Computed Distribution Factor	Required only if no UDF command for live load distribution factors is entered for both design and analysis	5.8
UDF	User Distribution Factor	Required only if no CDF command for live load distribution factors is entered for both design and analysis	5.9
URF	User Defined Reaction Distribution Factor	Required only if no CDF command for live load distribution factors is entered for both design and analysis	5.10
SSI	Span Specific Information	Required for both design and analysis	5.11
SPL	Span Length	Required for both design and analysis before any commands with distance parameters	5.12
SKW	Skew	Required for both design and analysis	5.13
MCS	Concrete Material Properties	Required for analysis; not used for design	5.14
MCA	Concrete Material Allowable Properties	Required for both design and analysis	5.15
MCG	Concrete Material Properties (All Girders)	Required for both design and analysis	5.16
MPS	Prestressing Steel Material Properties	Required for both design and analysis	5.17
MST	Mild Steel Material Properties	Required for both design and analysis	5.18
DES	Design	Required for design; not used for analysis	5.19
SST	Slab Reinforcement Location	Required for analysis for negative moment continuity reinforcement only if more than one span; not used for design or for single span	5.20
BDM	Beam Dimensions	Required for analysis; optional for design	5.21

Chapter 5 Input Description

Table 5.2-1 Recommended Order of Commands (Cont.)

Keyword	Command Description	Comments	Section
SCD	Strand Configuration for Design	Required for design; not used for analysis	5.22
SCA	Strand Configuration for Analysis	Required for analysis; not used for design	5.23
SCE	Strand Configuration at Beam End	Required for analysis with draped strands of adjacent beams; optional for analysis of other beams with draped strands. Not used for design.	5.24
STI	Stirrup	Required for shear design and analysis	5.25
DBS	Debonded Strands	Required only for each span of an analysis problem in which debonded strands have been specified; not used for design	5.26
SLB	Slab	Required for both design and analysis of composite beams only	5.27
DIA	Diaphragm Details	Optional for both design and analysis	5.28
DPL	Drape Point Location	Required for drape design and analysis	5.29
TND	Tendon Location	Required for drape design of adjacent beams.	5.30
PLD	Pedestrian Live Load	Required only if pedestrian live load is to be considered for both design and analysis	5.31
LDF	Load Factor	Required for both design and analysis if MC1 or MC2 dead loads are entered. Optional for analysis if special live loads are entered.	5.32
CLD	Concentrated Load	Optional for both design and analysis	5.33
DLD	Distributed Load	Optional for both design and analysis	5.34
SLL	Special Live Loading	Required for analysis only if a special live loading is specified on the CTL command; not used for design	5.35
SAL	Special Axle Load	Required for analysis only if a special live loading vehicle is specified on the CTL command; not used for design	5.36
OVH	Overhang	Optional for both design and analysis of interior girders; if this command is not input, maximum overhang will not be calculated; not used for exterior girders	5.37
BDT	Beam Detailing	Optional for both design and analysis.	5.38
GSC	Girder Stability (Part 1)	Optional for design and analysis	5.39
GS2	Girder Stability (Part 2)	Optional for design and analysis	5.40
GS3	Girder Stability (Part 3)	Optional for design and analysis	5.41

Chapter 5 Input Description

Table 5.2-1 Recommended Order of Commands (Cont.)

Keyword	Command Description	Comments	Section
OIN	Output of Input Data	Optional for design and analysis	5.42
OAN	Output of Analysis Results	Optional for design and analysis	5.43
OSC	Output of Specification Checking	Optional for design and analysis	5.44
ORF	Output of Rating Factors	Optional for design and analysis	5.45
OSM	Output Summary	Optional for design and analysis	5.46

Chapter 5 Input Description

Table 5.2-2 Commands in Alphabetical Order

Keyword	Command Description	Comments	Section
BDM	Beam Dimensions	Required for analysis; optional for design	5.21
BDT	Beam Detailing	Optional for analysis or design	5.38
CDF	Computed Distribution Factor	Required only if no UDF command for live load distribution factors is entered for both design and analysis	5.8
CFG	Configuration	Optional for both design and analysis	5.3
CLD	Concentrated Load	Optional for both design and analysis	5.33
CTL	Control	Required before other structure commands (other than CFG and TTL commands) for both design and analysis	5.5
DBS	Debonded Strands	Required only for each span of an analysis problem in which debonded strands have been specified; not used for design	5.26
DES	Design	Required for design; not used for analysis	5.19
DIA	Diaphragm Details	Optional for both design and analysis	5.28
DLD	Distributed Load	Optional for both design and analysis	5.34
DPL	Drape Point Location	Required for drape design and analysis	5.29
GEO	Geometry	Required for both design and analysis	5.7
GSC	Girder Stability (Part 1)	Optional for design and analysis	5.39
GS2	Girder Stability (Part 2)	Optional for design and analysis	5.40
GS3	Girder Stability (Part 3)	Optional for design and analysis	5.41
LDF	Load Factor	Required for both design and analysis if MC1 or MC2 dead loads are entered. Optional for analysis if special live loads are entered.	5.32
MCA	Concrete Material Allowable Properties	Required for both design and analysis	5.15
MCG	Concrete Material Properties (All Girders)	Required for both design and analysis	5.16
MCS	Concrete Material Properties	Required for analysis; not used for design	5.14
MPS	Prestressing Steel Material Properties	Required for both design and analysis	5.17
MST	Mild Steel Material Properties	Required for both design and analysis	5.18

Chapter 5 Input Description

Table 5.2-2 Commands in Alphabetical Order (Cont.)

Keyword	Command Description	Comments	Section
OAN	Output of Analysis Results	Optional for design and analysis	5.43
OIN	Output of Input Data	Optional for design and analysis	5.42
ORF	Output of Rating Factors	Optional for design and analysis	5.45
OSC	Output of Specification Checking	Optional for design and analysis	5.44
OSM	Output Summary	Optional for design and analysis	5.46
OVH	Overhang	Optional for both design and analysis of interior girders; if this command is not input, maximum overhang will not be calculated; not used for exterior girders	5.37
PLD	Pedestrian Live Load	Required only if pedestrian live load is to be considered for both design and analysis	5.31
SAL	Special Axle Load	Required for analysis only if a special live loading vehicle is specified on the CTL command; not used for design	5.36
SCA	Strand Configuration for Analysis	Required for analysis; not used for design	5.23
SCD	Strand Configuration for Design	Required for design; not used for analysis of composite beams only	5.22
SCE	Strand Configuration at Beam End	Required for analysis with draped strands of adjacent beams; optional for analysis of other beams with draped strands. Not used for design.	5.24
SID	Structure Identification	Required only for APRAS runs	5.6
SKW	Skew	Required for both design and analysis	5.13
SLB	Slab	Required for both design and analysis of composite beams only	5.27
SLL	Special Live Loading	Required for analysis only if a special live loading is specified on the CTL command; not used for design	5.35
SPL	Span Length	Required for both design and analysis before any commands with distance parameters	5.12
SSI	Span Specific Information	Required for both design and analysis	5.11
SST	Slab Reinforcement Location	Required for analysis for negative moment continuity reinforcement only if more than one span; not used for design or for single span	5.20

Chapter 5 Input Description

Table 5.2-2 Commands in Alphabetical Order (Cont.)

Keyword	Command Description	Comments	Section
STI	Stirrup	Required for shear design and analysis	5.25
TND	Tendon Location	Required for drape design of adjacent beams.	5.30
TTL	Title	At least one TTL command is required for both design and analysis	5.4
UDF	User Distribution Factor	Required only if no CDF command for live load distribution factors is entered for both design and analysis	5.9
URF	User Defined Reaction Distribution Factor	Required only if no CDF command for live load distribution factors is entered for both design and analysis	5.10

Chapter 5 Input Description

5.3 CFG - CONFIGURATION COMMAND

KEYWORD	COMMAND DESCRIPTION
CFG	CONFIGURATION - This command is used for configuring the program output from a given PC and printer setup. Only one CFG command may be used. If this command is not entered, each parameter listed below will be automatically set to its default value. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Number of Lines Per Page	Enter the number of printable lines per output page.	--	50 (W)	74 (W)	74
2. Number of Top Blank Lines	Enter the number of lines to be left blank at the top of each output page.	--	0 (E)	10 (W)	0

Chapter 5 Input Description

5.4 TTL - TITLE COMMAND

KEYWORD	COMMAND DESCRIPTION
TTL	TITLE - As many as ten TTL commands may be entered by the user. The first TTL command is printed in the header at the top of each output page. A maximum of ten TTL commands are printed on the first page of the output. Optional for both design and analysis.

PARAMETER	DESCRIPTION
1. Title	Enter any descriptive information about the project. Title information can be entered anywhere starting at Column 4. A maximum of 97 characters will be printed for the first title line printed at the top of each page. Only the first 91 characters of the first 10 title lines are displayed in the program header at the beginning of the output.

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND

KEYWORD	COMMAND DESCRIPTION
CTL	CONTROL - This command is used to set the control parameters for the input. The input file must have one and only one CTL command. The CTL command must be entered before any other structure command other than the CFG and TTL commands. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. System of Units	Enter type of units: US - US customary units.	--	US (E)	--	US
2. Design/ Analysis	Enter the design/analysis option: A - Analysis of applicable loadings, specification checking, and live load ratings. D - Designs the girder for applicable loadings in accordance with the LRFD Specifications and also gives the live load ratings.	--	A, D (E)	--	--
3. Shape of Beam	Select the two-letter notation to indicate the shape of the beam: For design runs: IP - I-beam - PennDOT type. IA - I-beam - AASHTO type. IB - I-beam - PennDOT & AASHTO types. BT - PA Bulb-Tee beam. NX - Type F NEXT (Northeast Extreme Tee) beam. PL - Adjacent Plank beam. AR - Adjacent box with rectangular void. SR - Spread box with rectangular void. For analysis runs you can select one of the options for the design runs (excluding IB) or one of the following: A1 - Adjacent box with one circular void. A2 - Adjacent box with two circular voids. A3 - Adjacent box with three circular voids. S1 - Spread box with one circular void. S2 - Spread box with two circular voids. S3 - Spread box with three circular voids. ND - Type D NEXT beam.	--	IP, IA, IB, BT, NX, PL, AR, SR, A1, A2, A3, S1, S2, S3, ND (E)	--	--
4. Exterior/ Interior	Enter beam location: E - Exterior beam. I - Interior beam.	--	E, I (E)	--	--

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Number of Beams	Enter the number of beams for the structure cross section.	--	2 (E)	20 (E)	--
6. Number of Spans	Enter the total number of spans for the structure. If more than one span is entered, the program assumes they are continuous spans. NOTE: NEXT Beams are limited to a single span.	--	1 (E)	20 (E)	--
7. Symmetry	Enter the symmetry option: Y - If the entire structure, including span length, section properties, and loads, is symmetric about the center of the structure. N - If not symmetric. If symmetric, span length, section properties, loads, etc. must only be entered to the center of the structure.	--	Y, N (E)	--	--
8. Beam Designation	Enter the beam designation: P - For PennDOT standard beams. U - For beams with user-specified dimensions. This parameter is used only when the BDM command is used. If 'P' is entered, then the user must enter the designation in parameter 2 of the BDM command. If 'U' is entered, then the user must enter the depth in parameter 2 of the BDM command.	--	P, U (E)	--	P
9. Multiple Presence Adjustment Factor	Note: This parameter is not used anymore and should be left blank. It is retained for compatibility with existing input files.	--	--	--	--

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	LOWER LIMIT	Default
10. Live Load	For Design, enter one of the following live load options: A - PHL-93 (Design¹); P-82 (Permit²); PHL-93, P-82, ML-80, TK527, HS20, H20 (Rating³). B - HL-93 (Design¹); P-82 (Permit²); HL-93, P-82, ML-80, TK527, HS20, H20 (Rating³). C - HL-93 (Design¹); None (Permit²); HL-93, HS20, H20 (Rating³). D - PHL-93, ML-80 (Design¹); P-82 (Permit²); PHL-93, P-82, ML-80, TK527, HS20, H20 (Rating³). E - PHL-93, ML-80, TK527 (Design¹); P-82 (Permit²); PHL-93, P-82, ML-80, TK527, HS20, H20 (Rating³). F - PHL-93, ML-80, TK527 (Design¹); P-82, P2016-13 (Permit²); PHL-93, P-82, P2016-13, ML-80, TK527, HS20, H20 (Rating³). For design runs, choose option E to ensure that the ML-80 and TK527 inventory ratings are greater than 1.0 as per D3.6.1.2.8P and 3.6.1.2.9P. To also ensure the P2016-13 Permit Vehicle operating ratings are greater than 1.0, choose option F.	A, B, C, D, E, F (E)	E

Notes:

- ¹ Design designated vehicle(s) are used to compute Factored Effects and live loads for specification checks not specific to Permit vehicles. Live load effects are enveloped for multiple design vehicles.
- ² Permit designated vehicle(s) are used to compute Factored Effects and live loads for specification checks specific to Permit vehicles. Live load effects are enveloped for multiple permit vehicles.
- ³ Rating designated vehicle(s) are used to compute rating factors. Refer to Table 2.6-1, Live Load Ratings, in the Users Manual for applicable ratings for each vehicle.

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	LOWER LIMIT	Default
10. Live Load (Continued)	For Analysis, enter one of the following live load options: A - PHL-93, ML-80, TK527 (Analysis¹); P-82 (Permit²); PHL-93, ML-80, TK527, P-82, HS20, H20 (Rating³). B - HL-93 (Analysis¹); HL-93, HS20, H20 (Rating³). C - ML-80 (Analysis¹, Rating³). D - P-82 (Permit², Rating³). E - Special live loading (Analysis¹, Rating³). F - TK527 (Analysis¹, Rating³). G - PHL-93, ML-80, TK527 (Analysis¹); P-82C (Permit²); PHL-93, P-82C, ML-80, TK527, HS20, H20 (Rating³). H - EV2, EV3, SU6TV (Permit², Rating³) I - P2016-13 (Permit², Rating³) J - PHL-93, ML-80, TK527 (Analysis¹); P-82, P2016-13 (Permit²); PHL-93, ML-80, TK527, P-82, P2016-13, HS20, H20 (Rating³) K - PHL-93, ML-80, TK527 (Analysis¹); P-82C, P2016-13C (Permit²); PHL-93, P-82C, P2016-13C, ML-80, TK527, HS20, H20 (Rating³) The SLL and SAL commands must be entered when using option 'E' for Analysis. Note: Analysis Live Load Code "G" should only be used for rating bridges with P-82 in one lane and PHL-93 in the other lanes. This combination of vehicles is denoted by the P-82C designation. Analysis Live Load Code "K" should only be used for rating bridges with P-82 in one lane and PHL-93 in the other lanes (referred to as P-82C) and rating bridges with P2016-13 in one lane and PHL-93 in the other lanes. This combination of vehicles is denoted by the P2016-13C designation.	A, B, C, D, E, F, G, H, I, J, K (E)	A

Notes:

- ¹ Analysis designated vehicle(s) are used to compute Factored Effects and live loads for specification checks not specific to Permit vehicles. Live load effects are enveloped for multiple analysis vehicles. Special live loads with Vehicle Type "D" are designated as Analysis vehicles.
- ² Permit designated vehicle(s) are used to compute Factored Effects and live loads for specification checks specific to Permit vehicles. Live load effects are enveloped for multiple permit vehicles. Special live loads with Vehicle Type "P" are designated as Permit vehicles.
- ³ Rating designated vehicle(s) are used to compute rating factors. Refer to Table 2.6-1, Live Load Ratings, in the Users Manual for applicable ratings for each vehicle.

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
11. Dynamic Load Allowance	Enter the factor by which a live load effect must be multiplied to obtain the live load plus dynamic load allowance (impact) effect.	--	1. (E)	2. (D)	1.33
12. Fatigue Dynamic Load Allowance	Enter the factor by which a fatigue live load effect must be multiplied to obtain the live load plus dynamic load allowance (impact) effect.	--	1. (E)	2. (D)	1.15
13. Pa. Traffic Factor	Note: This parameter is no longer used and should be left blank.	--	--	--	--
14. Strand Type	Enter the strand type: L - Low relaxation strands. S - Stress relieved strands. Note: Stress relieved strands will result in an error for a Design run and in a Chief Bridge Engineer warning for an Analysis run.	--	L, S (E)	--	L
15. P/S Loss Type	Enter LR for LRFD Refined Method.	--	LR (E)	--	LR
16. Prestress Transfer Time	Enter the time (in days) when prestress strands are released from tension jacks, counting from the time of concrete casting in pretensioned girder. This value is used for prestress loss calculations.	day	0.875 (E)	30. (D)	1.0
17. Relative Humidity	Enter the average ambient relative humidity (in percentage) that the girder is subjected to during its lifetime. Enter only for multi-span problems.	--	70 (W)	70 (W)	70
18. Composite Beam	Enter: Y - Composite girder. N - Non-composite girder.	--	Y, N (E)	--	--
19. Skew Override	Enter the skew override parameter: Y - Ignore the BD skew restrictions. N - Apply the BD skew restrictions. This value is used only for design.	--	Y, N (E)	--	N
20. Importance Factor	Enter the factor related to the operational importance. As per DM-4 Section 1.3.5, a factor other than 1.0 is not permitted by PENNDOT. See Note 1.	--	1. (E)	2. (W)	1.0

Notes:

- ¹ As per DM-4 Section 1.3.2.1, the product of the Importance, Ductility, and Redundancy Factors must be 1.0. If this product exceeds 1.16, the program will reset the value of the product and provide a warning message.

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
21. Ductility Factor	Enter the factor related to ductility. As per DM-4 Section 1.3.3, a factor other than 1.0 is not permitted by PennDOT. See Note 1.	--	0.95 (E)	1.05 (W)	1.0
22. Redundancy Factor	Enter the factor related to redundancy. As per DM-4 Section 1.3.4, a factor other than 1.0 is not permitted by PennDOT. See Note 1.	--	0.95 (E)	1.05 (W)	1.0
23. Shear Design/ Analysis	Enter one of the following: D - For shear design. A - For shear analysis. This parameter is only for analysis problems. For design problems, the program will always set this value to "D". For analysis problems, the user has the option of running the shear design or shear analysis. Stirrup information must be provided using the STI command.	--	D, A (E)	--	D
24. Skew Angle Designation	Enter: A - AASHTO skew angle designation. P - PennDOT skew angle designation. θ_A = AASHTO skew angle θ_P = PennDOT skew angle	--	A, P (E)	--	P
25. Shrinkage Only Analysis	Enter: Y - If the effect shrinkage effect is to be considered without the creep effect. N - If both creep effect and shrinkage effect are to be considered.	--	Y,N (E)	--	N
26. Output Points	Enter: 0 - Critical points only 1 - Critical points + 10 th points 2 - Critical points + 20 th points	--	0 (E)	2 (E)	0

Chapter 5 Input Description

5.5 CTL - CONTROL COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
27. Multi-Span Analysis Option	Enter: S - Continuous Analysis with Simple Span Check Option – Analyzes spans as both continuously and simply supported. C - Continuous Analysis Option – Analyzes spans as continuously supported only. Note: Parameter ignored for single span structures.	--	S,C (E)	--	S
28. Permit Dynamic Load Allowance	Enter the factor by which the Design Permit Vehicles (P-82 and/or P2016-13) live load effect must be multiplied by to obtain the live load plus dynamic load allowance (impact) effect.	--	1. (E)	2. (D)	1.20
29. Deck Placement Age	Enter the age (in days) of the beam concrete when the deck is cast counting from the time of the beam casting. This value is used for prestress loss calculations.	day	1. (E)	1000. (W)	120.
30. Overhang to Beam Depth Override	Enter the Overhang to Beam Depth override parameter for design runs: Y - Allow an exception to Overhang to Beam Depth criteria. N - Do not allow an exception to Overhang to Beam Depth criteria. This value is used only for exterior spread beams. Leave blank for analysis runs. This parameter allows an exception to the Overhang to Beam Depth criteria of DM-4 9.7.5.1P that limits the maximum overhang to the girder depth. Violations of this criterion will result in a District Bridge Engineer message even if the input allows an exception.	--	Y,N (E)	--	N
31. Allow C.L. Strands for Spread Box Beams	This option has been disabled to avoid interference with the 1" drain hole located at the centerline of the box as detailed on BD-661M. Select whether to allow use of strands at Center Line of Spread Boxes: ~~Y - Allow use of centerline strands.~~ N - Do not allow use of centerline strands. This value is used only for spread box beams.	--	N (E)	--	N

Chapter 5 Input Description

5.6 SID - STRUCTURE IDENTIFICATION COMMAND

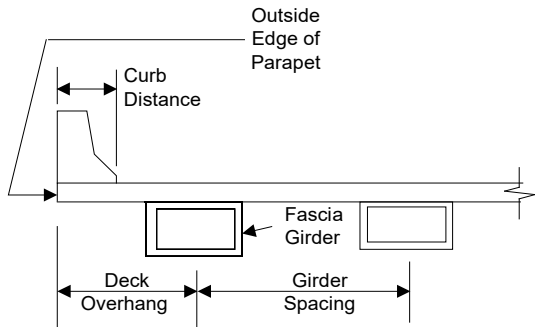
KEYWORD	COMMAND DESCRIPTION
SID	STRUCTURE IDENTIFICATION - This command is used to pass parameters to APRAS (Automated Permit Routing Analysis System) for processing a permit load. The input file must have this command if this data file is to be processed by APRAS. This command is optional for other data files. Only one SID command can be used. Refer to PennDOT's Bridge Management System (BMS2) Coding Manual, Publication 100A for instructions on how to enter this data. Required only for APRAS runs.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Program Identification	Enter "=PSLRFD" to identify that this data file is for the LRFD Prestressed Concrete Design and Rating program.	--	=PSLRFD (E)	--	=PSLRFD
2. County	Enter the county number as per PennDOT's Bridge Management System (BMS2) (the 2 digit subfield of item number 5A01).	--	1 (E)	99 (E)	--
3. State Route	Enter the state route number as per PennDOT's Bridge Management System (BMS2) (the 4 digit subfield of item number 5A01).	--	0 (E)	9999 (E)	--
4. Segment	Enter the segment number as per PennDOT's Bridge Management System (BMS2) (the 4 digit subfield of item number 5A01).	--	0 (E)	9999 (E)	--
5. Offset	Enter the offset distance as per PennDOT's Bridge Management System (BMS2) (the 4 digit subfield of item number 5A01).	--	0 (E)	9999 (E)	--
6. Span Identification	Enter the 4 character alphanumeric Span Identification as per PennDOT's Bridge Management System (BMS2) (item number SS01). Note: For APRAS data files, the third character must be "E" to identify PSLRFD is used to analyze the span.	--	--	--	--

Chapter 5 Input Description

5.7 GEO - GEOMETRY COMMAND

KEYWORD	COMMAND DESCRIPTION
GEO	GEOMETRY - This command is used to define the beam geometry information. Only one GEO command can be used. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Girder Spacing	Enter the center to center beam spacing. This value is used to compute distribution factors, slab weight, and effective slab width. For flared girders, a suggested spacing would be the spacing at the quarter point of the span closest to the end with the larger spacing. NOTE: For NEXT beams this value is used to compute the width of the top flange.	ft Type F NEXT Type D NEXT All others	8. 8.75 3. (E)	12. 10.75 18. (E)	--
2. Deck Overhang	Enter the overhang of the deck from the centerline of the left-most or right-most fascia girder to the outside of the parapet. 	ft	1. (W)	*1	--2
3. Number of Design Lanes	Enter the number of design lanes. This value is used to compute the live load distribution factors and for performing lever rule computations. If the bridge cross section includes one or more sidewalks, this parameter is to be entered assuming that the sidewalks are not present.	--	1 (E)	8 (W)	--
4. Deflection Distribution Factor	Enter the distribution factor for live load deflection. If left blank, the program will compute this value. If parameters 3 and 4 are both entered, the program will use the value entered in parameter 4 as the deflection distribution factor. If the bridge cross section includes one or more sidewalks, this parameter is to be entered assuming that the sidewalks are not present.	--	0. (E)	2. (E)	--

Chapter 5 Input Description

5.7 GEO - GEOMETRY COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Beam Projection	Enter the beam projection from the centerline of bearing to the end of the beam.	in	3. (E)	24. (W)	9.
6. Number of Design Lanes with Sidewalks	Enter the number of design lanes assuming that the sidewalks are present. This value is used to compute the live load distribution factors and for performing lever rule computations. With respect to the calculation of the multiple presence factor, the program will automatically increase the number of design lanes entered by 1 due to the pedestrian loads applied to sidewalks. Leave blank if pedestrian loading is not included in this run.	--	1 (E)	8 (W)	--
7. Deflection Distribution Factor with Sidewalks	Enter the distribution factor for live load deflection assuming that the sidewalks are present. Calculate the multiple presence factor based on the total number of loaded lanes, both vehicular and pedestrian. A single pedestrian lane accounts for the presence of one or more sidewalks. If left blank, the program will compute this value as the number of design lanes with sidewalks multiplied by the applicable multiple presence factor and then divided by the number of beams (from the CTL command). Leave blank if pedestrian loading is not included in this run.	--	0. (E)	2. (E)	--
8. Parapet Width	Enter the width of the parapet. This parameter is used to check the number of design lanes, parameter 3, when the Centerline Exterior Beam to Curb, parameter 5 of CDF command, is not given.	in	9. (W)	30. (W)	20.25

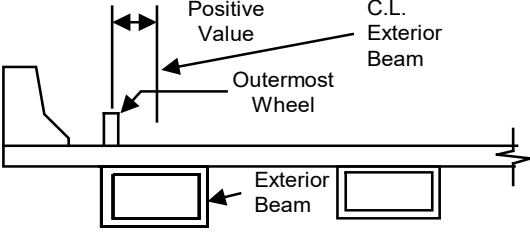
Notes:

- ¹ For information about the upper limit, refer to Section 6.7.2.
- ² For NEXT beams the deck overhang defaults to one-half of the beam width.

Chapter 5 Input Description

5.8 CDF - COMPUTED DISTRIBUTION FACTOR COMMAND

KEYWORD	COMMAND DESCRIPTION
CDF	COMPUTED DISTRIBUTION FACTOR - This command is used to input the required data for the program to compute the live load moment, shear, and reaction distribution factors. The program will compute distribution factors assuming an equally spaced multi-girder structure. Only one CDF command can be used. The user must enter the skew angle on the SKW command when a CDF command is entered. When a CDF command is entered, the user can not input the distribution factors using the UDF and URF commands. Required only if no UDF command for live load distribution factors is entered for both design and analysis.

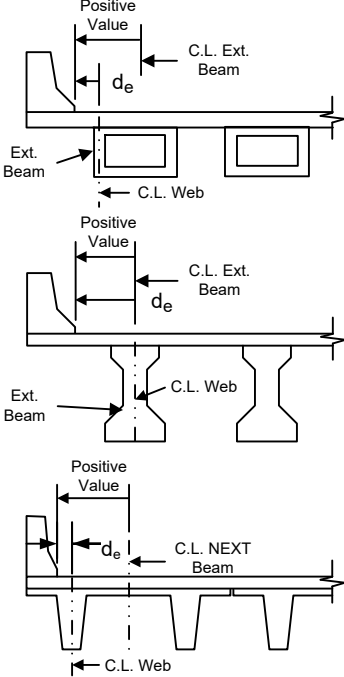
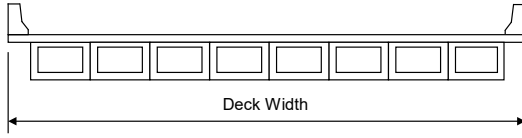
PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Lane Width	Enter the lane width.	ft	9. (E)	15. (W)	12.
2. Gage Distance	Enter the lateral distance between the wheels of the truck.	ft	6.0 (E)	10.0 (W)	6.0
3. Passing Distance	Enter the minimum distance between adjacent wheels of passing vehicles.	ft	4.0 (E)	10.0 (W)	4.0
4. Distance to Outermost Wheel ¹	Enter the distance from the centerline of the exterior beam to the outermost wheel. For the case shown below, a positive value indicates the wheel is to the left of the centerline of the exterior beam and a negative value indicates the wheel is to the right of the centerline of the exterior beam. If the bridge cross section includes one or more sidewalks, this parameter is to be entered assuming that the sidewalks are not present.  Required for Exterior beam only.	ft	-10. (E)	15. (W)	--

Notes:

¹ The Centerline Exterior Beam to Curb minus Distance to Outermost Wheel will give a warning message when less than 2 ft.

Chapter 5 Input Description

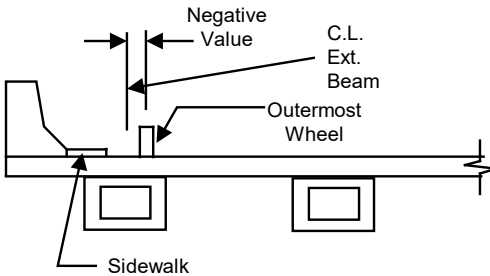
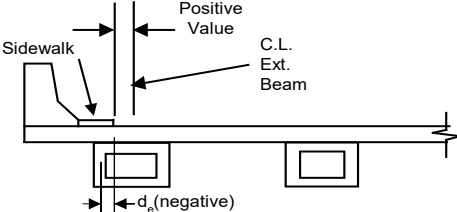
5.8 CDF - COMPUTED DISTRIBUTION FACTOR COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Centerline Exterior Beam to Curb ¹	Enter the distance from the centerline of the exterior beam to the face of the curb. For the case shown below, a positive value indicates the curb is to the left of the centerline of the exterior beam and a negative value indicates the curb is to the right of the centerline of the exterior beam. If the bridge cross section includes one or more sidewalks, this parameter is to be entered assuming that the sidewalks are not present.  Required for Exterior beams. Note: The program uses this input item to calculate variable "d_e" for the distribution factor equations. Variable "d_e" is computed at the exterior web centerline for box beams and NEXT beams and at the beam centerline for I-beams and adjacent plank beams.	ft	-10. (E)	10. (D)	--
6. Deck Width	Enter the deck width from outer edge of deck to outer edge of deck. This parameter is required for non-composite adjacent box beams. For all other beam types, leave blank. 	ft	10. (E)	100. (W)	--

¹ The Centerline Exterior Beam to Curb minus Distance to Outermost Wheel will give a warning message when less than 2 ft.

Chapter 5 Input Description

5.8 CDF - COMPUTED DISTRIBUTION FACTOR COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
7. Distance to Outermost Wheel with Sidewalks	Enter the distance from the centerline of the exterior beam to the outermost wheel. For the case shown below, a positive value indicates the wheel is to the left of the centerline of the exterior beam and a negative value indicates the wheel is to the right of the centerline of the exterior beam. Leave blank if pedestrian loading is not included in this run. This parameter is to be entered assuming that the sidewalks are present.  Required for Exterior beams with Pedestrian load.	ft	-10. (W)	15. (W)	--
8. Centerline Exterior Beam to Curb with Sidewalks	Enter the distance from the centerline of the exterior beam to the face of the curb. For the case shown below, a positive value indicates the curb is to the left of the centerline of the exterior beam and a negative value indicates the curb is to the right of the centerline of the exterior beam. Leave blank if pedestrian loading is not included in this run. This parameter is to be entered assuming that the sidewalks are present.  Required for Exterior beams with Pedestrian load. Note: The program uses this input item to calculate variable "d_e" for the distribution factor equations. Variable "d_e" is computed at the exterior web centerline for box beams and NEXT beams and at the beam centerline for I-beams and adjacent plank beams.	ft	-10. (W)	10. (W)	--

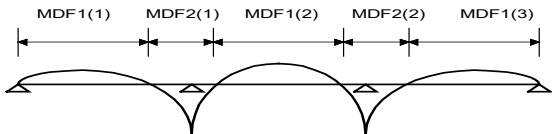
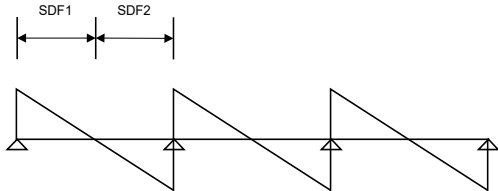
5.9 UDF - USER DISTRIBUTION FACTOR COMMAND

KEYWORD	COMMAND DESCRIPTION
UDF	USER DEFINED DISTRIBUTION FACTOR - This command is used to specify the moment and shear distribution factors. If the UDF command is not entered, the CDF command and SKW command must be entered, and the program will compute the distribution factors. When the UDF command is used, all moment and shear distribution factors must be entered for each span. If the UDF command is used and pedestrian loading is not included in the run, two user defined distribution factor commands are required: one for the design vehicle (D) and one for the fatigue vehicle (F). If the UDF command is used and pedestrian loading is included in the run, three user defined distribution factor commands are required: one for the design vehicle assuming no sidewalks are present (D), one for the fatigue vehicle assuming no sidewalks are present (F), and one for the design vehicle assuming sidewalks are present (P). When live load code G (or K) has been selected on the CTL command for an Analysis run and the UDF command is used, single lane distribution factors for P-82C (P2016-13C) combination (CS) and multi-lane distribution factors for P-82C (P2016-13C) combination (CM) are required. The parameters of this command are repeatable, beginning with parameter 1. This command is repeatable. A maximum of 6 distribution factor data sets (parameters 1 through 6) can be entered on each command. A maximum of 60 UDF commands can be entered. One hundred sets of distribution factors are required for a twenty-span bridge when all five distribution factor types are to be entered. User defined distribution factors must be entered in units of lane fractions. The shear distribution factors must include any applicable skew correction factors. When this command is used the URF command must be used to define the reaction distribution factors. Required only if no CDF command for live load distribution factors is entered for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number. Enter zero to indicate that all spans for a multi-span girder will use the same distribution factors.	--	0 (E)	NSP ¹ (E)	--
2. Distribution Factor Type	Enter the distribution factor type: D - Design live load distribution factor. F - Fatigue live load distribution factor. P - Pedestrian live load distribution factor. CS - Single lane distribution factor for the P-82C or P2016-13C combination CM - Multi-lane distribution factor for the P-82C or P2016-13C combination If pedestrian loading is included in this run, use the P indicator for design live load distribution factors assuming that the sidewalks are present and use the D indicator for design live load distribution factors assuming that the sidewalks are not present. (Continued next page)	--	D, F, P, CS, CM (E)	--	--

Chapter 5 Input Description

5.9 UDF - USER DISTRIBUTION FACTOR COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
2. Distribution Factor Type (Continued)	The CS and CM distribution factors should only be entered if live load code G or K for an Analysis run has been selected on the CTL command. Please see Section 3.6.2 of this manual for how the CS and CM distribution factors are used.				
3. Moment DF1	Enter the moment distribution factor to be used in calculating the live load moments in the dead load positive moment region for this span. (See note 2)	--	0. (E)	2. (E)	--
4. Moment DF2	Enter the moment distribution factor to be used in calculating the live load moments in the dead load negative moment region. This distribution factor is applied to the live load moments from the computed dead load contraflexure point in this span to the contraflexure point in the next span. There is no moment DF2 factor for the last span, and it therefore does not need to be entered. (See note 3) 	--	0. (E)	2. (E)	--
5. Shear DF1	Enter the shear distribution factor to be used in calculating the live load shear from the left support to the midspan point for this span. Apply skew correction factor if applicable. 	--	0. (E)	2. (E)	--
6. Shear DF2	Enter the shear distribution factor to be used in calculating the live load shear from the midspan point to the right support for this span. Apply skew correction factor if applicable.	--	0. (E)	2. (E)	--

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² For the continuous analysis with simple span check option, 'Moment DF1' is used to factor all live load moments in this span.
- ³ For the continuous analysis with simple span check option, 'Moment DF2' is not used and therefore should not be entered.

Chapter 5 Input Description

5.10 URF - USER DEFINED REACTION DISTRIBUTION FACTOR COMMAND

KEYWORD	COMMAND DESCRIPTION
URF	USER DEFINED REACTION DISTRIBUTION FACTOR - This command is used to specify the reaction distribution factors. This command is required if the UDF command has been entered. If the URF command is used and pedestrian loading is not included in the run, two user defined reaction distribution factor commands are required: one for the design vehicle (D) and one for the fatigue vehicle (F). If the URF command is used and pedestrian loading is included in the run, three user defined reaction distribution factor commands are required: one for the design vehicle assuming no sidewalk are present (D), one for the fatigue vehicle assuming no sidewalks are present (F), and one for the design vehicle assuming sidewalks are present (P). The parameters of this command are repeatable, beginning with parameter 1. This command is repeatable. A maximum of 10 reaction distribution factor data sets (parameters 1 through 3) can be entered on each command. A maximum of 60 URF commands can be entered. Sixty-three distribution factors are required for a twenty-span bridge when all three distribution factor types are to be entered. The URF command cannot be used with the CDF command. Required only if no CDF command for live load distribution factors is entered for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Support Number	Enter the support number. Enter zero to indicate that all supports for a multi-span girder will use the same distribution factors.	--	0 (E)	NSP ¹ +1 (E)	--
2. Distribution Factor Type	Enter the distribution factor type: D - Design live load distribution factor. F - Fatigue live load distribution factor. P - Pedestrian live load distribution factor. If pedestrian loading is included in this run, use the P indicator for design live load distribution factors assuming that the sidewalks are present and use the D indicator for design live load distribution factors assuming that the sidewalks are not present.	--	D, F, P (E)	--	--
3. Reaction Distribution Factor	Enter the reaction distribution factor to be used in calculating the live load reaction for this support.	--	0. (E)	2. (E)	--

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

Chapter 5 Input Description

5.11 SSI - SPAN SPECIFIC INFORMATION COMMAND

KEYWORD	COMMAND DESCRIPTION
SSI	SPAN SPECIFIC INFORMATION - This command is used to specify information that is specific to each span, such as debonding and draping. The parameters of this command are repeatable, beginning with parameter 1. This command is repeatable. A maximum of 20 span specific information data sets (parameters 1 and 2) can be entered on a single command. A maximum of 20 SSI commands can be entered. A total of 20 span specific information data sets must be entered for a twenty-span bridge using any combination of SSI commands and repeatable parameters to define 20 data sets. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number. Enter zero to indicate that all spans for a multi-span girder will use the same span specific information.	--	0 (E)	NSP ¹ (E)	--
2. Draped or Debonded	Enter the draped or debonded parameter as follows: DP - Designed as Draped strands without debonded strands; Analyzed as Draped strands with or without debonded strands. Note: Draped strands are not allowed for NEXT Beams. DB - Designed or Analyzed as straight strands with Normal Debonded strands ST - Designed as Straight strands without debonded strands; Analyzed as Straight strands with or without Crack Control debonded strands.	--	DP, DB, ST (E)	--	--

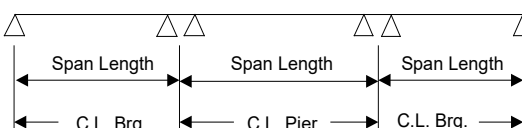
Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

Chapter 5 Input Description

5.12 SPL - SPAN LENGTH COMMAND

KEYWORD	COMMAND DESCRIPTION
SPL	SPAN LENGTH - This command is used to specify the length of spans present in the girder. For a symmetrical structure, enter the spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the span length for spans 1, 2, and 3. The parameters of this command are repeatable, beginning with parameter 1. This command is repeatable. A maximum of 20 span length data sets (parameters 1 and 2) can be entered on a single command. A maximum of 20 SPL commands can be entered. A total of 20 span length data sets must be entered for a twenty-span bridge using any combination of SPL commands and repeatable parameters to define 20 data sets. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number for the span length being defined. Enter zero to indicate that all spans for a multi-span girder will use the same span length.	--	0 (E)	NSP ¹ (E)	--
2. Span Length	Enter the span length. For exterior supports (abutments), the span length is measured from the centerline of bearing. For interior supports (piers), the span length is measured from the centerline of pier. Enter only one span length for each span number. 	ft	8. (E)	200. (W)	--

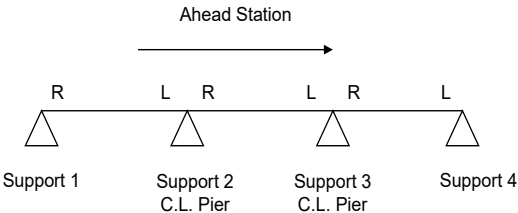
Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

Chapter 5 Input Description

5.13 SKW - SKEW COMMAND

KEYWORD	COMMAND DESCRIPTION
SKW	SKEW - This command is used to specify the information at the support, such as skew angle and distance between the centerlines of bearings of two adjacent spans. If the CDF command has been entered, parameters 1, 2, and 5 are required and this command must be entered after the CDF command. If the UDF command has been entered, the program ignores parameter 5. For a symmetrical structure, enter the supports up to and including the middle support. That is, for a symmetrical 5 span structure, enter the information for supports 1, 2, and 3. The parameters of this command are repeatable, beginning with parameter 1. A maximum of 8 skew data sets (parameters 1 through 5) can be entered on a single command. A maximum of 21 SKW commands can be entered. A total of 21 skew data sets must be entered for a twenty-span bridge using any combination of SKW commands and repeatable parameters to define 21 data sets. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Support Number	Enter the support number. The left most support is designated as Support 1. Enter zero to indicate that all spans for a multi-span girder will use the same skew information.  R L R L R L Support 1 Support 2 C.L. Pier Support 3 C.L. Pier Support 4	--	0 (E)	NSP ¹ +1 (E)	--

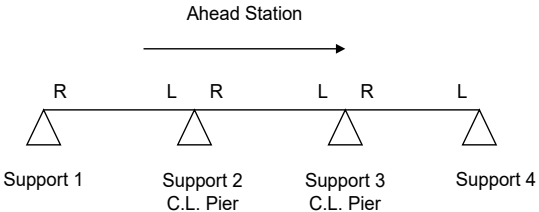
Chapter 5 Input Description

5.13 SKW - SKEW COMMAND (cont)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
2. Skew Angle	Enter the value for either the PennDOT or AASHTO skew angle based on the skew angle designation input parameter on the CTL command. This value is used in computing the distribution factors if a CDF command is entered, and for checking if the beam specified is valid for the skew angle provided. For PennDOT, a positive skew is measured counterclockwise from the centerline of girder. For AASHTO, a positive skew is measured counterclockwise from a line perpendicular to the centerline of girder. As shown, AASHTO skew angle (θ_A) is negative and PennDOT skew angle (θ_P) is positive. See Note 3 for NEXT Beams. θ_A = AASHTO skew angle θ_P = PennDOT skew angle	deg 'P' (+) (-) 'A' (C)	 30. -90.	 90. -30. 60. (C)	--
3. Support Distance 1	Enter the distance from the centerline of the left bearing to the centerline of pier (see diagram). For the support at the abutments, this parameter is to be left blank.	ft	*2 (E)	6. (W)	0.
4. Support Distance 2	Enter the distance from the centerline of pier to the centerline of the right bearing (see above diagram). For the support at the abutments, this parameter is to be left blank.	ft	*2 (E)	6. (W)	0.

Chapter 5 Input Description

5.13 SKW - SKEW COMMAND (cont)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Apply Skew Correction Factor	Enter: L - Shear skew correction factor is applied only to the left of the support. R - Shear skew correction factor is applied only to the right of the support. B - Shear skew correction factor is applied to both the left and right of the support. N - If an interior girder or if there is no skew or if an exterior girder is at an acute corner. 	--	L, R, B, N (E)	--	--

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² The lower limit for interior supports is equal to the "Beam Projection" entered on the GEO command plus 1/8 (in). For supports at the ends of the bridge the lower limit is 0.0.
- ³ For NEXT Beams the Skew Angles at each support must be equal. The lower and upper limits are:

PennDOT (+)	70.	90.
PennDOT (-)	-90.	-70.
AASHTO	-20.	20.

Chapter 5 Input Description

5.14 MCS - CONCRETE MATERIAL PROPERTIES COMMAND

KEYWORD	COMMAND DESCRIPTION
MCS	CONCRETE MATERIAL PROPERTIES - This command is used to specify the concrete material properties related to the concrete girder for each span. For a symmetrical structure, enter the concrete material properties for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the concrete material properties for spans 1, 2, and 3. If the properties are the same for all spans, then only one set of values needs to be entered. The parameters of this command are repeatable, beginning with parameter 1. This command is repeatable. A maximum of 20 concrete material properties data sets (parameters 1 through 3) can be entered on a single command. A maximum of 20 MCS commands can be entered. A total of 20 data sets must be entered for a twenty-span bridge using any combination of MCS commands and repeatable parameters to define 20 data sets. Required for analysis; not used for design.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number for the concrete material properties. Enter zero to indicate that all spans for a multi-span girder will use the same properties.	--	0 (E)	NSP ¹ (E)	--
2. Beam Concrete 28 Day Strength	Enter the compressive strength of beam concrete at 28 days, f'_c .	ksi	5. (C)	10. (C)	--
3. Beam Concrete Initial Strength	Enter the compressive strength of beam concrete at initial prestressing, f'_{ci} .	ksi	4.23 (W)	8.5 (W)	--

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

Chapter 5 Input Description

5.15 MCA - CONCRETE MATERIAL ALLOWABLE PROPERTIES COMMAND

KEYWORD	COMMAND DESCRIPTION
MCA	CONCRETE MATERIAL ALLOWABLE PROPERTIES - This command is used to specify the concrete material properties related to the concrete girder for each span. For a symmetrical structure, enter the concrete material allowable properties for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the concrete material allowable properties for spans 1, 2, and 3. If the properties are the same for all spans, then only one set of values needs to be entered using 0 for the span number. If allowables are needed for each span, enter one of these commands for each span. This command is repeatable. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number for the concrete material properties. If a zero is entered, all spans for a multi-span girder will use the same properties.	--	0 (E)	NSP ¹ (E)	--
2. Initial Allowable Compression	Enter the initial allowable compressive stress in concrete before losses at transfer of prestress for all locations in the span except at the centerline of bearing.	ksi	-5.4 (D)	-1.8 (W)	DM-4 ²
3. Initial Allowable Tension	Enter the initial allowable tensile stress before losses at transfer in top fiber of concrete for all locations in the span except at the centerline of bearing. This must be less than or equal to the Final Allowable Tension (parameter 5).	ksi	0.16 (W)	0.29 (D)	DM-4
4. Final Allowable Compression	Enter the final allowable compressive stress in concrete under design loads after losses for all locations in the span except at the centerline of bearing.	ksi	-6.6 (D)	-2.4 (W)	DM-4
5. Final Allowable Tension	Enter the final allowable tensile stress in precompressed tensile zone under design load after losses at all locations in the span except at the centerline of bearing.	ksi	0.18 (W)	0.31 (D)	DM-4
6. Final Allowable DL Compression	Enter the final allowable compressive stress for dead load for all locations in the span except at the centerline of bearing.	ksi	-4.4 (D)	-1.6 (W)	DM-4
7. Final Allowable Compression 1/2(DL+PS) + LL	Enter the final allowable compressive stress for one-half of (dead load plus P/S) and all live load for all locations in the span except at the centerline of bearing.	ksi	-4.4 (D)	-1.6 (W)	DM-4
8. Final Allowable Slab Compression	Enter the final allowable compressive stress for the slab for all locations in the span except at the centerline of bearing.	ksi	-3.6 (D)	-1.8 (W)	DM-4

Chapter 5 Input Description

5.15 MCA - CONCRETE MATERIAL ALLOWABLE PROPERTIES COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
9. Final Allowable Tension Creep/Shrinkage	Enter the final allowable tensile stress in the concrete under design load to be used in checking creep and shrinkage. This must be greater than or equal to the Final Allowable Tension (parameter 5).	ksi	0.27 (W)	0.64 (C)	DM-4
10. Initial Allowable Compression at Centerline Bearing	Enter the initial allowable compressive stress in concrete before losses at transfer of prestress at the centerline of bearing.	ksi	-5.4 (D)	-1.8 (W)	DM-4
11. Initial Allowable Tension at Centerline Bearing	Enter the initial allowable tensile stress before losses at transfer in top fiber of concrete at the centerline of bearing. This must be less than or equal to the Final Allowable Tension at Centerline Bearing (parameter 13).	ksi	0.16 (W)	0.29 (D)	DM-4
12. Final Allowable Compression at Centerline Bearing	Enter the final allowable compressive stress in concrete under design loads after losses at the centerline of bearing.	ksi	-6.6 (D)	-2.4 (W)	DM-4
13. Final Allowable Tension at Centerline Bearing	Enter the final allowable tensile stress in precompressed tensile zone under design load after losses at the centerline of bearing.	ksi	0.27 (W)	0.64 (D)	DM-4
14. Final Allowable DL Compression at Centerline Bearing	Enter the final allowable compressive stress for dead load at the centerline of bearing.	ksi	-4.4 (D)	-1.6 (W)	DM-4
15. Final Allowable Compression 1/2(DL+PS) + LL at Centerline Bearing	Enter the final allowable compressive stress for one-half of (dead load plus P/S) and all live load at the centerline of bearing.	ksi	-4.4 (D)	-1.6 (W)	DM-4
16. Final Allowable Slab Compression at Centerline Bearing	Enter the final allowable compressive stress for the slab at the centerline of bearing.	ksi	-3.6 (D)	-1.8 (W)	DM-4
17. Final Allowable Tension Creep/Shrinkage at Centerline Bearing	Enter the final allowable tensile stress in the concrete under design load to be used in checking creep and shrinkage at the centerline of bearing. This must be greater than or equal to parameter 13.	ksi	0.27 (W)	0.64 (C)	DM-4

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² The default values are computed as per DM-4.

Chapter 5 Input Description

5.16 MCG - CONCRETE MATERIAL PROPERTIES (ALL GIRDERS) COMMAND

KEYWORD	COMMAND DESCRIPTION
MCG	CONCRETE MATERIAL PROPERTIES (ALL GIRDERS) - This command is used to specify some of the material properties related to the concrete girder. These values are the same for all spans for multispan girders. Only one MCG command can be used. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Creep Factor	Enter the estimated creep coefficient for computing camber.	--	1.5 (W)	2.2 (D)	1.6
2. Beam Concrete Unit Weight for DL	Enter the beam concrete unit weight/density for computing the dead load of the girder. This value must be greater than or equal to the "Beam Concrete Unit Weight for E" (parameter 3).	lb/ft ³	140. (W)	160. (E)	150.
3. Beam Concrete Unit Weight for E	Enter the beam concrete unit weight/density for computing the beam modulus of elasticity.	lb/ft ³	135. (W)	155. (E)	145.
4. Slab Beam Interface	Enter the type of interface between deck slab and girder: C - Cast-in-place slab on roughened surface. M - Monolithic. U - Unroughened. I - Intentionally roughened. Refer to Section 6.16 for additional information. This parameter is not required for non-composite girders.	--	C, M, U, I (E)	--	C
5. Steam Cure/ Moist Cure	Note: This parameter is not used anymore and should be left blank. It is retained for compatibility with existing input files.	--	--	--	--

Chapter 5 Input Description

5.17 MPS - PRESTRESSING STEEL MATERIAL PROPERTIES COMMAND

KEYWORD	COMMAND DESCRIPTION
MPS	PRESTRESSING STEEL MATERIAL PROPERTIES - This command is used to specify the material properties related to the prestressing steel. Only one MPS command can be entered. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. P/S Steel Ultimate Strength	Enter the specified ultimate strength of prestressing steel, f_{pu} .	ksi	225. (W)	300. (D)	270.
2. Jacking P/S Tension	Enter the jacking tensile stress in prestressing steel.	ksi	155. (W)	210. (D)	*1
3. P/S Steel Yield Strength	Enter the specified yield point stress of prestressing steel.	ksi	190. (W)	250. (D)	*2
4. P/S Steel Modulus of Elasticity	Enter the modulus of elasticity of prestressing steel.	ksi	28000. (E)	30000. (D)	28500.
5. Estimated % P/S Loss	Leave blank to calculate camber values for beam seat elevations and for checking probable sag based on the default values. Enter the estimated percent loss in prestressing force for computing set of camber values based on this parameter.	--	10. (W)	40. (D)	*3

Notes:

- ¹ Set to $0.70 f_{pu}$ for stress-relieved strands and $0.75 f_{pu}$ for low relaxation strands.
- ² Set to $0.85 f_{pu}$ for stress-relieved strands and $0.90 f_{pu}$ for low relaxation strands.
- ³ Program uses 10% loss for calculating the camber values that should be used for establishing beam seat elevations, and uses 15% loss for calculating the camber values that should be used for checking for probable beam sag. Output is printed for both values.

Chapter 5 Input Description

5.18 MST - MILD STEEL MATERIAL PROPERTIES COMMAND

KEYWORD	COMMAND DESCRIPTION
MST	MILD STEEL MATERIAL PROPERTIES - This command is used to specify the material properties related to the mild steel used in the beam. For a symmetrical structure, enter the mild steel properties for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the mild steel material properties for spans 1, 2, and 3. This command is repeatable. Required for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number. Enter zero to indicate that all spans for a multi-span girder will use the same parameters.	--	0 (E)	NSP ¹ (E)	--
2. Beam Stirrup Yield Strength	Enter the yield strength of steel stirrups used as shear reinforcement in the girder.	ksi	60. (D)	60. (D)	60.
3. Beam F _y Other Steel	Enter the yield strength for all other beam mild steel.	ksi	60. (D)	60. (D)	60.
4. Dev. Length Factor Positive	Enter the development length modification factor for mild steel for positive regions. This value is applied directly to the basic development length of the mild reinforcement located in the bottom half of the girder.	--	0.5 (W)	2. (W)	1.
5. Dev. Length Factor Negative	Enter the development length modification factor for mild steel for negative regions. This value is applied directly to the basic development length of the mild reinforcement located in the top half of the girder.	--	0.5 (W)	2. (W)	1.
6. Dev. Length Factor for Slabs	Enter the development length modification factor for mild longitudinal slab reinforcement. This value is applied directly to the basic development length of the longitudinal mild reinforcement located in the slab (both top and bottom).	--	0.5 (W)	2. (W)	1.
7. Beam F _u Other Steel	Enter the ultimate tensile strength for all other beam mild steel.	ksi	90. (D)	90. (D)	*2

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

² Defaults to 90 ksi when Beam F_y Other Steel is 60 ksi; otherwise no default value.

Chapter 5 Input Description

5.19 DES - DESIGN COMMAND

KEYWORD	COMMAND DESCRIPTION
DES	DESIGN - This command is used to specify the design parameters of the beam. The limits of the command are dependent on the type of beam selected. This command can be entered only once. Required for design; not used for analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. f'_c Optimization	Specify whether the program should optimize for f'_c of the beam: Y - Optimize for f'_c of the beam. N - Do not optimize for f'_c of the beam.	--	Y, N (E)	--	N
2. Minimum Depth	Enter the minimum depth of the beam to be designed. The program will not consider a beam less than this depth when performing the design. For design, the program will try to design a beam corresponding to the shape of beam specified on the CTL command, parameter 3, but selected only from those beams listed in the PennDOT BD Standards.	in I-beam or Bulb- tee Adj. Plank Adj. Box Spread Box Type F NEXT Beam	29. 12. 17. 17. 24. (E)	96. 12. 66. 66. 36. (E)	29. ¹ 12. ¹ 17. ¹ 17. ¹ 24. ¹

Notes:

- ¹ The default minimum depth will be the minimum beam depth in the PennDOT BD Standards for the specified beam shape. If the Overhang to Beam Depth Override check is set to N on the CTL command then for spread exterior beams the default minimum depth is the maximum of the default shown and the overhang length to satisfy DM-4 Section 9.7.1.5.1P.

Chapter 5 Input Description

5.19 DES - DESIGN COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
3. Maximum Depth	Enter the maximum depth of the beam to be designed. The program will not consider a beam greater than this depth when performing the design. For design, the program will try to design a beam corresponding to the shape of beam specified on the CTL command, parameter 3, but selected only from those beams listed in the PennDOT BD Standards.	in I-beam or Bulb- tee	29.	96.	96.
		Adj. Plank	12.	12.	12.
		Adj. Box	17.	66.	66.
		Spread Box	17.	66.	66.
		Type F NEXT Beam	24. (E)	36. (E)	36.
4. Depth Difference	Enter the maximum difference in depth of beams between two adjacent spans. Leave blank for a simple span.	in Bulb- tee	0.	8.	8.
		All others	0. (E)	6. (W)	6.
5. Box Beam Width or Top Flange Width	Enter the width of the box beam or the width of the top flange for bulb-tees. Enter this value only for spread box beam, adjacent box beam, or bulb-tee designs.	in Bulb- tee	36.	48.	--
		Box	36. (E)	48. (E)	--
6. Design f'_c	Enter the value for f'_c of the beam. The program will design for this value. If 'Y' is entered in parameter 1, the program will make an initial design run using this value. Subsequent f'_c optimization design runs will use the beams selected for the initial design f'_c value and iteratively reduce the initial design f'_c value by the value entered for parameter 7 of this command.	ksi	5. (C)	10. (C)	8.0
7. f'_c Increment	Enter this value if f'_c optimization has been chosen. This value is the increment by which f'_c is decreased.	ksi	0.5 (W)	3. (W)	0.5
8. f'_{ci} / f'_c Ratio	Enter the ratio of f'_{ci} to f'_c .	--	0.85 (W)	0.95 (W)	0.85

Chapter 5 Input Description

5.19 DES - DESIGN COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
9. Bottom Flange Thickness	Enter the thickness of the bottom flange for bulb-tee beams. Leave blank for all other beam types.	in	7. (W)	9. (W)	--

5.20 SST - SLAB REINFORCEMENT LOCATION COMMAND

KEYWORD	COMMAND DESCRIPTION
SST	SLAB REINFORCEMENT LOCATION - This command is used to define the longitudinal slab reinforcement for the negative moment connection. The parameters of this command are repeatable, beginning with parameter 2. A maximum of six ranges of reinforcement can be entered on each command. Six ranges are the maximum for each interior support. A maximum of 57 SST commands can be entered. For a twenty-span bridge, three SST commands could be entered for each of the 19 interior supports with each command having two ranges of reinforcement to have the maximum of 6 ranges at each interior support. For a symmetrical structure, enter the slab reinforcement location for supports up to and including the middle support. For example, both a symmetrical 4-span structure and a symmetrical 5-span structure, requires data for supports 2 and 3. This information is only entered for analysis problems; for design, the required area of negative moment connection reinforcement is computed by the program. NOTE: Any longitudinal slab reinforcement outside of the ranges described here must be entered using parameter 10 of the SLB command. Required for analysis for negative moment continuity steel only if more than one span; not used for design or for single span.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Support Number	Enter the interior support number. Enter zero to indicate that all interior supports will use the same negative moment connection slab reinforcement.	--	0 (E)	NSP ¹ (E)	--
2. Bar Number	Enter the bar size number for the range (the distance from the left cutoff point to the right cutoff point).	US	3 (E)	8 ⁴ (E)	--
3. Left Cutoff Point	Enter the distance from the centerline of the pier to the cutoff point left of the pier. This is the physical bar cutoff location. (See Figure 5.20-3)	ft	0. (E)	$\frac{1}{2}$ MXSP1 ² (E)	--
4. Right Cutoff Point	Enter the distance from the centerline of the pier to the cutoff point right of the pier. This is the physical bar cutoff location. (See Figure 5.20-3)	ft	0. (E)	$\frac{1}{2}$ MXSP2 ³ (E)	--

Chapter 5 Input Description

5.20 SST - SLAB REINFORCEMENT LOCATION COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Area of Reinforcement	Enter the area of negative moment connection reinforcement per effective slab width only for the bars whose lengths are defined by the range. The area of reinforcement defined by each bar range is added together by the program to compute the total area available at any analysis point. Note: The negative moment resistance at a particular analysis point is based on the maximum of either the effective area of reinforcement, entered here, or the area entered for parameter 10 of the SLB command.	in ²	0. (E)	30. (W)	--
6. Location in Slab	Enter the location of the bar in the slab: T – Top longitudinal reinforcement B – Bottom longitudinal reinforcement Longitudinal rebars in the top are considered when checking crack control (serviceability checks). (See Figure 5.20-6)	--	T, B ⁴ (E)	--	T

Notes:

- ¹ NSP is equal to the number of spans entered in the CTL command.
- ² MXSP1 is equal to the span length to the left of the support defined.
- ³ MXSP2 is equal to the span length to the right of the support defined.
- ⁴ Bottom longitudinal rebars have an upper limit of #6.

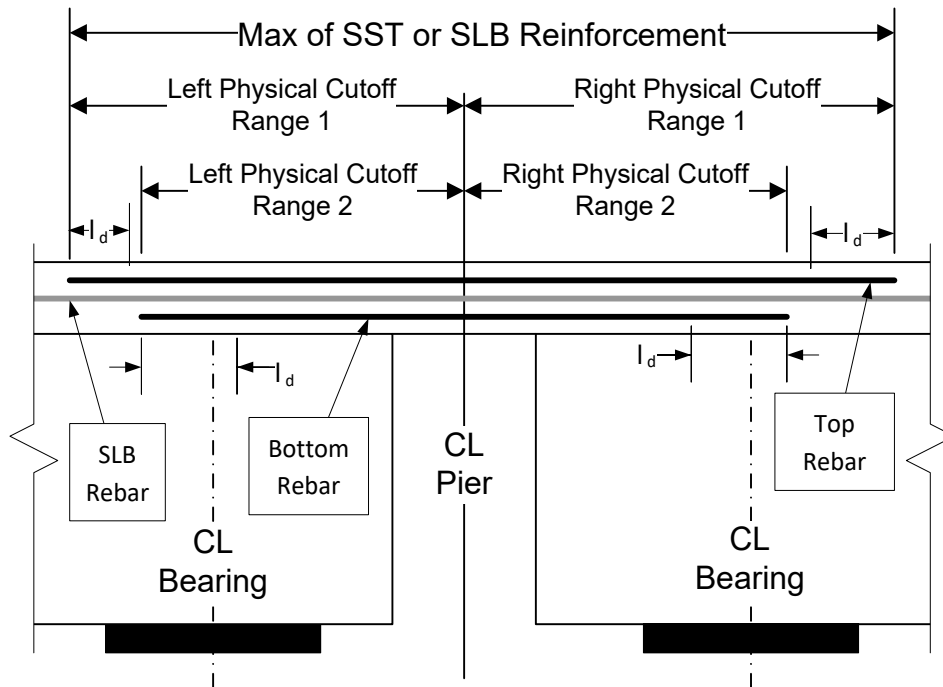
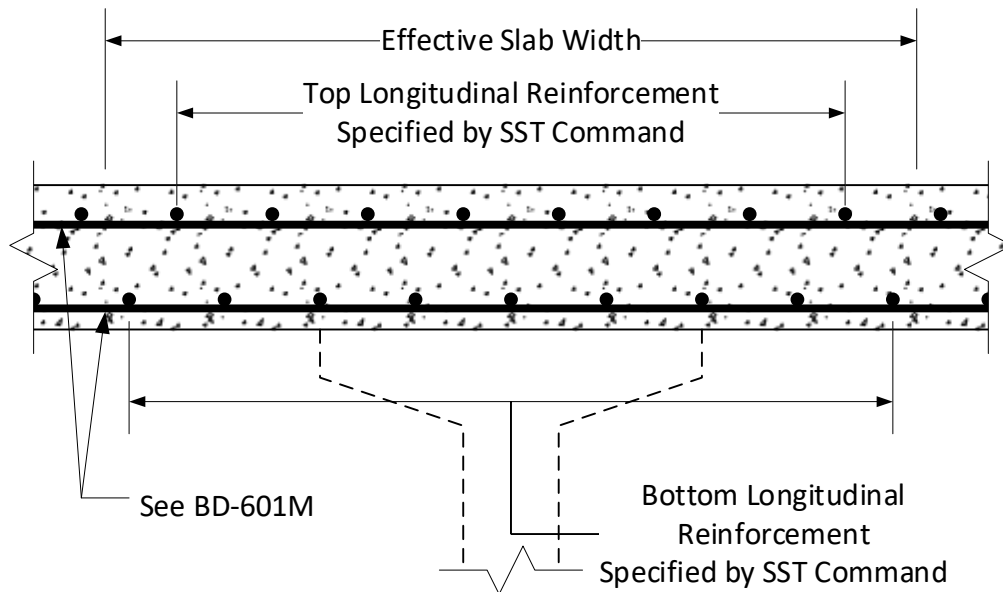


Figure 5.20-3 Definition of Left and Right Cutoff Points



Girder Cross Section

For deck top reinforcement mat: Longitudinal bars shown on top per BD-601M Change 2 dated 08/30/2019, similar when longitudinal bars on bottom per earlier versions of BD-601M

Figure 5.20-6 Longitudinal Slab Reinforcement Negative Moment Regions

Chapter 5 Input Description

5.21 BDM - BEAM DIMENSIONS COMMAND

KEYWORD	COMMAND DESCRIPTION
BDM	BEAM DIMENSIONS - This command is used to specify the typical dimensions of the beam cross section for each span. For a symmetrical structure, enter the beam dimensions for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the beam dimensions for spans 1, 2, and 3. The input for this command should be listed in the order shown in the table below. If a dimension is not needed for a particular beam, that field should be left blank. See the accompanying figures for the dimensions required for each beam type. This command is repeatable. Use the BDM command to specify a beam to be used for a design problem. If the beam dimensions are entered, then the SCD command must be used to define the available strand pattern. If a beam designation is entered, then the SCD command may be used to change the strand pattern defined by the beam table. Required for analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the beam dimensions. Enter zero to indicate that all spans will use the same beam dimensions.	--	0 (E)	NSP ¹ (E)	--
2. Designation or D	Enter the beam designation or enter the dimension for D (see tables and figures on the following pages). The beam designation is a 4-digit number for I-Beams and Box Beams, a 4, 6 or 7 digit number for Bulb-Tee Beams consisting of the W1 and D dimensions, a 7 character text string for NEXT Beams consisting of NEXTdda; where dd is the beam depth and a is F for Type F NEXT beams or D for Type D NEXT beams. See PennDOT BD Standards for standard beam dimensions. If the value 'P' is entered for "Beam Designation" in the CTL command, enter a designation for this parameter (see User Manual Tables 3.22-1 through 3.22-8 for available designations). If a 'U' is entered for beam designation on the CTL command, enter a depth for this parameter. If the beam designation is entered, parameters 3 through 21 are to be left blank. However, if the user has entered a beam designation, the beam properties specified in the BD Standards, parameters 3 through 21, may be overridden by entering a value for any of those parameters.	in	(see tables and figures) (C)	(see tables and figures) (C)	--
3. W1	Beam Dimensions (See Figures 1 through 14)	in (all)	*2 (W or C)	*2 (W or C)	*6
4. W2	For standard beams in BD-652M entered using the beam designation, inputs that deviate from the standard require the approval of the Chief Bridge Engineer.		*2 (W or C)	*2 (W or C)	*6

Chapter 5 Input Description

5.21 BDM - BEAM DIMENSIONS COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. W3	Beam Dimensions (See Figures 1 through 14) For standard beams in BD-652M entered using the beam designation, inputs that deviate from the standard require the approval of the Chief Bridge Engineer.		*2 (W or C)	*2 (W or C)	*6
6. T1			*2 (W or C)	*2 (W or C)	*6
7. T2			*2 (W or C)	*2 (W or C)	*6
8. B1			*2 (W or C)	*2 (W or C)	*6
9. B2			*2 (W or C)	*2 (W or C)	*6
10. B3			*2 (W or C)	*2 (W or C)	*6
11. B4			*2 (W or C)	*2 (W or C)	*6
12. D1			*2 (W or C)	*2 (W or C)	*6
13. D2			*2 (W or C)	*2 (W or C)	*6
14. X1			*2 (W or C)	*2 (W or C)	*6
15. X2			*2 (W or C)	*2 (W or C)	*6
16. Area Beam Long. Steel Positive	Enter the area of longitudinal mild steel for the positive region (bottom steel).	in ²	0. (E)	5. (W)	*6
17. Area Beam Long. Steel Negative	Enter the area of longitudinal mild steel for the negative region (top steel).	in ²	0. (E)	5. (W)	*6
18. Positive Steel CGS	Enter the center of gravity of the longitudinal mild steel for the positive region, measured from the bottom of the beam.	in	0. (W)	*3 (W)	*4
19. Negative Steel CGS	Enter the center of gravity of the longitudinal mild steel for the negative region, measured from the bottom of the beam.	in	0. (W)	*3 (W)	*5
20. Beam Bar Number Positive	Enter the beam bar number for the positive region.	--	3 (E)	8 (W)	*6
21. Beam Bar Number Negative	Enter the beam bar number for the negative region.	--	3 (E)	8 (W)	*6

Chapter 5 Input Description

5.21 BDM - BEAM DIMENSIONS COMMAND (Cont.)

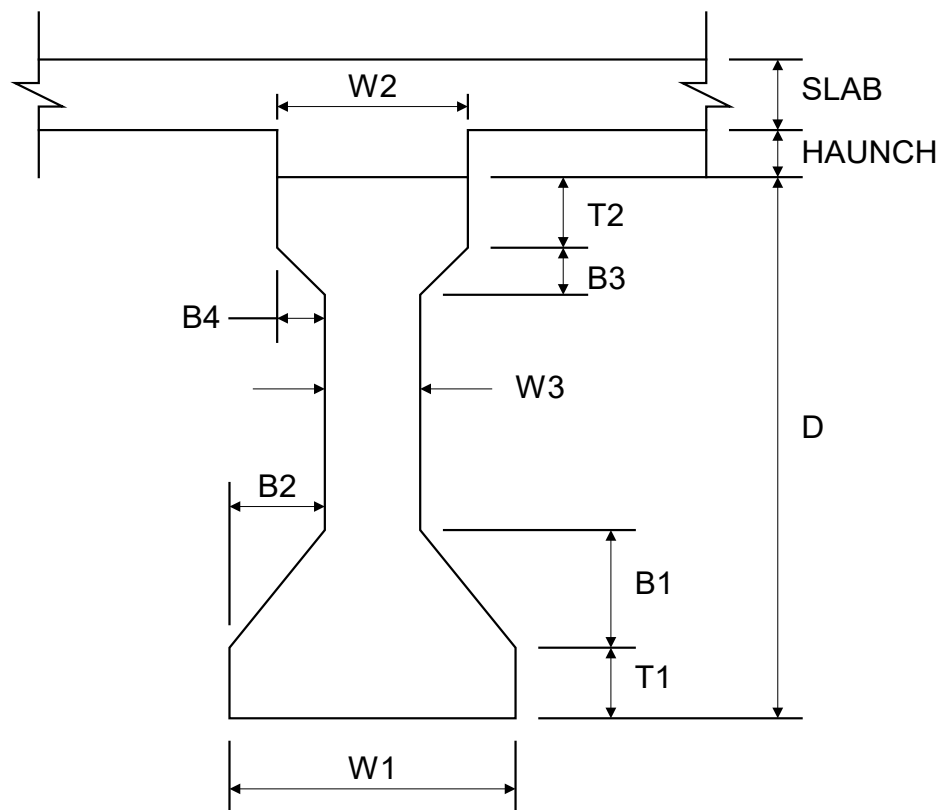
Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² **If parameter 2 is a Beam Depth, see the tables and figures on the following pages for the upper and lower limits. Violations of the limits result in Warning messages.**
If parameter 2 is a Beam Designation, values other than those based on BD-652M result in a Chief Bridge Engineer warning.
- ³ CGS is dependent on the beam depth.
- ⁴ Conservatively assumed as:

<u>Beam Type</u>	<u>CGS</u>
PA I-Beam	$T1 + B1$
AASHTO I-Beam	$D/4$
Box Beams	Not Applicable (Area of Steel = 0.)
Adjacent Plank Beams	Not Applicable (Area of Steel = 0.)
PA Bulb-Tee Beam	$D/4$
NEXT Beam	Not Applicable (Area of Steel = 0)
- ⁵ Conservatively assumed as:

<u>Beam Type</u>	<u>CGS</u>
PA I-Beam	$D - (T2 + B3)$
AASHTO I-Beam	$D - (T2 + D1 + B3)$
PA Bulb-Tee Beam	$D - (T2 + D1 + B3)$
Box Beam	$D - (T2/2)$
Adjacent Plank Beam	$D - 4"$
NEXT Beam	Not Applicable (Area of Steel = 0)
- ⁶ If parameter 2 is a Beam Designation, the default value is based on the BD Standards. If parameter 2 is a Beam Depth, no default value.

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	30.	63.
W1	18.	26.
W2	12.	26.
W3	6.	14.
T1	4.	9.
T2	3.	14.
B1	8.	10.
B2	6.	8.
B3	3.	6.
B4	3.	8.

Dimension Compatibility Requirements

$$2*B4 + W3 = W2$$

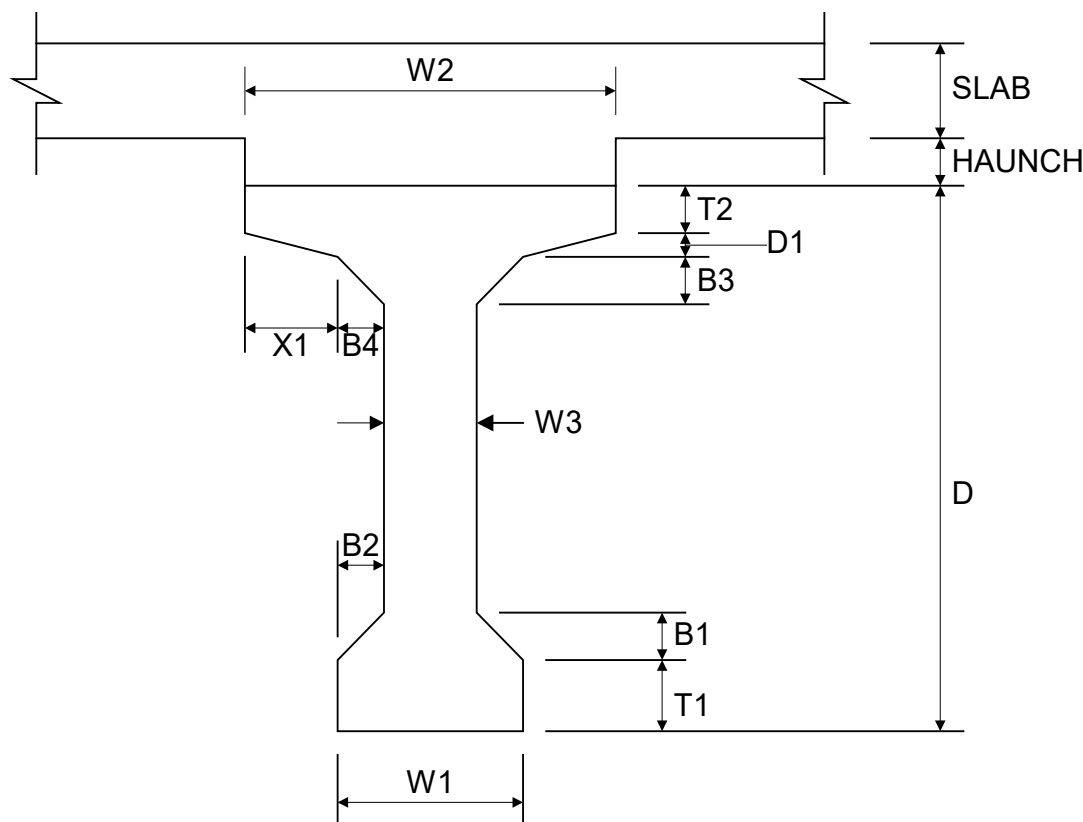
$$2*B2 + W3 = W1$$

$$T2 + B3 + B1 + T1 \leq D$$

Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-1 PennDOT Regular I-Beam



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	54.	96.
W1	26.	28.
W2	20.	42.
W3	8.	8.
T1	8.	8.
T2	5.	8.
B1	9.	10.
B2	9.	10.
B3	4.	6.
B4	4.	6.
D1	0.	3.
X1	0.	13.

Dimension Compatibility Requirements

$$2*(X1 + B4) + W3 = W2$$

$$2*B2 + W3 = W1$$

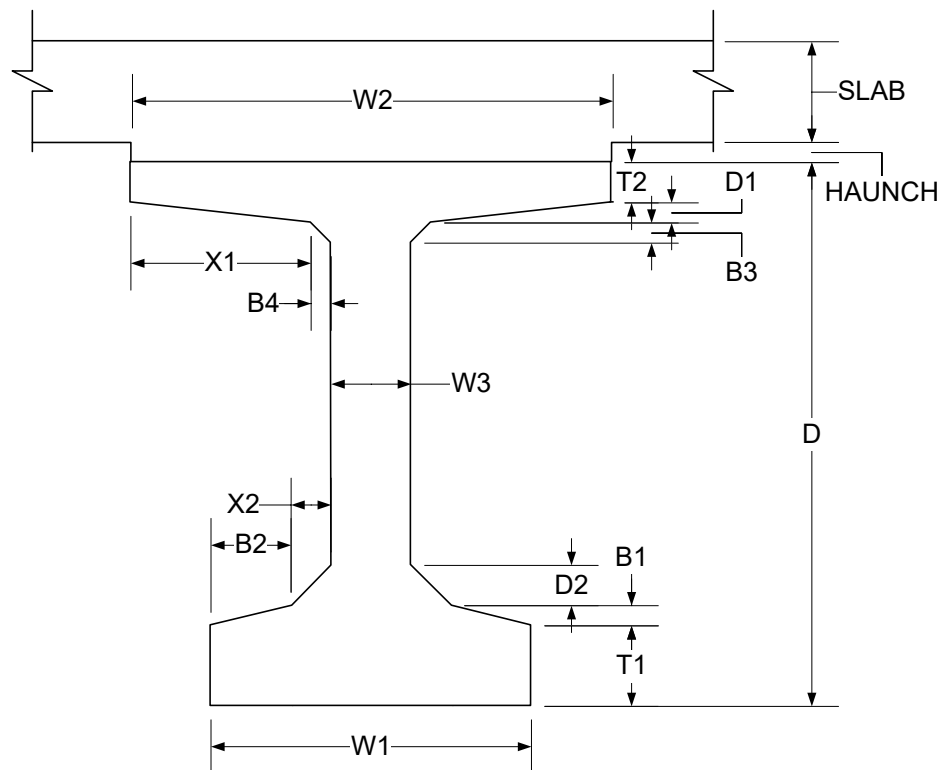
$$T2 + D1 + B3 + B1 + T1 \leq D$$

Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-2 AASHTO Type I-Beam

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	29.	96.
W1	33.	33.
W2	36.	48.
W3	8.	8.
T1	7.	9.
T2	4.5	4.5
B1	3.	3.
B2	9.	9.
B3	2.	2.
B4	2.	2.
D1	1.	1.5
D2	3.5	3.5.
X1	12.	18.
X2	3.5	3.5

Dimension Compatibility Requirements

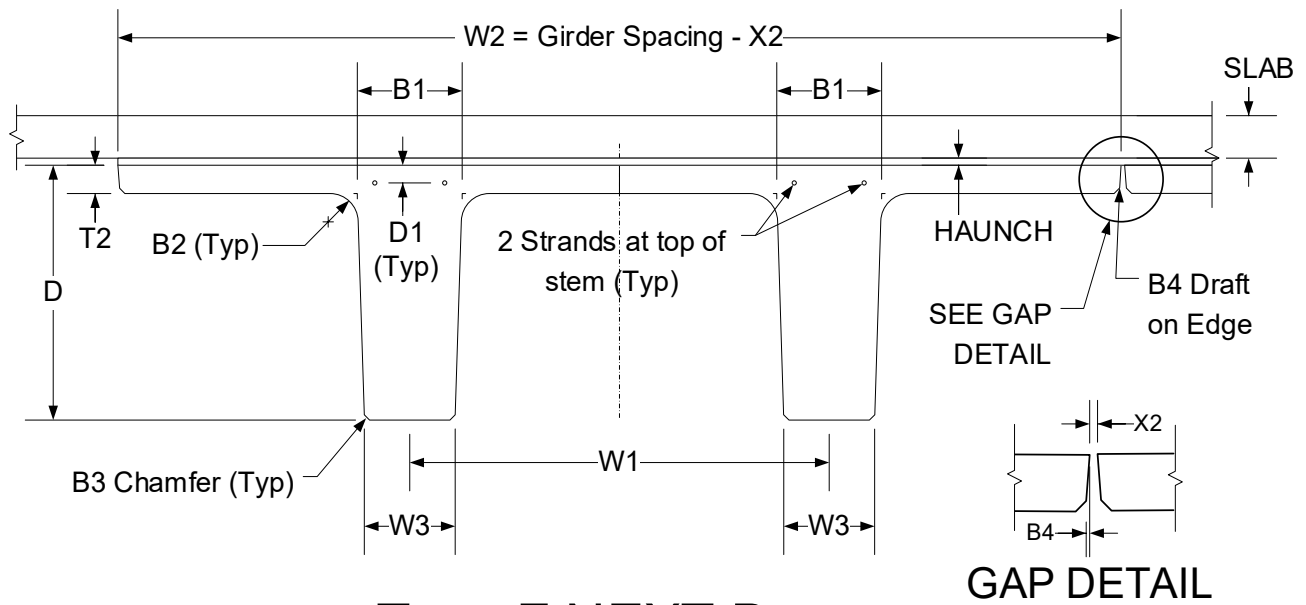
$$2*(X1 + B4) + W3 = W2$$

$$2*(X2 + B2) + W3 = W1$$

$$T2 + D1 + B3 + D2 + B1 + T1 \leq D$$

Lower and upper limits apply for beams with user specified dimensions.
(CTL parameter "Beam Designation" = U)

Figure 5.21-3 PA Bulb-Tee-Beam



Type F NEXT Beam

PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	24.	36.
W1	60.	60.
W2	n/a	n/a
W3	13.	13.75
T1	n/a	n/a
T2	4.	4.
B1	15.	15.
B2	4.	4.
B3	0.	1.
B4	0.	0.5
D1	1.5	3.5
D2	n/a	n/a.
X1	n/a	n/a
X2	0.	1.

Dimension Compatibility Requirements

$$B1 \geq W3$$

$$T2 + B2 + B3 \leq D$$

$$2*B3 \leq W3$$

$$2*B2 + B1 \leq W1$$

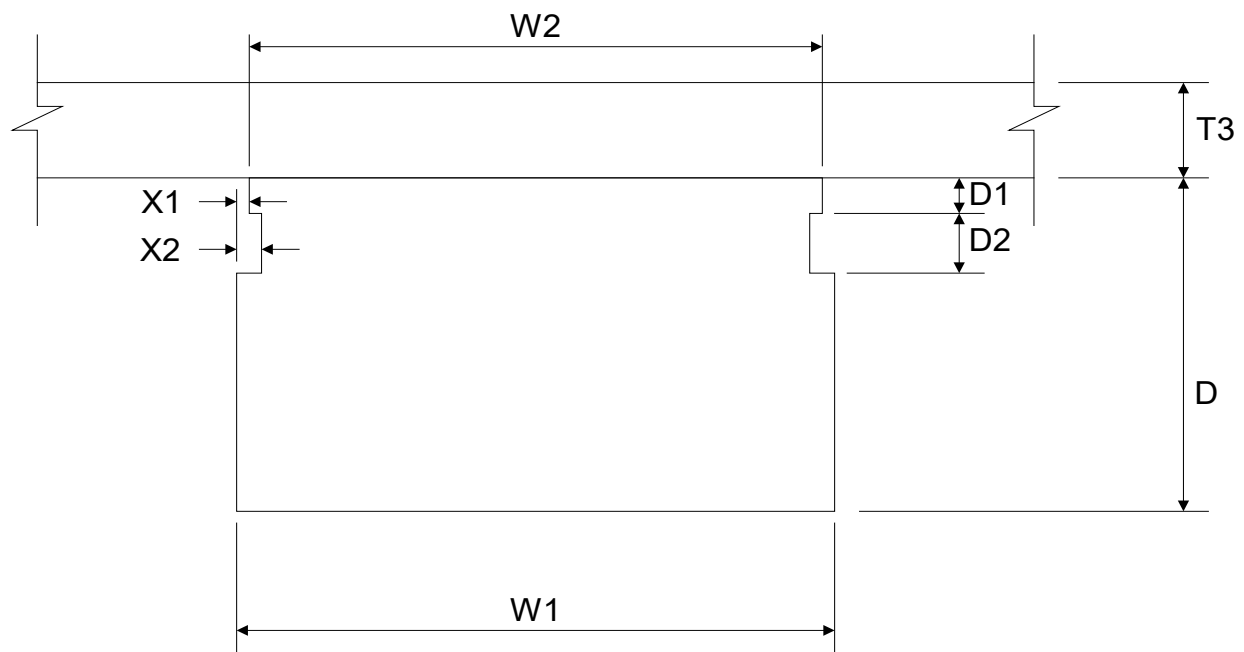
$$W1 + B1 + 2*B2 \leq W2$$

Lower and upper limits apply for beams

with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-4 Type F NEXT Beam



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	12.	12.
W1	36.	48.
W2	35.25	47.25
D1	3.	6.
D2	4.	6.
X1	0.375	0.375
X2	0.75	0.75

Dimension Compatibility Requirements

$$2 \cdot X1 + W2 = W1$$

$$X_2 \geq X_1$$

$$2 \cdot X_2 \leq W_1$$

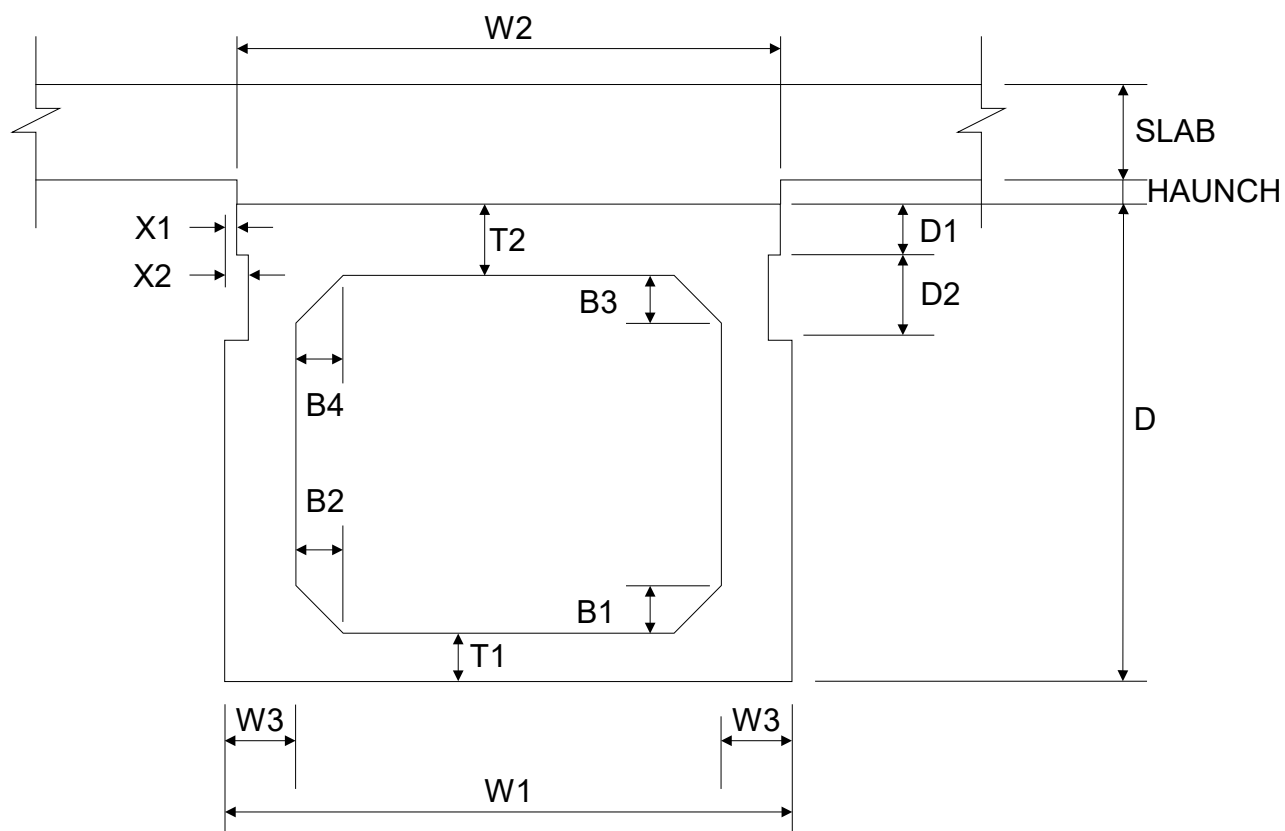
$$D1 + D2 \leq D$$

Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-5 Adjacent Plank Beam

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	17.	66.
W1	36.	48.
W2	35.25	47.25
W3	5.	5.
T1	5.5	7.
T2	3.	5.5
B1	1.5	3.
B2	1.5	3.
B3	1.5	3.
B4	1.5	3.
D1	3.	6.
D2	4.	6.
X1	0.375	0.375
X2	0.75	0.75

Dimension Compatibility Requirements

$$2 \cdot X1 + W2 = W1$$

$$X2 \geq X1$$

$$2 \cdot X2 \leq W1$$

$$D1 + D2 \leq D$$

$$2 \cdot W3 + 2 \cdot B2 \leq W1$$

$$2 \cdot W3 + 2 \cdot B4 \leq W1$$

$$T2 + B3 + B1 + T1 \leq D$$

Shear Key Not Intersect Rectangular Opening

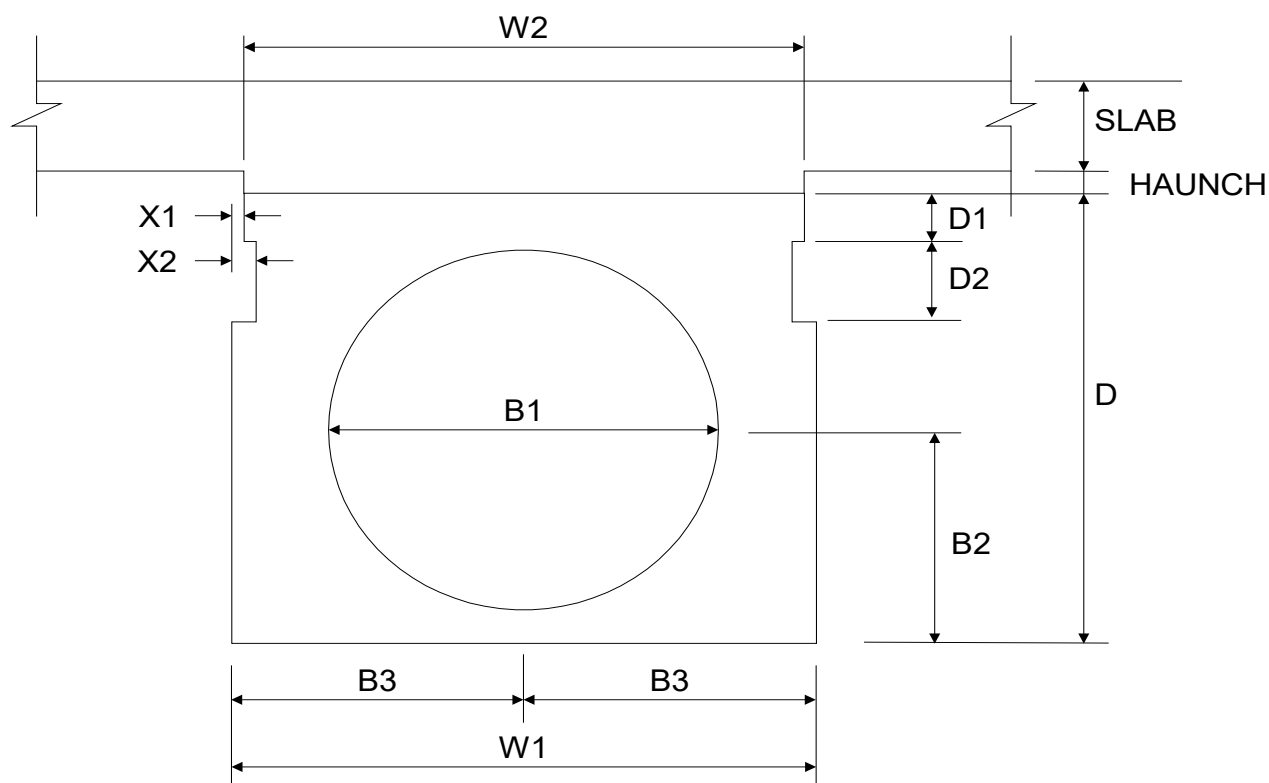
Lower and upper limits apply for beams

with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-6 Adjacent Box Beam - Rectangular Opening

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	33.	33.
W1	36.	36.
W2	35.25	35.25
B1	24.75	24.75
B2	16.50	16.5
B3	18.	18.
D1	6.	6.
D2	6.	6.
X1	0.375	0.375
X2	0.75	0.75

Dimension Compatibility Requirements

$$2 \cdot X1 + W2 = W1$$

$$X2 \geq X1$$

$$2 \cdot X2 \leq W1$$

$$D1 + D2 \leq D$$

$$2 \cdot B3 = W1$$

$$B1 \leq W1$$

$$2 \cdot B2 \geq B1$$

$$B2 + B1/2 \leq D$$

$$B1 \leq D$$

Shear Key Not Intersect Circular Opening

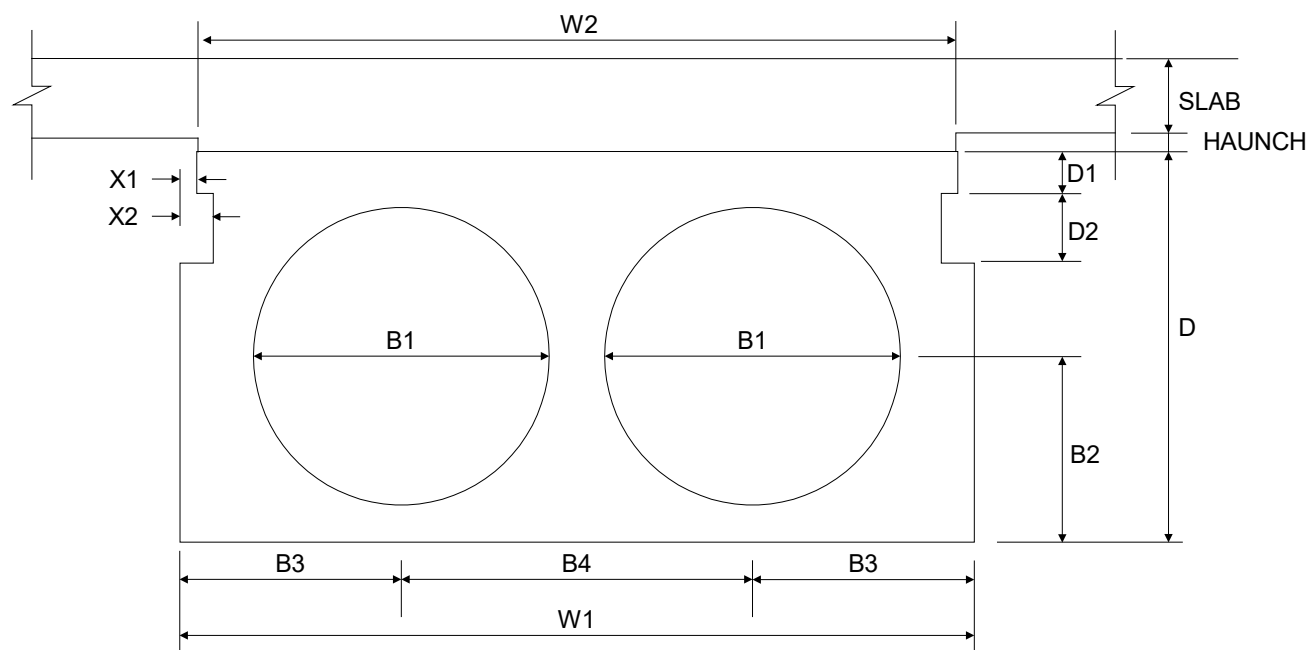
Lower and upper limits apply for beams
with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Note: Dimensions obtained from Department's Old Standards, 1940 to 1960.

Figure 5.21-7 Adjacent Box Beam - One Circular Opening

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	17.	21.
W1	36.	36.
W2	35.25	35.25
B1	10.5	12.5
B2	9.	10.5
B3	10.25	10.25
B4	13.5	15.5
D1	3.	6.
D2	4.	6.
X1	0.375	0.375
X2	0.75	0.75

Dimension Compatibility Requirements

$$2 \cdot X1 + W2 = W1$$

$$X2 \geq X1$$

$$2 \cdot X2 \leq W1$$

$$D1 + D2 \leq D$$

$$2 \cdot B3 + B4 = W1$$

$$B4 \geq B1$$

$$2 \cdot B1 \leq W1$$

$$2 \cdot B2 \geq B1$$

$$B2 + B1/2 \leq D$$

$$B1 \leq D$$

Shear Key Not Intersect Circular Openings

Shear Key Not Between Circular Openings

Lower and upper limits apply for beams

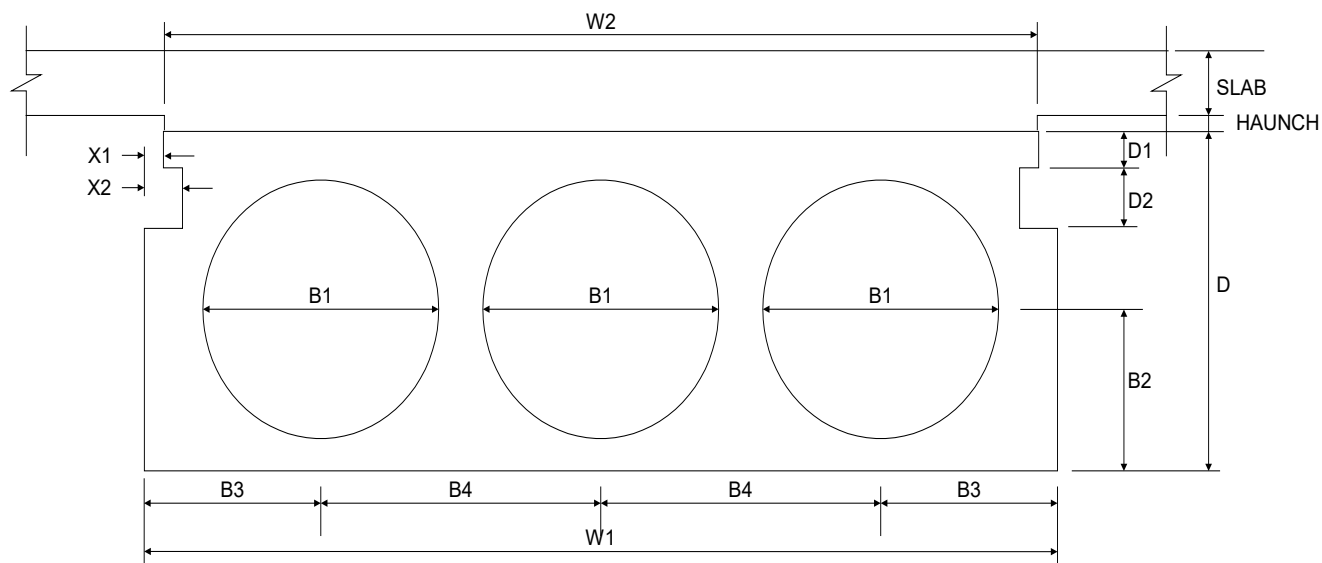
with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Note: Dimensions obtained from Department's Old Standards, 1940 to 1960.

Figure 5.21-8 Adjacent Box Beam - Two Circular Openings

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	19.	24.
W1	48.	48.
W2	47.25	47.25
B1	8.5	10.5
B2	11.	14.
B3	9.5	10.
B4	14.	14.5
D1	3.	6.
D2	4.	6.
X1	0.375	0.375
X2	0.75	0.75

Dimension Compatibility Requirements

$$2 \cdot X1 + W2 = W1$$

$$X2 \geq X1$$

$$2 \cdot X2 \leq W1$$

$$D1 + D2 \leq D$$

$$2 \cdot B2 \geq B1$$

$$B2 + B1/2 \leq D$$

$$B1 \leq D$$

$$2 \cdot B3 + 2 \cdot B4 = W1$$

$$3 \cdot B1 \leq W1$$

$$B4 \geq B1$$

$$2 \cdot B3 \geq B1$$

Shear Key Not Intersect Circular Openings

Shear Key Not Between Circular Openings

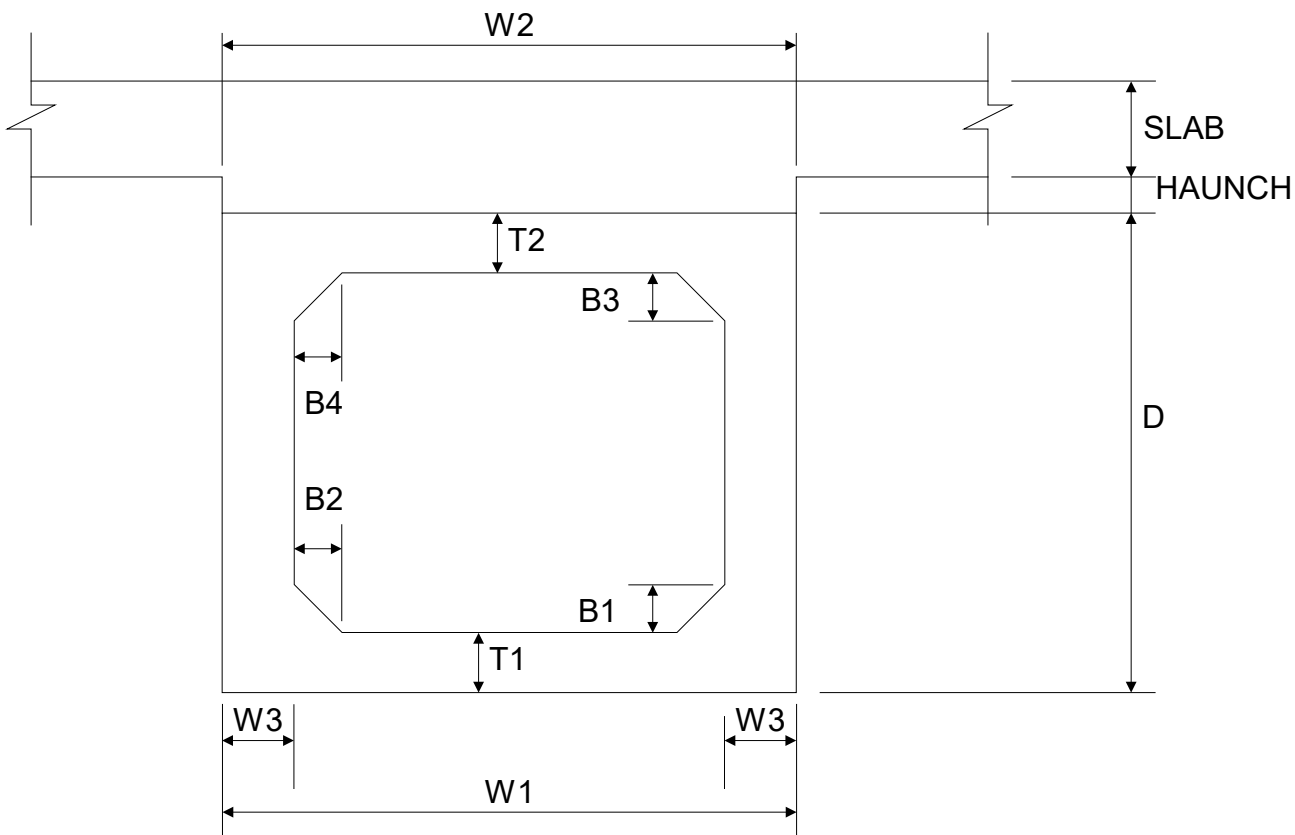
Lower and upper limits apply for beams

with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Note: Dimensions based on Federal Standards, Concrete Superstructures, June 1962, Sheet 3 of 4.

Figure 5.21-9 Adjacent Box Beam - Three Circular Openings



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	17.	66.
W1	36.	48.
W2	36.	48.
W3	5.	5.
T1	5.5	7.
T2	3.	3.
B1	1.5	3.
B2	1.5	3.
B3	1.5	3.
B4	1.5	3.

Dimension Compatibility Requirements

$$2*W3 + 2*B2 \leq W1$$

$$2*W3 + 2*B4 \leq W1$$

$$T2 + B3 + B1 + T1 \leq D$$

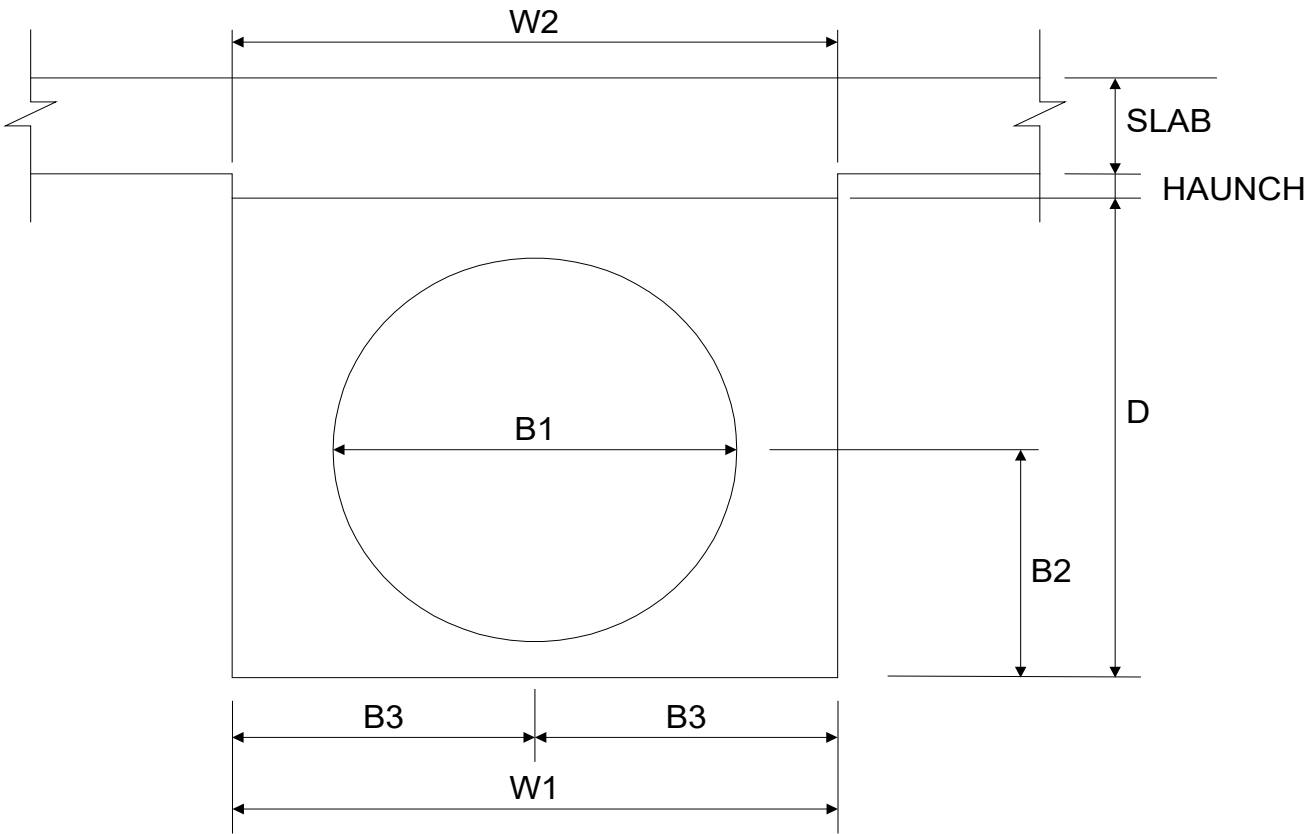
$$W1 = W2$$

Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-10 Spread Box Beam - Rectangular Opening

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	33.	33.
W1	36.	36.
W2	36.	36.
B1	24.75	24.75
B2	16.50	16.5
B3	18.	18.

Dimension Compatibility Requirements

$$2 \cdot B3 = W1$$

$$B1 \leq W1$$

$$2 \cdot B2 \geq B1$$

$$B2 + B1/2 \leq D$$

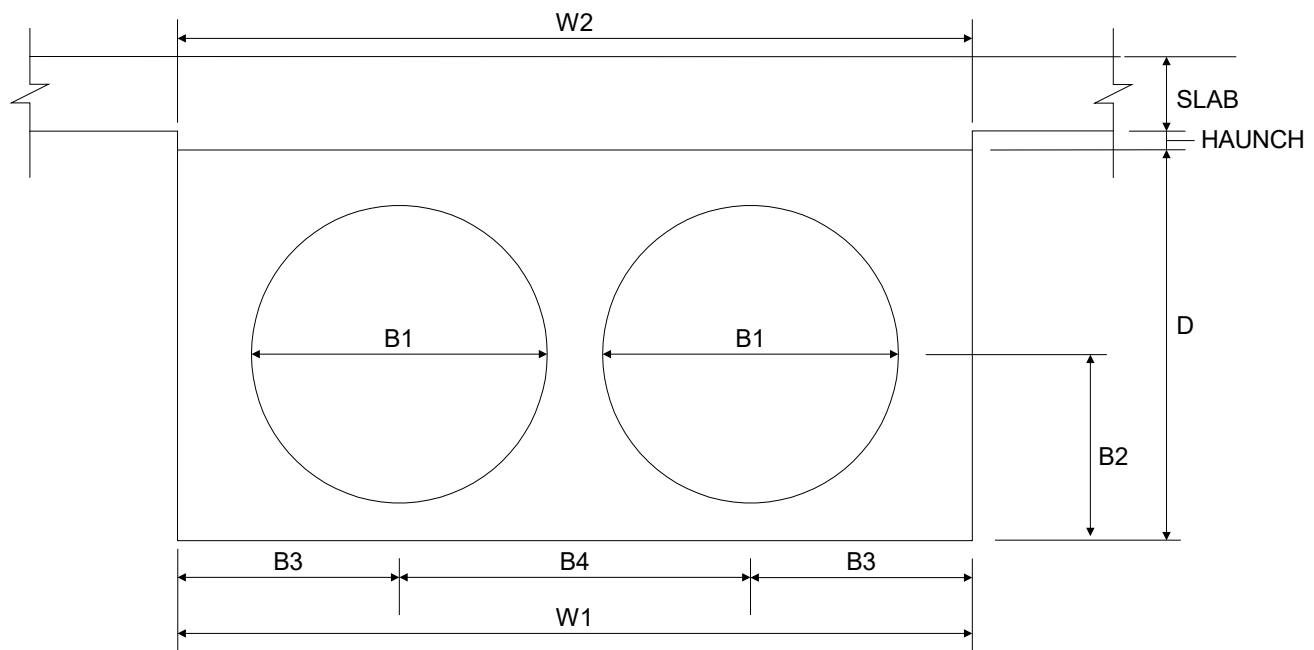
$$B1 \leq D$$

Lower and upper limits apply for beams with user specified dimensions.
(CTL parameter "Beam Designation" = U)

Note: Dimensions obtained from Department's Old Standards, 1940 to 1960.

Figure 5.21-11 Spread Box Beam - One Circular Opening

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	17.	21.
W1	36.	36.
W2	36.	36.
B1	10.5	12.5
B2	9.	10.5
B3	10.25	10.25
B4	13.5	15.5

Dimension Compatibility Requirements

$$2*B3 + B4 = W1$$

$$B4 \geq B1$$

$$2*B1 \leq W1$$

$$2*B2 \geq B1$$

$$B2 + B1/2 \leq D$$

$$B1 \leq D$$

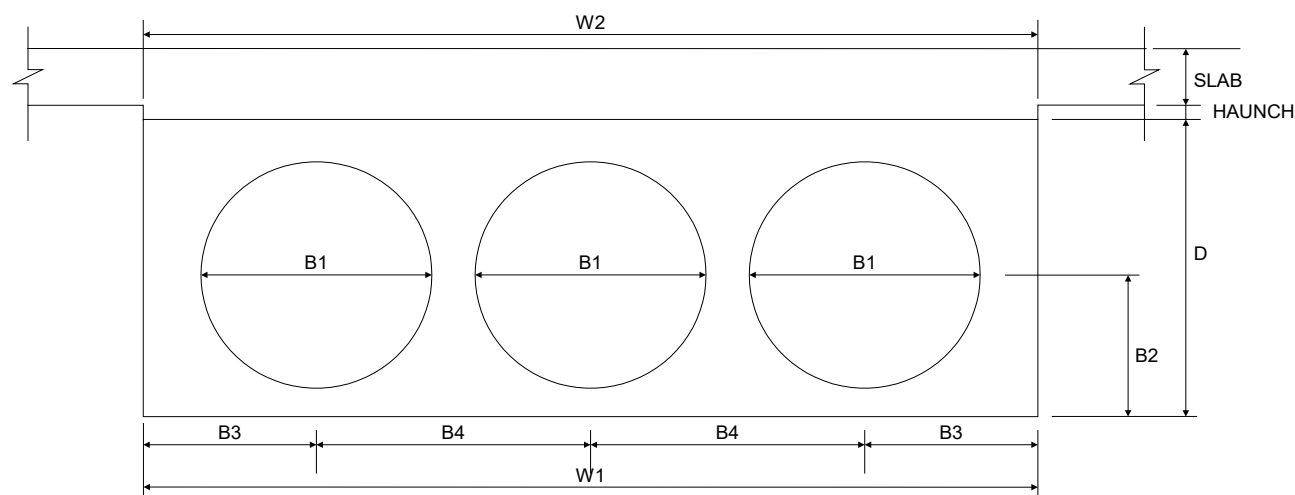
Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Note: Dimensions obtained from Department's Old Standards, 1940 to 1960.

Figure 5.21-12 Spread Box Beam - Two Circular Openings

Chapter 5 Input Description



PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	19.	24.
W1	48.	48.
W2	48.	48.
B1	8.5	10.5
B2	11.	14.
B3	9.5	10.
B4	14.	14.5

Dimension Compatibility Requirements

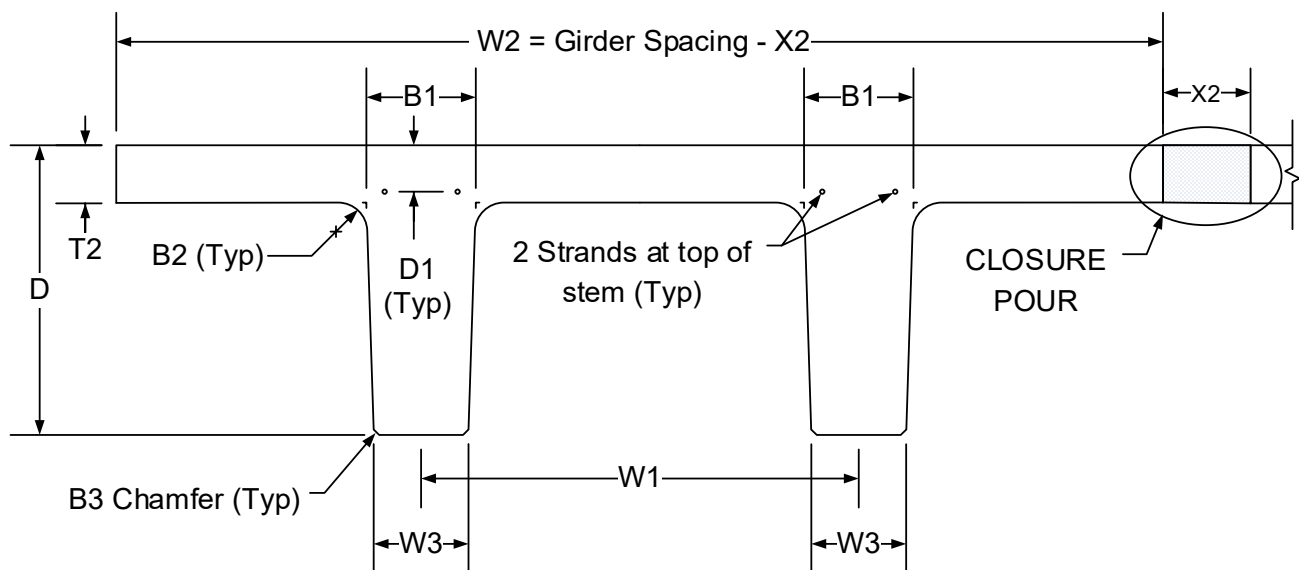
$2 \cdot B2 \geq B1$
 $B2 + B1/2 \leq D$
 $B1 \leq D$
 $2 \cdot B3 + 2 \cdot B4 = W1$
 $3 \cdot B1 \leq W1$
 $B4 \geq B1$
 $2 \cdot B3 \geq B1$

Lower and upper limits apply for beams
with user specified dimensions.
(CTL parameter "Beam Designation" = U)

Note: Dimensions based on Federal Standards, Concrete Superstructures, June 1962, Sheet 3 of 4.

Figure 5.21-13 Spread Box Beam - Three Circular Openings

Chapter 5 Input Description



Type D NEXT Beam

PARAMETER	LOWER LIMIT (in)	UPPER LIMIT (in)
D	28.	40.
W1	60.	60.
W2	n/a	n/a
W3	13.	13.75
T1	n/a	n/a
T2	8.	8.
B1	15.	15.
B2	4.	4.
B3	0.	1.
B4	n/a	n/a
D1	1.5	7.5
D2	n/a	n/a
X1	n/a	n/a
X2	6.	9.5

Dimension Compatibility Requirements

$$B1 \geq W3$$

$$T2 + B2 + B3 \leq D$$

$$2*B3 \leq W3$$

$$2*B2 + B1 \leq W1$$

$$W1 + B1 + 2*B2 \leq W2$$

Lower and upper limits apply for beams with user specified dimensions.

(CTL parameter "Beam Designation" = U)

Figure 5.21-14 Type D NEXT Beam

5.22 SCD - STRAND CONFIGURATION FOR DESIGN COMMAND

KEYWORD	COMMAND DESCRIPTION
SCD	STRAND CONFIGURATION FOR DESIGN - This command is used to specify the configuration of prestressing strands. Enter one of these commands for each span. For a symmetrical structure, enter the strand configuration for design for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the strand configurations for design for spans 1, 2, and 3. Parameter 9 is repeatable. Required for design; not used for analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the strand configuration. Enter zero to indicate that all spans will use the same strand configuration.	--	0 (E)	NSP ¹ (E)	--
2. P/S Strand Diameter	Enter the diameter of a single prestressing strand. Note: For Type F NEXT beams the strand diameter must be 1/2" special strands (dia. = 0.52") per NEXT Beam Standard Drawing No. 09-602-BQAD. For Adjacent Plank Beams the strand diameter must be 1/2" special strands per DM-4 Section 5.4.4.1.	in	0.375 (E)	0.60 (W)	0.52
3. P/S Strand Area	Enter the area of a single prestressing strand.	in ²	0.085 (E)	0.217 (W)	0.167
4. Row to Start Debonding	For debonded strand problems only, enter the row number to start debonding. Leave blank for non-debonded strand problems.	--	1 (E)	48 (E)	1
5. Distance to First Row	Enter the distance from the bottom of the beam to the first row of strands. See note 3.	in	2. (E)	3.25 (D)	*5
6. Vertical Spacing of Rows	Enter the vertical distance between the prestressing strand rows. See note 4 for Type F NEXT beams.	in	2. (E)	4. (D)	2.
7. Minimum Distance to Top	Enter the minimum distance from the top of the beam that a draped strand can be placed. This value is used to determine how high the draped strand pattern can be placed at the end of the beam. Standard Drawings BD-661M and BD-662M should be reviewed to determine the depth of any beam notch. This parameter should be at least equal to the beam notch depth plus 2 inches. This value does not affect the strand pattern at midspan. Leave blank for non-draped strand pattern.	in	2. (E)	20. (D)	2.

Chapter 5 Input Description

5.22 SCD - STRAND CONFIGURATION FOR DESIGN COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
8. Number of Strand Rows at Midspan	Enter the total number of prestressing strand rows at midspan. This parameter is used to override the available strand pattern defined in the beam tables. (Leave blank to use pattern defined in beam tables.) See note 2.	--	0 (E)	48 (E)	0
9. Number of positions in Row i at Midspan	Enter the number of possible strands positions in row i at midspan. For Type F NEXT beams enter the total for both stems. See note 2. To eliminate the last row of strands in Type F NEXT beams, see note 6. Note: If values are entered for this parameter, then input must also be entered for Parameter 8, Number of Strand Rows At Midspan.	--	0 (E)	30 (D)	0

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² Parameters 8 and 9 are required input when "D" is entered for the "Design/Analysis" parameter of the CTL command, "U" is entered for the "Beam Designation" parameter of the CTL command and the BDM command is used. Parameters 8 and 9 are not required when the beam designation is entered in the BDM command.
- ³ When a beam is dapped Parameter 5 should be entered larger than the default values. For box beams (spread and adjacent), the difference between the entered value and the default value is added to the thickness of the bottom slab to ensure that the minimum concrete cover is provided on the prestressing strands adjacent to the inner void. For I-Beams (PENNDOT, AASHTO, or Bulb-Tee), the entered value determines the allowable number of strands per row by selecting from the available strand patterns defined in the tables of Section 3.22.
- ⁴ For Type F NEXT beams the last strand row is located a "D1" distance (defined on BDM Command) below the top of the beam (2.5" on Standard Drawing No. 09-602-BQAD, SOL 431-10-05).
- ⁵ For Type F NEXT beams the distance to the first strand row defaults to 2.5". For all other beam shapes the distance defaults to 2.0".
- ⁶ For Type F NEXT beams the last row of strands is located a "D1" distance (defined on BDM Command) below the top of the beam. To eliminate consideration of the last row of strands, the number of available strands in the last row must be set to zero and a specific beam designation must be entered in parameter 2 of the BDM command.

Chapter 5 Input Description

5.23 SCA - STRAND CONFIGURATION FOR ANALYSIS COMMAND

KEYWORD	COMMAND DESCRIPTION
SCA	STRAND CONFIGURATION FOR ANALYSIS - This command is used to specify some of the section properties of the girder related to the configuration of prestressing strands. If the actual strand pattern at midspan is not known or is not to be entered, the user must enter parameters 7 and 8 and leave parameters 9 and 10 blank. If the actual strand pattern is entered, then the user must leave parameters 7 and 8 blank and enter parameters 9 and 10. Parameter 10 is repeatable. For a debonded strand problem and for a straight strand problem with crack control debonding or a draped strand problem with crack control debonding or normal debonding, parameters 9 and 10 must be entered, thus parameters 7 and 8 must be left blank. For a symmetrical structure, enter the strand configuration for analysis for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the span configuration for analysis for spans 1, 2, and 3. This command is repeatable. Required for analysis; not used for design.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the strand configuration. Enter zero to indicate that all spans will use the same strand configuration.	--	0 (E)	NSP ¹ (E)	--
2. P/S Strand Diameter	Enter the diameter of a single prestressing strand.	in	0.375 (E)	0.60 (W)	0.52
3. P/S Strand Area	Enter the area of a single prestressing strand.	in ²	0.085 (E)	0.217 (W)	0.167
4. C.L. CGS of Draped Strands	Enter the distance to the center of gravity of the strands measured from the bottom of the girder at the centerline of bearing. The value entered for this parameter is assumed to be the same at each end of the beam. Leave blank for a non-draped strand problem. Note: Leave blank for adjacent beams or if the SCE command is used to specify the CGS of the draped strands. The value should not include the effects due to crack control debonding or partial strand development.	in	1. (W)	100. (W)	--
5. Distance to First Row	Enter the distance from the bottom of the beam to the first row of strands. See note 2.	in	1. (W)	3.25 (W)	*4
6. Vertical Spacing of Rows	Enter the vertical distance between the prestressing strand rows. See note 3 for NEXT beams.	in	2. (E)	4. (W)	2.

Chapter 5 Input Description

5.23 SCA - STRAND CONFIGURATION FOR ANALYSIS COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
7. Total Number of Strands	Enter the total number of strands. For NEXT beams enter the total for both stems. Leave blank for a debonded strand problem and for a straight strand problem with crack control debonding or a draped strand problem with crack control debonding or normal debonding.	--	1 (E)	150 (W)	--
8. CGS at Midspan	Enter the distance from the center of gravity of all prestressing strands (CGS) to the bottom of the girder at midspan. Leave blank for a debonded strand problem and for a straight strand problem with crack control debonding or a draped strand problem with crack control debonding or normal debonding.	in	2. (E)	100. (W)	--
9. Number of Strand Rows at Midspan	Enter the total number of prestressing strand rows at midspan. This parameter is used by the program to compute the CGS from a known strand pattern. Enter this parameter and parameter 10 only if parameters 7 and 8 have not been entered. This parameter must be entered for a debonded strand problem and for a straight strand problem with crack control debonding or a draped strand problem with crack control debonding or normal debonding.	--	0 (E)	48 (E)	0
10. Number of Strands in Row i at Midspan	Enter the number of strands in row i at midspan. For NEXT beams enter the total for both stems. This parameter must be entered for a debonded strand problem and for a straight strand problem with crack control debonding or a draped strand problem with crack control debonding or normal debonding. To eliminate the last row of strands in NEXT beams, see note 5.	--	0 (E)	30 (D)	0

Chapter 5 Input Description

5.23 SCA - STRAND CONFIGURATION FOR ANALYSIS COMMAND (Cont.)

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command.
- ² When a beam is dapped Parameter 5 should be entered larger than the default. For box beams (spread and adjacent), the difference between the entered value and the default value is added to the thickness of the bottom slab to ensure that the minimum concrete cover is provided on the prestressing strands adjacent to the inner void. For I-Beams (PENNDOT, AASHTO, or Bulb-Tee), the entered value determines the allowable number of strands per row by selecting from the available strand patterns defined in the tables of Section 3.22.
- ³ For NEXT beams the last strand row is located a "D1" distance (defined on BDM Command) below the top of the beam (2.5" for Type F NEXT beams on Standard Drawing No. 09-602-BQAD, SOL 431-10-05, 6.5" for Type D NEXT beams per PCINE Northeast Extreme Tee (NEXT) Beam Guidelines, updated Dec 2017, sheet 5, NEXT D Beam detail).
- ⁴ For NEXT beams the distance to the first strand row defaults to 2.5". For all other beam shapes the distance defaults to 2.0".
- ⁵ For NEXT beams the last row of strands is located a "D1" distance (defined on BDM Command) below the top of the beam. To eliminate consideration of the last strand row below the top of the beam, then an additional strand row must be added to the strand configuration with zero strands in that last row.

Chapter 5 Input Description

5.24 SCE - STRAND CONFIGURATION AT BEAM END COMMAND (DRAPED STRANDS)

KEYWORD	COMMAND DESCRIPTION
SCE	STRAND CONFIGURATION AT BEAM END (DRAPED STRANDS) - This command is used to specify the configuration of draped prestressing strands at the beam end for draped strand analysis problems. Parameter 4 is repeatable. For a symmetrical structure, enter the strand configuration at beam end for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the span configuration at beam end for spans 1, 2, and 3. This command is repeatable. Only enter this command for analysis problems with draped strands. This command is required for the program to check for possible interference between draped strands and tendon pockets of adjacent box beams. This command is optional for other prestress beams with draped strands.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the strand configuration. Enter zero to indicate that all spans will use the same strand configuration.	--	0 (E)	NSP ¹ (E)	--
2. Distance to Top Row	Enter the distance from the top of the beam to the top draped strand row at the beam end.	in	2. (E)	20. (W)	2.
3. Number of Rows with Draped Strands	Enter the total number of rows with draped prestressing strands. This will be equal to the Number of Strand Rows at Midspan minus the lowest numbered strand row with draped strands plus one. Any in-between rows with zero strands or in-between rows with only straight strands should be included in this number.	--	1 (E)	20 (E)	--
4. Number of Draped Strands in Row i	Enter the number of draped strands in each row starting with the top row; working down to the lowest numbered strand row with draped strands. The top row number is defined as the Number of Strand Rows at Midspan, parameter 9 on SCA command. This parameter is repeatable. The number of values entered for this parameter should equal the value entered for parameter 3.	--	0 (E)	*2 (E)	--

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

² The upper limit is equal to the number of available strands in the web.

5.25 STI - STIRRUP COMMAND

KEYWORD	COMMAND DESCRIPTION
STI	STIRRUP - This command is used to specify the configuration of stirrups in the girder. The parameters of this command are repeatable, beginning with parameter 2. A maximum of 7 stirrup data sets (parameters 2 through 6) can be entered on each command. A maximum of 20 STI commands can be entered. For a shear design problem, only the shear reinforcement areas are required for each span. Enter multiple Stirrup Locations to specify varying stirrup area within a span. For a symmetrical structure, enter the stirrup information for spans up to and including the middle span up to the point of symmetry. That is, for a symmetrical 5 span structure, enter the stirrup information for spans 1, 2, and up to the point of symmetry for span 3. This command is repeatable. Parameter 23 of the CTL command controls whether the program performs a shear analysis or design. Required for shear design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the stirrup locations. Enter zero to indicate that all spans will use the same stirrup locations.	--	0 (E)	NSP ¹ (E)	--
2. Stirrup Location	Enter the distance of the starting point of the shear reinforcement with spacing specified by "Stirrup Spacing" as measured from the centerline of the left support when at an abutment or the centerline of the supporting pier . Expressed as a distance. Successive values entered for "Stirrup Location" must be greater than those entered previously. If no stirrup locations are entered for locations to the right of midspan, stirrups will be placed symmetrically in the right half of the span. For a shear design problem, enter zero or leave blank if using a single stirrup area; otherwise, enter the distance from the left support when at an abutment or the centerline of the supporting pier to the start of the changed stirrup area.	ft	0. (E)	MXSP ² (E)	0.
3. Vertical Shear Reinforcement Area	Enter the total cross-sectional area for all stirrup legs used to resist vertical shear. Enter this value for shear design and shear analysis.	in ²	0.2 (W)	0.8 (D)	*3
4. Stirrup Spacing	Enter the stirrup spacing corresponding to the stirrup location specified by "Stirrup Location." For a shear design problem, enter zero or leave blank.	in	3.0 (W)	24. (D)	--
5. Horizontal Shear Reinforcement Area	Enter the total cross-sectional area for all stirrup legs for checking horizontal shear at the beam-slab interface. Enter this value for shear design and shear analysis of composite beams, leave blank for non-composite beams.	in ²	0.2 (W)	0.8 (D)	*4

Chapter 5 Input Description

5.25 STI - STIRRUP COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
6. Horizontal Shear Stirrup Spacing	Enter the stirrup spacing for checking horizontal shear of a composite beam. For a shear design problem of a composite beam, enter zero or leave blank. Leave blank for a non-composite beam.	in	*5 (W)	24. (D)	--

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command for a non-symmetrical structure. For a symmetrical structure NSP is equal to the symmetrical span.
- ² **For shear analysis** MXSP is equal to the span length corresponding to the span number for a non-symmetrical structure. For a symmetrical structure, MXSP is equal to half of the span length when the span number is the symmetrical span and the number of spans is an odd number. **For shear design MXSP is equal to half of the span length.**
- ³ Defaults to 4-#4 (0.8 in²) for NEXT beams and to 2-#4 (0.4 in²) for all other beams.
- ⁴ For composite beams defaults to 4-#4 (0.8 in²) for Type F NEXT beams and adjacent plank beams; defaults to 2-#4 (0.4 in²) for all other beams. For non-composite beams defaults to zero.
- ⁵ **Lower limit is 6 for Beam Shapes AR (Adjacent box with rectangular void) and SR (Spread box with rectangular void). For all other Beam Shapes the lower limit is 3.**

Chapter 5 Input Description

5.26 DBS - DEBONDED STRANDS COMMAND

KEYWORD	COMMAND DESCRIPTION
DBS	DEBONDED STRANDS - This command is used to specify the configuration of debonded strands used in the girder for debonded strand problems and for crack control debonding in straight strand problems and crack control debonding or normal debonding in draped strand problems. This command is required for any span for which debonded strands were specified in the SSI command. The parameters of this command are repeatable, beginning with parameter 3. A maximum of 6 debonded strand data sets (parameters 3 and 4) can be entered on each command. All data sets on a single command will have the same debonded length. A maximum of 8 debonded lengths may be specified for each span. A maximum of 160 DBS commands can be entered for a twenty-span bridge with the maximum number of debonded lengths in each span. For a symmetrical structure, enter the debonded strands information for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the debonded strands information for spans 1, 2, and 3. This command is repeatable. Required only for each span of an analysis problem in which debonded strands have been specified; not used for design.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the debonded strands. Enter zero to indicate that all spans will use the same debonded strands.	--	0 (E)	NSP ¹ (E)	--
2. Debonded Length	Enter the distance of debonding location for prestressing strands from the centerline of bearing. This is the location relative to the center line of the simple span bearing where the debonding begins. The strand is debonded from this location to the end of the beam.	ft m	-BMPRJ ⁴ (E)	$\frac{1}{2}$ MXSP ² (D)	--
3. Strand Row Number	Enter the row number of prestressing strands being debonded for the cutoff point specified in parameter 2. This value cannot exceed the total number of strand rows entered for parameter 9 of the SCA command.	--	1 (E)	48 (E)	--
4. Strands Debonded	Enter the number of strands debonded in the row specified by parameter 3. This value cannot exceed the value entered in parameter 10 of the SCA command for the given strand row. (Repeat "Strand Row Number" and "Strands Debonded" as many times as there are debonded strand rows.) Note: The total number of debonded strands for a row is limited to the number of straight strands in the row.	--	0 (E)	NSTR ³ (E)	--

Chapter 5 Input Description

5.26 DBS – DEBONDED STRANDS COMMAND (Cont.)

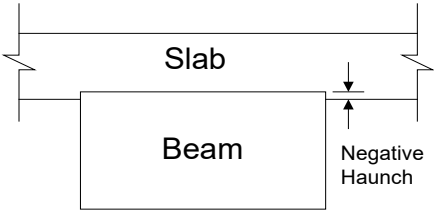
Notes:

- ¹ NSP is equal to the number of spans entered in the CTL command.
- ² MXSP is equal to the span length corresponding to the span number.
- ³ NSTR is equal to the number of strands defined for the row.
- ⁴ BMPRJ is equal to the beam projection entered in GEO command.

Chapter 5 Input Description

5.27 SLB - SLAB COMMAND

KEYWORD	COMMAND DESCRIPTION
SLB	SLAB - This command is used to specify the section properties of the deck slab constructed with the prestressed girder as a composite section. Only one SLB command can be used. Required for both design and analysis of composite beams only.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Actual Slab Thickness	Enter the average actual slab thickness. This is the slab thickness used in calculating the slab weight. If this value is not entered and the effective slab thickness was entered, the program will default this value to the effective slab thickness plus $\frac{1}{2}$". Note: The difference between the actual slab thickness and the effective slab thickness should be a minimum of $\frac{1}{2}$".	in	*6 (W)	12. (W)	*8
2. Effective Slab Thickness	Enter the average effective slab thickness. This is the slab thickness used in calculating the composite section properties. If this value is not entered and the actual slab thickness was entered, the program will default this value by subtracting $\frac{1}{2}$" from the actual slab thickness. Note: The effective slab thickness should be a multiple of $\frac{1}{2}$".	in	*7 (W)	12. (W)	*5
3. Haunch Depth for Dead Load	Enter the haunch depth to be used for dead load calculations. The haunch is measured from the top of the girder to the bottom of the deck slab. A negative haunch may be entered as shown below. 	in	-0.5 (W)	5. (W)	--
4. Slab Concrete Strength	Enter the 28-day compressive strength of the concrete slab. This value should be entered as 4 ksi, corresponding to Class AAAP concrete (BD-601M). The upper limit for this value is 15 ksi for normal weight concrete (concrete density for $E_c \geq 135$ pcf) or 10 ksi for lightweight concrete (concrete density for $E_c < 135$ pcf).	ksi	2.4 (E)	*9 (E)	4.

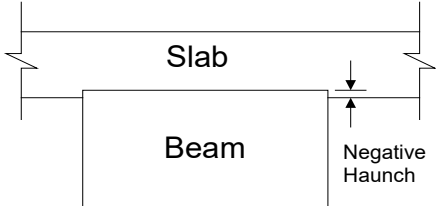
Chapter 5 Input Description

5.27 SLB - SLAB COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Concrete Density for Loads	Enter the unit weight of concrete for computing the dead loads due to the concrete slab and haunch. This value should be entered as 150 lb/ft ³ for normal weight concrete or as 115 lb/ft ³ for lightweight concrete. This value must be greater than or equal to the "Concrete Density for Ec" (parameter 6).	lb/ft ³	95. (E)	160. (E)	150.
6. Concrete Density for E _c	Enter the unit weight of concrete for computing the modulus of elasticity (E _c). The modulus of elasticity is used to compute the modular ratio for computing the section properties and the moment capacity when ductility controls. This value should be entered as 145 lb/ft ³ for normal weight concrete or as 110 lb/ft ³ for lightweight concrete.	lb/ft ³	90. (E)	155. (E)	145.
7. Slab Concrete Type	Enter the type of concrete used for the slab: N - Normal. L - Light weight. S - Sand-lightweight (same as Light weight). O - Other-lightweight (same as Light weight).	-	N, L, S, O (E)	--	N
8. Slab Reinforcement Strength	Enter the yield strength of the longitudinal reinforcement in the slab.	ksi	60. (D)	60. (D)	60.
9. Slab Reinforcement CGS	Enter the distance from the center of gravity of the deck reinforcement to the top of the effective slab.	in	2. (W)	8. (W)	--
10. Slab Reinforcement Area	Enter the sum of the longitudinal temperature (top) slab reinforcement area and the distribution (bottom) slab reinforcement area per foot in the positive moment region of the deck. Refer to BD-601, S4 and S3 bars. For non-composite beams, leave this parameter blank. NOTE: Negative moment connection reinforcement should be entered using the SST command. However, if the area of reinforcement entered here is greater than the area entered using the SST command for a particular analysis point in the negative region, this area will be used for determining the negative moment resistance.	in ² /ft	0.11 (W)	1.0 (E)	*1
11. Slab Transverse Reinforcement Bar Size	Enter the bar number of the top transverse reinforcement in the slab. Leave blank for single span bridges.	--	3 (E)	8 (E)	*2

Chapter 5 Input Description

5.27 SLB - SLAB COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
12. Haunch Depth for Section Properties	Enter the haunch depth to be used for section properties. The haunch is measured from the top of the girder to the bottom of the deck slab. A negative haunch may be entered as shown below. 	in	-0.5 (W)	5. (W)	*3
13. Slab Reinforcement Ultimate Tensile Strength	Enter the ultimate tensile strength of the longitudinal reinforcement in the slab.	ksi	90. (D)	90. (D)	*4
14. Slab Transverse Reinforcement Location	Enter the location of the top transverse reinforcement relative to the top longitudinal reinforcement: A - Above longitudinal bar. B - Below longitudinal bar.	-	A, B, (E)	--	B

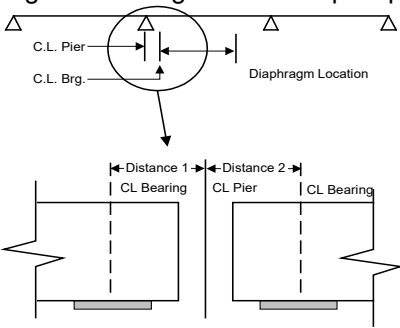
Notes:

- ¹ Defaults to #4@12" for composite adjacent box beams and to #4@12" + #4@9" for composite spread box beams, I-beams, bulb-tee, and Type F NEXT beams for positive moment region rebars. For spread box beams, I-beams, and bulb-tee beams the area of the #4@9" is reduced to account for bottom longitudinal bars not being placed over portions of the beam top flange per BD-601M.
- ² All beams default to #5 except for the following:
 Spread Boxes:
 36" wide: beam spacing – 2'-7" > 6'-10" use #6
 48" wide: beam spacing – 3'-7" > 6'-10" use #6
 I-beams or Bulb-Tees:
 top flange width < 18": beam spacing > 9'-6" use #6
 top flange width ≥ 18", but < 36": beam spacing > 8'-10" use #6
 top flange width ≥ 36": beam spacing > 9'-2" use #6
 Used when computing negative moment longitudinal slab reinforcement at interior supports.
- ³ The haunch depth for Section Properties will default to the value entered for the Haunch Depth for Dead Load for an analysis run. For a design run the default value is zero.
- ⁴ Defaults to 90 ksi when Slab Reinforcement Strength is 60 ksi; otherwise no default value.
- ⁵ Defaults to ½ inch less than Actual Slab Thickness.
- ⁶ Lower limit is 8 inches for spread beams (I-beam, Bulb-tee, boxes) and Type F NEXT beams. For adjacent beams (box and plank) the lower limit is 5½ inches.
- ⁷ Lower limit is 7½ inches for spread beams (I-beam, Bulb-tee, boxes) and Type F NEXT beams. For adjacent beams (box and plank) the lower limit is 5 inches.
- ⁸ Defaults to ½ inch more than the Effective Slab Thickness.
- ⁹ Upper limit 15 ksi for normal weight concrete, 10 ksi for lightweight concrete.

Chapter 5 Input Description

5.28 DIA - DIAPHRAGM DETAILS COMMAND

KEYWORD	COMMAND DESCRIPTION
DIA	DIAPHRAGM DETAILS - This command is used to specify the information related to interior (internal) and/or exterior (external) diaphragms used in the girder. This command is repeatable. The parameters of this command are repeatable, beginning with parameter 2. A maximum of 10 diaphragm data sets (parameters 2 through 5) can be entered on each command. A maximum of 20 diaphragms can be entered for each span of the bridge. A maximum of 40 DIA commands can be entered. For a symmetrical structure, enter the diaphragm details for spans up to and including the middle span up to the point of symmetry. That is, for a symmetrical 5 span structure, enter the diaphragm details for spans 1, 2, and up to the point of symmetry for span 3. Note: If this command is entered, do not use the CLD or DLD commands to enter diaphragm loads. The program will compute the diaphragm load based on the information provided here. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number where the diaphragm is located. Enter zero to indicate that all spans will use the same diaphragm locations.	--	0 (E)	NSP ¹ (E)	--
2. Location	Enter the distance from the centerline of bearing at the left end of the span to the point where the diaphragm is located. This is expressed as a percentage of the length of the simple span. 	--	0. (E)	100. ² (E)	--
3. Exterior/ Interior	Enter whether the diaphragm being considered is exterior or interior: E - Exterior (External) diaphragm. I - Interior (Internal) diaphragm. Note: Interior diaphragms are valid for box beams and NEXT beams. Exterior diaphragms are not valid for adjacent beams.	--	E, I (E)	--	--
4. Weight	Enter the weight of the diaphragm to be applied to the girder.	kip	1. (W)	10. (W)	*3

Chapter 5 Input Description

5.28 DIA – DIAPHRAGM DETAILS COMMAND (Cont.)

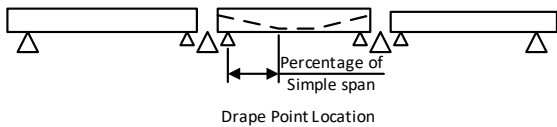
PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Thickness	Enter the thickness of the diaphragm being considered. Leave blank if parameter 4 is entered.	in	6. (W)	24. (W)	10.

Notes:

- ¹ NSP is equal to the number of spans entered in the CTL command for a non-symmetrical structure. For a symmetrical structure NSP is equal to the symmetrical span.
- ² Upper limit is 50 for symmetrical span of symmetrical structure with odd number of spans.
- ³ The default diaphragm weight will be determined by the diaphragm thickness and beam dimensions. See Section 6.28 of this manual for further details.

5.29 DPL - DRAPE POINT LOCATION COMMAND

KEYWORD	COMMAND DESCRIPTION
DPL	DRAPE POINT LOCATION - This command is used to specify the drape point locations in the longitudinal profile of the girder. Use this command if draped strands have been specified in the SSI command. This command is repeatable. For a symmetrical structure, enter the drape point location for spans up to and including the middle span. That is, for a symmetrical 5 span structure, enter the drape point location for spans 1, 2, and 3. The parameters of this command are repeatable, beginning with parameter 1. A maximum of 20 drape point data sets (parameters 1 and 2) can be entered on each command. A maximum of 20 DPL commands can be entered. Use any combination of DPL commands and repeatable parameters to define the drape point for all spans with draped strands. Required for draped design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of draped strands, assuming the left-most span to be Span Number 1. Enter zero to indicate that all spans will use the same drape point locations.	--	0 (E)	NSP ¹ (E)	--
2. Drape Point Location	Enter the distance from the left-most drape point to the left simple bearing of the span, expressed as a percentage of the simple span length. 	--	20. (E)	45. (E)	33.

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

5.30 TND - TENDON LOCATION COMMAND

KEYWORD	COMMAND DESCRIPTION
TND	TENDON LOCATION - This command is used for adjacent box beams or adjacent plank beams to specify the location of transverse tendons along the longitudinal profile of the beams. The first and last tendon locations are used when computing the End Block Length for adjacent boxes. If only the first tendon location is entered a second tendon location is assumed symmetrical with respect to the right simple bearing. Use this command if draped strands have been specified in the SSI command for adjacent box beams or adjacent plank beams or if debonded strands have been specified in the SSI command for adjacent box beams. This command is repeatable. A maximum of 20 TND commands can be entered. For a symmetrical structure, enter the tendon locations for spans up to and including the middle span up to the point of symmetry. That is, for a symmetrical 5 span structure, enter the tendon locations for spans 1 and 2, and up to the point of symmetry for span 3. This command should only be used for adjacent box beams or adjacent plank beams.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number, assuming the left-most span to be Span Number 1. Enter zero to indicate that all spans will use the same tendon locations.	--	0 (E)	NSP ¹ (E)	--
2. Tendon Height	Enter the height of the tendon measured from the bottom of the beam to the centerline of the tendon.	in	*2 (W)	*2 (W)	*4
3. Tendon Longitudinal Location 1	Enter the distance measured along the beam from the left simple bearing of this span to the location of the first tendon.	ft	0 (E)	MXSSP ³ (E)	--
4. Tendon Longitudinal Location 2	Enter the distance measured along the beam from the left simple bearing of this span to the location of the second tendon.	ft	*5 (E)	MXSSP ³ (E)	--
5. Tendon Longitudinal Location 3	Enter the distance measured along the beam from the left simple bearing of this span to the location of the third tendon.	ft	*5 (E)	MXSSP ³ (E)	--
6. Tendon Longitudinal Location 4	Enter the distance measured along the beam from the left simple bearing of this span to the location of the fourth tendon.	ft	*5 (E)	MXSSP ³ (E)	--
7. Tendon Longitudinal Location 5	Enter the distance measured along the beam from the left simple bearing of this span to the location of the fifth tendon.	ft	*5 (E)	MXSSP ³ (E)	--

Chapter 5 Input Description

5.30 TND – TENDON LOCATION COMMAND (Cont.)

Notes:

- ¹ NSP is equal to the number of spans entered on the CTL command for a non-symmetrical structure. For a symmetrical structure NSP is equal to the symmetrical span.
- ² Lower limit is half of beam depth minus 1.5 inches. Upper limit is half of beam depth plus 1.5 inches.
- ³ MXSSP is equal to the simple span length corresponding to the span number for a non-symmetrical structure. For a symmetrical structure, MXSSP is equal to half of the simple span length when the span number is the symmetrical span and the number of spans is an odd number. The simple span length is the distance from the left simple bearing to the right simple bearing of the span.
- ⁴ Defaults to the mid-point between strands that is closest to the mid-height of the beam for PennDOT standard beams (Beam Designation on CTL command is entered as "P"). Defaults to the mid-height for user defined beams (Beam Designation on CTL command is entered as "U").
- ⁵ **Lower limit is 1.0 feet more than the previous Tendon Longitudinal Location.**

Chapter 5 Input Description

5.31 PLD - PEDESTRIAN LIVE LOAD COMMAND

KEYWORD	COMMAND DESCRIPTION
PLD	PEDESTRIAN LIVE LOAD - This command is used to specify the pedestrian live load and associated dead loads. This command is required if pedestrian loading is to be included in the run. This command should not be used if pedestrian loading is not to be included in the run. Only one PLD command can be used. Required only if pedestrian live load is to be considered for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Total Pedestrian Live Load	Enter the total pedestrian live load acting on all girders in the structure cross section.	kip/ft	0. (W)	20. (W)	--
2. Pedestrian Live Load	Enter the pedestrian live load acting on the girder being investigated only. The user must compute and enter the portion of the total pedestrian live load that acts on the girder.	kip/ft	0. (W)	20. (W)	--
3. Sidewalk Dead Load	Enter the sidewalk dead load acting on the girder being investigated only. The user must compute and enter the portion of the total sidewalk dead load that acts on the girder. The sidewalk dead load is defined as all DC2 dead load that is present when the sidewalks are present and is not present when the sidewalks are not present.	kip/ft	-20. (W)	20. (W)	--
4. Additional Future Wearing Surface Dead Load	Enter the additional future wearing surface dead load acting on the girder being investigated only. The user must compute and enter the portion of the total additional future wearing surface dead load that acts on the girder. The additional future wearing surface dead load is defined as all future wearing surface dead load that is present when the sidewalks are present and is not present when the sidewalks are not present. If the future wearing surface dead load decreases when the sidewalks are present, a negative value should be entered.	kip/ft	-20. (W)	20. (W)	--
5. Additional DC1 Dead Load	Enter the non-composite additional dead load acting on the girder being investigated. The non-composite additional dead load is the difference between the "with sidewalk" typical cross-section and the "without sidewalk" typical cross-section. This difference would account for the extra 2-inch deck slab thickness at the deck edge for raised sidewalk or alternate sidewalk details.	kip/ft	-2. (W)	2. (W)	0.0

5.32 LDF - LOAD FACTOR COMMAND

KEYWORD	COMMAND DESCRIPTION
LDF	LOAD FACTOR - This command is used to set the combinations of load factors. Repeat the load factor command line to enter additional load factor types and combinations. A maximum of 10 different load factor types can be entered. Load factors for other live loads, DC dead loads, and DW dead loads are stored in the program and cannot be changed by the user. Required if MC1 or MC2 dead loads are entered. Used to change default load factors for special live load vehicles. Used for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Load Factor Type	Enter one of the following load factor types: MC1 - Miscellaneous non-composite dead load. MC2 - Miscellaneous composite dead load. SLL - Applies to all Special live loads. 1 - Applies to Special live load 1. 2 - Applies to Special live load 2. 3 - Applies to Special live load 3. 4 - Applies to Special live load 4. 5 - Applies to Special live load 5. 6 - Applies to Special live load 6. 7 - Applies to Special live load 7. 8 - Applies to Special live load 8. Note: Each Load Factor Type can be given only once. Additionally, the SLL load factor type cannot be given after any of types 1 through 8 has been given.	--	MC1, MC2, SLL, 1, 2, 3, 4, 5, 6, 7, 8 (E)	--	--
2. Load Factor Strength I	Enter the load factor for Strength I. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
3. Load Factor Strength IP	Enter the load factor for Strength IP. Leave blank if pedestrian loading is not included in the run. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
4. Load Factor Strength IA	Enter the load factor for Strength IA. This load factor is only used with MC1 and MC2 load factor types.	--	0. (E)	2. (E)	--
5. Load Factor Strength II	Enter the load factor for Strength II. This load factor is used with MC1 and MC2 loads and all Special live loads.	--	0. (E)	2. (E)	--

Chapter 5 Input Description

5.32 LDF - LOAD FACTOR COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
6. Load Factor Service I	Enter the load factor for Service I. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
7. Load Factor Service IP	Enter the load factor for Service IP. Leave blank if pedestrian loading is not included in the run. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
8. Load Factor Service III	Enter the load factor for Service III. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
9. Load Factor Service IIIP	Enter the load factor for Service IIIP. Leave blank if pedestrian loading is not included in the run. This load factor is used with MC1 and MC2 loads and Special live loads where the Vehicle Type is "D".	--	0. (E)	2. (E)	--
10. Load Factor Service IIIA	Enter the load factor for Service IIIA. This load factor is used with MC1 and MC2 loads and all Special live loads.	--	0. (E)	2. (E)	--
11. Load Factor Service IIIB	Enter the load factor for Service IIIB. This load factor is used with MC1 and MC2 loads and all Special live loads.	--	0. (E)	2. (E)	--
12. Load Factor Fatigue I	Enter the load factor for Fatigue I. This load factor is only used with MC1 and MC2 load factor types.	--	0. (E)	2. (E)	--
13. Load Factor Deflection	Enter the load factor for Deflection. This load factor is only used with MC1 and MC2 load factor types.	--	0. (E)	2. (E)	--
14. Minimum Load Factor Strength I	Enter the minimum load factor for Strength I to be applied to MC1 and MC2 loads only. This parameter does not apply to Special live loads and should be left blank.	--	0. (E)	2. (E)	0. ¹
15. Minimum Load Factor Strength IP	Enter the minimum load factor for Strength IP to be applied to MC1 and MC2 loads only. Leave blank if pedestrian loading is not included in the run. This parameter does not apply to Special live loads and should be left blank.	--	0. (E)	2. (E)	0. ¹

Chapter 5 Input Description

5.32 LDF - LOAD FACTOR COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
16. Minimum Load Factor Strength IA	Enter the minimum load factor for Strength IA to be applied to MC1 and MC2 loads only. This parameter does not apply to Special live loads and should be left blank.	--	0. (E)	2. (E)	0. ¹
17. Minimum Load Factor Strength II	Enter the minimum load factor for Strength II to be applied to MC1 and MC2 loads only. This parameter does not apply to Special live loads and should be left blank.	--	0. (E)	2. (E)	0. ¹

Notes:

¹ The default value is only used for MC1 and MC2 loads.

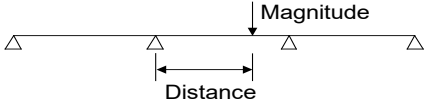
5.33 CLD - CONCENTRATED LOAD COMMAND

KEYWORD	COMMAND DESCRIPTION
CLD	CONCENTRATED LOAD - This command is used to specify concentrated loads in each span. For a symmetrical structure, enter the concentrated loads for spans up to and including the middle span up to the point of symmetry. That is, for a symmetrical 5 span structure, enter the concentrated loads for spans 1, 2, and up to the point of symmetry for span 3. The maximum number of concentrated loads that can be entered (for the entire structure and for all load types combined) is ten times the number of spans. For load types ID, ED, CW1, CW2, UT1, UT2, DC1, and DC2, the default load factors are used. The parameters of this command are repeatable, beginning with parameter 2. A maximum of 10 concentrated load data sets (parameters 2 through 4) can be entered on each command. A maximum of 40 CLD commands can be entered. For MC1 and MC2 type loads, an LDF command must be entered for each miscellaneous load type. Note: If the DIA command was used to defined interior or exterior diaphragms, do not enter diaphragm loads using this command. Note: The program automatically calculates the beam weight using the weight of the beam cross section between simple span bearings. However, the program does not automatically include any weight for diaphragms, for the beam extension beyond the simple span bearing, or for box beam end blocks. The user must input all other DC1 loads due to other components using the DIA, CLD and DLD commands. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Type of Load	Enter the type of load: ID - Interior diaphragm load applied to the non-composite section. ED - Exterior diaphragm load applied to the non-composite section. DC1 - Permanent load applied to the non-composite section, excluding the load due to the beam, slab, haunch, interior diaphragms, and exterior diaphragms. DC2 - Permanent load applied to the composite section. CW1 - Counterweight load applied to the noncomposite section. CW2 - Counterweight load applied to the composite section. UT1 - Utility loads applied to the noncomposite section. UT2 - Utility loads applied to the composite section. The following are applied with the LDF command: MC1 - Miscellaneous dead load applied to the non-composite section. MC2 - Miscellaneous dead load applied to the composite section.	--	ID, ED, DC1, DC2, CW1, CW2, UT1, UT2, MC1, MC2 (E)	--	--

Chapter 5 Input Description

5.33 CLD - CONCENTRATED LOAD COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
2. Span Number	Enter the span number in which the load is located.	--	1 (E)	NSP ¹ (E)	--
3. Distance	Enter the distance measured from the left end of the span to the concentrated load.	ft	0. (E)	MXSP ² (E)	--
4. Magnitude	Enter the magnitude of the concentrated load. 	kip	-20. (W)	20. (W)	--

Notes:

- ¹ NSP is equal to the number of spans entered in the CTL command for a non-symmetrical structure. For a symmetrical structure NSP is equal to the symmetrical span.
- ² MXSP is equal to the span length corresponding to the span number for a non-symmetrical structure. For a symmetrical structure, MXSP is equal to half of the span length when the span number is the symmetrical span and the number of spans is an odd number.

Chapter 5 Input Description

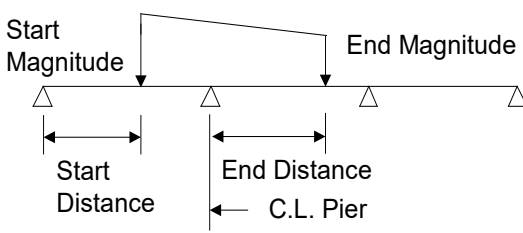
5.34 DLD - DISTRIBUTED LOAD COMMAND

KEYWORD	COMMAND DESCRIPTION
DLD	DISTRIBUTED LOAD - This command is used to specify a distributed load. A distributed load can be either uniform or linearly varying. A maximum of 30 distributed loads can be entered for the entire structure and for all load types combined. For load types ID, ED, CW1, CW2, DC1, FWS, UT1, UT2, and DC2, the default load factors are used. For a symmetrical structure, enter the distributed loads for spans up to and including the middle span up to the point of symmetry. That is, for a symmetrical 5 span structure, enter the distributed loads for spans 1, 2, and up to the point of symmetry for span 3. The parameters of this command are repeatable, beginning with parameter 2. A maximum of 7 distributed load data sets (parameters 2 through 7) can be entered on each command. A maximum of 40 DLD commands can be entered. For MC1 and MC2 type loads, an LDF command must be entered for each miscellaneous load type. Note: If the DIA command was used to defined interior or exterior diaphragms, do not enter diaphragm loads using this command. Note: The program automatically calculates the beam weight using the weight of the beam cross section between simple span bearings. However, the program does not automatically include any weight for diaphragms, for the beam extension beyond the simple span bearing, or for box beam end blocks. The user must input all other DC1 loads due to other components using the DIA, CLD and DLD commands. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Type of Load	Enter the type of load:				
ID	- Interior diaphragm load applied to the non-composite section.				
ED	- Exterior diaphragm load applied to the non-composite section.				
DC1	- Permanent load applied to the non-composite section, excluding the load due to the beam, slab, haunch, interior diaphragms, and exterior diaphragms.		ID, ED, DC1, FWS, DC2, CW1, CW2, UT1, UT2, MC1, MC2 (E)		
FWS	- Future wearing surface load applied to the composite section.	--		--	--
DC2	- Permanent load applied to the composite section. (Compute parapet loads according to DM-4 Article 3.5.1.1P.)				
CW1	- Counterweight load applied to the noncomposite section.				
CW2	- Counterweight load applied to the composite section.				

Chapter 5 Input Description

5.34 DLD - DISTRIBUTED LOAD COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Type of Load (Cont.)	UT1 - Utility loads applied to the noncomposite section. UT2 - Utility loads applied to the composite section. The following are applied with the LDF command: MC1 - Miscellaneous dead load applied to the non-composite section. MC2 - Miscellaneous dead load applied to the composite section.	--	ID, ED, DC1, FWS, DC2, CW1, CW2, UT1, UT2, MC1, MC2 (E)	--	--
2. Start Span Number	Enter the span number of the start location. Enter zero to indicate that all spans will have the same load and parameters 3,4 and 5 are ignored. Refer to Figure 5.34-1 for Distributed Load options.	--	0 (E)	NSP ¹ (E)	0
3. Start Distance	Enter the start location of the distributed load measured from the left end of the start span.	ft	0. (E)	MXSP ² (E)	0
4. End Span Number ⁵	Enter the span number of the end location.	--	1 (E)	NSP (E)	*3
5. End Distance ⁵	Enter the end location of the distributed load measured from the left end of the end span.	ft	0. (E)	MXSP (E)	MXSP ²
6. Start Magnitude	Enter the magnitude of the distributed load acting on the girder at the start distance.	kip/ft	-20. (W)	20. (W)	--
7. End Magnitude	Enter the magnitude of the distributed load acting on the girder at the end distance. 	kip/ft	-20. (W)	20. (W)	SMAG ⁴

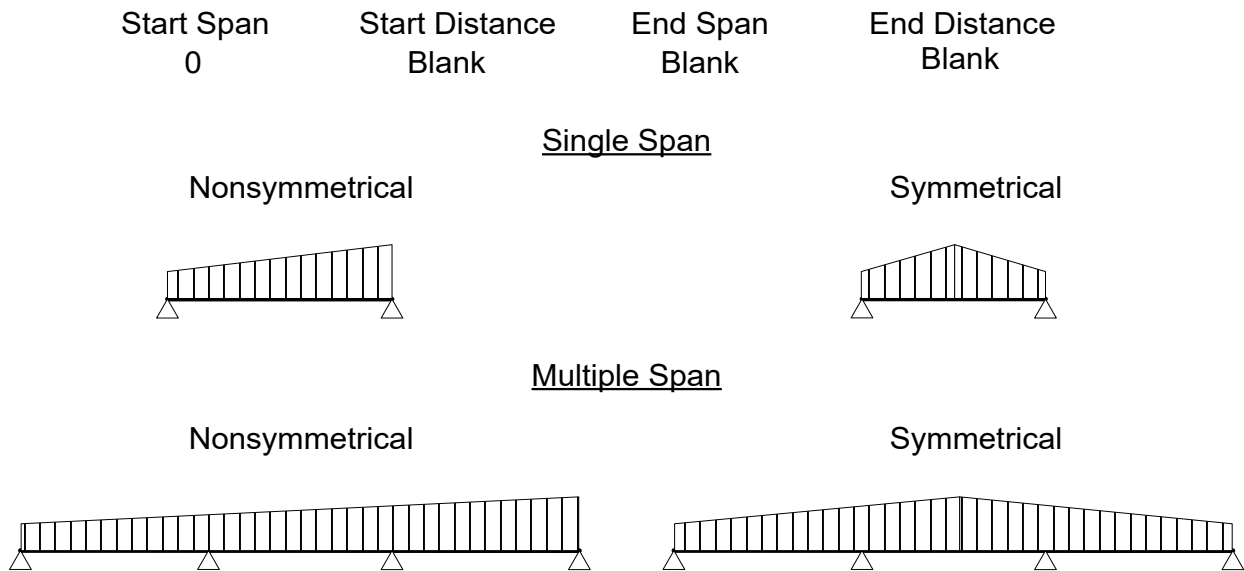
Chapter 5 Input Description

5.34 DLD - DISTRIBUTED LOAD COMMAND (Cont.)

Notes:

- ¹ NSP is equal to the number of spans entered in the CTL command for a non-symmetrical structure. For a symmetrical structure NSP is equal to the symmetrical span.
- ² MXSP is equal to the span length corresponding to the span number for a non-symmetrical structure. For a symmetrical structure, MXSP is equal to half of the span length when the span number is the symmetrical span and the number of spans is an odd number.
- ³ Defaults to NSP if Start Span Number is zero, otherwise defaults to Start Span Number.
- ⁴ SMAG is equal to start magnitude.
- ⁵ The End Span Number must be greater than or equal to the Start Span Number. The Start Location (Start Span and Start Distance) must be less than the End Location (End Span and End Distance).

Option 1 – Distributed Load along Entire Structure



Option 2 – Distributed Load along Specific Span

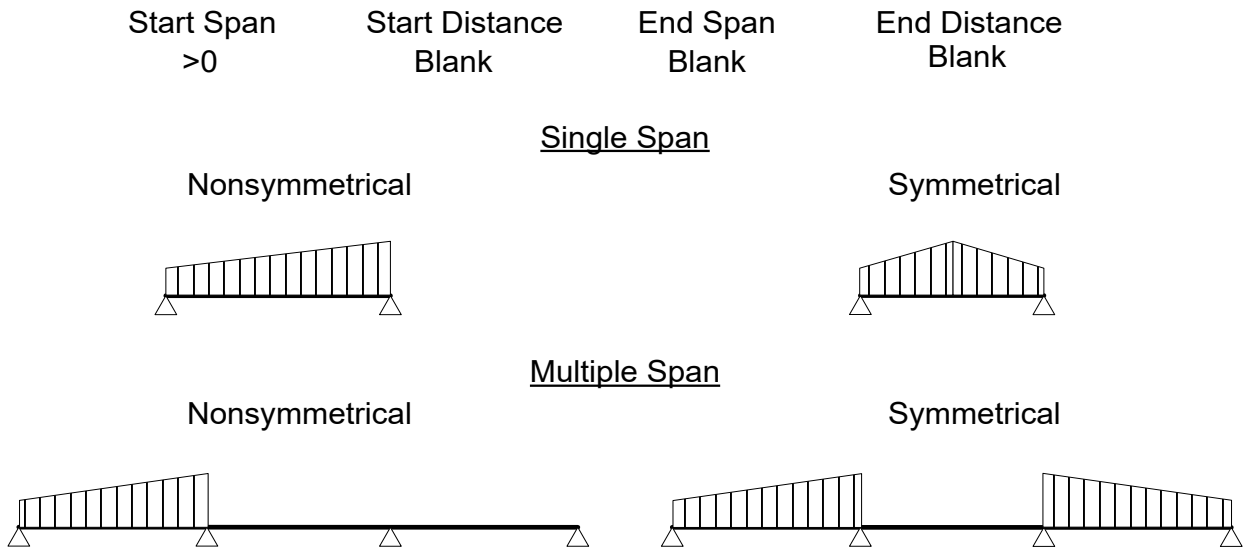
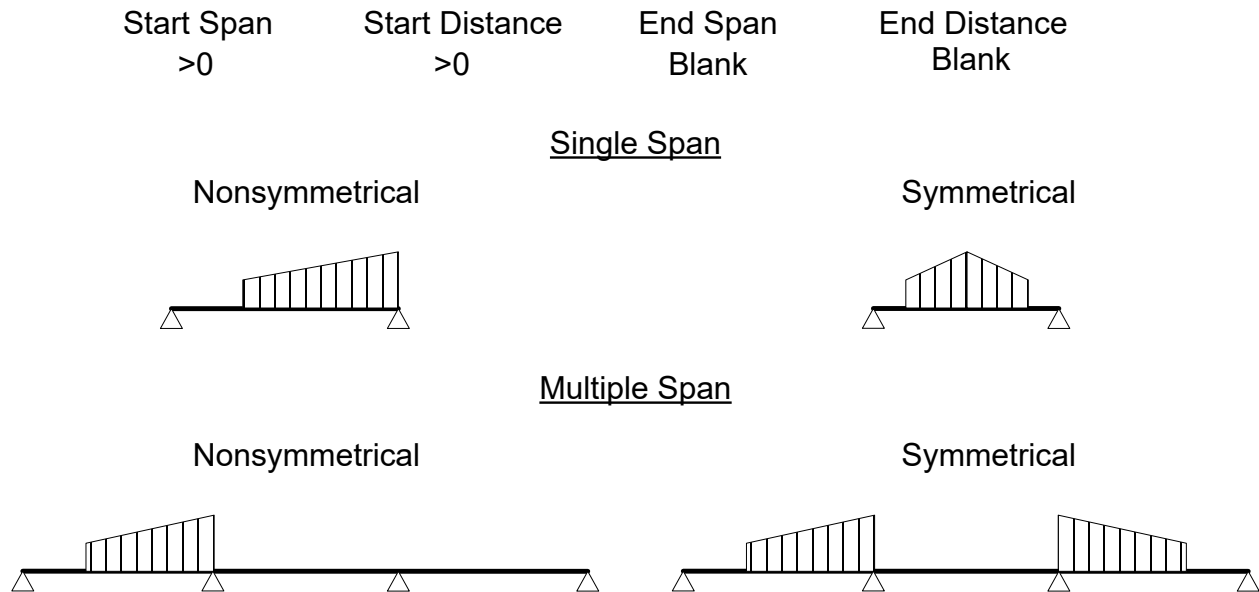


Figure 5.34-1 Distributed Load Command Options

Option 3 – Distributed Load along Specific Span with a Start Distance



Option 4 – Distributed Load along Specific Span with a Start Distance and End Distance

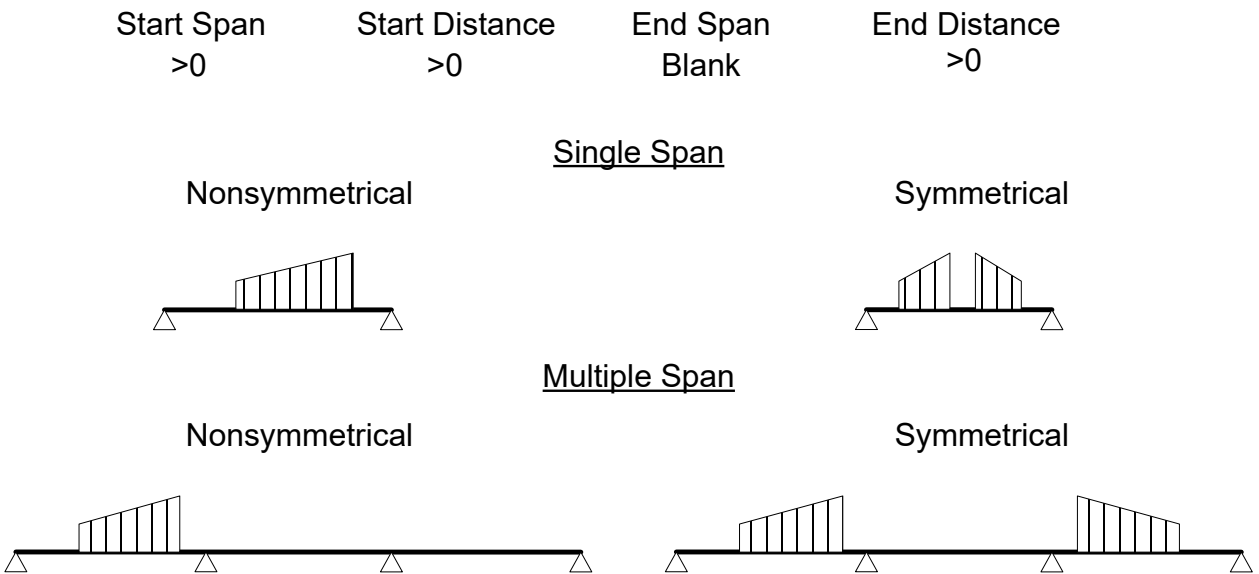


Figure 5.34-1 Distributed Load Command Options (cont.)

5.35 SLL - SPECIAL LIVE LOADING COMMAND

KEYWORD	COMMAND DESCRIPTION
SLL	SPECIAL LIVE LOADING - This command must be entered when an 'E' was entered as the live load option for analysis in the CTL command. Up to eight SLL commands can be used. The load factors as shown on Table 3.2-2 of this manual will be applied to all special live loads. If different load factors are desired, they can be specified using the Load Factor (LDF) command. Different load factors can be specified for each special live load. Required for analysis only if s special live loading is specified on the CTL command; not used for design.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Special LL Number	Enter the number of the special live load being defined. Up to eight special live loads can be defined. For each special live load number entered a corresponding set of SAL commands must be entered.	--	1 (E)	8 (E)	--
2. Axle Effect	Enter: Y - If the effects of all axle loads are to be included in calculating a given live load effect. N - If the axle loads that do not contribute to the effect are to be neglected.	--	Y, N (E)	--	N
3. Lane Load	Enter a uniform lane load to be applied in combination with the SAL command.	kip/ft	0. (E)	1.5 (W)	0.
4. Percent Increase	Enter the percentage to increase the live load for checking permit loads for overweight.	--	0. (E)	10. (W)	3.

Chapter 5 Input Description

5.345 SLL – SPECIAL LIVE LOADING COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Vehicle Type	Enter: D - If the Dynamic Load Allowance (Impact) is for Design vehicles. Ratings will be computed for limit states Strength I, Strength II, Service I, Service III, and Service IIIA. Also, Strength IP, Service IP, and Service IIIP when Pedestrian load is entered. P - If the Dynamic Load Allowance (Impact) is for Permit vehicles. Ratings will be computed for limit states Strength II and Service IIIA. The Dynamic Load Allowance for Design vehicles is specified on the CTL command as parameter "Dynamic Load Allowance". The Dynamic Load Allowance for Permit vehicles is specified on the CTL command as parameter "Permit Dynamic Load Allowance".	--	D, P (E)	--	D

5.36 SAL - SPECIAL AXLE LOAD COMMAND

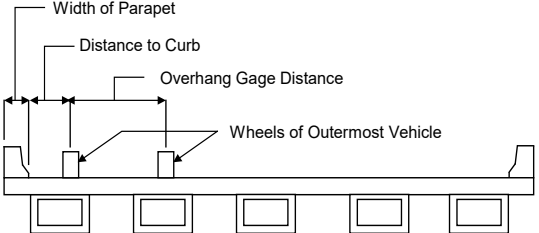
KEYWORD	COMMAND DESCRIPTION
SAL	SPECIAL AXLE LOAD - This command must be entered when an “E” was entered as the live load option for analysis in the CTL command. This command is repeatable. A maximum of 80 axle loads and 79 axle spacings can be entered for each Special Live Load Number. The parameters of this command are repeatable, beginning with parameter 2. A maximum of 12 axle data sets (parameters 2 and 3) can be entered on each command. A maximum of 8 SAL commands can be entered for each Special LL Number. Multiple SAL commands will be treated as cumulative for each Special Live Load Number; that is, if five axles are defined on the first SAL command for Special Live Load Number 1 and 10 axles are defined on the second SAL command for Special Live Load Number 1, there will be a total of 15 axles defined for Special Live Load Number 1. The load factors as shown on Table 3.2-2 of this manual will be applied to all special live loads. If different load factors are desired, they can be specified by using the Load Factor (LDF) command. Different load factors can be specified for each special live load.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Special LL Number	Enter the number of the special live load being defined. Up to eight special live loads can be defined. For each special live load number entered a corresponding SLL command must be entered.	--	1 (E)	8 (E)	--
2. Axle Load	Enter the magnitude of the axle load.	kip	0. (E)	150. (W)	--
3. Axle Spacing	Enter the spacing from the previously entered axle to the next axle. For example, the fourth spacing is the distance between axle 4 and axle 5. The axle spacing following the last axle load should be entered as 0.0.	ft	0. (E)	50. (W)	--

Chapter 5 Input Description

5.37 OVH - OVERHANG COMMAND

KEYWORD	COMMAND DESCRIPTION
OVH	OVERHANG - This command is used to define the criteria needed to compute the maximum overhang. This command is optional. If it is not entered, maximum overhang will not be computed. Only one OVH command can be entered. These values are only used in computing the maximum overhang. This command is to be used for interior, composite , spread girders only.

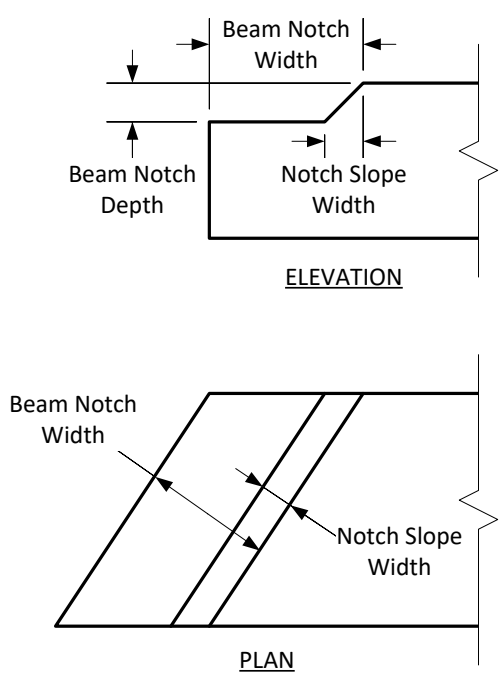
PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Future Wearing Surface	Enter the thickness of the future-wearing surface.	in	0. (E)	5. (W)	--
2. Wearing Surface Density	Enter the density of the future-wearing surface.	lb/ft ³	100. (W)	180. (W)	--
3. Weight of Rail	Enter the weight of the railing.	kip/ft	0. (E)	1. (W)	--
4. Weight of Parapet	Enter the weight of the parapet.	kip/ft	0. (E)	2. (W)	--
5. Width of Parapet	Enter the width of the parapet. 	in	0. (E)	24. (W)	--
6. Weight of Formwork	Enter the weight of the formwork.	psf	0. (E)	40. (W)	--
7. Distance to Curb	Enter the distance from the curb to the closest vehicle wheel.	ft	2. (E)	4. (W)	2.0
8. Overhang Gage Distance	Enter the gage distance to be used for the overhang calculation.	ft	6.0 (E)	10. (W)	*1

¹ When the CDF command is entered the Overhang Gage Distance defaults to the CDF Gage Distance; otherwise, there is no default.

Chapter 5 Input Description

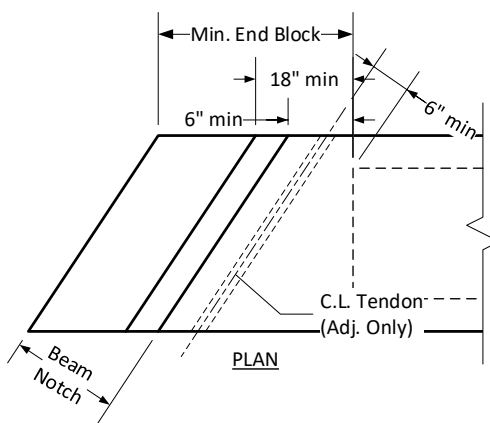
5.38 BDT – BEAM DETAILING COMMAND

KEYWORD	COMMAND DESCRIPTION
BDT	BEAM DETAILING - This command is used to define the variables needed to detail the stirrup reinforcement for each beam. These variables are also used for box beams to determine the End Block Length. The End Block Length is used to determine the location of the first debonding length in box beams. If it is not entered, detailed stirrup reinforcement will not be computed. A BDT command can be entered for each span of the structure. These values are used in computing the stirrup spacing near the ends of the beam. This command is to be used for PennDOT standard beams detailed in standards BD-661M or BD-662M. Required for design of box beams with debonded strands. Optional for all other designs and all analyses.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the beam. Enter zero to indicate that all spans will use the same values.	--	0 (E)	NSP ¹ (E)	0
2. Left or Right Beam End	Enter L to indicate input values are for the left beam end. Enter R to indicate input values are for the right beam end.	--	L, R (E)	--	--
3. Beam Notch Width	Enter the width of the beam notch. Either left or right depending on parameter 2.  <u>ELEVATION</u> <u>PLAN</u>	in	0. (E)	36. (W)	*2
4. Beam Notch Depth	Enter the depth of the beam notch. Either left or right depending on parameter 2.	in	0. (E)	15. (W)	*3

Chapter 5 Input Description

5.38 BDT - BEAM DETAILING COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
5. Notch Slope Width	Enter the width of the notch slope. Either left or right depending on parameter 2. Note: Zero for standard PA I-Beams, AASHTO I-Beams, and Bulb Tee Beams.	in	0. (E)	15. (W)	*4
6. Min. End Block Length	Enter the minimum length of the end block measured from the obtuse corner to the void. The actual end block length will be the maximum of: 1) this value 2) end block length with 6" between notch and void 3) end block length with 18" between toe of notch slope and void 4) for Adjacent Boxes only, the end block length with 6" between the C.L. Tendon and the void Either left or right depending on parameter 2. Note: This input applies only to box beams. Leave blank for other beam types. 	in	0. (E)	54. (W)	*5
7. Substructure Type	Enter the Substructure Type for this beam end as follows: I – Integral abutment N – Traditional abutment, <u>No</u> Backwall B – Traditional abutment, <u>With</u> Backwall P – Pier	--	I, N, B, P (E)	--	N

Notes:

¹ NSP is equal to the number of spans entered on the CTL command.

Chapter 5 Input Description

5.38 BDT - BEAM DETAILING COMMAND (Cont.)

- ² Beam Notch Width has the following defaults.

Adjacent Boxes

With Backwall – 15" plus the Beam Notch Depth (BC-775M, Sheet 2)

No Backwall – 15" plus the Beam Notch Depth (BC-775M, Sheet 2)

At Piers and Integral Abutments – 0" (BD-665M, Sheet 1, BD-667M, Sheet 8)

Spread Boxes

With Backwall – 15" plus the Beam Notch Depth (BC-775M, Sheet 1)

No Backwall – 12" plus the Beam Notch Depth (BC-775M, Sheet 1)

At Piers and Integral Abutments – 0" (BD-665M, Sheet 1, BD-667M, Sheet 8)

All other beam shapes – 0"

- ³ Beam Notch Depth has the following defaults.

No Backwall and With Backwall

Adjacent Boxes 4 ½" for 17" depths (BD-661M, Sheet 8)

6" for > 17" depths (BD-661M, Sheet 8)

Spread Boxes 3 ½" for all depths (BD-661M, Sheet 8)

All other beam shapes 0"

At Piers and Integral Abutments:

All beam shapes 0"

- ⁴ Notch Slope Width defaults to the Beam Notch Depth

- ⁵ The End Block Minimum Length has the following defaults:

Adjacent Box Beam with Beam Notch - 33.0" (BD-661M, Sheet 2)

Spread Box Beam with Beam Notch - 30.0" (BD-661M, Sheet 6)

Adjacent or Spread Box Beam w/o Beam Notch - 24.0" (BD-661M, Sheet 2 & 6)

Adjacent or Spread Box Beam with Integral Abutments - 51.0" (BD-667M, Sheet 8)

Chapter 5 Input Description

5.39 GSC – GIRDER STABILITY (PART 1) COMMAND

KEYWORD	COMMAND DESCRIPTION
GSC	GIRDER STABILITY (PART 1) – Hanging Girder This command is used to define the parameters needed to check the lateral stability of a girder lifted with devices attached to its web or embedded in its top near each end. A girder suspended from the top is commonly referred to as a hanging girder. This command is optional. If it is not entered, girder stability checks will not be computed. A GSC command can be entered for each span of the structure. This check is done only for I-Beam type cross sections. (PennDOT I-beams, AASHTO I-beams, PA Bulb Tee beams) Only one GSC command can be entered per span. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the beam. Enter zero to indicate that all spans will use the same values.	--	0 (E)	NSP ¹ (E)	0
2. Overhang Distance	Enter the distance from the beam end to the girder lifting loops. (See Figure 5.39-1)	ft	0. (E)	2*D ² (W)	--
3. Cable Angle	Enter the angle of the lifting cables from horizontal. A vertical cable has an angle of 90 degrees. (See Figure 5.39-1)	deg	30. (W)	90. (E)	--
4. Wind Pressure	Enter the lateral wind pressure at the time of lift. The wind pressure depends on the wind speed for construction, duration of exposure during construction, height of beam above surrounding ground, and the wind drag coefficient. Lifting operations are limited to low wind velocity conditions. Typical design wind speeds would be limited to 20 mph. For a 50 ft height of beam above ground and typical values for other items the corresponding wind pressure would be about 2.5 psf.	psf	0. (E)	5.0 (W)	--
5. Impact Factor	Enter the impact factor during lifting as a percentage. Positive for downward acceleration and negative for upward rebound acceleration. A typical impact factor is 20%.	%	-30. (W)	30 (W)	--
6. Lifting Loops Eccentricity	Enter the lifting loop eccentricity transverse to the centerline of the girder. (See Figure 5.39-2) The fabrication tolerance for the position of handling devices (lifting loops) transverse to the centerline of the girder is ± 1 ".	In	0. (E)	1.0 (W)	--

Chapter 5 Input Description

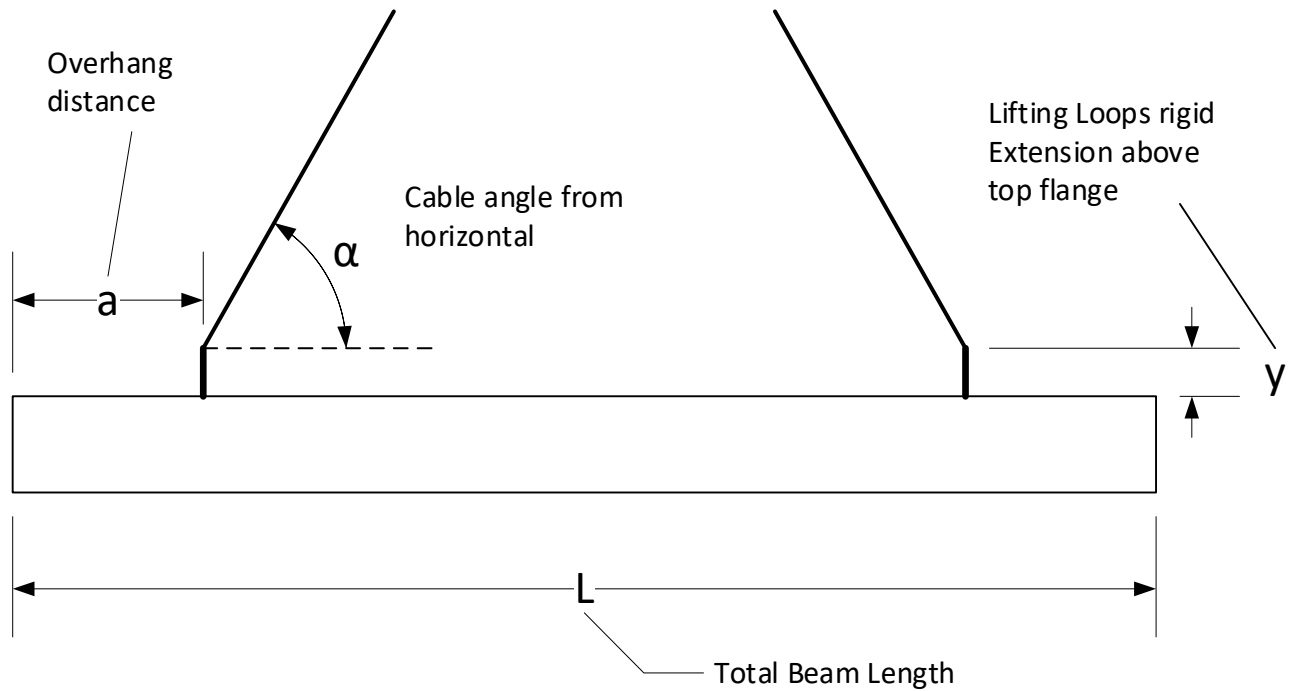
5.39 GSC – GIRDER STABILITY CHECKS COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
7. Lifting Loops Extension	Enter the lifting device rigid extension above the girder top flange. For lifting loops this would be 0.0 due to the flexibility of the loops. A non-zero extension increases the stability of the girder. (See Figure 5.39-1)	in	0. (E)	4. (W)	--
8. Sweep	Enter the built-in transverse deformation from a straight line parallel to the centerline of the girder, which is defined as sweep. (See Figure 5.39-2) The fabrication tolerance for sweep is 1/8 in. per 10 ft of beam length or L/960. Where L is the total girder length.	in	0. (E)	L/960 ³ (W)	L/960 ³
9. fc at lift	Enter the concrete strength at the time of the lift.	ksi	f'ci ^{*4} (W)	f'c ^{*5} (D)	--
10. Camber at lift	Enter the midspan beam camber at the time of the lift.	in	0. (W)	8. (W)	--

Notes:

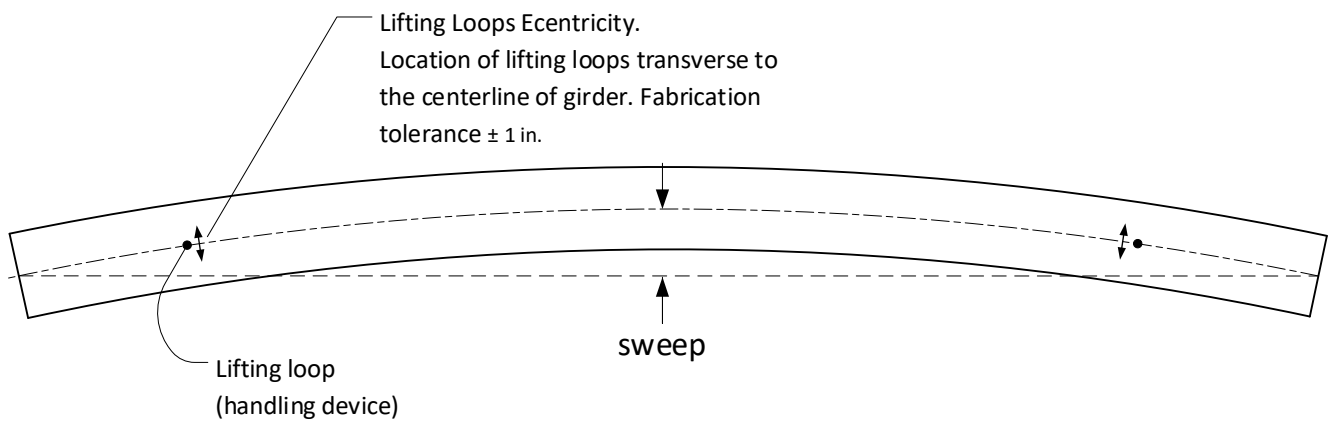
- ¹ NSP is the number of spans entered on the CTL command.
- ² D is the depth of the beam entered on the BDM command for analysis or the DES command for design.
- ³ L is the total beam length which equals the distance between simple bearings plus twice the beam projection entered on the GEO command.
- ⁴ f'ci is the concrete initial strength entered on the MCS command for analysis or the DES command for design.
- ⁵ f'c is the concrete design strength entered on the MCS command for analysis or the DES command for design.

Chapter 5 Input Description



Elevation View

Figure 5.39-1 Definition of Overhang, Cable angle, and Extension



Plan View

Figure 5.39-2 Definition of Sweep and Lifting Loop Eccentricity

Chapter 5 Input Description

5.40 GS2 – GIRDER STABILITY (PART 2) COMMAND

KEYWORD	COMMAND DESCRIPTION
GS2	GIRDER STABILITY (PART 2) – First Girder Seated on Bearings, Multiple Girders Seated - Inactive Construction This command is used to define the parameters needed to check the bracing requirements for seating the first girder at the bridge site with construction active wind condition (20 mph), followed by all girders seated with construction inactive wind condition (90 mph). The girder is assumed to be on elastomeric bearings that must be sufficient to resist the overturning tendency of the tilted girder. This command is optional. If it is not entered, girder stability of seated girders at the bridge site will not be computed. A GS2 command can be entered for each span of the structure. This check is done only for I-Beam type cross sections. (PennDOT I-beams, AASHTO I-beams, PA Bulb Tee beams) Only one GS2 command can be entered per span. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the beam. Enter zero to indicate that all spans will use the same values.	--	0 (E)	NSP ¹ (E)	0
2. f_c at Seating	Enter the girder concrete strength at the time of seating the girder on the bearings at the bridge.	ksi	f_{ci}^{*2} (W)	f_c^{*3} (D)	--
3. Camber at Seating	Enter the midspan beam camber at the time of seating the girder on bearings at the bridge.	in	0. (W)	8. (W)	--
4. Sweep at Seating	Enter the built-in transverse deformation from a straight line parallel to the centerline of the girder, which is defined as sweep, at the time of seating the girder on bearings at the bridge. (See Figure 5.39-2) The fabrication tolerance for sweep is 1/8 in. per 10 ft of beam length or L/960. Where L is the total girder length.	in	0. (E)	L/960 ⁴ (W)	L/960 ⁴
5. Prestress Force at Seating	Enter the prestress force at the time of seating the girder on the bearings at the bridge.	kip	$P(e)^{*6}$ (W)	$P(t)^{*5}$ (W)	$P(e)^{*6}$

Chapter 5 Input Description

5.40 GS2 – GIRDER STABILITY (PART 2) COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
6. Wind Pressure (Active Constr.)	Enter the lateral wind pressure at the time of seating the girders on the bearings at the bridge (Active Construction). The wind pressure depends on the wind speed for construction, duration of exposure during construction, height of beam above surrounding ground, and the wind drag coefficient. Girder seating operations are limited to low wind velocity conditions. Typical design wind speeds would be limited to 20 mph. For a 50 ft height of beam above ground and typical values for other items the corresponding wind pressure would be about 2.5 psf. Refer to Section 6.39.4 for more information.	psf	0. (E)	5.0 (W)	--
7. Bearing Rotational Stiffness	Enter the bearing rotational stiffness of both bearings (twice the rotational stiffness of the bearing pad at each beam end). This value is computed by BPLRFD v1.10.0.0 for a single pad.	in-kip/ rad	10000. (E)	200000. (W)	--
8. Bearing Height	Enter the total bearing height of the elastomeric bearing pad.	in	1. (E)	8. (W)	--
9. Bearing Width	Enter the width of the bearing pad measured transverse to the longitudinal axis of the girder. (Refer to Figure 5.40-1)	in	10. (W)	24. (W)	--
10. Bearing Tolerance from C.L.	Enter the bearing tolerance from centerline of beam to centerline of support. This is the transverse distance between the beam centerline and the bearing centerline. (Refer to Figure 5.40-1)	in	0. (E)	1.0 (W)	0.5
11. Bearing Tolerance from Level	Enter the maximum transverse bearing tolerance from level.	ft/ft	0.0 (E)	0.005 (W)	0.005

Chapter 5 Input Description

5.40 GS2 – GIRDER STABILITY (PART 2) COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
12. Wind Pressure (Inactive Constr.)	Enter the lateral wind pressure at the time of multiple girders seated on bearings (Inactive Construction). The wind pressure depends on the wind speed for construction, duration of exposure during construction, height of beam above surrounding ground, and the wind drag coefficient. Multiple girders seated can be exposed to higher wind velocity conditions. Typical design wind speeds would be 90 mph. For a 50 ft height of beam above ground and typical values for other items the corresponding wind pressure would be about 45 psf. Refer to Section 6.39.4 for more information.	psf	0. (E)	50.0 (W)	--
13. Vertical Wind Pressure (Inactive Constr.)	Enter the upward wind pressure at the time of multiple girders seated on bearings (Inactive Construction). AASHTO Article 3.8.2 specifies a pressure of 10 psf for Service IV load combinations.	psf	0. (E)	20.0 (W)	10.0
14. End Braces Provided	Enter: Y – If end braces are provided N – If end braces are NOT provided This parameter affects the analysis of the first girder seated. When end braces are provided, the Factor of Safety against Rollover is not considered due to the bracing.	--	Y, N (E)	--	Y
15. Number of Intermed. Braces	Enter the number of intermediate braces between end braces. Enter -1 to have the number of braces computed. This parameter affects the analysis of multiple girders seated with inactive construction wind conditions. When intermediate braces are specified, only concrete stresses are checked due to the intermediate bracing satisfying factor of safety and bearing pad effectiveness checks.	--	-1	10	-1

Chapter 5 Input Description

5.40 GS2 – GIRDER STABILITY (PART 2) COMMAND (Cont.)

Notes:

- ¹ NSP is the number of spans entered on the CTL command.
- ² f'_{ci} is the girder concrete initial strength entered on the MCS command for analysis or the DES command for design.
- ³ f'_c is the girder concrete design strength entered on the MCS command for analysis or the DES command for design.
- ⁴ L is the total beam length which equals the distance between simple bearings plus twice the beam projection entered on the GEO command.
- ⁵ $P(t)$ is the prestress force at transfer as reported in output table Prestress Values Based on Losses at Midspan of Simple Span.
- ⁶ $P(e)$ is the effective prestress force as reported in output table Prestress Values Based on Losses at Midspan of Simple Span.

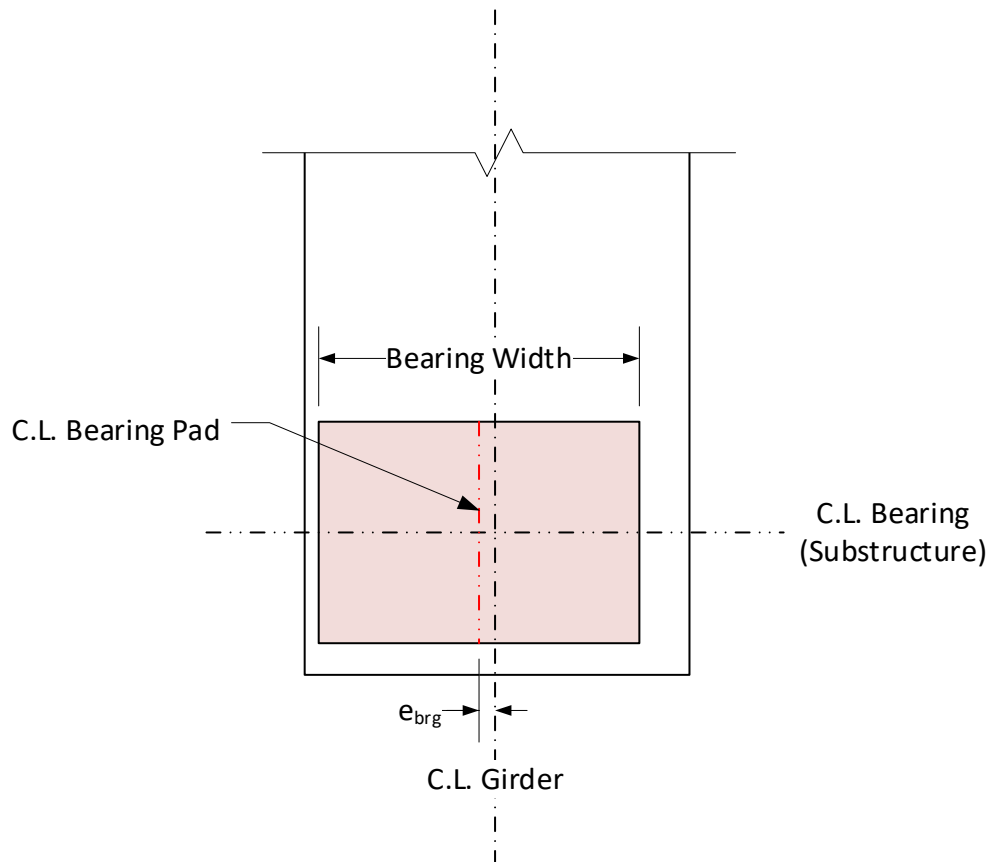


Figure 5.40-1 Plan View of Bearing Pad and Girder End

Chapter 5 Input Description

5.41 GS3 – GIRDER STABILITY (PART 3) COMMAND

KEYWORD	COMMAND DESCRIPTION
GS3	GIRDER STABILITY (PART 3) – Deck (Active) Construction - Deck Casting This command is used to define the parameters needed to check the bracing requirements for the exterior girder during deck casting with construction active wind condition (20 mph). The bracing is checked to control the rotation of the girder during the casting of the bridge deck to maintain concrete cover over the reinforcing steel. This command is optional. If it is not entered, girder stability during casting will not be computed. A GS3 command can be entered for each span of the structure. This check is done only for <u>Exterior</u> I-Beam type cross sections. (PennDOT I-beams, AASHTO I-beams, PA Bulb Tee beams) Only one GS3 command can be entered per span. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Span Number	Enter the span number of the beam. Enter zero to indicate that all spans will use the same values.	--	0 (E)	NSP ¹ (E)	0
2. f_c at Deck Casting	Enter the girder concrete strength at the time of deck casting.	ksi	f_{ci}^{*2} (W)	f_c^{*3} (D)	--
3. Formwork Extension	Enter the formwork extension length beyond the edge of the deck. Refer to Figure 5.41.1.	ft	1.0 (W)	3.0 (W)	2.0
4. Screed Rail Distance	Enter the distance from the edge of the deck to the center of the rail supporting the screed machine. Refer to Figure 5.41.1.	in	0. (E)	8. (W)	2.5
5. Thickness of Deck Overhang	Enter the average thickness of the concrete deck in the overhang. Refer to Figure 5.41.1.	in	Slab(t) ^{*4} (W)	12.0 (W)	--
6. Weight of SIP Forms	Enter the weight per square foot of Stay-In-Place forms and the concrete fill in the flutes of the forms.	psf	15.0 (W)	25.0 (W)	--
7. Weight of Cantilever Forms	Enter the weight per square foot of removable cantilever deck forms and handrails.	psf	15.0 (W)	25.0 (W)	--
8. Live Load on Deck	Enter the construction live load on the deck.	psf	15.0 (W)	25.0 (W)	--
9. Live Load from Screed	Enter the construction live load from the screed machine.	kip	2.0 (W)	12.0 (W)	--
10. Live Load on Walkway	Enter the construction live load on the walkway extension.	lb/ft	50.0 (W)	100.0 (W)	75.0

Chapter 5 Input Description

5.41 GS3 – GIRDER STABILITY (PART 3) COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
11. Length of Live Load on Walkway	Enter the length over which the walkway live load is to be applied.	ft	10. (W)	30. (W)	20.

Notes:

- ¹ NSP is the number of spans entered on the CTL command.
- ² f'_{ci} is the girder concrete initial strength entered on the MCS command for analysis or the DES command for design.
- ³ f'_c is the girder concrete design strength entered on the MCS command for analysis or the DES command for design.
- ⁴ Slab(t) is the Actual Slab Thickness entered on the SLB command.

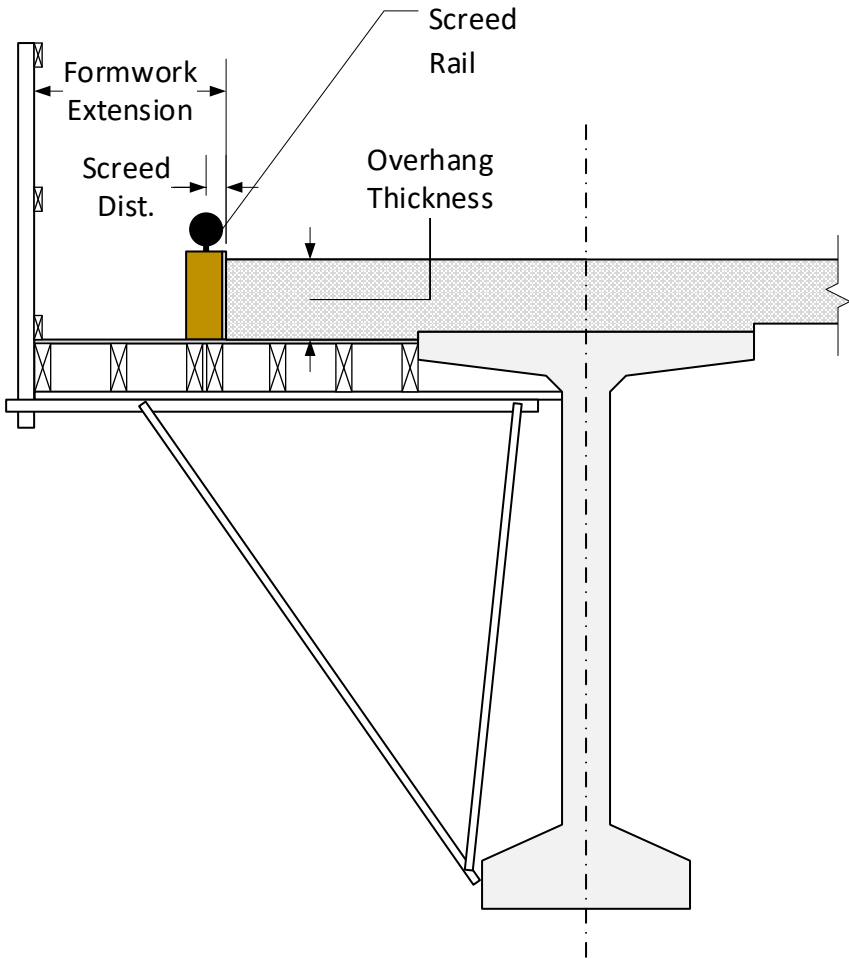


Figure 5.41-1 Definition of Formwork Extension, Screed Distance, and Overhang Thickness

Chapter 5 Input Description

5.42 OIN - OUTPUT OF INPUT DATA COMMAND

KEYWORD	COMMAND DESCRIPTION
OIN	OUTPUT OF INPUT DATA - This command allows the user to control the output of the input data. Only one OIN command can be used. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Input File Echo	Enter: 0 - Do not print input file echo. 1 - Print input file echo.	--	0 (E)	1 (E)	0
2. Input Commands	Enter: 0 - Do not print input commands. 1 - Print input commands.	--	0 (E)	1 (E)	0
3. Input Summary	Enter: 0 - Do not print input summary. 1 - Print input summary.	--	0 (E)	1 (E)	1

Chapter 5 Input Description

5.43 OAN - OUTPUT OF ANALYSIS RESULTS COMMAND

KEYWORD	COMMAND DESCRIPTION
OAN	OUTPUT OF ANALYSIS RESULTS - This command controls the analysis result output tables generated in the output file. Only one OAN command can be used. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Section Properties	Enter: 0 - Do not print the section properties. 1 - Print the section properties.	--	0 (E)	1 (E)	*1
2. Analysis Points	Enter: 0 - Do not print the significance of each analysis point. 1 - Print the significance of each analysis point.	--	0 (E)	1 (E)	*1
3. Distribution Factor	Enter: 0 - Do not print the live load distribution factors. 1 - Print the live load distribution factors. 2 - Print detailed distribution factors for NEXT beams 3 - Print option "2" with D.F. controlling criteria 4 - Print option "3" with Range of Applicability variables	--	0 (E)	4 (E)	*1
4. Points of Contraflexure	Enter: 0 - Do not print the points of composite dead load contraflexure. 1 - Print the points of composite dead load contraflexure.	--	0 (E)	1 (E)	*1
5. Loads and Load Modifiers	Enter: 0 - Do not print the loads and load modifiers. 1 - Print the loads and load modifiers.	--	0 (E)	1 (E)	*1
6. Dead Load Non-composite Forces and Moments	Enter: 0 - Do not print the individual unfactored non-composite dead load forces and moments. 1 - Print the individual unfactored non-composite dead load forces and moments.	--	0 (E)	1 (E)	*1

Chapter 5 Input Description

5.43 OAN - OUTPUT OF ANALYSIS RESULTS COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
7. Total Non-composite Dead Load Forces and Moments	Enter: 0 - Do not print the total unfactored non-composite dead load forces and moments. 1 - Print the total unfactored non-composite dead load forces and moments.	--	0 (E)	1 (E)	*1
8. Dead Load Composite Forces and Moments	Enter: 0 - Do not print the individual unfactored composite dead load forces and moments. 1 - Print the individual unfactored composite dead load forces and moments.	--	0 (E)	1 (E)	*1
9. Total Composite Dead Load Forces and Moments	Enter: 0 - Do not print the total unfactored composite dead load forces and moments. 1 - Print the total unfactored composite dead load forces and moments.	--	0 (E)	1 (E)	*1
10. Dead Load Creep and Shrinkage Moments	Enter: 0 - Do not print the unfactored dead load creep and shrinkage moments. 1 - Print the unfactored dead load creep and shrinkage moments.	--	0 (E)	1 (E)	*1
11. Live Load Effects	Enter: 0 - Do not print the unfactored live load forces and moments. 1 - Print the unfactored live load forces and moments.	--	0 (E)	1 (E)	*1
12. Live Load Reactions	Enter: 0 - Do not print the unfactored live load reactions. 1 - Print the unfactored live load reactions.	--	0 (E)	1 (E)	*1
13. HS20 Effects and Reactions	Enter: 0 - Do not print the HS20 live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions). 1 - Print the HS20 live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions).	--	0 (E)	1 (E)	*1

Chapter 5 Input Description

5.43 OAN - OUTPUT OF ANALYSIS RESULTS COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
14. H2O Effects and Reactions	Enter: 0 - Do not print the H2O live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions). 1 - Print the H2O live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions).	--	0 (E)	1 (E)	*1
15. Fatigue Effects and Reactions	Enter: 0 - Do not print the fatigue live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions). 1 - Print the fatigue live load forces, moments and reactions with the output requested in parameters 11 (Live Load Effects) and 12 (Live Load Reactions).	--	0 (E)	1 (E)	*1
16. Factored Effects	Enter: 0 - Do not print the factored forces and moments from the total factored loads for each applicable limit state. 1 - Print the factored forces and moments from the total factored loads for each applicable limit state.	--	0 (E)	1 (E)	*1
17. Factored Reactions	Enter: 0 - Do not print the factored reactions from the total factored loads for each applicable limit state. 1 - Print the factored reactions from the total factored loads for each applicable limit state. Note – This table will always print when uplift exists at any support regardless of the defaulted or entered value.	--	0 (E)	1 (E)	*1
18. Overall Reaction Summary	Enter: 0 - Do not print the overall reactions summary table. 1 - Print the overall reactions summary table.	--	0 (E)	1 (E)	*1

Notes:

- ¹ The default values for every parameter on this command are determined based on the type of run (analysis or design). The defaults for all output commands are detailed in Chapter 6.

Chapter 5 Input Description

5.44 OSC - OUTPUT OF SPECIFICATION CHECKING COMMAND

KEYWORD	COMMAND DESCRIPTION
OSC	OUTPUT OF SPECIFICATION CHECKING - This command controls the specification checking output tables generated in the output file. Only one OSC command can be used. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Allowable and Design Load Stresses	Enter: 0 - Do not print the allowable and design load stresses. 1 - Print the allowable and design load stresses.	--	0 (E)	1 (E)	*1
2. Final Compressive Stresses LL+1/2 (DL+P/S) or FAT+1/2(DL+P/S)	Enter: 0 - Do not print the final compressive stresses under one-half of (dead load plus prestress) and design live load or fatigue live load. 1 - Print the final compressive stresses under one-half of (dead load plus prestress) and design live load or fatigue live load.	--	0 (E)	1 (E)	*1
3. End Block Stresses	Enter: 0 - Do not print the end block stresses based on a solid section. 1 - Print the end block stresses based on a solid section. Note: Applicable to adjacent boxes or spread boxes with either ST or DP strands specified on SSI Command.	--	0 (E)	1 (E)	*1
4. Cracking Moment	Enter: 0 - Do not print the cracking moments. 1 - Print the cracking moments.	--	0 (E)	1 (E)	*1
5. Negative Moment Capacity	Enter: 0 - Do not print the negative moment capacity. 1 - Print the negative moment capacity.	--	0 (E)	1 (E)	*1
6. Shear Reinforcement	Enter: 0 - Do not print the shear reinforcement results. 1 - Print the shear reinforcement results.	--	0 (E)	1 (E)	*1
7. Prestressing Data ²	Enter: 0 - Do not print the prestressing data. 1 - Print the prestressing data.	--	0 (E)	1 (E)	*1

Chapter 5 Input Description

5.44 OSC - OUTPUT OF SPECIFICATION CHECKING COMMAND (Cont.)

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
8. Fatigue Stress Range	Enter: 0 - Do not print the fatigue stress range in the prestressing steel. 1 - Print the fatigue stress range in the prestressing steel.	--	0 (E)	1 (E)	*1
9. Longitudinal Slab Reinforcement	Enter: 0 - Do not print the longitudinal slab reinforcement requirements at the supports. 1 - Print the longitudinal slab reinforcement requirements at the supports.	--	0 (E)	1 (E)	*1
10. Positive Moment Connection	Enter: 0 - Do not print the required steel for a positive moment connection over the supports. 1 - Print the required steel for a positive moment connection over the supports.	--	0 (E)	1 (E)	*1
11. Overhang Width	Enter: 0 - Do not print the parapet overhang width requirements. 1 - Print the parapet overhang width requirements.	--	0 (E)	1 (E)	*1
12. Camber and Deflection	Enter: 0 - Do not print the cambers and deflections. 1 - Print the cambers and deflections.	--	0 (E)	1 (E)	*1
13. Strand Code Detail Check	Enter: 0 - Do not print the strand code detail check. 1 - Print the strand code detail check.	--	0 (E)	1 (E)	*1
14. Principal Stresses	Enter: 0 - Do not print the principal stresses. 1 - Print the principal stresses.	--	0 (E)	1 (E)	*3
15. Girder Stability Checks	Enter: 0 - Do not print the girder stability checks. 1 - Print the girder stability checks.	--	0 (E)	1 (E)	*1
16. Rating Vehicle Stresses	Enter: 0 - Do not print the rating vehicle stresses. 1 - Print the rating vehicle stresses.	--	0 (E)	1 (E)	*1
17. Shear Detail	Enter: 0 - Do not print the shear detail. 1 - Print the shear detail.	--	0 (E)	1 (E)	*1

Chapter 5 Input Description

5.44 OSC - OUTPUT OF SPECIFICATION CHECKING COMMAND (Cont.)

Notes:

- ¹ The default values for every parameter on this command are determined based on the type of run (analysis or design). The defaults for all output commands are detailed in Chapter 6.
- ² The Prestressing Data output table is located after the input and before the section properties.
- ³ Principal Stresses are not usually needed for design calculations. This option has been provided for research purposes.

Chapter 5 Input Description

5.45 ORF - OUTPUT OF RATING FACTORS COMMAND

KEYWORD	COMMAND DESCRIPTION
ORF	OUTPUT OF RATING FACTORS - This command controls the rating factor output tables generated in the output file. Only one ORF command can be used. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. Detailed Rating Factors	Enter: 0 - Do not print the detailed ratings (service moment, strength moment, and strength shear) for each applicable point, live loading, and limit state. 1 - Print the detailed ratings (service moment, strength moment, and strength shear) for each applicable point, live loading, and limit state.	--	0 (E)	1 (E)	*1
2. Live Loading Rating Summary	Enter: 0 - Do not print the rating summary for each live loading. 1 - Print the rating summary for each live loading.	--	0 (E)	1 (E)	*1
3. Overall Rating Summary	Enter: 0 - Do not print the overall rating summary and bridge load ratings table. 1 - Print the overall rating summary and bridge load ratings table.	--	0 (E)	1 (E)	*1
4. Rating Vehicle Specification Checking	Enter: 0 - Do not print the rating vehicle specification checking. 1 - Print the rating vehicle specification checking.	--	0 (E)	1 (E)	*1
5. Ratings Without Future Wearing Surface	Enter: 0 - Only print the ratings with FWS. 1 - Print the ratings both with FWS and without FWS. Note: This parameter only applies to analysis runs with shear analysis (stirrups specified) and FWS loads specified.	--	0 (E)	1 (E)	*1

Notes:

- ¹ The default values for every parameter on this command are determined based on the type of run (analysis or design). The defaults for all output commands are detailed in Chapter 6.

Chapter 5 Input Description

5.46 OSM - OUTPUT SUMMARY COMMAND

KEYWORD	COMMAND DESCRIPTION
OSM	OUTPUT SUMMARY - This command allows the user to output various summaries information. Only one OSM command can be used. Optional for both design and analysis.

PARAMETER	DESCRIPTION	UNITS	LOWER LIMIT	UPPER LIMIT	Default
1. TS&L/Design Summary	Print the information typically needed for a TS&L or Design Summary. Enter: 0 - Do not print the TS&L/Design Summary. 1 - Print the TS&L/Design Summary.	--	0 (E)	1 (E)	0
2. Q/A - Q/C Summary	Print the information typically needed for Q/A - Q/C. Enter: 0 - Do not print the Q/A - Q/C Summary. 1 - Print the Q/A - Q/C Summary.	--	0 (E)	1 (E)	0
3. Detailer Summary	Print the information usually given to the detailer for placement on the design drawings. Enter: 0 - Do not print the Detailer Summary. 1 - Print the Detailer Summary.	--	0 (E)	1 (E)	0

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DETAILED INPUT DESCRIPTION

This chapter provides a detailed description of some of the input parameters which were described in Chapter 5, but may need further explanation or commentary. The numbering scheme used here is as follows. The section number for a command corresponds to the same section number in Chapter 5. The parameter being described is preceded by a section number, whose last extension number refers to the parameter number in the corresponding command in Chapter 5. For example, 6.27.2 Effective Slab Thickness corresponds to Section 5.27 SLB - Slab Command, parameter 2.

Only the commands and parameters for which detailed description is given are included here. For parameters which are not presented in this chapter, sufficient description and explanation is provided in Chapter 5.

Chapter 6 Detailed Input Description

6.5 CTL - CONTROL COMMAND

6.5.3 Shape of Beam

For design runs only PennDOT and AASHTO beams as presented in the PennDOT BD Standards may be selected. PennDOT BD Standard beam shapes are "IP", "IA", "BT", "NX", "PL", "AR", "SR" and "ND".

6.5.7 Symmetry

If the user enters 'Y' for this parameter, indicating that the entire structure is symmetrical, then the user must specify input for only the first half of the girder. The program will provide output for only the first half of the girder, with one exception. The single exception is that the program will provide an input summary near the beginning of the output which includes the entire length of the girder, providing the user with a check that the program has mirrored the input correctly. Although the input and the output will be for only the first half of the girder, the program will perform the analysis for the entire girder length.

6.5.8 Beam Designation

This parameter is used only when the BDM command is used. If the user leaves this parameter blank the program will set the parameter to 'P'. PennDOT standard beams refer to those beams listed in the PennDOT BD Standards, which include both PennDOT and AASHTO standard beams. Beam Designation of "P" is not valid with Beam Shapes of "A1", "A2", "A3", "S1", "S2", or "S3". Also, Beam Designation of "U" is not valid with Beam Shape of "IB" since "IB" is the design option for both "IA" and "IP" beam shapes.

6.5.18 Composite Beam

A girder must be considered either composite over its entire length or non-composite over its entire length. It cannot have portions that are composite and other portions that are non-composite.

An I-beam type girder (PennDOT I-Beam, AASHTO I-Beam, or Bulb-Tee) and a Type F NEXT beam must be considered as composite. A Type D NEXT beam must be considered as non-composite.

6.5.19 Skew Override

This parameter overrides the beam skew applicability limits of the BD Standards for design runs.

6.5.23 Shear Design/Analysis

For a beam analysis problem, the program can perform either shear design or shear analysis of the prestressed concrete beam in accordance with the LRFD Specifications and DM-4. For shear design, the program calculates the required shear reinforcement stirrup spacing based on the shear reinforcement

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stirrup area inputted on the STI command. For shear analysis, the program performs all the required specification checks based on the shear reinforcement stirrup area and spacing inputted on the STI command. For further information, see Section 3.12.

6.5.25 Shrinkage Only Analysis

For the analysis of a deck replacement project for which the existing beams will be reused, enter 'Y' to analyze the structure without creep assuming that any creep in the beam has already taken place.

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6.7 GEO - GEOMETRY COMMAND

6.7.1 Girder Spacing

For NEXT beams the girder spacing is used to compute the width of the top flange. For Type F NEXT beams the top flange width is equal to the girder spacing minus the beam gap width (parameter X2 on the BDM Command). For PennDOT standard Type F NEXT beams the gap width is 1/2 inch. For Type D NEXT beams the top flange width is equal to the girder spacing minus the longitudinal joint width (parameter X2 on the BDM Command). For PennDOT standard Type D NEXT beams the joint width is 9 inches.

6.7.2 Deck Overhang

The input deck overhang is adjusted when performing the maximum overhang check. For spread box beams, the overhang is measured from the centerline of the exterior web (wall) of the box. For I-beams and bulb-tee beams, the overhang is measured from the centerline of the web. For NEXT beams the deck overhang is measured from the centerline of the beam.

For a spread box, I-beam, or bulb-tee beam run, if the deck overhang is greater than 0.5 times the girder spacing, then the program will print a warning that can be accepted/ignored only upon the approval of the District Bridge Engineer (D). In addition, for a design run, if the deck overhang is greater than 0.625 times the girder spacing, then the program will print an error message (E).

For adjacent box or adjacent plank beam runs, the input Deck Overhang is checked against the allowable overhangs of 8 inches plus half of the beam width for composite beams. No parapet overhang is allowed for non-composite beams.

By default, for Type F NEXT beams the edge of the concrete deck is even with the beam top flange of the exterior beam resulting in the overhang being one-half of the beam width as shown on the Typical Bridge Section on Sheet 1 of the NEXT Beam standard drawing No. 09-602-BQAD. The overhang defaults to one-half of the beam width and does not need to be entered. The deck overhang upper limit is 8 inches plus one-half of the beam width. Deck overhangs less than one-half of the beam width are reset equal to one-half of the beam width.

For Type D NEXT beams the default overhang is one-half of the beam width. The maximum overhang is one-half of the maximum beam width of 10 feet. The minimum overhang is one-half of the minimum beam width of 8 feet.

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6.7.3 Number of Design Lanes

This parameter is to be entered assuming that sidewalks are not present. It is used in the computations for all limit states except Strength IP. The number of design lanes is based on the roadway width shown in the bottom schematic drawing of Figure 1. The user should enter the number of design lanes based on LRFD Specifications Article 3.6.1.1.1. However, roadway widths from 20 to 24 feet should have two design lanes, each equal to one-half the roadway width.

6.7.4 Deflection Distribution Factor

The deflection distribution factor is the distribution factor, in units of lane fractions, to be used in computing live load deflection in a multi-beam bridge. The program uses this parameter only to compute live load deflection. The deflection distribution factor is equal to the number of design lanes multiplied by the multiple presence factor and then divided by the number of beams in the bridge cross section. If this parameter is not entered, the program computes this value as the inputted number of design lanes multiplied by the applicable multiple presence factor and then divided by the inputted number of beams.

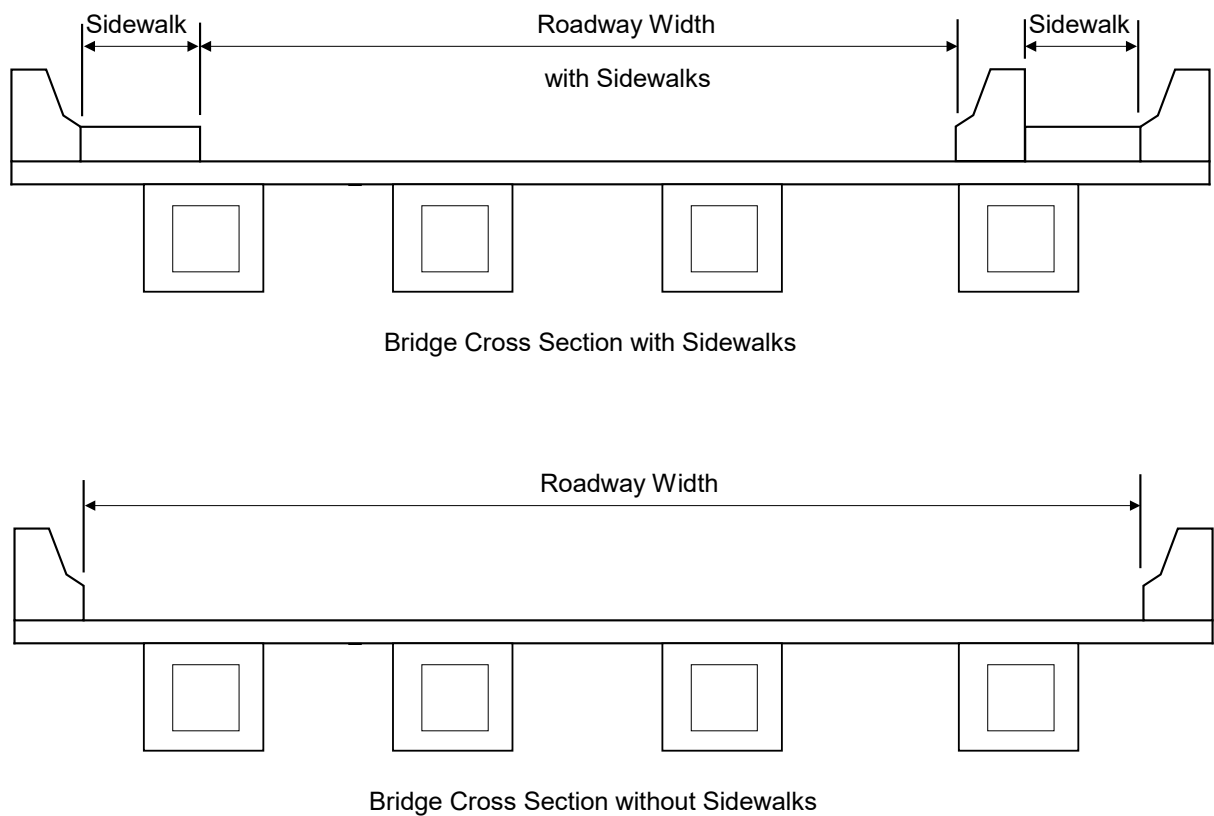


Figure 6.7-1 Bridge Cross Sections

Chapter 6 Detailed Input Description

This parameter is to be entered assuming that sidewalks are not present. The applicable multiple presence factor is based on the inputted number of design lanes. It is used in the computations for all limit states except Strength IP.

6.7.5 Beam Projection

The beam projection is used to determine the total length of the beam, from end to end rather than from centerline of bearing to centerline of bearing. The total length of the beam is required for (1) creep and shrinkage calculations to compute the fixed end forces, (2) debonding if required between the end of the beam and the centerline of the bearing, (3) girder camber, and (4) transfer length from the end of the beam.

6.7.6 Number of Design Lanes with Sidewalks

This parameter is to be entered assuming that sidewalks are present. It is used in the computations for the Strength IP limit state only. The number of design lanes with sidewalks is based on the roadway width with sidewalks shown in the top schematic drawing of Figure 1. The user should enter the number of design lanes based on LRFD Specifications Article 3.6.1.1.1. However, roadway widths from 18 to 24 feet should have two design lanes, each equal to one-half the roadway width. When computing the Multiple Presence Factor for the deflection distribution factor, the program automatically increases the Number of Design Lanes with Sidewalks by 1 to account for the pedestrian loads based on LRFD Specifications Article 3.6.1.1.2.

6.7.7 Deflection Distribution Factor with Sidewalks

For a detailed input description of the deflection distribution factor, refer to Section 6.7.4. This parameter is to be entered assuming that sidewalks are present. The deflection distribution factor with sidewalks is equal to the number of design lanes with sidewalks multiplied by the multiple presence factor and then divided by the number of beams in the bridge cross section. If this parameter is not entered, the program computes this value as just described. The applicable multiple presence factor is based on the inputted number of design lanes with sidewalk increased by 1 to account for the pedestrian loads. The deflection distribution factor with sidewalks is used in the computations of vehicular live load deflections when sidewalks are present. This includes the maximum actual live load deflection with pedestrian loading output table.

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6.8 CDF - COMPUTED DISTRIBUTION FACTOR COMMAND

6.8.4 Distance to Outermost Wheel

This input value is used for the Lever Rule distribution factor calculations. It is used in the computations for all limit states except Strength IP.

6.8.5 Centerline Exterior Beam to Curb

This parameter is to be entered assuming that sidewalks are not present. It is used to calculate the d_e value used in the distribution factor equations for all limit states except Strength IP. To calculate d_e for box beams the program subtracts half the width of the box beam less half of the web thickness. To calculate d_e for NEXT beams the program subtracts the distance from the centerline of the beam to the centerline of the web. For all other beam types d_e equals the input value.

6.8.7 Distance to Outermost Wheel with Sidewalks

This input value is used for the Lever Rule distribution factor calculations. It is used in the computations for the Strength IP limit state only.

6.8.8 Centerline Exterior Beam to Curb with Sidewalks

It is used to calculate the d_e value used in the distribution factor equations for the Strength IP limit state only. To calculate d_e for box beams the program subtracts half the width of the box beam less half of the web thickness. To calculate d_e for NEXT beams the program subtracts the distance from the centerline of the beam to the centerline of the web. For all other beam types d_e equals the input value.

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6.9 UDF - USER DISTRIBUTION FACTOR COMMAND

User defined distribution factors must include any skew correction factors. For a description of where the skew correction factor should be applied, refer to Section 3.5.

User defined distribution factors may be entered as zero to eliminate the live load effect for special analysis conditions. When Design distribution factors are entered as zero, if Pedestrian distribution factors are specified, they must also be entered as zero.

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6.10 URF - USER DEFINED REACTION DISTRIBUTION FACTOR COMMAND

User defined distribution factors may be entered as zero to eliminate the live load effect for special analysis conditions. When Design distribution factors are entered as zero, if Pedestrian distribution factors are specified, they must also be entered as zero.

6.10.3 Reaction Distribution Factor

For a description of computing the reaction distribution factors and where the skew correction factors should be applied, refer to Section 3.5 and Figures 3.5-3 and 3.5-4.

Chapter 6 Detailed Input Description

6.13 SKW - SKEW ANGLE COMMAND

For a description of how the program computes the skew correction factors, refer to Section 3.5.

6.13.3 Support Distance 1

6.13.4 Support Distance 2

At interior supports a check is made for the Support Distance parameters to be a minimum of 2" larger than the Beam Projection parameter on the GEO command. This will provide a minimum 4" gap between beam ends at interior supports in accordance with BD Standards. A violation of this check will only result in a warning and the program will continue execution using the input support distances.

6.13.5 Apply Skew Correction Factor

For a description of where the skew correction factor should be applied, refer to Section 3.5 and Figures 3.5-1 and 3.5-2.

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6.16 MCG – CONCRETE MATERIAL PROPERTIES (ALL GIRDERS) COMMAND

6.16.4 Slab Beam Interface

The beam slab interface parameter in conjunction with the Slab Concrete Type parameter (SLB Command) are used to determine the cohesion and friction factors for computation of the nominal interface shear resistance. The table below summarizes the Cohesion and Friction values that will be used based on the user input.

PSLRFD Input Commands		Cohesion and Friction Factors from DM-4 / LRFD Specifications 5.7.4.4 (<u>Underlined</u> text denotes DM-4 modifications)	
MCG	SLB		
Cast-in-place	Normal weight or Lightweight	For a cast-in-place concrete slab on clean concrete girder surfaces, free of laitance with surface roughened to an amplitude of 0.25 in.:	
		c	= <u>0.10</u> ksi
		μ	= 1.0
		K ₁	= 0.3
Monolithic	Normal weight	K ₂	= 1.8 ksi for normal-weight concrete = 1.3 ksi for lightweight concrete
		For normal-weight concrete placed monolithically:	
		c	= <u>0.15</u> ksi
		μ	= 1.4
Monolithic or Intentionally roughened	Lightweight	K ₁	= 0.25
		K ₂	= 1.5 ksi
		For lightweight concrete placed monolithically, or nonmonolithically, against a clean concrete surface, free of laitance with surface intentionally roughened to an amplitude of 0.25 in.:	
		c	= <u>0.10</u> ksi
Intentionally roughened	Normal weight	μ	= <u>0.85</u>
		K ₁	= 0.25
		K ₂	= 1.0 ksi
		For normal-weight concrete placed against a clean concrete surface, free of laitance, with surface intentionally roughened to an amplitude of 0.25 in.:	
Unroughened	Normal weight or Lightweight	c	= <u>0.10</u> ksi
		μ	= 1.0
		K ₁	= 0.25
		K ₂	= 1.5 ksi
		For concrete placed against a clean concrete surface, free of laitance, but not intentionally roughened:	
		c	= 0.075 ksi
		μ	= 0.6
		K ₁	= 0.2
		K ₂	= 0.8 ksi

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6.18 MST - MILD STEEL MATERIAL PROPERTIES COMMAND

6.18.4 Dev. Length Factor Positive

The positive development length modification factor applies only to mild steel reinforcement located in the bottom half of the girder (the flexural tension side of the member caused by positive moment). It is defined as the product of the modification factors which increase l_{db} (as specified in LRFD Article 5.10.8.2.1b) and the modification factors which decrease l_{db} (as specified in LRFD Article 5.10.8.2.1c) divided by the concrete density modification factor (as specified in LRFD Article 5.4.2.8). The positive development length modification factor is given by the following equation:

$$\text{Total Modification Factor} = \frac{\lambda_{rl} \times \lambda_{cf} \times \lambda_{rc} \times \lambda_{er}}{\lambda}$$

Where;

λ_{rl} = reinforcement location factor. 1.3 for bars located more than 12" above the bottom of the beam. 1.0 for all other bars.

λ_{cf} = coating factor. 1.0 for non-epoxy-coated bars, 1.5 for epoxy-coated bars with less than $3d_b$ cover **or with clear spacing less than $6d_b$, 1.2 for other epoxy-coated bars**. Note: product $\lambda_{rl} \times \lambda_{cf}$ limited to 1.7.

λ_{rc} = reinforcement confinement factor

$$0.4 \leq \lambda_{rc} \leq 1.0$$

In which:

$$\lambda_{rc} = \frac{d_b}{c_b + k_{tr}}$$

c_b = distance from center of bar to nearest concrete surface

$$k_{tr} = 40 A_{tr} / (sn)$$

k_{tr} = transverse reinforcement index

A_{tr} = total area of transverse reinforcement crossing splitting plane

s = maximum center-to-center spacing of transverse reinforcement

n = number of bars developed along plane of splitting

λ_{er} = excess reinforcement factor. 1.0

λ = concrete density modification factor. 1.0 for normal weight concrete.

Reinforcement confinement factor examples

1) Bars in the web

These are typically #4 longitudinal bars located inside of the #4 stirrups bars. The stirrup bars have a minimum cover of 1". In the development area the stirrup bars have a maximum spacing of 6". The plane of splitting is a horizontal line from the bar to the surface of the web.

$$c_b = 1" (\text{cover}) + \frac{1}{2}" (\#4 \text{ stirrup}) + \frac{1}{2}" / 2 (\text{diameter } \#4 \text{ long. Bar} / 2) = 1.75"$$

$$A_{tr} = 0.2 \text{ in}^2 (\text{area of } \#4 \text{ stirrup})$$

$$s = 6" (\text{transverse spacing of stirrups})$$

$$n = 1$$

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$$k_{tr} = 40 \times 0.2 / (6 \times 1) = 1.333"$$

$$\lambda_{rc} = \frac{0.5}{1.75 + 1.333} = 0.162 \text{ Use minimum of 0.4}$$

2) Bars in the top flange

These are typically #4 bars placed below a horizontal, transverse #4 bar with the same 1" minimum cover as in the web. The spacing of the transverse bar is also at a maximum of 6". The plane of splitting is a vertical line from the bar to the surface of the top flange. Due to the similarity of these bars to the bars in the web, all the variables have the same values resulting in the reinforcement confinement factor having a value of 0.4.

3) Bars in the slab

In negative moment regions the bottom longitudinal bars are located above the transverse bottom bars. The bottom transverse bar has a minimum cover of 1". The spacing of the transverse bar varies from a maximum of 9.5" to a minimum 5.5". Generally, the transverse bar is a #5 bar and the longitudinal bar is a #5 bar. The plane of splitting is a vertical line from the bar to the surface of the bottom of the slab.

$$c_b = 1" \text{ (cover)} + 5/8" \text{ (#5 transverse)} + 5/8" / 2 \text{ (diameter #5 long. Bar / 2)} = 1.9375"$$

$$A_{tr} = 0.31 \text{ in}^2 \text{ (area of #5 transverse)}$$

$$s = 9.5" \text{ (maximum transverse spacing)}$$

$$n = 1$$

$$k_{tr} = 40 \times 0.31 / (9.5 \times 1) = 1.305"$$

$$\lambda_{rc} = \frac{0.625}{1.9375 + 1.305} = 0.193 \text{ Use minimum of 0.4}$$

The Total Modification Factor is applied directly to the basic development length, as specified in LRFD Article 5.10.8.2.1a.

The user must compute the positive development length modification factor using the Total Modification Factor equation and then the positive development length modification factor must be entered as input for this parameter.

6.18.5 Dev. Length Factor Negative

The negative development length modification factor applies only to mild steel reinforcement located in the top half of the girder (the flexural tension side of the member caused by negative moment). It is defined as the product of the modification factors which increase l_{db} (as specified in LRFD Article 5.10.8.2.1b), and the modification factors which decrease l_{db} (as specified in LRFD Article 5.10.8.2.1c) divided by the concrete density modification factor (as specified in LRFD Article 5.4.2.8). The negative development length modification factor is applied directly to the basic development length, as specified in LRFD Article 5.10.8.2.1a.

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The user must compute the negative development length modification factor using the Total Modification Factor equation shown in Section 6.18.4 and then the negative development length modification factor must be entered as input for this parameter.

6.18.6 Dev. Length Factor for Slabs

The slab development length modification factor applies only to mild longitudinal steel reinforcement in the slab (both top and bottom). It is defined as the product of the modification factors which increase l_{db} (as specified in LRFD Article 5.10.8.2.1b), and the modification factors which decrease l_{db} (as specified in LRFD Article 5.10.8.2.1c). The slab development length modification factor is applied directly to the basic development length, as specified in LRFD Article 5.10.8.2.1a.

The user must compute the slab development length modification factor using the Total Modification Factor equation shown in Section 6.18.4 and then the slab development length modification factor must be entered as input for this parameter.

Chapter 6 Detailed Input Description

6.19 DES - DESIGN COMMAND

For the design option, the program uses only beams that are presented in the PennDOT BD Standards.

6.19.1 f'_c Optimization

If 'Y' is entered for this parameter, the program optimizes the beam concrete strength as described in Section 3.8.3.

If 'N' is entered for this parameter, the program does not optimize the beam concrete strength. The program uses the f'_c value entered by the user in parameter 6 of the DES command.

6.19.8 f'_{ci} / f'_c Ratio

The program uses the f'_{ci} / f'_c ratio to compute the value of f'_{ci} for each new value of f'_c for a problem in which f'_c is being optimized. The value of f'_{ci} is simply the product of this parameter and the new value of f'_c . The allowable range for the f'_{ci}/f'_c ratio is based on the allowable range as follows:

$$1.05f'_{ci} \leq f'_c \leq 1.18f'_{ci}$$

Where;

$$\frac{f'_{ci}}{f'_c} \leq \frac{1.00}{1.05} \cong 0.95$$

$$0.85 \cong \frac{1.00}{1.18} \leq \frac{f'_{ci}}{f'_c}$$

Chapter 6 Detailed Input Description

6.20 SST - SLAB REINFORCEMENT LOCATION COMMAND

6.20.3 Left Cutoff Point

The left cutoff point is used to calculate the shear capacity in the negative moment region of the girder. As shown in Figure 6.20-1, the left cutoff point is measured from the centerline of the pier to the physical end of the bar on the left side of the pier. Similarly, as shown in Figure 6.20-1, the development length is calculated by the program and is measured from the end of the bar towards the centerline of the pier. Therefore, the left cutoff point is required to define the location of the left end of the development length for negative bending reinforcement in the slab.

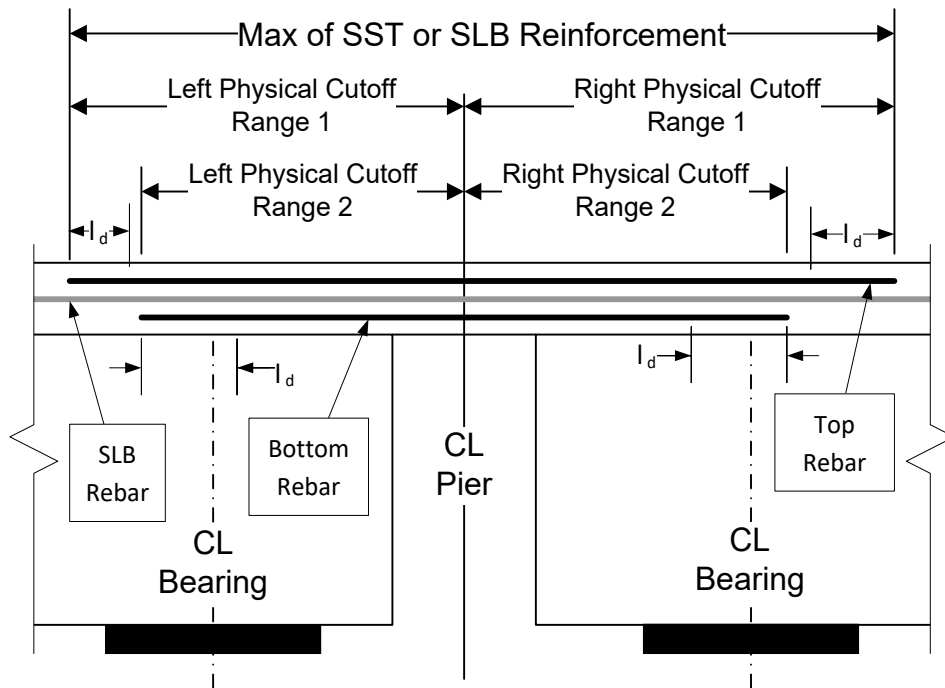


Figure 6.20-1 Definition of Left and Right Cutoff Points

6.20.4 Right Cutoff Point

The right cutoff point is used to calculate the shear capacity in the negative moment region of the girder. As shown in Figure 6.20-1, the right cutoff point is measured from the centerline of the pier to the physical end of the bar on the right side of the pier. Similarly, as shown in Figure 6.20-1, the development length is calculated by the program and is measured from the end of the bar towards the centerline of the pier. Therefore, the right cutoff point is required to define the location of the right end of the development length for negative bending reinforcement in the slab.

Chapter 6 Detailed Input Description

6.20.6 Location in Slab

The reinforcement located in the top of the slab is considered when checking serviceability requirements. At least one range of reinforcement at each interior support must be located in the top of the slab. When different bar sizes are entered for the top of the slab at the same support the calculations are based on the larger bar size.

Chapter 6 Detailed Input Description

6.21 BDM - BEAM DIMENSIONS COMMAND

The user can enter a beam designation or a set of beam dimensions. If a beam designation is entered for Parameter 2, the beam properties specified in the BD Standards for Parameters 3 through 21 will be used unless they are overridden by the user.

For example, if the user specifies an AASHTO type beam designation 28/96 for Parameter 2, the program will automatically set the top flange width, W2, to 42 inches, in accordance with the BD Standards. The program will also set all other dimensions and longitudinal mild steel parameters to the values presented in the BD Standards for that beam designation. However, if the user enters another value for W2, say 36 inches, using the BDM command and leaves all other values blank, then the program will set W2 to 36 inches. The program will set all other parameters to the values presented in the BD Standards for that beam designation.

Note: Entering a value for a dimension (Parameters 3 through 15) that deviates from the standards will require specific approval from the Chief Bridge Engineer.

If the beam depth is entered for Parameter 2, then all dimensions that apply for the beam shape selected on the CTL command must be entered.

6.21.2 Designation or D

The beam designation is a 4-digit integer for I-Beams and Box Beams that identifies the standard PennDOT beams listed in the BD Standards. The designation combines the bottom flange (W1) dimension and the beam depth (D) dimension to uniquely identify each standard beam. For example, the beam designation for a 30" deep 48" wide box beam is "4830".

The beam designation is a 4, 6 or 7 digit number for Bulb-Tee Beams that identifies the standard PennDOT beams listed in the BD Standards. The designation combines the bottom flange (W1) dimension and the beam depth (D) dimension to uniquely identify each standard beam. The number of digits in the designation depends to the number of digits in the beam depth since the bottom flange width is always 33 inches. The following table shows the number of digits in the designation for each top flange width:

Top Flange Width	Digits in Beam Depth	Digits in Designation	Example
48	4	6	3331.5
42	5	7	3331.25
36	2	4	3331

The beam designation is a 7-character text string for Type F and Type D NEXT Beams that identifies the standard PennDOT beams listed in the BD Standards. The designation combines the text "NEXT", the beam depth (D) dimension, and either character "F" or "D" to uniquely identify each standard beam. For example, the beam designation for a 28" deep Type F NEXT beam is "NEXT28F". The beam designation for a 40" deep Type D NEXT beam is "NEXT40D".

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6.21.12 D1

NEXT Beams

For NEXT Beams dimension D1 defines the location of the last strand row and is intended to be located in the top flange of the NEXT Beam. For standard PennDOT beams listed in the BD Standards this is the sixth row of strands and has a maximum of four strands (two above each stem). For design runs, Type F NEXT Beams only, the program will consider either four strands or zero strands in this row to ensure the strand pattern is symmetrical.

If the strand configuration does not include strands located in the top flange refer to the strand configuration commands (SCD for design or SCA for analysis) for specific input instructions.

Other Beam Types

For other beam types, refer to Figures 5.21-1 to 5.21-3 and 5.21-5 to 5.21-13 for location of the D1 dimension.

6.21.16 Area Beam Long. Steel Positive

This parameter is used to define the mild steel in the positive moment region of the girder, as presented in LRFD Specifications Article 5.7.3.4.2. The program uses this parameter to compute the shear capacity of the girder. The effective steel area is computed using the following equation:

$$A'_s = A_s \left[\text{Minimum} \left[\left(\frac{X_{anal}}{L_d} \right), 1.0 \right] \right]$$

Where A'_s equals the effective area of mild steel, A_s equals the area of mild steel on the tension side of the member, X_{anal} equals the distance from the end of the beam to the analysis point, and L_d equals the mild steel development length.

6.21.17 Area Beam Long. Steel Negative

This parameter is used to define the mild steel in the negative moment region of the girder. For additional information about the use of this parameter and about the computation of the effective steel area, refer to Section 6.21.16.

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6.21.18 Positive Steel CGS

This parameter is used to compute the girder shear depth, d_v , in the positive moment region of the girder, as presented in LRFD Specifications Article 5.7.2.6. The program uses this parameter to compute the shear capacity of the girder.

6.21.19 Negative Steel CGS

This parameter is used to compute the girder shear depth, d_v , in the negative moment region of the girder, as presented in LRFD Specifications Article 5.7.2.6. The program uses this parameter to compute the shear capacity of the girder.

6.21.20 Beam Bar Number Positive

This parameter is used to compute the development length, L_d , of the mild steel in the positive moment region of the girder, as presented in LRFD Specifications Article 5.10.8.2.1.

6.21.21 Beam Bar Number Negative

This parameter is used to compute the development length, L_d , of the mild steel in the negative moment region of the girder, as presented in LRFD Specifications Article 5.10.8.2.1.

Chapter 6 Detailed Input Description

6.22 SCD – STRAND CONFIGURATION FOR DESIGN COMMAND

6.22.7 Minimum Distance To Top

For draped strand design where a beam notch is present, the Standard Drawings BD-661M and BD-662M should be reviewed to determine the depth of any beam notch. Since the final beam designation has not been determined at this point, use the calculated beam notch plus 2 inches for the largest beam expected from the design. Once the initial design is complete, recalculate the beam notch depth for the initially designed beam, add 2 inches and run the design once more to ensure the correct beam notch is used for the final design.

Chapter 6 Detailed Input Description

6.25 STI - STIRRUP COMMAND

6.25.4 Stirrup Spacing

Presented in Figure 1 is an example of a 3-span bridge with each span having the same stirrup spacing used to resist the vertical shear and the horizontal shear. The simple span length is the same for each span, but the continuous span lengths differ for the end spans and the center span.

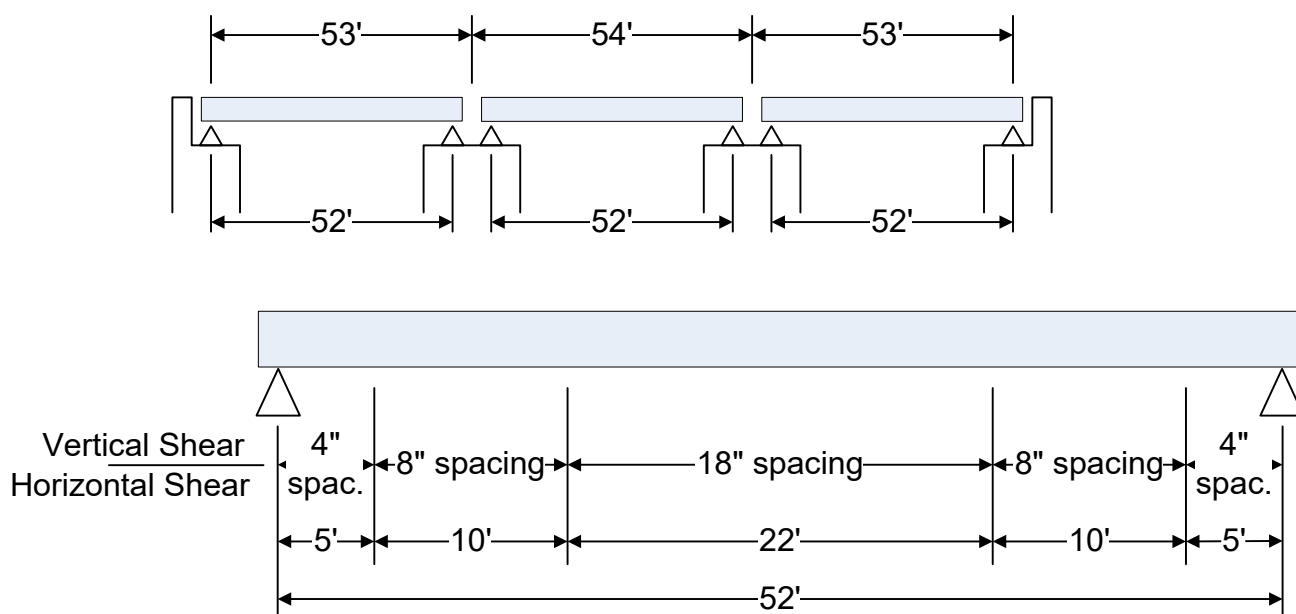


Figure 6.25-1 Example of Stirrup Spacings

For this example, the STI commands are entered as follows:

```
STI 1, 0, .4, 4, .4, 4, 5, .4, 8, .4, 8, 15, .4, 18, .4, 18
STI 2, 1, .4, 4, .4, 4, 6, .4, 8, .4, 8, 16, .4, 18, .4, 18
STI 3, 1, .4, 4, .4, 4, 6, .4, 8, .4, 8, 16, .4, 18, .4, 18
```

This STI commands shows stirrup locations of 0, 5, and 15, with corresponding stirrup spacings of 4, 8, and 18 for the first span. The stirrup locations for span 2 and span 3 are 1, 6 and 16 with corresponding stirrup spacings of 4, 8 and 18. All shear reinforcement areas are 0.4.

6.26 DBS - DEBONDED STRANDS COMMAND

The DBS command is used to specify the configuration of debonded strands used in the beam. This command is used to specify crack control debonding for a straight (fully bonded) strand problem, and crack control or normal debonding for a draped strand problem. For a debonded strand analysis problem, this command is used to specify all the debonded strands in the beam, including both the typical debonded strands and the crack control debonding (if any). Presented in Figure 1 is an example of a debonded strand problem girder. Both the midspan strand pattern and the debonded strand pattern are shown in the figure.

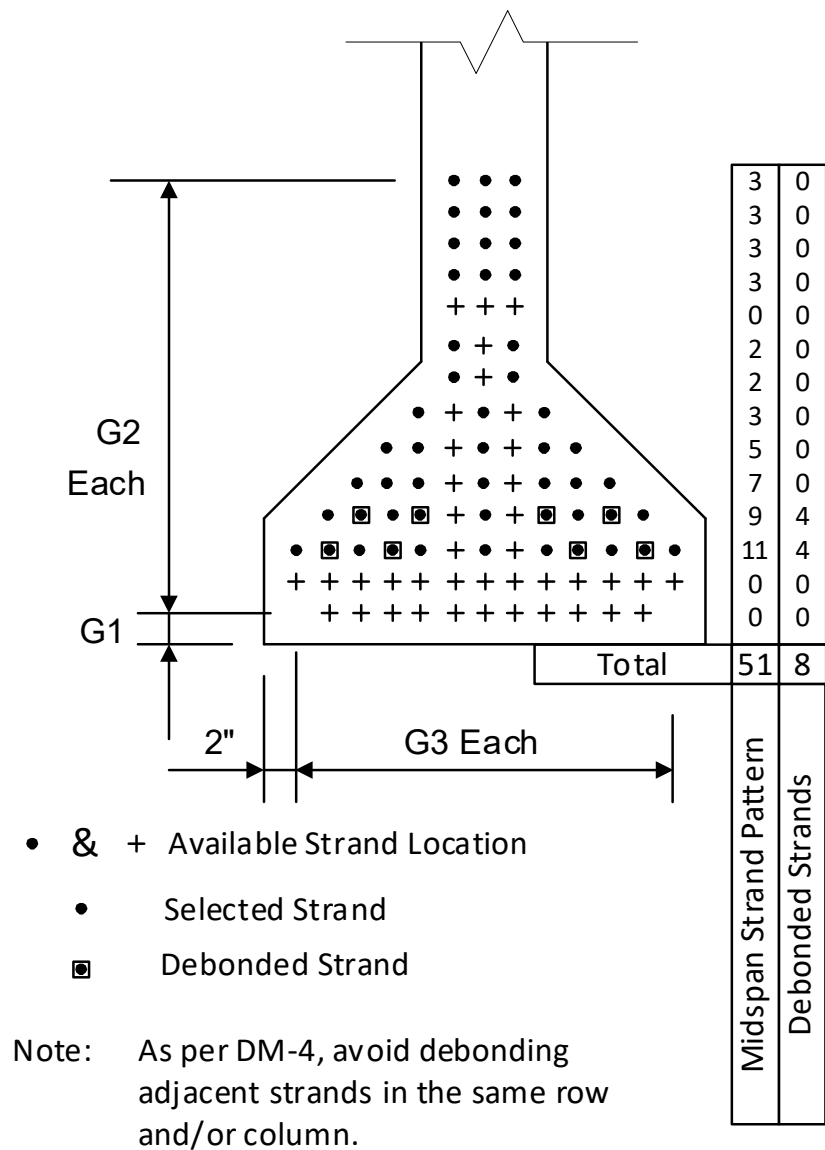


Figure 6.26-1 Example of a Debonded Strand Configuration

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For this example, the DBS command is entered as follows:

```
DBS 1, 2.99, 3, 2, 4, 4
```

```
DBS 1, 4.0, 3, 2
```

These DBS commands indicate that, at location 2.99 in Span 1, two strands are debonded in row 3 and four strands are debonded in row 4. Note that parameters 3 and 4 of this command are repeatable. At location 4.0 in Span 1, two strands are debonded in row number 3. Therefore, the cumulative total for debonded strands at the end of the beam is four in row 3 and four in row 4.

An input check is made to verify the strands are debonded symmetrically about the vertical centerline of the cross section. The check looks for an odd number of strands being debonded in a row with an even number of bonded strands. If the debonding is unsymmetrical, a warning message is printed. Also, a check is made to verify adjacent strands in the same row and/or column are not debonded and a warning message is printed if found.

Chapter 6 Detailed Input Description

6.27 SLB - SLAB COMMAND

6.27.2 Effective Slab Thickness

The effective slab thickness is illustrated in Figure 1. If the effective slab thickness is not input, the program computes the effective slab thickness based on the following equations:

$$t_{s,eff} = t_s - 0.5 \text{ inches}$$

Where $t_{s,eff}$ is the effective slab thickness, t_s is the actual slab thickness, and 0.5 inches is the assumed integral wearing surface thickness.

The program uses the actual slab thickness in all dead load calculations. The program uses the effective slab thickness in all section property calculations.

Since integral wearing surfaces and overlays are included in the dead load calculations but generally are not included in the section property calculations, the user should subtract the thickness of integral wearing surfaces and overlays when computing the effective slab thickness.

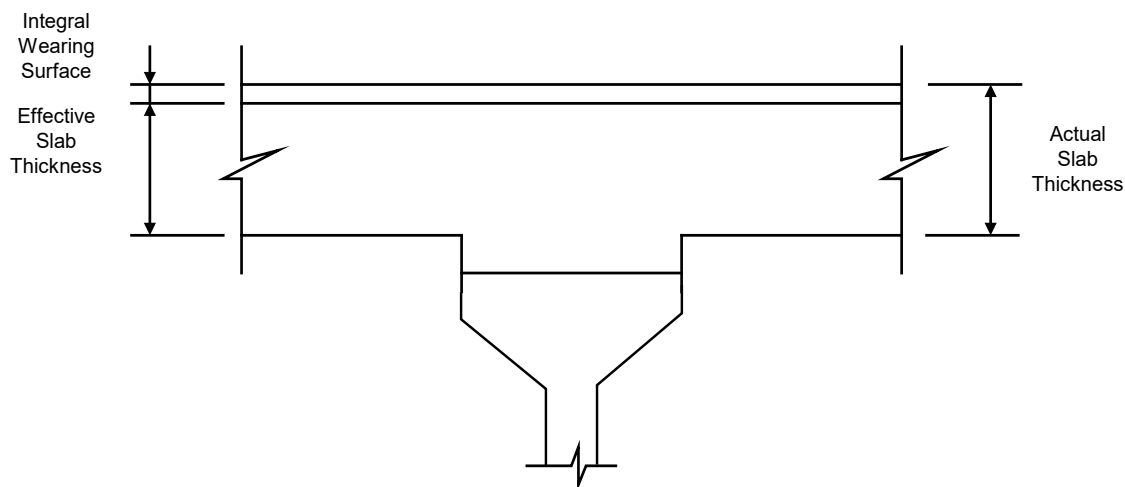


Figure 6.27-1 Effective Slab Thickness

6.27.3 Haunch Depth for Dead Load

This parameter is used to compute the haunch weight for both design and analysis runs.

6.27.8 Slab Reinforcement Strength

The value entered for this parameter corresponds with the value entered in the SST command, parameter 5, for the area of steel per effective slab width.

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This parameter is used to calculate the negative moment capacity in the negative moment region, as well as to calculate the shear depth, d_v , in the negative moment region. Therefore, this parameter applies to continuous girders only and is not required for simple span girders.

6.27.9 Slab Reinforcement CGS

The value entered for this parameter corresponds with the value entered in the SST command, parameter 5, for the area of steel per effective slab width. It is based on both the top and bottom steel reinforcement mats within the effective slab width.

This parameter is used to calculate the negative moment capacity in the negative moment region, as well as to calculate the shear depth, d_v , in the negative moment region. Therefore, this parameter applies to continuous girders only and is not required for simple span girders.

6.27.10 Slab Reinforcement Area

The value entered for this parameter represents the total area per unit width of the slab of the longitudinal temperature (top) and the longitudinal distribution (bottom) slab reinforcement required for the positive moment region of the span. This reinforcement is used to compute the negative flexural resistance at any location outside of the ranges defined in the SST command. Negative moment connection reinforcement (defined by the SST command) is typically stopped at the dead load contraflexure points, but negative factored moments can exist beyond the inflection points. This parameter allows a negative moment resistance to be computed at these locations based on the standard slab reinforcement (refer to BD-601, S4 and S3 bars). In addition, if the area of slab reinforcement, entered here, is greater than the total effective area of negative moment connection reinforcement from the SST command at a particular analysis, this area will be used to compute the negative flexural resistance.

6.27.12 Haunch Depth for Section Properties

This parameter is used to determine the separation between the slab and the top of the beam for computing composite section properties including the haunch area. For design-run composite section property calculations, the program assumes that the bottom of the deck sits directly on the beam and the haunch area is not included. Any greater than zero haunch value will be set to zero.

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6.28 DIA - DIAPHRAGM DETAILS COMMAND

6.28.3 Exterior / Interior

Exterior diaphragms are located external to the beam cross section and between girders. Interior diaphragms are located internal to the beam cross section for box beams. For NEXT beams interior diaphragms are located between the stems of the beam cross section. I-beam cross sections cannot have interior diaphragms. Refer to Figures 6.28-1 through 6.28-3 for typical interior and exterior diaphragm locations.

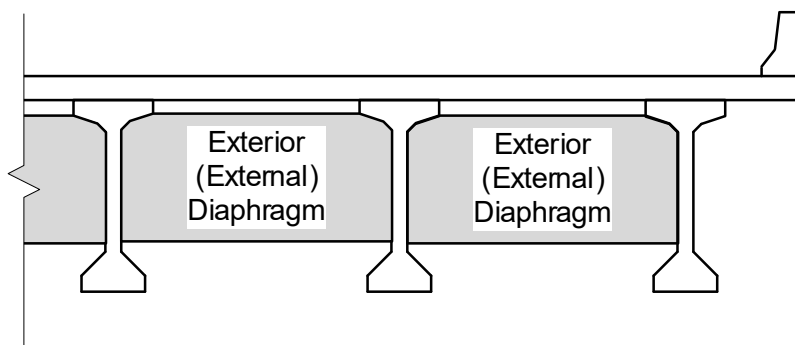


Figure 6.28-1 Typical Diaphragms for I-beams

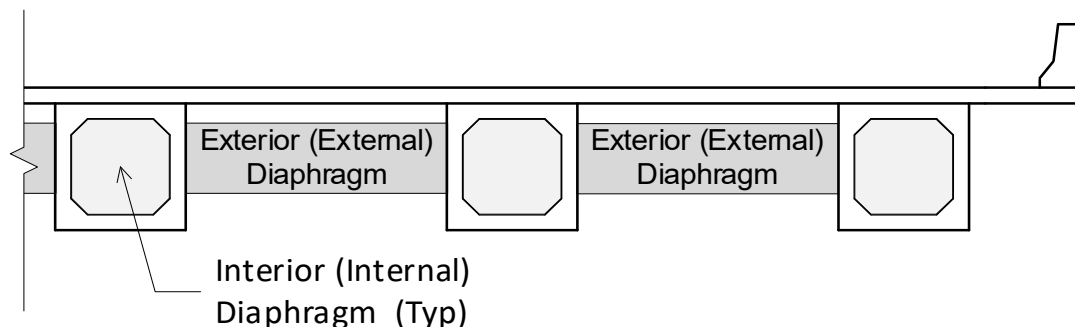


Figure 6.28-2 Typical Diaphragms for Spread Boxes

6.28.5 Thickness

The diaphragm thickness is used to compute the weight of the diaphragm to be applied to the girder. The program uses this parameter only if parameter 4 (weight) is left blank.

For I-beams, bulb-tee beams, and spread box beams, this thickness is used to compute the weight of exterior diaphragms, assuming an intermediate diaphragm spanning from beam to beam and having a depth equal to the beam depth minus standard distances from the top and bottom of the beam. The weight of exterior diaphragms placed at or near supports is computed as intermediate diaphragms. For exterior beams half of the computed exterior diaphragm weight is used since the diaphragm is only on one side of

Chapter 6 Detailed Input Description

the beam. Exterior diaphragms at or near supports are placed along the skew of the support. Exterior diaphragms not near supports are placed along the average skew of the left and right supports when the average skew is between 90 and 75 degrees; otherwise, the exterior diaphragms are placed perpendicular to the beams. In addition, for box beams, this thickness is also used to compute the weight of interior diaphragms placed perpendicular to the beam.

For NEXT beams intermediate diaphragms are not required. The thickness is used to compute the weight of exterior end diaphragms assuming a width, W_E , spanning from one beam stem to the adjacent beam stem along the skew. The depth, D , of the diaphragm is equal to the beam depth minus the top flange thickness. Fillets and chamfers are ignored when computing the diaphragm weight. The thickness is also used to compute the weight of interior end diaphragms assuming a width, W_I , spanning between the stems of the NEXT beam along the skew.

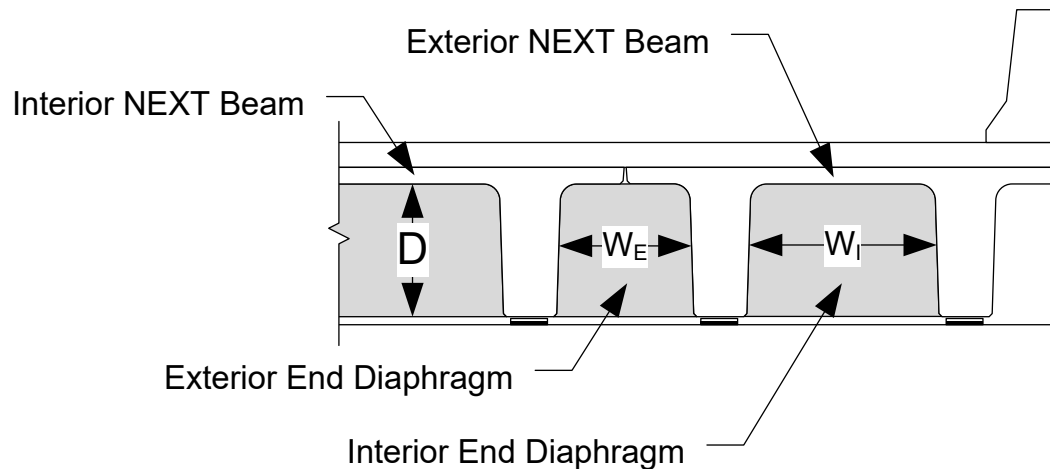


Figure 6.28-3 NEXT Beam Bridge Section at Ends

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6.30 TND - TENDON LOCATION COMMAND

6.30.3 Tendon Longitudinal Location 1

The first tendon can control the End Block Length for some geometry configurations. The void in the adjacent box is located 6" from the center line of the tendon based on BC-775M Sheet 2, Detail A. The center line of the tendon needs to be located to clear the cheekwall for U-wing abutments (or the abutment corner for flared wing walls). The cheekwall and abutment corner are typically located flush with the front face of the abutment. This would require the center line of the tendon to be beyond the front face of the abutment enough to allow placement and tensioning of the tendon.

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6.31 PLD - PEDESTRIAN LIVE LOAD COMMAND

The parameters entered on this command are used in the computations for limit states Strength IP, Service IP, Service IIIP, and Deflection. They do not affect any other limit state in any way. Pedestrian live load and vehicular live load are combined in accordance with the load factors for limit states Strength IP, Service IP, Service IIIP and Deflection, as presented in Table 3.2-2.

The program can analyze or design a cross section with a sidewalk on the left side, a sidewalk on the right side, or a sidewalk on both sides. All values on this command are entered in units of kip/ft in the longitudinal direction.

6.31.1 Total Pedestrian Live Load

This parameter is entered in units of kip/ft acting on all girders in the structure cross section. Therefore, the user must convert the total load from ksf to kip/ft.

If two sidewalks are present, this parameter should include the effects of the loads from both sidewalks. The only difference between this parameter and parameter 2 is that this parameter is the total load acting on all girders and parameter 2 is the load acting only on the girder being investigated.

The program uses this parameter to compute the live load deflection for pedestrian live load, which is distributed equally to all girders. The live load deflection check for pedestrian live load is based on the following equation:

$$\frac{L}{1000} \geq \left(\frac{\Delta_{pedestrian}}{Number\ of\ Beams} + \frac{\Delta_{vehicle}(Number\ of\ Lanes\ with\ SW)}{Number\ of\ Beams} \right) \times MPFactor_{including\ sidewalks} \times MPAFactor$$

where:

L	=	span length
$\Delta_{pedestrian}$	=	total deflection due to pedestrian live load acting on all beams in the structure cross section
$Number\ of\ Beams$	=	total number of beams for the structure cross section
$\Delta_{vehicle}$	=	total deflection due to one lane of vehicular live load
$Number\ of\ Lanes\ with\ SW$	=	total number of lanes of vehicular live load, assuming the sidewalks are present
$MPFactor_{including\ sidewalks}$	=	Multiple Presence Factor as per LRFD Specifications Table 3.6.1.1.2-1 based on the number of loaded lanes counting pedestrian loads as one loaded lane
$MPAFactor$	=	Multiple Presence Adjustment Factor as per LRFD Specifications Article C3.6.1.1.2

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In the above formula, the program sets the vehicular deflection distribution factor with sidewalks equal to (Number of Lanes with Sidewalks) / (Number of Beams) x Multiple Presence Factor x Multiple Presence Adjustment Factor. However, the user can enter a different vehicular deflection distribution factor with sidewalks to be used for the live load deflection check. See Section 5.7, GEO command, parameter 7.

The program does not use this parameter for any computations other than the live load deflections and rotations for pedestrian live load. All other pedestrian live load computations are based on the value entered in parameter 2.

6.31.2 Pedestrian Live Load

This parameter is entered in units of kip/ft acting on the girder. Therefore, the user must convert the load from ksf to kip/ft. In addition, the user must compute the portion of the total kip/ft that is carried by the girder being analyzed in accordance with the LRFD Specifications and DM-4 Article 3.5.1.1P and Article 3.6.1.6.

The only difference between this parameter and parameter 1 is that this parameter is the load acting only on the girder being investigated and parameter 1 is the total load acting on all girders.

The program uses this parameter for all pedestrian live load computations except the pedestrian live load deflections and rotations, which are based on the value entered in parameter 1.

The program factors this value using the γ_{PL} load factors, as presented in Table 3.2-2.

6.31.3 Sidewalk Dead Load

The sidewalk dead load is defined as the **difference between the DC2 dead load with sidewalks minus the DC2 dead load without the sidewalks for the girder being analyzed**. Therefore, the value for this parameter must include parapets or railings if they are present when the sidewalk is present and are not present when the sidewalk is not present. For the cross section illustrated in Figure 1, the sidewalk dead load includes **either the raised sidewalk and railing on the right side or the alternate sidewalk and vertical wall concrete barrier on the left side minus the F-shape barrier**.

This parameter is entered in units of kip/ft acting on the girder. In addition, the user must compute the portion of the total kip/ft that is carried by the girder being analyzed in accordance with the LRFD Specifications and DM-4 Article 3.5.1.1P and Article 3.6.1.6.

The program factors this value using the γ_{DC} load factors, as presented in Table 3.2-2.

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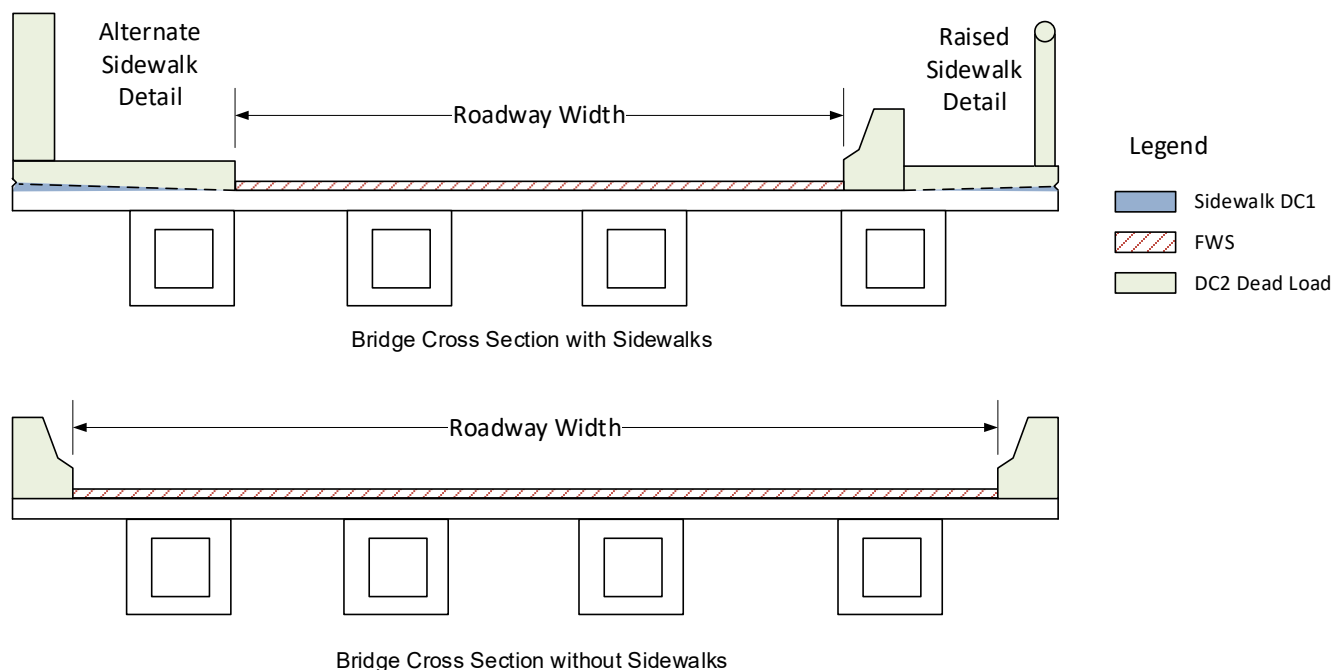


Figure 6.31-1 Sidewalk Loads

6.31.4 Additional Future Wearing Surface Dead Load

The additional future wearing surface dead load is defined **as the difference between** the future wearing surface dead load **with** sidewalks **minus the future wearing surface without** sidewalks. Since the total future wearing surface dead load usually decreases when the sidewalks are present, a negative value will usually be entered. For the cross section illustrated in Figure 1, a negative value should be entered for the additional future wearing surface dead load.

This parameter is entered in units of kip/ft acting on the girder. Therefore, the user must convert the load from ksf to kip/ft. In addition, the user must compute the portion of the total kip/ft that is carried by the girder being analyzed in accordance with the LRFD Specification and DM-4 Article 3.5.1.1P and Article 3.6.1.6.

The program factors this value using the γ_{DW} load factors, as presented in Table 3.2-2.

6.31.5 Additional DC1 Dead Load

For the typical sidewalk detail (as shown on BD-601M sheet 4 of 12) the Additional DC1 Dead Load would be zero. This parameter is entered using units of kip/ft acting on the girder. For the raised sidewalk detail and the alternate sidewalk detail (as shown on BD-601M sheet 4 of 12) the Additional DC1 Dead Load would include the extra 2-inch deck slab thickness at the deck edge.

The program factors this value using the γ_{DC} load factors, as presented in Table 3.2-2.

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6.34 DLD – DISTRIBUTED LOAD COMMAND

6.34.6 Start Magnitude

This parameter is used to enter the uniform dead load from formwork (pans and accessories) and/or additional concrete weight due to camber acting on the basic beam section. Additional information follows for specific beam types.

Interior Beams:

I-beam	UDLF = 0.015 * SPA kips/ft
Spread Box	UDLF = 0.015 * SPA kips/ft
Adjacent Box	UDLF = 0.006 * SPA kips/ft

Where:

SPA = Girder spacing (parameter 1 of GEO Command) – feet.

Adjustments may be made when using closed valley forms (consult manufacturer).

For a more accurate approximation for an interior beam UDLF load, use the following calculations:

$$UDLF = WT1 + WT2 \text{ kips/ft}$$

Where:

$$WT1 = \frac{1}{3} \left[\frac{C}{12} \right] \left[\frac{W2}{12} \right] Ws \quad (\text{Additional concrete due to camber})$$

$$WT2 = \left[SPA - \frac{W2}{12} \right] WTF \quad (\text{Weight of permanent formwork})$$

Where:

- C = Final camber – inches.
- W2 = Top flange width – inches.
- Ws = Unit weight of slab concrete – kips/ft³.
- SPA = Girder spacing (parameter 1 of GEO Command) – feet.
- WTF = Weight of permanent formwork – kips/ft². Use 0.015 kips/ft². For closed valley forms, 0.005 kips/ft² may be used.

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Exterior Beams:

$$UDLF = WT1 + WT2 + WT3 \quad \text{kips/ft}$$

Where:

$$WT1 = \left[\frac{1+C+T4}{12} \right] \left[\delta - \frac{W2}{24} \right] Ws \quad \text{(Additional overhang thickness)}$$

$$WT2 = \frac{1}{3} \left[\frac{C}{12} \right] \left[\frac{W2}{12} \right] Ws \quad \text{(Additional concrete due to camber)}$$

$$WT3 = \left[\frac{SPA}{2} - \frac{W2}{24} \right] WTF \quad \text{(Weight of permanent formwork)}$$

Where:

- C = Final camber – inches.
- T4 = Haunch thickness – inches.
- δ = Parapet overhang, measured from centerline of fascia beam to outside of parapet – feet.
- W2 = Top flange width – inches.
- Ws = Unit weight of slab concrete – kips/ft³.
- SPA = Girder spacing (parameter 1 of GEO Command) – feet.
- WTF = Weight of permanent formwork – kips/ft². Use 0.015 kips/ft². For closed valley forms, 0.005 kips/ft² may be used.

Adjacent non-composite box beams only:

Determine the UDLF by using the above procedures. Before entering this value, add the effect of loads due to curb, parapet, railing, etc., and bituminous surface.

For 3 and 4 foot beams, distribute the load due to curb, parapet, railing, etc., to the fascia and first interior beam.

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6.37 OVH - OVERHANG COMMAND

For a detailed description of the maximum parapet overhang, including the maximum parapet overhang equation, the engineering logic behind the derivation of the equation, the limitations for the use of the equation, and the use of each of the input parameters in the equation, refer to Section 3.18.

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6.39 GSC – GIRDER STABILITY CHECKS COMMAND

When a girder becomes very long and slender, the potential increases for the girder to be unstable during lifting of the girder. Most of the criteria affecting the stability of the girder will be unknown during the design of the girder. Initial checks of girder stability will need to be based on assumptions and prior experience for typical values of the required input parameters.

A conservative approach would be to use fabrication tolerances upper limits with other input parameters taken at values (maximum or minimum) that decreases the stability of the girder. If the girder passes all the checks assuming conservative values, then stability is not likely an issue for the girder. If the girder does not pass all the checks, then selectively change some of the values to typical values based on similar projects and experience until the girder passes all checks.

6.39.2 Overhang Distance

The overhang distance can be as long as two times the depth of the member. This reduces the dead load at midspan and increases the cantilever stresses at the lifting loops. To help reduce the tensile stresses at the top flange and compressive stresses at the bottom flange, temporary prestressing may be required in the top flange.

Note: If temporary strands are required in the top flange, they are debonded the full length of the strand except for 10 to 15 ft from each end of the girder. Analyzing this type of temporary strand is beyond the capabilities of PSLRFD.

6.39.3 Cable Angle

When using a single crane, the crane hook is attached to the girder with two wire rope slings. These are then further divided into four slings at the girder. The angle of these slings induces significant longitudinal forces through the lifting loops as shown in Figure 6.39-1. This figure also illustrates how the use of a spreader beam can be used to eliminate the horizontal forces. If a spreader beam is used, then the Cable Angle should be entered as 90 degrees.

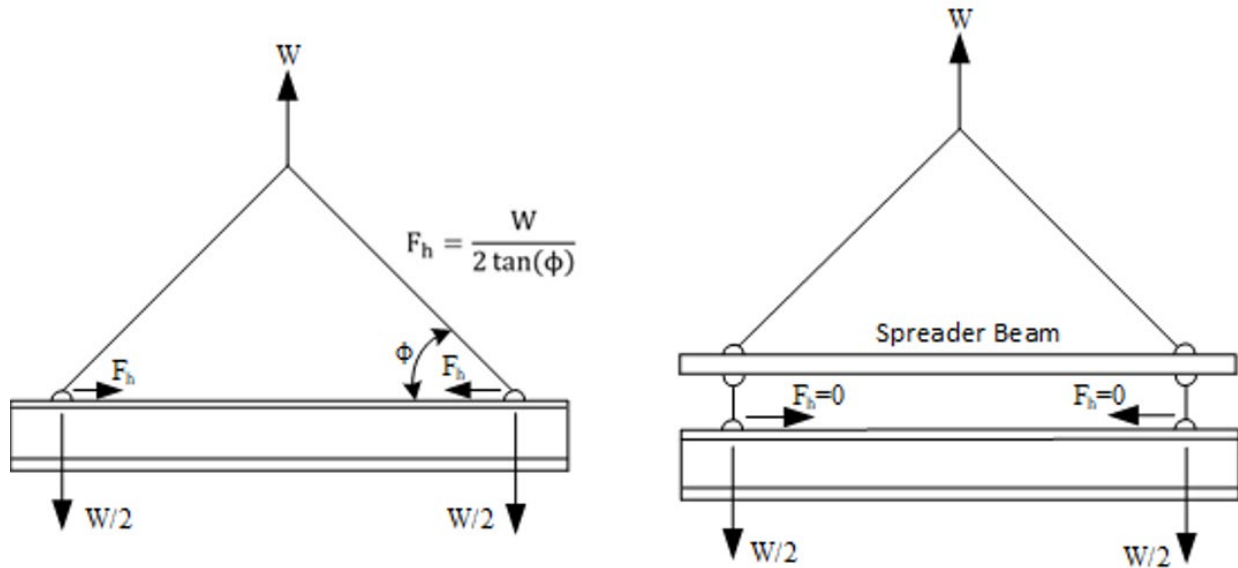


Figure 6.39-1 Horizontal Forces Developed During Single Crane Lift

6.39.4 Wind Pressure

A girder lift is done during low wind velocity conditions. This results in wind pressures significantly lower than typical wind pressures used to design the structure. Two criteria are used to specify wind velocity:

- Fastest-mile wind velocity is the average wind velocity of a volume of air travelling one mile. AASHTO LRFD Bridge Design Specifications prior to the 2016 Interim Revisions to the Seventh Edition specify fastest-mile wind velocity.
- Three-second gust wind velocity is the average wind velocity of a volume of air during a 3-second interval. The U. S. Weather Service now records wind velocity using 3-second gust wind velocity.

The equations for developing wind pressures from these two wind velocity criteria are significantly different. Provisions in these standards should not be mixed. The PCI document, *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*, uses the 2016 Interim Revisions to the Seventh Edition of AASHTO LRFD Bridge Design Specifications to determine the wind pressure.

Typically, lifting operations are curtailed when wind velocity during the lift is expected to exceed 20 to 25 miles per hour (3-second gust).

The wind pressures are calculated in accordance with the following formulas.

$$q_{wind} = 0.00256 K_z G C_d (V_m V)^2$$

Where

q_{wind} = wind pressure in psf

K_z = velocity pressure exposure coefficient

G = gust effect factor

C_d = pressure (drag) coefficient

V_m = velocity modification factor

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V = basic wind velocity in miles per hour (3-second gust)

$$f = \pi^2 \sqrt{\frac{EI_y}{\frac{w}{g} L^4}} = \text{girder lateral natural frequency}$$

Where

E = modulus of elasticity

I_y = lateral moment of inertia of the girder

w = unit weight

g = gravitational acceleration

L = girder span length

Girders during erection have changing orientations that negate the reduction due to the lower probability of wind direction being in the critical direction. In these cases, the directionality factor should be assumed as 1.0.

Drag coefficients for individual girders and erected girder groups without concrete deck are significantly higher than those for a complete bridge. According to the PCI document, the Florida Department of Transportation has undertaken a significant amount of research to establish the following guidance for horizontal drag:

$$C_d = 2.2 \text{ for I-shaped girders with no deck forms in place}$$

The gust effect factor is a function of the size and dynamic characteristics of the structure including the natural frequency of the girder. The PCI document uses 1.0 when the natural frequency is greater than 1 Hz.

Values of the velocity pressure exposure coefficient are tabulated in AASHTO LRFD Table C3.8.1.2.1-1 for various structure height and wind exposure categories.

The velocity modification factor depends on the duration of the exposure during construction with an upper limit of 1.0.

A typical basic wind velocity would be in the range of 20 to 25 mph.

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6.42 OIN - OUTPUT OF INPUT DATA COMMAND

A summary of the defaults for this command is presented in Table 1. Also presented in Table 1 is a list of the output tables printed with each parameter.

Table 6.42-1 Summary of Defaults for OIN Command

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Input File Echo	INPUT DATA FILE ECHO	0	0
2. Input Commands	COMMAND LINE INPUT	0	0
3. Input Summary	CONTROL PARAMETERS BEAM GEOMETRY BEAM GEOMETRY (SIDEWALK) COMPUTED DISTRIBUTION FACTORS COMPUTED DISTRIBUTION FACTORS (SIDEWALK) SPAN SPECIFIC INPUT SPAN LENGTHS SUPPORT INFORMATION BEAM CONCRETE MATERIAL PROPERTIES CONCRETE MATERIAL PROPERTIES (ALL GIRDERS) PRESTRESSING STEEL MATERIAL PROPERTIES MILD STEEL MATERIAL PROPERTIES DESIGN PARAMETERS STRAND DIMENSIONS SLAB PROPERTIES DIAPHRAGM DETAILS DRAPE POINT LOCATION PEDESTRIAN LOAD STIRRUP LOCATIONS SPECIAL LIVE LOAD SPECIAL AXLE LOAD OVERHANG	1	1

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6.43 OAN - OUTPUT OF ANALYSIS RESULTS COMMAND

The defaults for this command are dependent on whether an analysis or design run is being generated. A summary of the defaults is presented in Table 1. Also presented in Table 1 is a list of the output tables printed with each parameter. For parameters 11 and 12, live loadings specified on the CTL command are printed in the output. If a live loading is not specified on the CTL command, its live load effects are not printed in the output.

Table 6.43-1 Summary of Defaults for OAN Command

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Section Properties	EFFECTIVE SLAB DIMENSIONS SECTION PROPERTIES (BASIC BEAM, GROSS SECTION) SECTION PROPERTIES (COMPOSITE BEAM, GROSS SECTION) SECTION PROPERTIES (COMPOSITE BEAM, TRANSFORMED SECTION) ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (1 OF 2) ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (2 OF 2) INTERIOR BEAM SECTION PROPERTIES FOR DISTRIBUTION FACTOR MODULUS OF ELASTICITY MODULAR RATIOS MISCELLANEOUS STRESSES BEAM DESIGNATIONS PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3) PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3) PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)	1	1
2. Analysis Points	SPAN DISTANCE PRESENTED IN OUTPUT TABLES	1	1
3. Distribution Factor	COMPUTED DISTRIBUTION FACTORS - DESIGN LIVE LOAD (LANE FRACTION, INCL. SKEW) COMPUTED DISTRIBUTION FACTORS - FATIGUE LOAD (LANE FRACTION, INCL. SKEW) COMPUTED DISTRIBUTION FACTORS WITH SIDEWALKS (LANE FRACTION, INCL. SKEW) USER INPUT DISTRIBUTION FACTORS - DESIGN LIVE LOAD (LANE FRACTION, INCL. SKEW) USER INPUT DISTRIBUTION FACTORS - FATIGUE LOAD (LANE FRACTION, INCL. SKEW) USER INPUT DISTRIBUTION FACTORS WITH SIDEWALKS (LANE FRACTION, INCL. SKEW) DISTRIBUTION FACTORS FOR REACTIONS DISTRIBUTION FACTORS FOR REACTIONS WITH SIDEWALKS	1	1

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Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
3. Distribution Factor (Cont.)	The following output tables only apply to NEXT beams and print when the entered value is greater than 1. COMPUTED DISTRIBUTION FACTORS - INTERIOR MOMENT (LANES/BEAM) COMPUTED DISTRIBUTION FACTORS - INTERIOR SHEAR (LANES/BEAM) COMPUTED DISTRIBUTION FACTORS - EXTERIOR MOMENT (LANES/BEAM) COMPUTED DISTRIBUTION FACTORS - EXTERIOR SHEAR (LANES/BEAM)		
4. Points of Contraflexure	POINTS OF CONTRAFLEXURE	0 [^]	0 [^]
5. Loads and Load Modifiers	LOAD MODIFIER RESISTANCE FACTORS LOAD FACTORS AND COMBINATIONS LIVE LOADING SUMMARY (aaaaaaaa, Live Load Code: a) CONCENTRATED LOADS DISTRIBUTED LOADS CREEP AND SHRINKAGE LOADS	1 [*]	1 [*]

[^] - Defaults to 1 if the "Multi-Span Analysis Method" parameter of the CTL command is 'C'.

^{*} - Defaults to 0 if the "Output Points: parameter of the CTL command is 0.

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Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
6. Dead Load Non-composite Forces and Moments	GIRDER WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) GIRDER WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS SLAB AND HAUNCH WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) SLAB AND HAUNCH WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS INTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) INTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS EXTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) EXTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS ADDITIONAL DC1 WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) ADDITIONAL DC1 WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS MISC. NONCOMP. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) MISC. NONCOMP. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) – REACTIONS NON-COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) NON-COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) – REACTIONS NON-COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) NON-COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS	0	0
7. Total Non-composite Dead Load Forces and Moments	TOTAL NONCOMPOSITE LOAD ANALYSIS (UNFACTORED, BASIC BEAM) TOTAL NONCOMPOSITE LOAD ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS	1	1

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Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
8. Dead Load Composite Forces and Moments	DC2 WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) DC2 WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS FUTURE WEARING SURF WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) FUTURE WEARING SURF WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS MISC COMPOSITE WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) MISC COMPOSITE WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS SIDEWALK WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) SIDEWALK WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS ADDITIONAL FWS WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) ADDITIONAL FWS WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS	0	0
9. Total Composite Dead Load Forces and Moments	TOTAL COMPOSITE LOAD ANALYSIS (UNFACTORED, COMPOSITE BEAM) TOTAL COMPOSITE LOAD ANALYSIS WITH SIDEWALKS (UNFACTORED, COMPOSITE BEAM) TOTAL COMPOSITE LOAD ANALYSIS WITHOUT SIDEWALKS (UNFACTORED, COMPOSITE BEAM) TOTAL COMPOSITE LOAD ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS TOTAL COMPOSITE LOAD ANALYSIS WITH SIDEWALKS (UNFACTORED, COMPOSITE BEAM) - REACTIONS TOTAL COMPOSITE LOAD ANALYSIS WITHOUT SIDEWALKS (UNFACTORED, COMPOSITE BEAM) - REACTIONS	1	1
10. Dead Load Creep and Shrinkage Moments	CREEP AND SHRINKAGE MOMENTS BASED ON 30 DAYS CREEP AND SHRINKAGE MOMENTS BASED ON 450 DAYS	0*	0*

* - Defaults to 1 if the "Multi-Span Analysis Method" parameter of the CTL command is 'C'.

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Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
11. Live Load Effects	PHL-93 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) PHL-93 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) PHL-93 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) HL-93 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) HL-93 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) HL-93 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) P-82 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) P-82 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) P-82C LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) P-82C LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) P2016-13 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) P2016-13 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) P2016-13C LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) P2016-13C LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) ML-80 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) ML-80 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) ML-80 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) TK527 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) TK527 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) TK527 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) EV2 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) EV2 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) EV2 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) EV3 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) EV3 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) EV3 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
11. Live Load Effects (Cont.)	SU6TV LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) SU6TV LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) SU6TV LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) HS20 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) HS20 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) HS20 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) H20 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) H20 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) H20 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) FATIGUE LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) FATIGUE LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) SLL #i LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT) SLL #i LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT) SLL #i LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT) PEDESTRIAN LIVE LOAD ANALYSIS (UNFACTORED)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
12. Live Load Reactions	PHL-93 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) PHL-93 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) HL-93 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) P-82 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) P-82 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) P-82 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) P-82 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) P-82 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) P2016-13 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) P2016-13 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) P2016-13 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) P2016-13 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) P2016-13 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
12. Live Load Reactions (Cont.)	ML-80 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) ML-80 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) ML-80 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) ML-80 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) ML-80 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) ML-80 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) TK527 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) TK527 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) EV2 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) EV2 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) EV3 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) EV3 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
12. Live Load Reactions (Cont.)	SU6TV LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) SU6TV LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) HS20 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) HS20 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) H20 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) H20 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) FATIGUE LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) FATIGUE LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) FATIGUE LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) FATIGUE LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) FATIGUE LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
12. Live Load Reactions (Cont.)	SLL #i LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/O IMPACT, W/ DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS) SLL #i LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS) PEDESTRIAN LL ANALYSIS (REACTIONS)	1	1

Chapter 6 Detailed Input Description

Table 6.43-1 Summary of Defaults for OAN Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
13. HS20 Effects and Reactions	Not applicable. (This parameter allows the user to not include HS20 live load forces, moments and reactions with the output requested using parameters 11 and 12.)	0	0
14. H20 Effects and Reactions	Not applicable. (This parameter allows the user to not include H20 live load forces, moments and reactions with the output requested using parameters 11 and 12.)	0	0
15. Fatigue Effects and Reactions	Not applicable. (This parameter allows the user to not include fatigue live load forces, moments and reactions with the output requested using parameters 11 and 12.)	0	0
16. Factored Effects	FACTORED ANALYSIS RESULTS	1	1
17. Factored Reactions	FACTORED ANALYSIS RESULTS - REACTIONS	0	0
18. Overall Reaction Summary	REACTIONS & ROTATIONS PER GIRDER (UNFACTORED, w/o IMPACT, w/ DISTRIBUTION) FOR ELASTOMERIC BEARING PAD DESIGN REACTIONS & ROTATIONS PER GIRDER (UNFACTORED, w/ IMPACT, w/ DISTRIBUTION) FOR POT, STEEL OR DISC BEARING DESIGN REACTIONS (UNFACTORED) FOR ABUTMENT DESIGN REACTIONS (UNFACTORED) FOR PIER DESIGN	1	1

Chapter 6 Detailed Input Description

6.44 OSC - OUTPUT OF SPECIFICATION CHECKING COMMAND

The defaults for this command are dependent on whether an analysis or design run is being generated. A summary of the defaults is presented in Table 1. Also presented in Table 1 is a list of the output tables printed with each parameter.

Table 6.44-1 Summary of Defaults for OSC Command

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Allowable and Design Load Stresses	ALLOWABLE CONCRETE STRESSES INITIAL STRESSES AT TRANSFER OF PRESTRESS FINAL STRESSES UNDER DEAD LOAD AND PRESTRESS FINAL COMPRESSIVE STRESSES-DESIGN LOADS FINAL COMPRESSIVE STRESSES-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE) FINAL TENSILE STRESSES-DESIGN LOADS FINAL TENSILE STRESSES-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE) FINAL STRESSES IN SLAB-DESIGN LOADS FINAL STRESSES IN SLAB-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE)	1	1
2. Final Compressive Stresses LL+1/2 (DL+P/S) FAT+1/2(DL+P/S)	FINAL COMPRESSIVE STRESSES UNDER LL+1/2(DL+P/S) FINAL COMPRESSIVE STRESSES – FATIGUE-I + 1/2(DL+P/S)	0	0
3. End Block Stresses	END BLOCK STRESSES BASED ON SOLID SECTION END BLOCK STRESSES BASED ON SOLID SECTION WITH BEAM NOTCH	0	0
4. Cracking Moment	MINIMUM PRESTRESSING STEEL CHECK FLEXURAL RESISTANCE FACTORS SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (aaaaaa) CRACKING MOMENT SERVICE CHECK (aaaaaa)	1	1
5. Negative Moment Capacity	NEGATIVE MOMENT CAPACITY (aaaaaa)	1*	1*
6. Shear Reinforcement	SHEAR REINFORCEMENT AND RESISTANCE SHEAR DESIGN/ANALYSIS RESISTANCE OF LONGITUDINAL STEEL HORIZONTAL SHEAR (aaaaa) ADDITIONAL STIRRUPS REQUIRED FOR END ZONE SPLITTING STRESSES	1	1

* - Defaults to 0 for single span runs.

Chapter 6 Detailed Input Description

Table 6.44-1 Summary of Defaults for OSC Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
7. Prestressing Data	DRAPED STRAND (BEAM DESIG. <aaaaaa>) DEBONDED STRAND (BEAM DESIG. <aaaaaa>) STRAIGHT STRAND (BEAM DESIG. <aaaaaa>) USER INPUT C.G.S. PRESTRESS VALUES BASED ON LOSSES AT MIDSPAN OF SIMPLE SPAN PRESTRESS LOSS VALUES ULTIMATE MOMENT AND SERVICEABILITY CHECKS TRANSFER AND DEVELOPMENT LENGTHS	1	1
8. Fatigue Stress Range	FATIGUE STRESS RANGE IN PRESTRESSING STEEL	0	0
9. Longitudinal Slab Reinforcement	LONGITUDINAL SLAB REINFORCEMENT LOCATION LONGITUDINAL SLAB REINFORCEMENT AT CONTINUOUS SUPPORTS	1	1
10. Positive Moment Connection	POSITIVE MOMENT CONNECTION STEEL AT CONTINUOUS SUPPORT (aaaaa)	0 [^]	0 [^]
11. Overhang Width	PARAPET OVERHANG WIDTH	1	1
12. Camber and Deflection	CAMBER TO DETERMINE BRIDGE SEAT ELEVATIONS CAMBER TO CHECK A PROBABLE SAG IN BRIDGE CAMBER BASED ON ENTERED VALUE OF LOSS DEFLECTION LIMITS FOR LIVE LOAD DEFLECTION LIMITS FOR LIVE LOAD WITH PEDESTRIAN	1	1
13. Strand Code Detail Check	STRAND CODE DETAIL CHECKS AVAILABLE STRANDS PER ROW	0	1*

* - Defaults to 0 if the "Output Points" parameter of the CTL command is 0.

[^] - Defaults to 1 if the "Multi-Span Analysis Method" parameter of the CTL command is 'C'.

Chapter 6 Detailed Input Description

Table 6.44-1 Summary of Defaults for OSC Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
14. Principal Stresses	PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - PHL-93 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - HL-93 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P-82 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P-82C PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P2016-13 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P2016-13C PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - ML-80 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - TK527 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - EV2 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - EV3 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - SU6TV PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - HS20 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - H20 PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - SLL #i	0	0

Chapter 6 Detailed Input Description

Table 6.44-1 Summary of Defaults for OSC Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
14. Principal Stresses (Cont.)	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - PHL-93	0	0
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - HL-93		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - P-82		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - P-82C		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - P2016-13		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - P2016-13C		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - ML-80		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - TK527		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - EV2		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - EV3		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - SU6TV		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - HS20		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - H20		
	PRINCIPAL STRESSES - CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS - SLL #i		

Chapter 6 Detailed Input Description

Table 6.44-1 Summary of Defaults for OSC Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
15. Girder Stability Checks	HANGING GIRDER (SPAN n) FIRST GIRDER SEATED ON BEARING (SPAN n) MULTIPLE GIRDERS SEATED – INACTIVE CONSTRUCTION (SPAN n) DECK (ACTIVE) CONSTRUCTION – DECK CASTING (SPAN n)	1	1
16. Rating Vehicle Stresses	FINAL COMPRESSIVE STRESSES-aaaaaaaa FINAL COMPRESSIVE STRESSES-aaaaaaaa (INCLUDES CREEP AND SHRINKAGE) FINAL TENSILE STRESSES-aaaaaaaa FINAL TENSILE STRESSES-aaaaaaaa (INCLUDES CREEP AND SHRINKAGE) FINAL STRESSES IN SLAB-aaaaaaaa FINAL STRESSES IN SLAB-aaaaaaaa (INCLUDES CREEP AND SHRINKAGE)	1	0
17. Shear Detail	THETA & BETA VALUES – TABLE B5.2-1 DETAIL SHEAR OUTPUT – EPSILON(X) SHEAR STRESS ON CONCRETE EFFECTIVE SHEAR DEPTH	0	0

Chapter 6 Detailed Input Description

6.45 ORF - OUTPUT OF RATING FACTORS COMMAND

The defaults for this command are dependent on whether an analysis or design run is being generated. A summary of the defaults is presented in Table 1. Also presented in Table 1 is a list of the output tables printed with each parameter.

Table 6.45-1 Summary of Defaults for ORF Command

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Detailed Rating Factors	SERVICE MOMENT RATING: PHL-93 SERVICE MOMENT RATING: HL-93 SERVICE MOMENT RATING: P-82 SERVICE MOMENT RATING: P-82C SERVICE MOMENT RATING: P2016-13 SERVICE MOMENT RATING: P2016-13C SERVICE MOMENT RATING: ML-80 SERVICE MOMENT RATING: TK527 SERVICE MOMENT RATING: EV2 SERVICE MOMENT RATING: EV3 SERVICE MOMENT RATING: SU6TV SERVICE MOMENT RATING: HS20 SERVICE MOMENT RATING: H20 SERVICE MOMENT RATING: SLL #i SERVICE MOMENT RATING (CREEP AND SHRINKAGE): PHL-93 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): HL-93 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P-82 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P-82C SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P2016-13 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P2016-13C SERVICE MOMENT RATING (CREEP AND SHRINKAGE): ML-80 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): TK527 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): EV2 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): EV3 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): SU6TV SERVICE MOMENT RATING (CREEP AND SHRINKAGE): HS20 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): H20 SERVICE MOMENT RATING (CREEP AND SHRINKAGE): SLL #i	0	0

Chapter 6 Detailed Input Description

Table 6.45-1 Summary of Defaults for ORF Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Detailed Rating Factors (Cont.)	STRENGTH MOMENT RATING: PHL-93 STRENGTH MOMENT RATING: HL-93 STRENGTH MOMENT RATING: P-82 STRENGTH MOMENT RATING: P-82C STRENGTH MOMENT RATING: P2016-13 STRENGTH MOMENT RATING: P2016-13C STRENGTH MOMENT RATING: ML-80 STRENGTH MOMENT RATING: TK527 STRENGTH MOMENT RATING: EV2 STRENGTH MOMENT RATING: EV3 STRENGTH MOMENT RATING: SU6TV STRENGTH MOMENT RATING: HS20 STRENGTH MOMENT RATING: H20 STRENGTH MOMENT RATING: SLL #i STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): PHL-93 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): HL-93 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P-82 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P-82C STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P2016-13 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P2016-13C STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): ML-80 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): TK527 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): EV2 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): EV3 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): SU6TV STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): HS20 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): H20 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): SLL #i	0	0

* - Defaults to 0 if the "Output Points" parameter of the CTL command is 0.

Chapter 6 Detailed Input Description

Table 6.45-1 Summary of Defaults for ORF Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. Detailed Rating Factors (Cont.)	STRENGTH SHEAR RATING: PHL-93 STRENGTH SHEAR RATING: HL-93 STRENGTH SHEAR RATING: P-82 STRENGTH SHEAR RATING: P-82C STRENGTH SHEAR RATING: P2016-13 STRENGTH SHEAR RATING: P2016-13C STRENGTH SHEAR RATING: ML-80 STRENGTH SHEAR RATING: TK527 STRENGTH SHEAR RATING: EV2 STRENGTH SHEAR RATING: EV3 STRENGTH SHEAR RATING: SU6TV STRENGTH SHEAR RATING: HS20 STRENGTH SHEAR RATING: H20 STRENGTH SHEAR RATING: SLL #i	0	0
2. Live Loading Rating Summary	RATING SUMMARY: PHL-93 RATING SUMMARY: HL-93 RATING SUMMARY: P-82 RATING SUMMARY: P-82C RATING SUMMARY: P2016-13 RATING SUMMARY: P2016-13C RATING SUMMARY: ML-80 RATING SUMMARY: TK527 RATING SUMMARY: EV2 RATING SUMMARY: EV3 RATING SUMMARY: SU6TV RATING SUMMARY: HS20 RATING SUMMARY: H20 RATING SUMMARY: SLL #i	0	1*
3. Overall Rating Summary	RATING FACTORS - OVERALL SUMMARY BRIDGE LOAD RATINGS	1	1
4. Rating Vehicle Specification Checking	SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (ML-80:SPECIFICATION CHECK) CRACKING MOMENT SERVICE CHECK (ML-80: SPECIFICATION CHECK) HORIZONTAL SHEAR (ML-80: SPECIFICATION CHECK) NEGATIVE MOMENT CAPACITY (ML-80: SPECIFICATION CHECK) POSITIVE MOMENT CONNECTION STEEL AT CONTINUOUS SUPPORT (ML-80)	0	0

Chapter 6 Detailed Input Description

Table 6.45-1 Summary of Defaults for ORF Command (Cont.)

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
4. Rating Vehicle Specification Checking (Cont.)	SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (TK527:SPECIFICATION CHECK) CRACKING MOMENT SERVICE CHECK (TK527: SPECIFICATION CHECK) HORIZONTAL SHEAR (TK527: SPECIFICATION CHECK) NEGATIVE MOMENT CAPACITY (TK527: SPECIFICATION CHECK) POSITIVE MOMENT CONNECTION STEEL AT CONTINUOUS SUPPORT (TK527) SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (HS20:SPECIFICATION CHECK) CRACKING MOMENT SERVICE CHECK (HS20: SPECIFICATION CHECK) HORIZONTAL SHEAR (HS20: SPECIFICATION CHECK) NEGATIVE MOMENT CAPACITY (HS20: SPECIFICATION CHECK) POSITIVE MOMENT CONNECTION STEEL AT CONTINUOUS SUPPORT (HS20) SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (H20:SPECIFICATION CHECK) CRACKING MOMENT SERVICE CHECK (H20: SPECIFICATION CHECK) HORIZONTAL SHEAR (H20: SPECIFICATION CHECK) NEGATIVE MOMENT CAPACITY (H20: SPECIFICATION CHECK) POSITIVE MOMENT CONNECTION STEEL AT CONTINUOUS SUPPORT (H20)		
5. Ratings Without Future Wearing Surface	When ratings are requested for both with FWS and without FWS all tables included by parameters 1 through 3 are printed twice; once with FWS and once without FWS. See note 1. This parameter only applies to analysis runs with shear analysis (stirrups specified) and FWS loads specified.	1	0

Notes:

- Utility loads should be entered with the UT1 and UT2 load types which have the same load factors as the FWS load type.

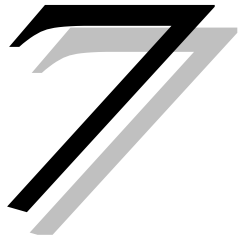
Chapter 6 Detailed Input Description

6.46 OSM - OUTPUT SUMMARY COMMAND

A summary of the defaults for this command is presented in Table 1. Also presented in Table 1 is a list of the output tables printed with each parameter.

Table 6.46-1 Summary of Defaults for OSM Command

PARAMETER	OUTPUT TABLES INCLUDED	DEFAULTS	
		ANALYSIS RUN	DESIGN RUN
1. TS&L/Design Summary	GENERAL INFORMATION COMPUTED DISTRIBUTION FACTORS COMPUTED DISTRIBUTION FACTORS (SIDEWALK) INITIAL STRESS CHECK FINAL STRESS CHECK @ MAXIMUM MOMENT	0	0
2. Q/A - Q/C Summary	QUALITY ASSURANCE/QUALITY CONTROL SUMMARY MAXIMUM MOMENTS FINAL TENSILE STRESSES IN PRECOMP. TENSILE ZONE BEAM REINFORCEMENT	0	0
3. Detailer Summary	CAMBER PRESTRESS INFORMATION SHEAR REINFORCEMENT CROSS SECTION PROPERTIES AT CENTERLINE SPAN BRIDGE LOAD RATINGS	0	0



OUTPUT DESCRIPTION

7.1 GENERAL OUTPUT INFORMATION

Information is provided for describing output table controls, page format, page numbering, and page header. In general, the page format is built into the program and cannot be changed by the user for either the .OUT output file or the .PDF output file. The one exception is that the user can specify the number of blank lines to be printed at the top of each page before the page header is printed. This formatting change will be reflected in both the .OUT and .PDF output files accordingly.

7.1.1 Output Table Controls

The output table controls are specified using a number of input commands and parameters to control which output reports will be printed. These controls are specified using five different input commands, according to which kind of output they represent. These five kinds of output are: input data, analysis results, specification checking, rating factors and summary. The commands and their defaults are discussed in Sections 6.40 through 6.44.

7.1.2 Page Format

There is a maximum of 88 columns in the output file. Column 1 has been left blank to provide a margin on the left side of the page. This has been done to make the output file less dependent on the output device capabilities. The output is therefore limited to 87 characters, column 2 to column 88. The user can specify the number of lines to be left blank at the top of the page with the CFG command.

7.1.3 Page Numbering

The program assigns page numbers and determines when a new page should begin. There are certain rules built into the program to determine when a new page should begin. The program will attempt to fit up to the number of lines specified on the CFG command on each page. Internally, the program keeps track of how many lines are left on the page and adjusts according to the number of lines in the heading of the output table and a minimum number of data lines required after the heading.

Chapter 7 Output Description

7.1.4 Page Header

After the cover page, header information is printed at the top of each page. A sample header is shown in Figure 1.

LRFD P/S Concrete Girder Design and Rating, Version 2.9.0.0	PAGE 2
Input File: EX1.DAT	10/28/2014 11:34:15

VERIFICATION EXAMPLE #1	
INPUT FILE	

Figure 7.1-1 Page Header

Information printed in the header includes:

1. Program Title, Version Number - the program name and version number is located at the top left corner of the header.
2. Page Number - the page number appears at the top right corner of the header.
3. Input File - the name of the input data file used to create this output is shown at the beginning of the second line.
4. Date and Time - the date and time of the program execution for this problem is printed at the right side of the second line.
5. A separator line is printed between program specific header information and user specified header information.
6. The next header line contains the first title line input by the user via the TTL command. This should be a general descriptive line used to describe the problem to be run.
7. The next header line contains the type of output specified by the user.
8. The final header line is another separator line.

7.1.5 Units

For each value presented in the output, the corresponding units are provided. The units are presented in the column headings directly below the column description. Presented in Table 1 is a summary of the basic units of measure used by this program.

Chapter 7 Output Description

Table 7.1-1 Units

Variable	Unit of Measure
DISTANCE ALONG SPAN	ft
MODULUS OF ELASTICITY	ksi
STRESS	ksi
EFFECTIVE SLAB DIMENSION	in
MOMENT OF INERTIA	in ⁴
DISTANCE TO NEUTRAL AXIS	in
SECTION MODULUS	in ³
BEAM DEPTH	in
AREA	in ²
WEIGHT	lbf
VOLUME	in ³ /ft
SURFACE AREA	in ² /ft
LONGITUDINAL STIFFNESS PARAMETER	in ⁴
TORSIONAL CONSTANT	in ⁴
CONCENTRATED LOAD	kips
DISTRIBUTED LOAD	kip/ft
MOMENT	k-ft
SHEAR	kips
DEFLECTION	in
REACTION	kips
ROTATION	radians
SPACING	in
FORCE	kips
STRAND SPACING	in
CAMBER AND DEFLECTION	in
OVERHANG WIDTH	ft
CONCRETE DENSITY OR UNIT WEIGHT	lbf/ft ³
GAGE DISTANCE	ft
LANE WIDTH	ft
MASS	N/A
PASSING DISTANCE	ft
RATING TONNAGE	tons
REINFORCEMENT AREA	in ² /ft

Chapter 7 Output Description

7.1.6 Sign Conventions

Presented in Table 2 is a summary of the sign conventions used by this program.

Table 7.1-2 Sign Conventions

Variable	Sign Convention
MOMENT	A moment that causes a compressive stress in the extreme top fiber of the girder is positive.
REACTION	A reaction acting in the upward direction is positive.
LOAD	A load acting in the downward direction is positive.
SHEAR	A shearing force acting downward on the right face of the free body in equilibrium is positive.
DEFLECTION	A downward deflection is positive.
AXIAL FORCE	A force causing tension is positive.
STRESS	A tensile stress is positive.
ROTATION	A counter clockwise rotation is positive. For live load maximum and minimum rotations, the maximum rotation would be the positive most rotation and the minimum rotation would be the negative most rotation.

Chapter 7 Output Description

7.2 COVER PAGE

The first page of the output is the cover page. The following information is shown at the top of the cover page:

1. Program Title - LRFD Prestressed Concrete Girder Design and Rating
2. Program Name - PSLRFD
3. Version ii.jj.kk.ll - where ii represents the numeric designation for major revisions and enhancements to the program; jj represents the numeric designation for minor revisions; non-zero kk values represent the numeric designation for test versions of the program; non-zero ll values represent the numeric designation for bug fix releases of the program.
4. Last Updated - this is the date the program was last revised.
5. Documentation - this is the date the User's Manual was last revised.
6. License Number - this is a unique number assigned to all licensees per the License Agreement.

The middle section of the cover page is reserved for the first 10 TTL commands input by the user. This information typically should describe the bridge, location, stationing, span length, type of structure, and any other information the user would need to identify the output.

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Chapter 7 Output Description

7.3 INPUT DATA OUTPUT

The input data consists of an echo of the input file, summary of input commands, and input summary tables. Each of these can individually be turned on or off. A summary of the output tables included is given in Section 6.40

7.3.1 Input File Echo

The input file echo (parameter 1) is a listing of the input commands and comments as entered by the user. The user can refer to this section to trace input errors and warnings by comparing the input data to the input descriptions provided in Chapter 5. The input file can contain 512 characters in a single line, but the output is limited to 87 characters on a single line. If the input line contains more than 87 characters, the input file echo will be wrapped to the next row. Other than this limitation, the echo of the input file should appear the same as the input data file.

7.3.2 Input Commands

This section (parameter 2) is a summary that includes a detailed description of each input parameter for all input commands entered by the user. The summary of input commands is in a vertical format. Two examples of the input commands are shown in Figure 1.

Chapter 7 Output Description

COMMAND: CTL		
SYSTEM OF UNITS	US	
DESIGN/ANALYSIS	D	
SHAPE OF BEAM	SR	
EXTERIOR/INTERIOR	I	
NUMBER OF BEAMS	5	
NUMBER OF SPANS	1	
SYMMETRY	Y	
BEAM DESIGNATION	U	
MULT. PRES. ADJ. FACTOR	1.0	(default)
LIVE LOAD	A	(default)
DYNAMIC LOAD ALLOWANCE	1.33	(default)
FATIGUE DYN. LOAD ALLOW.	1.15	(default)
PA. TRAFFIC FACTOR	*	(computed, if necessary)
STRAND TYPE	L	
P/S LOSS TYPE	LR	
PRESTRESS TRANSFER TIME	30.0	
RELATIVE HUMIDITY	70.0	(default)
COMPOSITE BEAM	Y	
SKEW OVERRIDE	N	
IMPORTANCE FACTOR	1.00	
DUCTILITY FACTOR	1.00	
REDUNDANCY FACTOR	1.00	
SHEAR DESIGN/ANALYSIS	D	(default)
SKEW ANGLE DESIGNATION	P	(default)
SHRINKAGE ONLY ANALYSIS	N	(default)
OUTPUT POINTS	2	
MULTI-SPAN ANALYSIS OPT	S	(default)
P-82 DYN. LOAD ALLOW.	1.20	(default)
DECK PLACEMENT TIME	120.0	(default)
OVERHANG-DEPTH OVERRIDE	N	(default)
COMMAND: SLB		
ACTUAL SLAB THICKNESS	8.0 in	
EFFECTIVE SLAB THICKNESS	7.5 in	
HAUNCH DEPTH FOR DL	0.5 in	
SLAB CONCRETE STRENGTH	5.0 ksi	
CONC. DENSITY FOR LOADS	150 lbf/ft ³	
CONC. DENSITY FOR E _c	150 lbf/ft ³	
SLAB CONCRETE TYPE	N	
DECK REINF. STRENGTH	60. ksi	(default)
SLAB REINFORCING CGS	7.0 in	
SLAB REINFORCING AREA	* in ² /ft	(computed, if necessary)
SLAB TRANSVERSE BAR SIZE	*	(computed, if necessary)
HAUNCH DEPTH SEC PROP.	0.0 in	

Figure 7.3-1 CTL and SLB Summary of Input Commands

The summary of input commands includes the following information:

1. Command keyword.
2. Input parameter description.
3. Value of the input parameter as entered or the default value as stored in the program. The value is displayed to the same number of significant figures as entered by the user or as stored in the input parameter file. The word (default) is placed to the right of the units when default values are used. An asterisk (*) indicates the input value is optional and was not entered.

Chapter 7 Output Description

4. Any warnings or errors encountered with respect to the input data.

Input values may be optional or required. Required input is input that is entered by the user or set to the default value stored in the program. Default values are indicated with the text (default) placed to the right of the units. If there is no default value stored in the program and the user does not enter a value, an error message is displayed.

Optional input does not need to be entered by the user. An asterisk (*) is printed for the value indicating the input value is optional. In some cases when input is not entered, the program sets the value. An example of an optional input parameter set by the program is the effective slab thickness. Some input is optional because it is not required for the particular problem being run. For example, the girder overhang is not required for an interior girder analysis. For more information regarding specific input requirements, refer to Chapter 5.

Any warnings or errors encountered while processing the input data will be reflected with the appropriate input command under the summary of input commands. If this level of input data output is turned off, the warnings will still appear, though without the added benefit of the warnings and errors being grouped with the corresponding input command. The program has almost 600 different input warning and error messages. After encountering warnings or errors, the program also prints a message to the screen advising the user to review the output file for explanations of the warnings and errors.

7.3.3 Input Summary

The input summary consists of tables that include summaries of all input parameters in horizontal tabular format. The input summary tables also include all processed input. Processed input is input that gets computed by the program based on other input items, including program set optional input values. A more complete description of all input items can be found in Chapters 5 and 6. Processed input items include the effective slab thickness and the modular ratios.

For symmetrical runs, the input ranges are mirrored to the symmetrical side of the bridge. All ranges are sorted into the correct order.

Two examples of input summary tables are shown in Figure 2.

Chapter 7 Output Description

CONTROL PARAMETERS							
Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	SPR BOX RECT	INTERIOR	5	1	YES	U
Multiple							
Presence	Live Load	Dyn. Load	Fatigue	PA	Strand	P/S	
Adj. Factor	Code	Allowance	Dyn. Load	Traffic	Type	Loss	
1.00	A	1.330	1.150	N/A	L	LR	
Prestress							
Transfer	Relative	Composite	Skew	Impor.	Duct.	Redun.	
Time	Humidity	Beam	Override	Factor	Factor	Factor	
30.00	70.00	Y	N	1.100	0.950	0.950	
Shear	Skew	Shrinkage	Multi-Span	P-82	Deck		
Design/ Analysis	Angle	Analysis	Output	Analysis	Dyn. Load	Placement	
D	Desig. P	Only N	Points 2	Method S	Allowance 1.200	Age 120.00	
Overhang to Beam Depth Override N							
SLAB PROPERTIES (1 OF 2)							
Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft ³)	Density Ec (lb/ft ³)	Haunch Depth for Section Prop (in)	
8.000	7.500	0.500	5.000	150.00	150.00	0.500	
SLAB PROPERTIES (2 OF 2)							
Slab Concrete Type	Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in ² /ft)	Transverse Reinforcement Size			
N	60.0	7.000	0.467	5			

Figure 7.3-2 CTL and SLB Input Summary Tables

The input summary tables contain the following information:

1. A description of the input data.
2. Input parameter header containing an abbreviated parameter description and units.
3. Input parameter values. The input values are shown to a fixed number of decimal places because of the tabular format. The actual input value may be rounded to fit the output format. Refer to the summary of input commands for the actual value input by the user.

Chapter 7 Output Description

7.4 ANALYSIS RESULTS OUTPUT

A summary of the output tables for each parameter is given in Section 6.4. The user can suppress all analysis output by entering zero for every analysis output parameter. These output parameters apply for both design and analysis runs.

7.4.1 Effective Slab Dimensions

This table presents the effective slab dimensions. The effective slab dimensions are constant for the entire structure. The following information is presented in this table:

1. Effective Slab Width - the effective slab width, as computed based on LRFD Specifications Article 4.6.2.6.
2. Effective Slab Thickness - the effective slab thickness, used in computing all section properties.
3. Effective Slab Haunch - the effective slab haunch thickness, used in computing all section properties.

7.4.2 Section Properties (Basic Beam, Gross Section)

This table presents gross section properties for the basic beam for each span. The following information is presented in this table:

1. Span No. - the span number for which the basic beam section properties are presented.
2. Moment of Inertia - the moment of inertia of the basic beam.
3. Dist. to Neutral Axis, Bot. of Beam - the distance from the neutral axis of the basic beam to the bottom of the beam.
4. Dist. to Neutral Axis, Top of Beam - the distance from the neutral axis of the basic beam to the top of the beam.
5. Section Modulus, Bot. of Beam - the section modulus of the basic beam at the bottom of the beam.
6. Section Modulus, Top of Beam - the section modulus of the basic beam at the top of the beam.

7.4.3 Section Properties (Composite Beam, Gross Section)

This table presents gross section properties for the composite beam within a given range. The span number and distance presented in this table correspond to the left end of the range, and all section properties are constant within that range. The following information is presented in this table:

1. Span No. - the span number in which the left end of the range is located.
2. Distance - the distance from the left end of the range to the left end of the specified span; this value is negative for Span 1 if the left end of the range is located at the beginning of the girder and if the beginning of the girder is located to the left of the centerline of bearing.

Chapter 7 Output Description

3. Moment of Inertia - the moment of inertia of the composite beam, gross section.
4. Dist. to Neutral Axis, Bot. of Beam - the distance from the neutral axis of the composite beam, gross section to the bottom of the beam.
5. Dist. to Neutral Axis, Top of Beam - the distance from the neutral axis of the composite beam, gross section to the top of the beam. A negative value indicates the neutral axis is above the top of the beam.
6. Dist. to Neutral Axis, Top of Slab - the distance from the neutral axis of the composite beam, gross section to the top of the slab.
7. Section Modulus, Bot. of Beam - the section modulus of the composite beam, gross section at the bottom of the beam.
8. Section Modulus, Top of Beam - the section modulus of the composite beam, gross section at the top of the beam. A negative value indicates the neutral axis is above the top of the beam.
9. Section Modulus, Top of Slab - the section modulus of the composite beam, gross section at the top of the slab.

7.4.4 Section Properties (Composite Beam, Transformed Section)

This table presents transformed section properties for the composite beam within a given range. The span number and distance presented in this table correspond to the left end of the range, and all section properties are constant within that range. The following information is presented in this table:

1. Span No. - the span number in which the left end of the range is located.
2. Distance - the distance from the left end of the range to the left end of the specified span; this value is negative for Span 1 if the left end of the range is located at the beginning of the girder and if the beginning of the girder is located to the left of the centerline of bearing.
3. Moment of Inertia - the moment of inertia of the composite beam, transformed section.
4. Dist. to Neutral Axis, Bot. of Beam - the distance from the neutral axis of the composite beam, transformed section to the bottom of the beam.
5. Dist. to Neutral Axis, Top of Beam - the distance from the neutral axis of the composite beam, transformed section to the top of the beam. A negative value indicates the neutral axis is above the top of the beam.
6. Dist. to Neutral Axis, Top of Slab - the distance from the neutral axis of the composite beam, transformed section to the top of the slab.
7. Section Modulus, Bot. of Beam - the section modulus of the composite beam, transformed section at the bottom of the beam.
8. Section Modulus, Top of Beam - the section modulus of the composite beam, transformed section at the top of the beam. A negative value indicates the neutral axis is above the top of the beam.
9. Section Modulus, Top of Slab - the section modulus of the composite beam, transformed section at the top of the slab.

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7.4.5 Additional Section Properties for Basic Beam (1 of 2)

This table presents additional section properties for the basic beam for each span. This table is presented only for I-beams, bulb-tee beams, NEXT beams, and adjacent plank beams. For box beams with voids, refer to Section 7.4.6. The following information is presented in this table:

1. Span No. - the span number for which the additional section properties are presented.
2. Depth - the depth of the basic beam.
3. Area Basic Beam - the area of the basic beam.
4. Weight Per Unit Length - the weight per unit length of the basic beam.
5. Volume - the volume of the basic beam.
6. Surface Area - the surface area of the basic beam.
7. Volume / Surface Area Ratio - the ratio of the volume to surface area of the basic beam.

7.4.6 Additional Section Properties for Basic Beam (1 of 2)

This table presents additional section properties for the basic beam for each span. This table is presented only for box beams with voids. For I-beams, bulb-tee beams, NEXT beams, or adjacent plank beams, refer to Section 7.4.5. The following information is presented in this table:

1. Span No. - the span number for which the additional section properties are presented.
2. Depth - the depth of the basic beam.
3. Area Basic Beam - the area of the basic beam.
4. Area w/ Addl. Conc. Around Void Perimeter - the area of the basic beam, plus the area of an additional 1/4 inch of concrete around the perimeter of the voids.
5. Weight Per Unit Length (w/ Addl. Conc.) - The weight per unit length of the basic beam, as well as an additional 1/4 inch of concrete around the perimeter of the voids.
6. Volume - the volume of the basic beam.
7. Surface Area - the surface area of the basic beam.
8. Volume / Surface Area Ratio - the ratio of the volume to surface area of the basic beam.

7.4.7 Additional Section Properties for Basic Beam (2 of 2)

This table presents additional section properties for the basic beam for each span. This table is presented for all beam types except for Type D NEXT beams. The following information is presented in this table:

1. Span No. - the span number for which the additional section properties are presented.
2. Longitud. Stiffness Parameter - the longitudinal stiffness parameter of the basic beam.
3. Torsional Constant - the St. Venant's torsional constant of the basic beam for all beam types except for composite adjacent box beams. For composite adjacent box beams, the slab is included.

Chapter 7 Output Description

4. Concrete 1/2 Area, Positive - the half-depth area of concrete containing the positive flexure tension zone.
5. Concrete 1/2 Area, Negative - the half-depth area of concrete containing the negative flexure tension zone.

7.4.8 Additional Section Properties for Basic Beam (2 of 2)

This table presents additional section properties for the basic beam for each span. This table is presented for Type D NEXT beams. The following information is presented in this table:

1. Span No. - the span number for which the additional section properties are presented.
2. Longitud. Stiffness Parameter - the longitudinal stiffness parameter of the basic beam.
3. Area Stems – the area of both stems up to the underside of the top flange.
4. Distance to Neutral Axis Top of Stem – the distance from the C.G. of the stems to the bottom of the top flange.
5. Moment of Inertia Stems – the moment of inertia of both stems up to the underside of the top flange.
6. Torsional Constant - the St. Venant's torsional constant of the basic beam for all beam types except for composite adjacent box beams. For composite adjacent box beams, the slab is included.
7. Concrete 1/2 Area, Positive - the half-depth area of concrete containing the positive flexure tension zone.
8. Concrete 1/2 Area, Negative - the half-depth area of concrete containing the negative flexure tension zone.

7.4.9 Interior Beam Section Properties for Distribution Factor

This table presents section properties for interior adjacent beams that are used to compute interior beam distribution factors. This table is presented for exterior adjacent beams. The following information is presented in this table:

1. Span No. – the span number for which the interior section properties are presented.
2. Distance – the distance from the left end of the range to the left end of the specified span.
3. Moment of Inertia – the moment of inertia of the interior composite beam.
4. Torsional Constant – the St. Venant's torsional constant for the interior composite beam.

7.4.10 Modulus of Elasticity

This table presents the moduli of elasticity for the girder concrete, slab concrete, prestressing steel, and mild steel for each span. The following information is presented in this table:

1. Span No. - the span number for which the moduli of elasticity are presented.

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2. Girder Concrete, Final, $E(c)$ - the modulus of elasticity of the girder concrete.
3. Girder Concrete, Initial, $E(ci)$ - the modulus of elasticity of the girder concrete at transfer.
4. Slab Concrete, $E(cs)$ - the modulus of elasticity of the slab concrete.
5. Prestressing Steel, $E(p)$ - the modulus of elasticity of the prestressing steel.
6. Mild Steel, $E(s)$ - the modulus of elasticity of the mild steel.

7.4.11 Modular Ratios

This table presents the various modular ratios for each span. The following information is presented in this table:

1. Span No. - the span number for which the modular ratios are presented.
2. $n(p)$ - the modular ratio of the prestressing steel to the girder concrete = $E(p)/E(c)$; this value can not be less than 2.0.
3. $n(s)$ - the modular ratio of the mild steel to the girder concrete = $E(s)/E(c)$; this value can not be less than 2.0.
4. $n(cs)$ - the modular ratio of the slab concrete to the girder concrete = $E(cs)/E(s)$.

7.4.12 Miscellaneous Stresses

This table presents miscellaneous stresses associated with the prestressing steel, the girder concrete, and the slab concrete for each span. The following information is presented in this table:

1. Span No. - the span number for which the miscellaneous stresses are presented.
2. Prestressing Steel Yield Stress, $f(py)$ - the yield stress of the prestressing steel.
3. Prestressing Steel Jacking Stress, $f(pj)$ - the jacking stress of the prestressing steel, computed as per Section 3.2.4.
4. Girder Concrete 28-Day Spec. Compr. Strength, $f'c$ - the specified compressive strength of concrete at 28 days of the girder concrete.
5. Girder Concrete Modulus of Rupture, $f(r)$ - the modulus of rupture of the girder concrete, computed as per Section 3.2.6.
6. Slab Concrete 28-Day Spec. Compr. Strength, $f'c$ - the specified compressive strength of concrete at 28 days of the slab concrete.

7.4.13 Beam Designations

This table presents the beam designations that were considered for design and that were selected for the final design. The following information is presented in this table:

Chapter 7 Output Description

1. Beam Table Designation (The following beams will be considered for design) - a list of the beam designations that the program considered during the design run.
2. The following beams were selected for this design - a summary of the beam designations, along with the corresponding span number, that were selected for this final design.

7.4.14 Prestress Concrete Beam Dimensions (Part 1 of 3)

This table presents specified beam dimensions for the designated beam in the specified span. The following information is presented in this table:

1. Span No. - the span number for which the specified prestressed concrete beam dimensions are presented.
2. Desig. - the beam designation for which the specified prestressed concrete beam dimensions are presented.
3. D - the D dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
4. W1 - the W1 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
5. W2 - the W2 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
6. W3 - the W3 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
7. T1 - the T1 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
8. T2 - the T2 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.

7.4.15 Prestress Concrete Beam Dimensions (Part 2 of 3)

This table presents specified beam dimensions for the specified span and the designated beam presented in Table 7.4.12. The following information is presented in this table:

1. Span No. - the span number for which the specified prestressed concrete beam dimensions are presented.
2. B1 - the B1 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
3. B2 - the B2 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
4. B3 - the B3 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.

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5. B4 - the B4 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
6. D1 - the D1 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
7. D2 - the D2 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
8. X1 - the X1 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.
9. X2 - the X2 dimension for the specified span and the specified beam, as shown in Figures 5.21-1 through 5.21-13.

7.4.16 Prestress Concrete Beam Dimensions (Part 3 of 3)

This table presents beam longitudinal mild steel information for the specified span and the designated beam presented in Table 7.4.12. The following information is presented in this table:

1. Span No. - the span number for which the beam longitudinal mild steel information is presented.
2. Beam Longitudinal Steel, Area, Pos. - the total area of the beam longitudinal mild steel for positive flexure.
3. Beam Longitudinal Steel, Area, Neg. - the total area of the beam longitudinal mild steel for negative flexure.
4. Beam Longitudinal Steel, CGS, Pos. - the center of gravity, measured from the bottom of the basic beam, of the total beam longitudinal mild steel for positive flexure.
5. Beam Longitudinal Steel, CGS, Neg. - the center of gravity, measured from the bottom of the basic beam, of the total beam longitudinal mild steel for negative flexure.
6. Beam Longitudinal Steel, Bar No., Pos. - the bar number of the beam longitudinal mild steel for positive flexure.
7. Beam Longitudinal Steel, Bar No., Neg. - the bar number of the beam longitudinal mild steel for negative flexure.

7.4.17 Span Distance Presented in Output Tables

This table presents the span distances for which output is presented, and it provides the significance of each span distance. In other words, it gives the reason that each output location was selected. The following information is presented in this table:

1. Span No. - the span number in which the span distance is located.
2. Distance - the distance from the left end of the span to that particular location.
3. Significance - the significance of that span distance; the following legend presents the various reasons that output locations were selected:

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TWENTH	-	twentieth point.
SMPBRG	-	simple span bearing location.
MIDSPN	-	midspan of the simple span.
TRANSF	-	prestressing transfer length.
DRAPE	-	drape point location.
EXTSUP	-	exterior or end support.
INTSUP	-	interior support.
CONCEN	-	concentrated load location.
TENTH	-	tenth points
STIRUP	-	stirrup change location

Several of the above items may be listed for one particular span distance if several items apply to that location.

7.4.18 Span Lengths and Girder Lengths

This table presents the span lengths as entered by the user and the corresponding computed simple span lengths and the overall girder lengths. The simple span length is computed by subtracting the two support distances from the input span length. The overall girder length is computed by adding twice the beam projection to the simple span length. The following information is presented in this table:

1. Span Number - the span number for which the lengths and distances are presented.
2. Input Span Length - the span length entered on the SPL Command.
3. Left Support Distance - the distance from the left simple bearing to the left continuous bearing for the left support of this span.
4. Right Support Distance - the distance from the right simple bearing to the right continuous bearing for the right support of this span.
5. Simple Span Length - the distance from the left simple bearing to the right simple bearing of this span.
6. Beam Projection - the distance from the simple bearing to the end of the beam as specified on the GEO Command.
7. Overall Girder Length - the length of the girder from the left end to the right end.

7.4.19 Computed Distribution Factors - Interior Moment (Lanes/Beam)

7.4.19.1 NEXT Beam Double-Tee Model

7.4.19.1.1 Design Live Load Moment

This table presents the computed interior moment distribution factors for the design vehicle when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as

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cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. D.Factor Interior Moment 1 Lane, $gDT(iM)^1$ - the interior moment distribution factor for one design lane loaded using the DM-4 equation.
3. D.Factor Interior Moment 2+ Lanes, $gDT(iM)^{2+}$ - the interior moment distribution factor for two or more design lanes loaded using the DM-4 equation.
4. D.Factor Interior Lever Rule 1 Lane, $gDT(iLR)^1$ - the interior moment distribution factor for one design lane loaded using the lever rule. This value is applicable when the number of beams equals three.
5. D.Factor Interior Lever Rule 2+ Lanes, $gDT(iLR)^{2+}$ - the interior moment distribution factor for two or more design lanes loaded using the lever rule. This value is applicable when the number of beams equals three.
6. Control* D.Factor Interior Moment (Nb3a3), $gDT(iM)$ - the controlling interior moment distribution factor for NEXT beams modeled as double-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.19.1.2 Fatigue Load Moment

This table presents the computed interior moment distribution factor for the fatigue load when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Control* D.Factor Fatigue Moment, $gDT(iM)^{Fat}$ - the controlling interior moment distribution factor for the fatigue load for NEXT beams modeled as double-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.19.1.3 Design Live Load Moment (w/ Sidewalks)

This table presents the computed interior moment distribution factors for the design live load with sidewalks considered when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT

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beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.19.1.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.19.2 NEXT Beam Single-Tee Model

7.4.19.2.1 Design Live Load Moment

This table presents the computed interior moment distribution factors for the design vehicle when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. D.Factor Interior Moment 1 Lane, $gST(iM)^1$ - the interior moment distribution factor for one design lane loaded using the DM-4 equation.
3. D.Factor Interior Moment 2+ Lanes, $gST(iM)^2+$ - the interior moment distribution factor for two or more design lanes loaded using the DM-4 equation.
4. Control* D.Factor Interior Moment ($Nb/3$), $gST(iM)$ - the controlling interior moment distribution factor for NEXT beams modeled as single-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.19.2.2 Fatigue Load Moment

This table presents the computed interior moment distribution factor for the fatigue load when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is

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considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Control* D.Factor Fatigue Moment, $gST(iM)^{Fat}$ - the controlling interior moment distribution factor for the fatigue load for NEXT beams modeled as single-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.19.2.3 Design Live Load Moment (w/ Sidewalks)

This table presents the computed interior moment distribution factors for the design live load with sidewalks considered when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.19.2.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.19.3 Controlling Interior Moment Distribution Factor

This table presents the controlling interior moment distribution factor between the double-tee model and the single-tee model for the design live load moment and the fatigue load moment. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. Design Live Load Moment, Control* D.Factor Live Load Moment, $g(iM)$ - the controlling interior moment distribution factor between the double-tee model and the single-tee model for the design live load.
3. Fatigue Load Moment, Control* D.Factor Fatigue Moment, $g(iM)^{Fat}$ - the controlling interior moment distribution factor between the double-tee model and the single-tee model for the fatigue load.

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When design live load with sidewalks is considered, an additional table presents the controlling interior moment distribution factor between the double-tee model and the single-tee model. The following information is presented in this table:

1. Control* D.Factor Live Load Moment, $g(iM)P$ - the controlling interior moment distribution factor between the double-tee model and the single-tee model for the design live load with sidewalk considered.

If requested by parameter 3 of the OAN command, the criteria to determine the controlling distribution factors are presented.

7.4.20 Computed Distribution Factors - Interior Shear (Lanes/Beam)

7.4.20.1 NEXT Beam Double-Tee Model

7.4.20.1.1 Design Live Load Shear

This table presents the computed interior shear distribution factors for the design vehicle when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. D.Factor Interior Shear 1 Lane, $gDT(iV)^1$ - the interior shear distribution factor for one design lane loaded using the DM-4 equation.
3. D.Factor Interior Shear 2+ Lanes, $gDT(iV)^2+$ - the interior shear distribution factor for two or more design lanes loaded using the DM-4 equation.
4. Control* D.Factor Interior Shear, $gDT(iV)$ - the controlling interior shear distribution factor for NEXT beams modeled as double-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

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7.4.20.1.2 Skew Correction

This table presents the computed skew correction factors for shear distribution factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Support No. - the support number for which the computed skew correction factors are presented.
2. Shear Factor - the skew correction factor for the shear distribution factor.
3. Applies - Either "Yes" if the skew correction applies or "No" if the skew correction does not apply.

Next the Range of Applicability variables for each skew correction factor are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

7.4.20.1.3 Fatigue Load Shear

This table presents the computed interior shear distribution factor for the fatigue load when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. Control* D.Factor Fatigue Shear, $gDT(iV)^{Fat}$ - the controlling interior shear distribution factor for the fatigue load for NEXT beams modeled as double-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.20.1.4 Design Live Load Shear (w/ Sidewalks)

This table presents the computed interior shear distribution factors for the design live load with sidewalks considered when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a "P" character appended to distinguish the "with Sidewalk"

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distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.20.1.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.20.2 NEXT Beam Single-Tee Model

7.4.20.2.1 Design Live Load Shear

This table presents the computed interior shear distribution factors for the design vehicle when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. D.Factor Interior Shear 1 Lane, $g_{ST(iV)}^1$ - the interior shear distribution factor for one design lane loaded using the DM-4 equation.
3. D.Factor Interior Shear 2+ Lanes, $g_{ST(iV)}^{2+}$ - the interior shear distribution factor for two or more design lanes loaded using the DM-4 equation.
4. Control* D.Factor Interior Shear, $g_{ST(iV)}$ - the controlling interior shear distribution factor for NEXT beams modeled as single-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

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7.4.20.2.2 Skew Correction

This table presents the computed skew correction factors for shear distribution factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Support No. - the support number for which the computed skew correction factors are presented.
2. Shear Factor - the skew correction factor for the shear distribution factor.

Next the Range of Applicability variables for each skew correction factor are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

7.4.20.2.3 Fatigue Load Shear

This table presents the computed interior shear distribution factor for the fatigue load when each tee of the Type F NEXT beam is considered as cross section type "k" or each tee of the Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. Control* D.Factor Fatigue Shear, $g_{ST(iV)}^{Fat}$ - the controlling interior shear distribution factor for the fatigue load for NEXT beams modeled as single-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.20.2.4 Design Live Load Shear (w/ Sidewalks)

This table presents the computed interior shear distribution factors for the design live load with sidewalks considered when each tee of the Type F NEXT beam is considered as cross section type "k" or each tee of the Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a "P" character appended to distinguish the

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“with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.20.2.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.20.3 Controlling Interior Shear Distribution Factor

This table presents the controlling interior shear distribution factor between the double-tee model and the single-tee model for the design live load shear and the fatigue load shear. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. Design Live Load Shear, Control* D.Factor Live Load Shear, $g(iV)$ - the controlling interior shear distribution factor between the double-tee model and the single-tee model for the design live load.
3. Fatigue Load Shear, Control* D.Factor Fatigue Shear, $g(iV)^{Fat}$ - the controlling interior shear distribution factor between the double-tee model and the single-tee model for the fatigue load.

When design live load with sidewalks is considered, an additional table presents the controlling interior shear distribution factor between the double-tee model and the single-tee model. The following information is presented in this table:

1. Control* D.Factor Live Load Shear, $g(iV)P$ - the controlling interior shear distribution factor between the double-tee model and the single-tee model for the design live load with sidewalk considered.

If requested by parameter 3 of the OAN command, the criteria to determine the controlling distribution factors are presented.

7.4.21 Computed Distribution Factors - Exterior Moment (Lanes/Beam)

7.4.21.1 NEXT Beam Double-Tee Model

7.4.21.1.1 Design Live Load Moment

This table presents the computed exterior moment distribution factors for the design vehicle when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This

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output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. D.Factor Exterior Moment 2+ Lanes, $gDT(eM)^{2+}$ - the exterior moment distribution factor for two or more design lanes loaded using the AASHTO equation.
3. D.Factor Exterior Lever Rule 1 Lane, $gDT(eLR)^1$ - the exterior moment distribution factor for one design lane loaded using the lever rule.
4. D.Factor Exterior Lever Rule 2+ Lanes, $gDT(eLR)^{2+}$ - the exterior moment distribution factor for two or more design lanes loaded using the lever rule. This value is applicable when the number of beams equals three.
5. Control* D.Factor Exterior Moment (Nb_{aa}3), $gDT(eM)$ - the controlling exterior moment distribution factor for NEXT beams modeled as double-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.21.1.2 Fatigue Load Moment

This table presents the computed exterior moment distribution factor for the fatigue load when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Control* D.Factor Fatigue Moment, $gDT(eM)^{Fat}$ - the controlling exterior moment distribution factor for the fatigue load for NEXT beams modeled as double-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.21.1.3 Design Live Load Moment (w/ Sidewalks)

This table presents the computed exterior moment distribution factors for the design live load with sidewalks considered when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to

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distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.21.1.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.21.2 NEXT Beam Single-Tee Model

7.4.21.2.1 Design Live Load Moment

This table presents the computed exterior moment distribution factors for the design vehicle when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. D.Factor Exterior Moment 2+ Lanes, $g_{ST(eM)^{2+}}$ - the exterior moment distribution factor for two or more design lanes loaded the AASHTO equation.
3. D.Factor Exterior Lever Rule 1 Lane, $g_{ST(eLR)^1}$ - the exterior moment distribution factor for one design lane loaded using the lever rule.
4. D.Factor Interior Moment 1 Lane, $g_{ST(iM)^1}$ - the interior moment distribution factor for one design lane loaded using the DM-4 equation.
5. D.Factor Interior Moment 2+ Lanes, $g_{ST(iM)^{2+}}$ - the interior moment distribution factor for two or more design lanes loaded using the DM-4 equation.
6. Control* D.Factor Exterior Moment, $g_{ST(eM)}$ - the controlling exterior moment distribution factor for NEXT beams modeled as single-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

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7.4.21.2.2 Fatigue Load Moment

This table presents the computed exterior moment distribution factor for the fatigue load when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Control* D.Factor Fatigue Moment, $gST(eM)^{Fat}$ - the controlling exterior moment distribution factor for the fatigue load for NEXT beams modeled as single-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.21.2.3 Design Live Load Moment (w/ Sidewalks)

This table presents the computed exterior moment distribution factors for the design live load with sidewalks considered when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.21.2.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.21.3 Controlling Exterior Moment Distribution Factor

This table presents the controlling exterior moment distribution factor between the double-tee model and the single-tee model for the design live load moment and the fatigue load moment. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. Design Live Load Moment, Control* D.Factor Live Load Moment, $g(eM)$ - the controlling exterior moment distribution factor between the double-tee model and the single-tee model for the design live load.

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3. Fatigue Load Moment, Control* D.Factor Fatigue Moment, $g(eM)^{Fat}$ - the controlling exterior moment distribution factor between the double-tee model and the single-tee model for the fatigue load.

When design live load with sidewalks is considered, an additional table presents the controlling exterior moment distribution factor between the double-tee model and the single-tee model. The following information is presented in this table:

1. Control* D.Factor Live Load Moment, $g(eM)^P$ - the controlling exterior moment distribution factor between the double-tee model and the single-tee model for the design live load with sidewalk considered.

If requested by parameter 3 of the OAN command, the criteria to determine the controlling distribution factors are presented.

7.4.22 Computed Distribution Factors - Exterior Shear (Lanes/Beam)

7.4.22.1 NEXT Beam Double-Tee Model

7.4.22.1.1 Design Live Load Shear

This table presents the computed exterior shear distribution factors for the design vehicle when each Type F NEXT beam is considered as cross section type “k” or each Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. D.Factor Exterior Shear 2+ Lanes, $gDT(eV)^{2+}$ - the exterior shear distribution factor for two or more design lanes loaded using the AASHTO equation.
3. D.Factor Exterior Lever Rule 1 Lane, $gDT(eLR)^1$ - the exterior shear distribution factor for one design lane loaded using the lever rule.
4. D.Factor Exterior Lever Rule 2+ Lanes, $gDT(eLR)^{2+}$ - the exterior shear distribution factor for two or more design lanes loaded using the lever rule.
5. Control* D.Factor Exterior Shear, $gDT(eV)$ - the controlling exterior shear distribution factor for NEXT beams modeled as double-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

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If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.22.1.2 Skew Correction

This table presents the computed skew correction factors for shear distribution factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Support No. - the support number for which the computed skew correction factors are presented.
2. Shear Factor - the skew correction factor for the shear distribution factor.
3. Applies - Either "Yes" if the skew correction applies or "No" if the skew correction does not apply.

Next the Range of Applicability variables for each skew correction factor are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

7.4.22.1.3 Fatigue Load Shear

This table presents the computed exterior shear distribution factor for the fatigue load when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. Control* D.Factor Fatigue Shear, $gDT(eV)^{Fat}$ - the controlling exterior shear distribution factor for the fatigue load for NEXT beams modeled as double-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.22.1.4 Design Live Load Shear (w/ Sidewalks)

This table presents the computed exterior shear distribution factors for the design live load with sidewalks considered when each Type F NEXT beam is considered as cross section type "k" or each Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO

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Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.22.1.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.22.2 NEXT Beam Single-Tee Model

7.4.22.2.1 Design Live Load Shear

This table presents the computed exterior shear distribution factors for the design vehicle when each tee of the Type F NEXT beam is considered as cross section type “k” or each tee of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. D.Factor Exterior Shear 2+ Lanes, $g_{ST(eV)}^{2+}$ - the exterior shear distribution factor for two or more design lanes loaded using the AASHTO equation.
3. D.Factor Exterior Lever Rule 1 Lane, $g_{ST(eLR)}^1$ - the exterior shear distribution factor for one design lane loaded using the lever rule.
4. D.Factor Interior Shear 1 Lane, $g_{ST(iV)}^1$ - the interior shear distribution factor for one design lane loaded using the DM-4 equation.
5. D.Factor Interior Shear 2+ Lanes, $g_{ST(iV)}^{2+}$ - the interior shear distribution factor for two or more design lanes loaded using the DM-4 equation.
6. Control* D.Factor Exterior Shear, $g_{ST(eV)}$ - the controlling exterior shear distribution factor for NEXT beams modeled as single-tee beams.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

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If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.22.2.2 Skew Correction

This table presents the computed skew correction factors for shear distribution factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Support No. - the support number for which the computed skew correction factors are presented.
2. Exterior - the skew correction factor for the exterior shear distribution factor.
3. Interior - the skew correction factor for the interior shear distribution factor.
4. Applies - Either "Yes" if the skew correction applies or "No" if the skew correction does not apply.

Next the Range of Applicability variables for each skew correction factor are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

7.4.22.2.3 Fatigue Load Shear

This table presents the computed exterior shear distribution factor for the fatigue load when each tee of the Type F NEXT beam is considered as cross section type "k" or each tee of the Type D NEXT beam is considered as cross section type "i" sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. This output table is presented only if detailed output is requested by parameter 3 of the OAN command. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented along with the flag DF1 or DF2. The DF1 flag identifies shear distribution factors to be applied from the left support to mid-span. The DF2 flag identifies shear distribution factors to be applied from mid-span to the right support.
2. Control* D.Factor Fatigue Shear, $g_{ST(eV)}^{Fat}$ - the controlling exterior shear distribution factor for the fatigue load for NEXT beams modeled as single-tee beams.

If requested by parameter 3 of the OAN command, the criterion to determine the controlling distribution factor is presented.

7.4.22.2.4 Design Live Load Shear (w/ Sidewalks)

This table presents the computed exterior shear distribution factors for the design live load with sidewalks considered when each tee of the Type F NEXT beam is considered as cross section type "k" or each tee

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of the Type D NEXT beam is considered as cross section type “i” sufficiently connected to act as a unit as defined in AASHTO Table 4.6.2.2.1-1. The distribution factors include applicable skew correction factors. The distribution factors presented in this table are based on the pedestrian input values noted in Section 3.5.4.13 of this Manual. Each distribution factor variable has a “P” character appended to distinguish the “with Sidewalk” distribution factors from the design live load distribution factors without sidewalk. Refer to section 7.4.22.2.1 for a detail description of the information reported in the output table.

Next the Range of Applicability variables are presented when requested by parameter 3 of the OAN command. The data presented includes the one or two character variable name, the variable value, the units of the variable, any lower or upper limits, and the status of the range of applicability.

If requested by parameter 3 of the OAN command the criterion to determine the controlling distribution factor is presented.

7.4.22.3 Controlling Exterior Shear Distribution Factor

This table presents the controlling exterior shear distribution factor between the double-tee model and the single-tee model for the design live load shear and the fatigue load shear. The distribution factors include applicable skew correction factors. The following information is presented in this table:

1. Span No. - the span number for which the computed factors are presented.
2. Design Live Load Shear, Control* D.Factor Live Load Shear, g(eV) - the controlling exterior shear distribution factor between the double-tee model and the single-tee model for the design live load.
3. Fatigue Load Shear, Control* D.Factor Fatigue Shear, g(eV)^Fat - the controlling exterior shear distribution factor between the double-tee model and the single-tee model for the fatigue load.

When design live load with sidewalks is considered, an additional table presents the controlling interior shear distribution factor between the double-tee model and the single-tee model. The following information is presented in this table:

1. Control* D.Factor Live Load Shear, g(eV)P - the controlling exterior shear distribution factor between the double-tee model and the single-tee model for the design live load with sidewalk considered.

If requested by parameter 3 of the OAN command, the criteria to determine the controlling distribution factors are presented.

7.4.23 Computed Distribution Factors - Design Live Load (Lane Fraction, Incl. Skew)

This table presents the computed distribution factors for the design vehicle. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. Computed distribution factors for the design live loading are based on the number of lanes loaded that result in the maximum

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distribution factors. This output table is presented only if a CDF command is input by the user. The following information is presented in this table:

1. Span No. - the span number for which the computed distribution factors are presented.
2. Moment DF1 - the moment distribution factor to be used in calculating the live load moments in the dead load positive moment region for the specified span. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses when the lever rule was used. Distribution factors computed by the lever rule will have the letters "LR" printed after the value. Distribution factors computed from AASHTO Table 4.6.2.2.2d-1 and DM-4 Table 4.6.2.2.2b-1 have the letters "EQ" printed after the value and in parentheses either S or M to indicate whether the Single- or Multi-lane equations are used.
3. Moment DF2 - the moment distribution factor to be used in calculating the live load moments in the dead load negative moment region; this distribution factor is applied to the live load moments from the computed dead load contraflexure point in this span to the contraflexure point in the next span; there is no Moment DF2 factor for the last span. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses when the lever rule was used. Distribution factors computed by the lever rule will have the letters "LR" printed after the value. Distribution factors computed from AASHTO Table 4.6.2.2.2d-1 and DM-4 Table 4.6.2.2.2b-1 have the letters "EQ" printed after the value and in parentheses either S or M to indicate whether the Single- or Multi-lane equations are used.
4. Shear DF1 - the shear distribution factor to be used in calculating the live load shear from the left end to the midspan for the specified span. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses when the lever rule was used. Distribution factors computed by the lever rule will have the letters "LR" printed after the value. Distribution factors computed from AASHTO Table 4.6.2.2.3a-1 and DM-4 Table 4.6.2.2.3b-1 have the letters "EQ" printed after the value and in parentheses either S or M to indicate whether the Single- or Multi-lane equations are used.
5. Shear DF2 - the shear distribution factor to be used in calculating the live load shear from the midspan to the right end for the specified span. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses when the lever rule was used. Distribution factors computed by the lever rule will have the letters "LR" printed after the value. Distribution factors computed from AASHTO Table 4.6.2.2.3a-1 and DM-4 Table 4.6.2.2.3b-1 have the letters "EQ" printed after the value and in parentheses either S or M to indicate whether the Single- or Multi-lane equations are used.
6. Deflection - the deflection distribution factor to be used in calculating the live load deflection.

After each line of output for a span an additional line of output is provided when any of the computed distribution factors for that span violates one or more of the range of applicability limits. The violated range of applicability is identified by a one or two character notation placed below the computed distribution factor. A single computed distribution factor might have more than one range of applicability violation. At the end

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of the computed distribution factor tables, a brief description is provided for any printed notations. The following are all possible range of applicability notations and their brief description:

- S - Spacing of beams
- L - Span Length of beam
- d - Depth of beam
- Nb - Number of beams
- de - Curb to Ext. Web of Ext. Girder distance
- b - Width of beam
- J - St. Venant torsional constant
- I - Moment of inertia
- ts - Slab thickness
- Kg - Longitudinal stiffness parameter
- Sk - Skew angle

The range of applicability lower limit and upper limit and the value that caused the violation are printed in a warning message near the beginning of the output file. A range of applicability will be reported even if the controlling distribution factor was not computed using the violated value.

7.4.24 Computed Distribution Factors - Fatigue Load (Lane Fraction, Incl. Skew)

This table presents the computed distribution factors for the fatigue load. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. Computed distribution factors for the fatigue load are based on a single loaded lane. This output table is presented only if a CDF command is input by the user. The same information is printed on this table as described in Section 7.4.23

7.4.25 Computed Distribution Factors with Sidewalks (Lane Fraction, Incl. Skew)

This table presents the computed distribution factors for the design vehicle with sidewalks present. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. Computed distribution factors for the design vehicle with sidewalks present are based on multiple lanes loaded when AASHTO and DM-4 Tables 4.6.2.2.2b-1, 4.6.2.2.2d-1, 4.6.2.2.23a-1, and 4.6.2.2.2d-1 are used to compute distribution factors. When the lever rule is used to compute the distribution factor, the multiple presence factor will be computed for one more lane loaded than the number of lanes loaded for the lever rule. This output table is presented only if CDF and PLD commands are input by the user. The same information is printed on this table as described in Section 7.4.23.

7.4.26 Computed Distribution Factors for P-82C Combination (Multi-lane, Lane Fraction, Incl. Skew)

The table presents the computed distribution factors used to determine the PHL-93 portion of the P-82C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code G on the CTL command for an Analysis run is entered and the CDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

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7.4.27 Computed Distribution Factors for P-82C Combination (Single lane, Lane Fraction, Incl. Skew)

The table presents the computed distribution factors used to determine the PHL-93 portion of the P-82C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code G on the CTL command for an Analysis run is entered and the CDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.28 Computed Distribution Factors for P-82C/P2016-13C Combination (Multi-lane, Lane Fraction, Incl. Skew)

The table presents the computed distribution factors used to determine the PHL-93 portion of the P-82C and P2016-13C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code K on the CTL command for an Analysis run is entered and the CDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.29 Computed Distribution Factors for P-82C/P2016-13C Combination (Single lane, Lane Fraction, Incl. Skew)

The table presents the computed distribution factors used to determine the PHL-93 portion of the P-82C and P2016-13C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code K on the CTL command for an Analysis run is entered and the CDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.30 User Input Distribution Factors - Design Live Load (Lane Fraction, Incl. Skew)

This table presents the user input distribution factors for the design vehicle. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. This output table is presented only if a UDF command is input by the user. The same information is printed on this table as described in Section 7.4.23.

7.4.31 User Input Distribution Factors - Fatigue Load (Lane Fraction, Incl. Skew)

This table presents the user input distribution factors for the fatigue load. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. This output table is presented only if a UDF command is input by the user. The same information is printed on this table as described in Section 7.4.23.

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7.4.32 User Input Distribution Factors with Sidewalks (Lane Fraction, Incl. Skew)

This table presents the user input distribution factors for the design vehicle with sidewalks present. All distribution factors are expressed as a fraction of a lane load and include any skew correction factors. This output table is presented only if UDF and PLD commands are input by the user. The same information is printed on this table as described in Section 7.4.23.

7.4.33 User Input Distribution Factors for P-82C Combination (Multi-lane, Lane Fraction, Incl. Skew)

The table presents the user input distribution factors used to determine the PHL-93 portion of the P-82C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code G on the CTL command for an Analysis run is entered and the UDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.34 User Input Distribution Factors for P-82C Combination (Single lane, Lane Fraction, Incl. Skew)

The table presents the user input distribution factors used to determine the PHL-93 portion of the P-82C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code G on the CTL command for an Analysis run is entered and the UDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.35 User Input Distribution Factors for P-82C/P2016-13C Combination (Multi-lane, Lane Fraction, Incl. Skew)

The table presents the user input distribution factors used to determine the PHL-93 portion of the P-82C and P2016-13C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code K on the CTL command for an Analysis run is entered and the UDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

7.4.36 User Input Distribution Factors for P-82C/P2016-13C Combination (Single lane, Lane Fraction, Incl. Skew)

The table presents the user input distribution factors used to determine the PHL-93 portion of the P-82C and P2016-13C vehicular live load. These distribution factors are expressed as a fraction of a lane load and include all corrections due to the skew of the supports. This output table is presented only if Live Load Code K on the CTL command for an Analysis run is entered and the UDF command is input by the user. The same information is printed in this table as described in Section 7.4.23.

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7.4.37 Computed Distribution Factors for Reactions and Rotations

This table presents the computed distribution factors for reactions and rotations for the design vehicle and for the fatigue vehicle. All distribution factors are expressed as a fraction of a lane load. The following information is presented in this table:

1. Support No. - the support number for which the computed distribution factor is presented.
2. Design Live Load Reaction - the reaction distribution factor, including the skew correction factor, to be used in calculating the design live load reaction at the specified support. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.
3. Design Live Load Rotation - the rotation distribution factor to be used in calculating the design live load rotation at the specified support. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.
4. Fatigue Load Reaction - the reaction distribution factor, including the skew correction factor, to be used in calculating the fatigue live load reaction at the specified support. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.
5. Fatigue Load Rotation - the rotation distribution factor to be used in calculating the fatigue live load rotation at the specified support. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.

7.4.38 Computed Distribution Factors for Reactions and Rotations with Sidewalks

This table presents the computed distribution factors for reactions and rotations with sidewalks present. All distribution factors are expressed as a fraction of a lane load. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Support No. - the support number for which the computed distribution factor is presented.
2. Reaction - the reaction distribution factor, including the skew correction factor, to be used in calculating the live load reaction at the specified support. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.
3. Rotation - the rotation distribution factor to be used in calculating the live load rotation at the specified support. The number of loaded lanes used to produce the maximum distribution factor appears in the parentheses. Distribution factors computed by the lever rule will have the letters "LR" printed after the value.

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7.4.39 User Input Distribution Factors for Reactions and Rotations

This table presents the user input distribution factors for reactions and rotations for the design vehicle and for the fatigue vehicle. All distribution factors are expressed as a fraction of a lane load. This output table is present only if a URF command is input by the user. The same information is printed on this table as described in Section 7.4.33.

7.4.40 User Input Distribution Factors for Reactions and Rotations with Sidewalks

This table presents the user input distribution factors for reactions and rotations with sidewalks present. All distribution factors are expressed as a fraction of a lane load. This output table is present only if URF and PLD commands are input by the user. The same information is printed on this table as described in Section 7.4.38.

7.4.41 Points of Contraflexure

This table presents, for each span, the points of Contraflexure used by the program. The following information is presented in this table:

1. Dead Load Points of Contraflexure, Span No. - the span number for which the dead load point of contraflexure is presented.
2. Dead Load Points of Contraflexure, Dist. – the distance from the dead load point of contraflexure to the left end of the specified span. These points are calculated by the program from the composite dead loads computed by the program.

7.4.42 Load Modifier

This table presents the load modifiers, as presented in LRFD Specifications Articles 1.3.3 through 1.3.5 and as modified by PennDOT. The following information is presented in this table:

1. Importance Factor, N_i - the Importance Factor, as described in LRFD Specifications Article 1.3.3.
2. Ductility Factor, N_d - the Ductility Factor, as described in LRFD Specifications Article 1.3.4.
3. Redundancy Factor, N_r - the Redundancy Factor, as described in LRFD Specifications Article 1.3.5.
4. Calculated $N_i \cdot N_d \cdot N_r$ - the product of the above three factors.
5. Used Load Modifier - the load modifier used in the specification check. This value depends on the limits imposed by DM-4 and the LRFD Specifications.

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7.4.43 Resistance Factors

This table presents the resistance factors, as presented in LRFD Specifications Article 5.5.4.2 and as modified by PennDOT. Strain Limits are provided for the prestressing steel, the slab reinforcement, and each unique yield strength of beam reinforcement. The following information is presented in this table:

1. Tension-Controlled Reinforced Concrete Sections - the flexure resistance factor for non-prestressed tension-controlled sections.
2. Tension-Controlled Prestressed Concrete Sections – the flexure resistance factor for prestressed sections that are tension-controlled.
3. Compression-Controlled Sections – the flexure resistance factor for all sections that are compression-controlled.
4. Shear, $\phi(V)$ - the resistance factor for shear.
5. Tension-Controlled Strain Limit, $(\text{in/in}) \times 1000$ – the value of the net tensile strain in the extreme tension steel that defines the begin of a tension-controlled section.
6. Compression-Controlled Strain Limit, $(\text{in/in}) \times 1000$ – the value of the net tensile strain in the extreme tension steel that defines the end of a compression-controlled section.

7.4.44 Load Factors and Combinations

This table presents the various load factors for each load type for each limit state. The first column of the table list gamma for each of the various load types. The other columns of the table correspond to each of the possible limit states. The following information is presented in this table:

1. Limit State (Column Headings) - the limit state for which the load factors apply; limit states applicable to this program include the following:
 - STR-I - Strength I limit state.
 - STR-IP - Strength IP limit state.
 - STR-IA - Strength IA limit state.
 - STR-II - Strength II limit state.
 - SRV-I - Service I limit state.
 - SRV-IP - Service IP limit state.
 - SRV-III - Service III limit state.
 - SRV-IIIP - Service IIIP limit state.
 - SRV-IIIA - Service IIIA limit state.
 - SRV-IIIB - Service IIIB limit state.
 - FAT-I - Fatigue I limit state.
 - DEFL - Deflection limit state.
2. gDC Max - the maximum load factor to be applied to the girder, slab, interior diaphragm, exterior diaphragm, counterweight, DC1 and DC2 self-weight loads for each limit state.

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3. gDC Min - the minimum load factor to be applied to the girder, slab, interior diaphragm, exterior diaphragm, counterweight, DC1 and DC2 self-weight loads for each limit state.
4. gDW Max - the maximum load factor to be applied to future wearing surface load and utility loads for each limit state.
5. gDW Min - the minimum load factor to be applied to future wearing surface load and utility loads for each limit state.
6. gSWK Max - the maximum load factor to be applied to the sidewalk load for each limit state.
7. gSWK Min - the minimum load factor to be applied to the sidewalk load for each limit state.
8. gAWS Max - the maximum load factor to be applied to the additional wearing surface load for each limit state.
9. gAWS Min - the minimum load factor to be applied to the additional wearing surface load for each limit state.
10. gMC1 Max - the maximum load factor to be applied to the miscellaneous dead load acting on the non-composite section for each limit state.
11. gMC1 Min - the minimum load factor to be applied to the miscellaneous dead load acting on the non-composite section for each limit state.
12. gMC2 Max – the maximum load factor to be applied to the miscellaneous dead load acting on the composite section for each limit state.
13. gMC2 Min – the minimum load factor to be applied to the miscellaneous dead load acting on the composite section for each limit state.
14. gCRSH – the load factor to be applied to the creep and shrinkage moment for each limit state.
15. gLL - the load factor to be applied to the live load for each limit state.
16. gPermit - the load factor to be applied to the permit live load for each limit state.
17. gRate - the load factor to be applied to rating vehicles for each limit state.
18. gPL - the load factor to be applied to pedestrian live load for each limit state.
19. gFAT - the load factor to be applied to fatigue live load for each limit state.
20. gSLL1 to gSLL8 – the load factors to be applied to Special live loads 1 through 8 for each limit state.

7.4.45 Live Loading Summary (Design/Analysis, Live Load Code: a)

This table presents the live load vehicles considered for each limit state and identifies when and Inventory Rating, Operating Rating, or a Specification Check is made. loads associated with the various dead load types. The following information is presented in this table:

1. Limit State (Column Headings) - the limit states applicable to this program include the following:
 - STR-I - Strength I limit state.
 - STR-IP - Strength IP limit state.
 - STR-IA - Strength IA limit state.
 - STR-II - Strength II limit state.

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SRV-I	-	Service I limit state.
SRV-IP	-	Service IP limit state.
SRV-III	-	Service III limit state.
SRV-IIIP	-	Service IIIP limit state.
SRV-IIIA	-	Service IIIA limit state.
SRV-IIIB	-	Service IIIB limit state.
FAT-I	-	Fatigue I limit state.
DEFL	-	Deflection limit state.

2. Analysis/Design and Rating Vehicles - the following rows list the vehicles considered for Analysis or Design. For each vehicle, the limit state column indicates if an I (Inventory Rating), O (Operating Rating), SC (Specification Check) or “—” (neither) applies to this vehicle and limit state combination. The limit states identified as I or O are also used for specification checks.
3. Permit and Rating Vehicles - the following rows list the vehicles considered for Permit. For each vehicle, the limit state column indicates if an I (Inventory Rating), O (Operating Rating), SC (Specification Check) or “—” (neither) applies to this vehicle and limit state combination. The limit states identified as I or O are used for specification checks.
4. Rating Only Vehicles - the following rows list the vehicles considered for Rating. These vehicles are in addition to the vehicles listed in the previous two groups. For each vehicle, the limit state column indicates if an I (Inventory Rating), O (Operating Rating), SC (Specification Check) or “—” (neither) applies to this vehicle and limit state combination.
5. Fatigue - this row list the vehicle considered for Fatigue. Only the Fatigue I Limit State applies to this vehicle and only a specification check is made.
6. Deflection - this row list the vehicle considered for Deflection. Only the Deflection Limit State applies to this vehicle and only a specification check is made.

7.4.46 Concentrated Loads

This table presents concentrated loads associated with the various dead load types. The following information is presented in this table:

1. U,C or M - the source of the concentrated load, as follows:
 - U - user input.
 - C - computed by program; examples of loads computed by the program are girder self-weight, slab, and haunch.
 - M - modified by program; this is a load that was input by the user but had to be modified by the program to obtain the proper reactions; this designation is used specifically for non-composite distributed loads placed between the centerlines of bearing at a pier; the load is resolved into sets of distributed loads and concentrated loads.
2. Span - span number in which the concentrated load is located.

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3. Location - the distance from the concentrated load to the left end of the span in which the concentrated load is located.
4. Magnit. - the magnitude of the concentrated load.
5. Description - a description of the concentrated load; descriptions include the following:
 - ADDITIONAL DC1
 - ADDITIONAL DC2
 - EXTERIOR DIAPHRAGM
 - FUTURE WEARING SURF
 - GIRDER
 - INTERIOR DIAPHRAGM
 - SLAB AND HAUNCH

7.4.47 Distributed Loads

This table presents distributed loads associated with the various dead load types. The following information is presented in this table:

1. U,C or M - the source of the distributed load, as follows:
 - U - user input.
 - C - computed by program; examples of loads computed by the program are girder self-weight, slab, and haunch.
 - M - modified by program; this is a load that was input by the user but had to be modified by the program to obtain the proper reactions; this designation is used specifically for non-composite distributed loads placed between the centerlines of bearing at a pier; the load is resolved into sets of distributed loads and concentrated loads.
2. Start Span - span number in which the left end of the distributed load is located.
3. Start Span Location - the distance from the left end of the distributed load to the left end of the start span.
4. Start Magnit. - the magnitude at the left end of the distributed load.
5. End Span - span number in which the right end of the distributed load is located.
6. End Span Location - the distance from the right end of the distributed load to the left end of the end span.
7. End Magnit. - the magnitude at the right end of the distributed load.
8. Description - a description of the distributed load; descriptions include the following:
 - ADDITIONAL DC1
 - ADDITIONAL DC2
 - EXTERIOR DIAPHRAGM
 - FUTURE WEARING SURF
 - GIRDER

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INTERIOR DIAPHRAGM SLAB AND HAUNCH

7.4.48 Creep and Shrinkage Loads

This table presents creep and shrinkage loads for continuous spans only. The following information is presented in this table:

1. Span - span number in which the creep and shrinkage load is located.
2. Location - the distance from the creep and shrinkage load to the left end of the span in which the load is located.
3. Magnit. - the magnitude of the creep and shrinkage load.
4. Type - the load type; types include the following:
MOMENT
REACTION
5. Description - a description of the creep and shrinkage load; descriptions include the following:
CREEP-30 DAY
CREEP-450 DAY
SHRINKAGE-30 DAY
SHRINKAGE-450 DAY

7.4.49 Girder Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the girder weight acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the girder weight.
4. Shear - the unfactored shear in the girder at the specified location due to the girder weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the girder weight.

7.4.50 Girder Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the girder weight acting on the basic beam. The following information is presented in this table:

1. Support No. - Support number at which the analysis values are presented followed by either an "L" or an "R" to identify the values as being to the LEFT or to the RIGHT of the support.
2. Reaction - the unfactored reaction at the specified support due to the girder weight.

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3. Rotation - the unfactored rotation at the specified support due to the girder weight.

7.4.51 Slab and Haunch Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the slab and haunch weight acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the slab and haunch weight.
4. Shear - the unfactored shear in the girder at the specified location due to the slab and haunch weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the slab and haunch weight.

7.4.52 Slab and Haunch Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the slab and haunch weight acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.53 Interior Diaphragm Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the interior diaphragm weight acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the interior diaphragm weight.
4. Shear - the unfactored shear in the girder at the specified location due to the interior diaphragm weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the interior diaphragm weight.

7.4.54 Interior Diaphragm Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the interior diaphragm weight acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

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7.4.55 Exterior Diaphragm Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the exterior diaphragm weight acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the exterior diaphragm weight.
4. Shear - the unfactored shear in the girder at the specified location due to the exterior diaphragm weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the exterior diaphragm weight.

7.4.56 Exterior Diaphragm Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the exterior diaphragm weight acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.57 Additional DC1 Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the additional DC1 weight acting on the basic beam. The analysis values presented in this table do not include the effects of the girder weight, slab and haunch weight, interior diaphragm weight, or exterior diaphragm weight. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the additional DC1 weight.
4. Shear - the unfactored shear in the girder at the specified location due to the additional DC1 weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the additional DC1 weight.

7.4.58 Additional DC1 Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the additional DC1 weight acting on the basic beam. The analysis values presented in this table do not include the effects of the girder weight, slab

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and haunch weight, interior diaphragm weight, or exterior diaphragm weight. The same information is presented in this table as described in Section 7.4.50.

7.4.59 Misc. Noncomp. Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the miscellaneous non-composite weight acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the miscellaneous non-composite weight.
4. Shear - the unfactored shear in the girder at the specified location due to the miscellaneous non-composite weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the miscellaneous non-composite weight.

7.4.60 Misc. Noncomp. Weight Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the miscellaneous non-composite weight acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.61 Non-Comp. Counter-Wt. Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the non-composite counter weight load acting on the basic beam. The same information is presented in this table as described in Section 7.4.49.

7.4.62 Non-Comp. Counter-Wt. Weight Analysis (Unfactored, Basic Beam) – Reactions

This table presents the unfactored reactions and rotations due to the non-composite counter weight load acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.63 Non-Comp. Utility Load Weight Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the non-composite utility load acting on the basic beam. The same information is presented in this table as described in Section 7.4.49.

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7.4.64 Non-Comp. Utility Load Weight Analysis (Unfactored, Basic Beam) – Reactions

This table presents the unfactored reactions and rotations due to the non-composite utility load acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.65 Total Non-composite Load Analysis (Unfactored, Basic Beam)

This table presents the unfactored moments, shears, and deflections due to the total non-composite load acting on the basic beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the total non-composite load.
4. Shear - the unfactored shear in the girder at the specified location due to the total non-composite load.
5. Deflection - the unfactored deflection in the girder at the specified location due to the total non-composite load.

7.4.66 Total Non-composite Load Analysis (Unfactored, Basic Beam) - Reactions

This table presents the unfactored reactions and rotations due to the total non-composite load acting on the basic beam. The same information is presented in this table as described in Section 7.4.50.

7.4.67 DC2 Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the DC2 weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the DC2 weight.
4. Shear - the unfactored shear in the girder at the specified location due to the DC2 weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the DC2 weight.

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7.4.68 DC2 Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the DC2 weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The following information is presented in this table:

1. Support No. - Support number at which the analysis values are presented followed by either an "L" or an "R" to identify the values as being to the LEFT or to the RIGHT of the support.
2. Simple Reaction - the unfactored reaction at the specified support due to the additional DC2 weight from the simple span analysis. Only present when the simple span check option is selected for multi-span structures.
3. Simple Rotation - the unfactored rotation at the specified support due to the DC2 weight from the simple span analysis. Only present when the simple span check option is selected for multi-span structures.
4. Reaction or Continuous Reaction - the unfactored reaction at the specified support due to the DC2 weight.
5. Rotation or Continuous Rotation - the unfactored rotation at the specified support due to the DC2 weight.

7.4.69 Future Wearing Surf. Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the future wearing surface weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the future wearing surface weight.
4. Shear - the unfactored shear in the girder at the specified location due to the future wearing surface weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the future wearing surface weight.

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7.4.70 Future Wearing Surf. Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the future wearing surface weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The same information is presented in this table as described in Section 7.4.68.

7.4.71 Misc. Composite Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the miscellaneous composite weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the miscellaneous composite weight.
4. Shear - the unfactored shear in the girder at the specified location due to the miscellaneous composite weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the miscellaneous composite weight.

7.4.72 Misc. Composite Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the miscellaneous composite weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The same information is presented in this table as described in Section 7.4.68.

7.4.73 Comp. Counter-Wt. Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the composite counter weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is

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from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The same information is presented in this table as described in Section 7.4.67.

7.4.74 Comp. Counter-Wt. Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the composite counter weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The same information is presented in this table as described in Section 7.4.68.

7.4.75 Comp. Utility Load Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the composite utility load acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The same information is presented in this table as described in Section 7.4.67.

7.4.76 Comp. Utility Load Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the composite utility load acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The same information is presented in this table as described in Section 7.4.68.

7.4.77 Sidewalk Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the sidewalk weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the sidewalk weight.

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4. Shear - the unfactored shear in the girder at the specified location due to the sidewalk weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the sidewalk weight.

7.4.78 Sidewalk Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the sidewalk weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. This output table is presented only if a PLD command is input by the user. The same information is presented in this table as described in Section 7.4.68.

7.4.79 Additional FWS Weight Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the additional future wearing surface weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the additional future wearing surface weight.
4. Shear - the unfactored shear in the girder at the specified location due to the additional future wearing surface weight.
5. Deflection - the unfactored deflection in the girder at the specified location due to the additional future wearing surface weight.

7.4.80 Additional FWS Weight Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the additional future wearing surface weight acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. This output table is presented only if a PLD command is input by the user. The same information is presented in this table as described in Section 7.4.68.

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7.4.81 Total Composite Load Analysis (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the total composite load acting on the composite beam. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Moment - the unfactored moment in the girder at the specified location due to the total composite load.
4. Shear - the unfactored shear in the girder at the specified location due to the total composite load.
5. Deflection - the unfactored deflection in the girder at the specified location due to the total composite load.

7.4.82 Total Composite Load Analysis with Sidewalks (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the total composite load acting on the composite beam with sidewalks present. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.81.

7.4.83 Total Composite Load Analysis without Sidewalks (Unfactored, Composite Beam)

This table presents the unfactored moments, shears, and deflections due to the total composite load acting on the composite beam without sidewalks present. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.81.

7.4.84 Total Composite Load Analysis (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the total composite load acting on the composite beam. If the continuous analysis with simple span check option is selected for multi-span structures, two pairs of reaction and rotation values are presented in this table; otherwise a single reaction and rotation value are presented in this table. The same information is presented in this table as described in Section 7.4.68.

7.4.85 Total Composite Load Analysis with Sidewalks (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the total composite load acting on the composite beam with sidewalks present. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.68.

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7.4.86 Total Composite Load Analysis without Sidewalks (Unfactored, Composite Beam) - Reactions

This table presents the unfactored reactions and rotations due to the total composite load acting on the composite beam without sidewalks present. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.68.

7.4.87 Creep and Shrinkage Moments Based on 30 Days

This table presents the creep and shrinkage moments based on the moment connection being made at 30 days. An asterisk (*) is shown next to the shrinkage moments for locations within the transfer length at each abutment. A footnote follows the table noting the moments are neglected. The following information is presented in this table:

1. Span No. - span number in which the creep and shrinkage moments are presented.
2. Distance - the distance from the location of the creep and shrinkage moments to the left end of the span in which the creep and shrinkage moments are located.
3. Creep Restraint Moment - the creep restraint moment in the girder at the specified location.
4. Final Shrinkage Moment - the final shrinkage moment in the girder at the specified location.
5. M(c&s) - the restraint moment due to creep and shrinkage in the girder at the specified location.

7.4.88 Creep and Shrinkage Moments Based on 450 Days

This table presents the creep and shrinkage moments based on the moment connection being made at 450 days. An asterisk (*) is shown next to the shrinkage moments for locations within the transfer length at each abutment. A footnote follows the table noting the moments are neglected. The following information is presented in this table:

1. Span No. - span number in which the creep and shrinkage moments are presented.
2. Distance - the distance from the location of the creep and shrinkage moments to the left end of the span in which the creep and shrinkage moments are located.
3. Creep Restraint Moment - the creep restraint moment in the girder at the specified location.
4. Final Shrinkage Moment - the final shrinkage moment in the girder at the specified location.
5. M(c&s) - the restraint moment due to creep and shrinkage in the girder at the specified location.

For the shrinkage only analysis, all creep restraint moments will be zero.

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7.4.89 PHL-93 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to PHL-93 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to PHL-93 live loading.
4. Maximum Moments, Positive, LC - the PHL-93 live loading code corresponding with the maximum, positive, unfactored moment; PHL-93 live loading codes include the following:
 - 1 - tandem + lane governs
 - 2 - truck + lane governs
 - 3 - tandem pair + lane governs
 - 4 - truck pair + lane governs
 - 5 - truck alone governs
 - 6 - 25% truck + lane governs
 - 7 - 90% (truck pair + lane governs)
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to PHL-93 live loading.
6. Maximum Moments, Negative, LC - the PHL-93 live loading code corresponding with the maximum, negative, unfactored moment. Codes are as denoted above.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to PHL-93 live loading.
8. Maximum Shears, Positive, LC - the PHL-93 live loading code corresponding with the maximum, positive, unfactored shear. Codes are as denoted above.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to PHL-93 live loading.
10. Maximum Shears, Negative, LC - the PHL-93 live loading code corresponding with the maximum, negative, unfactored shear. Codes are as denoted above.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to PHL-93 live loading. Also, the PHL-93 live loading code corresponding with the maximum, unfactored deflection. Codes are as denoted above.

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7.4.90 PHL-93 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to PHL-93 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.89.

7.4.91 PHL-93 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to PHL-93 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.89.

7.4.92 PHL-93 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to PHL-93 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to PHL-93 live loading.
4. Maximum Reaction, LC - the PHL-93 live loading code corresponding with the maximum, unfactored reaction; PHL-93 live loading codes include the following:
 - 1 - tandem + lane governs
 - 2 - truck + lane governs
 - 3 - tandem pair + lane governs
 - 4 - truck pair + lane governs
 - 5 - truck alone governs
 - 6 - 25% truck + lane governs
 - 7 - 90% (truck pair + lane governs)
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to PHL-93 live loading.

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6. Minimum Reaction, LC - the PHL-93 live loading code corresponding with the minimum, unfactored reaction. Codes are as denoted above.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to PHL-93 live loading.
8. Maximum Rotation, LC - the PHL-93 live loading code corresponding with the maximum, unfactored rotation. Codes are as denoted above.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to PHL-93 live loading.
10. Minimum Rotation, LC - the PHL-93 live loading code corresponding with the minimum, unfactored rotation. Codes are as denoted above.

7.4.93 PHL-93 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to PHL-93 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.92.

7.4.94 PHL-93 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to PHL-93 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.92.

7.4.95 PHL-93 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to PHL-93 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the PHL-93 design truck.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the PHL-93 design truck.

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5. Maximum Lane - the maximum, unfactored reaction in the girder at the specified location due to the PHL-93 design lane load.
6. Minimum Lane - the minimum, unfactored reaction in the girder at the specified location due to the PHL-93 design lane load.

7.4.96 HL-93 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HL-93 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to HL-93 live loading.
4. Maximum Moments, Positive, LC - the HL-93 live loading code corresponding with the maximum, positive, unfactored moment; HL-93 live loading codes include the following:
 - 1 - tandem + lane governs
 - 2 - truck + lane governs
 - 3 - tandem pair + lane governs
 - 4 - 90% (truck pair + lane governs)
 - 5 - truck alone governs
 - 6 - 25% truck + lane governs
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to HL-93 live loading.
6. Maximum Moments, Negative, LC - the HL-93 live loading code corresponding with the maximum, negative, unfactored moment. Codes are as denoted above.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to HL-93 live loading.
8. Maximum Shears, Positive, LC - the HL-93 live loading code corresponding with the maximum, positive, unfactored shear. Codes are as denoted above.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to HL-93 live loading.
10. Maximum Shears, Negative, LC - the HL-93 live loading code corresponding with the maximum, negative, unfactored shear. Codes are as denoted above.

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11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to HL-93 live loading. Also, the HL-93 live loading code corresponding with the maximum, unfactored deflection. Codes are as denoted above.

7.4.97 HL-93 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HL-93 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.96.

7.4.98 HL-93 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HL-93 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.96.

7.4.99 HL-93 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HL-93 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to HL-93 live loading.
4. Maximum Reaction, LC - the HL-93 live loading code corresponding with the maximum, unfactored reaction; HL-93 live loading codes include the following:
 - 1 - tandem + lane governs
 - 2 - truck + lane governs
 - 3 - tandem pair + lane governs
 - 4 - 90% (truck pair + lane governs)
 - 5 - truck alone governs
 - 6 - 25% truck + lane governs

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5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to HL-93 live loading.
6. Minimum Reaction, LC - the HL-93 live loading code corresponding with the minimum, unfactored reaction. Codes are as denoted above.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to HL-93 live loading.
8. Maximum Rotation, LC - the HL-93 live loading code corresponding with the maximum, unfactored rotation. Codes are as denoted above.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to HL-93 live loading.
10. Minimum Rotation, LC - the HL-93 live loading code corresponding with the minimum, unfactored rotation. Codes are as denoted above.

7.4.100 HL-93 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HL-93 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.99.

7.4.101 HL-93 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HL-93 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.99.

7.4.102 HL-93 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to HL-93 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the HL-93 design truck.

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4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the HL-93 design truck.
5. Maximum Lane - the maximum, unfactored reaction in the girder at the specified location due to the HL-93 design lane load.
6. Minimum Lane - the minimum, unfactored reaction in the girder at the specified location due to the HL-93 design lane load.

7.4.103 P-82 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P-82 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to P-82 live loading.
4. Maximum Moments, Positive, LC - for P-82 live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to P-82 live loading.
6. Maximum Moments, Negative, LC - for P-82 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to P-82 live loading.
8. Maximum Shears, Positive, LC - for P-82 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to P-82 live loading.
10. Maximum Shears, Negative, LC - for P-82 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to P-82 live loading.

7.4.104 P-82 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P-82 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.103.

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7.4.105 P-82 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to P-82 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

- 1. Span No. - span number in which the analysis values are presented.
- 2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
- 3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to P-82 live loading.
- 4. Maximum Reaction, LC - for P-82 live load analysis, this column is left blank.
- 5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to P-82 live loading.
- 6. Minimum Reaction, LC - for P-82 live load analysis, this column is left blank.
- 7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to P-82 live loading.
- 8. Maximum Rotation, LC - for P-82 live load analysis, this column is left blank.
- 9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to P-82 live loading.
- 10. Minimum Rotation, LC - for P-82 live load analysis, this column is left blank.

7.4.106 P-82 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to P-82 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.105.

7.4.107 P-82 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to P-82 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

- 1. Span No. - span number in which the reactions are presented.
- 2. Support - the support at which the reactions are located; supports include the following:

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LEFT

RIGHT

3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the P-82 live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the P-82 live loading.
5. Maximum Lane - since P-82 live loading does not include a lane loading, this value is always zero.
6. Minimum Lane - since P-82 live loading does not include a lane loading, this value is always zero.

7.4.108 P-82C Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P-82C live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to P-82C live loading.
4. Maximum Moments, Positive, LC - for P-82C live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to P-82C live loading.
6. Maximum Moments, Negative, LC - for P-82C live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to P-82C live loading.
8. Maximum Shears, Positive, LC - for P-82C live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to P-82C live loading.
10. Maximum Shears, Negative, LC - for P-82C live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to P-82C live loading.

7.4.109 P-82C Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P-82C live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution

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factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.108.

7.4.110 P2016-13 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P2016-13 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to P2016-13 live loading.
4. Maximum Moments, Positive, LC - for P2016-13 live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to P2016-13 live loading.
6. Maximum Moments, Negative, LC - for P2016-13 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to P2016-13 live loading.
8. Maximum Shears, Positive, LC - for P2016-13 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to P2016-13 live loading.
10. Maximum Shears, Negative, LC - for P2016-13 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to P2016-13 live loading.

7.4.111 P2016-13 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P2016-13 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.110.

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7.4.112 P2016-13 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to P2016-13 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

- 1. Span No. - span number in which the analysis values are presented.
- 2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
- 3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to P2016-13 live loading.
- 4. Maximum Reaction, LC - for P2016-13 live load analysis, this column is left blank.
- 5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to P2016-13 live loading.
- 6. Minimum Reaction, LC - for P2016-13 live load analysis, this column is left blank.
- 7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to P2016-13 live loading.
- 8. Maximum Rotation, LC - for P2016-13 live load analysis, this column is left blank.
- 9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to P2016-13 live loading.
- 10. Minimum Rotation, LC - for P2016-13 live load analysis, this column is left blank.

7.4.113 P2016-13 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to P2016-13 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.112.

7.4.114 P2016-13 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to P2016-13 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

- 1. Span No. - span number in which the reactions are presented.
- 2. Support - the support at which the reactions are located; supports include the following:

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LEFT

RIGHT

3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the P2016-13 live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the P2016-13 live loading.
5. Maximum Lane - since P2016-13 live loading does not include a lane loading, this value is always zero.
6. Minimum Lane - since P2016-13 live loading does not include a lane loading, this value is always zero.

7.4.115 P2016-13C Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P2016-13C live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to P2016-13C live loading.
4. Maximum Moments, Positive, LC - for P2016-13C live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to P2016-13C live loading.
6. Maximum Moments, Negative, LC - for P2016-13C live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to P2016-13C live loading.
8. Maximum Shears, Positive, LC - for P2016-13C live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to P2016-13C live loading.
10. Maximum Shears, Negative, LC - for P2016-13C live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to P2016-13C live loading.

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7.4.116 P2016-13C Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to P2016-13C live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.115.

7.4.117 ML-80 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to ML-80 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to ML-80 live loading.
4. Maximum Moments, Positive, LC - for ML-80 live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to ML-80 live loading.
6. Maximum Moments, Negative, LC - for ML-80 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to ML-80 live loading.
8. Maximum Shears, Positive, LC - for ML-80 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to ML-80 live loading.
10. Maximum Shears, Negative, LC - for ML-80 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to ML-80 live loading.

7.4.118 ML-80 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to ML-80 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.117.

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7.4.119 ML-80 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to ML-80 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.117.

7.4.120 ML-80 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to ML-80 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to ML-80 live loading.
4. Maximum Reaction, LC - for ML-80 live load analysis, this column is left blank.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to ML-80 live loading.
6. Minimum Reaction, LC - for ML-80 live load analysis, this column is left blank.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to ML-80 live loading.
8. Maximum Rotation, LC - for ML-80 live load analysis, this column is left blank.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to ML-80 live loading.
10. Minimum Rotation, LC - for ML-80 live load analysis, this column is left blank.

7.4.121 ML-80 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to ML-80 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.120.

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7.4.122 ML-80 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to ML-80 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.120.

7.4.123 ML-80 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to ML-80 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

- 1. Span No. - span number in which the reactions are presented.
- 2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
- 3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the ML-80 live loading.
- 4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the ML-80 live loading.
- 5. Maximum Lane - since ML-80 live loading does not include a lane loading, this value is always zero.
- 6. Minimum Lane - since ML-80 live loading does not include a lane loading, this value is always zero.

7.4.124 TK527 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to TK527 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

- 1. Span No. - span number in which the analysis values are presented.
- 2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
- 3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to TK527 live loading.
- 4. Maximum Moments, Positive, LC - for TK527 live load analysis, this column is left blank.

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5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to TK527 live loading.
6. Maximum Moments, Negative, LC - for TK527 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to TK527 live loading.
8. Maximum Shears, Positive, LC - for TK527 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to TK527 live loading.
10. Maximum Shears, Negative, LC - for TK527 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to TK527 live loading.

7.4.125 TK527 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to TK527 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.124.

7.4.126 TK527 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to TK527 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.124.

7.4.127 TK527 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to TK527 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to TK527 live loading.

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4. Maximum Reaction, LC - for TK527 live load analysis, this column is left blank.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to TK527 live loading.
6. Minimum Reaction, LC - for TK527 live load analysis, this column is left blank.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to TK527 live loading.
8. Maximum Rotation, LC - for TK527 live load analysis, this column is left blank.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to TK527 live loading.
10. Minimum Rotation, LC - for TK527 live load analysis, this column is left blank.

7.4.128 TK527 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to TK527 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.127.

7.4.129 TK527 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to TK527 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.127.

7.4.130 TK527 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to TK527 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the TK527 live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the TK527 live loading.
5. Maximum Lane - since TK527 live loading does not include a lane loading, this value is always zero.

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6. Minimum Lane - since TK527 live loading does not include a lane loading, this value is always zero.

7.4.131 EV2 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV2 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to EV2 live loading.
4. Maximum Moments, Positive, LC - for EV2 live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to EV2 live loading.
6. Maximum Moments, Negative, LC - for EV2 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to EV2 live loading.
8. Maximum Shears, Positive, LC - for EV2 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to EV2 live loading.
10. Maximum Shears, Negative, LC - for EV2 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to EV2 live loading.

7.4.132 EV2 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV2 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.131.

7.4.133 EV2 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV2 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution

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factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.131.

7.4.134 EV2 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV2 live loading . All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

- 1. Span No. - span number in which the analysis values are presented.
- 2. Support - the support at which the analysis values are located; supports include the following:

LEFT

RIGHT
- 3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to EV2 live loading.
- 4. Maximum Reaction, LC - for EV2 live load analysis, this column is left blank.
- 5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to EV2 live loading.
- 6. Minimum Reaction, LC - for EV2 live load analysis, this column is left blank.
- 7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to EV2 live loading.
- 8. Maximum Rotation, LC - for EV2 live load analysis, this column is left blank.
- 9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to EV2 live loading.
- 10. Minimum Rotation, LC - for EV2 live load analysis, this column is left blank.

7.4.135 EV2 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV2 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.134.

7.4.136 EV2 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV2 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This

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output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.134.

7.4.137 EV2 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to EV2 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the EV2 live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the EV2 live loading.
5. Maximum Lane - since EV2 live loading does not include a lane loading, this value is always zero.
6. Minimum Lane - since EV2 live loading does not include a lane loading, this value is always zero.

7.4.138 EV3 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV3 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to EV3 live loading.
4. Maximum Moments, Positive, LC - for EV3 live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to EV3 live loading.
6. Maximum Moments, Negative, LC - for EV3 live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to EV3 live loading.

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8. Maximum Shears, Positive, LC - for EV3 live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to EV3 live loading.
10. Maximum Shears, Negative, LC - for EV3 live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to EV3 live loading.

7.4.139 EV3 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV3 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.138.

7.4.140 EV3 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to EV3 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.138.

7.4.141 EV3 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV3 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to EV3 live loading.
4. Maximum Reaction, LC - for EV3 live load analysis, this column is left blank.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to EV3 live loading.
6. Minimum Reaction, LC - for EV3 live load analysis, this column is left blank.

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7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to EV3 live loading.
8. Maximum Rotation, LC - for EV3 live load analysis, this column is left blank.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to EV3 live loading.
10. Minimum Rotation, LC - for EV3 live load analysis, this column is left blank.

7.4.142 EV3 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV3 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.141.

7.4.143 EV3 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to EV3 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.141.

7.4.144 EV3 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to EV3 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the EV3 live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the EV3 live loading.
5. Maximum Lane - since EV3 live loading does not include a lane loading, this value is always zero.
6. Minimum Lane - since EV3 live loading does not include a lane loading, this value is always zero.

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7.4.145 SU6TV Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to SU6TV live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to SU6TV live loading.
4. Maximum Moments, Positive, LC - for SU6TV live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to SU6TV live loading.
6. Maximum Moments, Negative, LC - for SU6TV live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to SU6TV live loading.
8. Maximum Shears, Positive, LC - for SU6TV live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to SU6TV live loading.
10. Maximum Shears, Negative, LC - for SU6TV live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to SU6TV live loading.

7.4.146 SU6TV Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to SU6TV live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.145.

7.4.147 SU6TV Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to SU6TV live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.145.

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7.4.148 SU6TV Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to SU6TV live loading . All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

- 1. Span No. - span number in which the analysis values are presented.
- 2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
- 3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to SU6TV live loading.
- 4. Maximum Reaction, LC - for SU6TV live load analysis, this column is left blank.
- 5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to SU6TV live loading.
- 6. Minimum Reaction, LC - for SU6TV live load analysis, this column is left blank.
- 7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to SU6TV live loading.
- 8. Maximum Rotation, LC - for SU6TV live load analysis, this column is left blank.
- 9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to SU6TV live loading.
- 10. Minimum Rotation, LC - for SU6TV live load analysis, this column is left blank.

7.4.149 SU6TV Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to SU6TV live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.148.

7.4.150 SU6TV Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to SU6TV live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.148.

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7.4.151 SU6TV Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to SU6TV live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the SU6TV live loading.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the SU6TV live loading.
5. Maximum Lane - since SU6TV live loading does not include a lane loading, this value is always zero.
6. Minimum Lane - since SU6TV live loading does not include a lane loading, this value is always zero.

7.4.152 HS20 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HS20 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to HS20 live loading.
4. Maximum Moments, Positive, LC - the HS20 live loading code corresponding with the maximum, positive, unfactored moment; HS20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to HS20 live loading.
6. Maximum Moments, Negative, LC - the HS20 live loading code corresponding with the maximum, negative, unfactored moment; HS20 live loading codes include the following:
L - Lane Governs.

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- Blank - Truck Governs.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to HS20 live loading.
 8. Maximum Shears, Positive, LC - the HS20 live loading code corresponding with the maximum, positive, unfactored shear; HS20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
 9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to HS20 live loading.
 10. Maximum Shears, Negative, LC - the HS20 live loading code corresponding with the maximum, negative, unfactored shear; HS20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
 11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to HS20 live loading.

7.4.153 HS20 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HS20 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.131.

7.4.154 HS20 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to HS20 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.131.

7.4.155 HS20 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HS20 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:

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LEFT

RIGHT

3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to HS20 live loading.
4. Maximum Reaction, LC - the HS20 live loading code corresponding with the maximum, unfactored reaction; HS20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to HS20 live loading.
6. Minimum Reaction, LC - the HS20 live loading code corresponding with the minimum, unfactored reaction; HS20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to HS20 live loading.
8. Maximum Rotation, LC - the HS20 live loading code corresponding with the maximum, unfactored rotation; HS20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to HS20 live loading.
10. Minimum Rotation, LC - the HS20 live loading code corresponding with the minimum, unfactored rotation; HS20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.

7.4.156 HS20 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HS20 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.155.

7.4.157 HS20 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to HS20 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.155.

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7.4.158 HS20 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to HS20 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the HS20 truck load.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the HS20 truck load.
5. Maximum Lane - the maximum, unfactored reaction in the girder at the specified location due to the HS20 lane load.
6. Minimum Lane - the minimum, unfactored reaction in the girder at the specified location due to the HS20 lane load.

7.4.159 H20 Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to H20 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to H20 live loading.
4. Maximum Moments, Positive, LC - the H20 live loading code corresponding with the maximum, positive, unfactored moment; H20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to H20 live loading.

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6. Maximum Moments, Negative, LC - the H20 live loading code corresponding with the maximum, negative, unfactored moment; H20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to H20 live loading.
8. Maximum Shears, Positive, LC - the H20 live loading code corresponding with the maximum, positive, unfactored shear; H20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to H20 live loading.
10. Maximum Shears, Negative, LC - the H20 live loading code corresponding with the maximum, negative, unfactored shear; H20 live loading codes include the following:
 - L - Lane Governs.
 - Blank - Truck Governs.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to H20 live loading.

7.4.160 H20 Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to H20 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.159.

7.4.161 H20 Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to H20 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.159.

7.4.162 H20 Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to H20 live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

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1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to H20 live loading.
4. Maximum Reaction, LC - the H20 live loading code corresponding with the maximum, unfactored reaction; H20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to H20 live loading.
6. Minimum Reaction, LC - the H20 live loading code corresponding with the minimum, unfactored reaction; H20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to H20 live loading.
8. Maximum Rotation, LC - the H20 live loading code corresponding with the maximum, unfactored rotation; H20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to H20 live loading.
10. Minimum Rotation, LC - the H20 live loading code corresponding with the minimum, unfactored rotation; H20 live loading codes include the following:
L - Lane Governs.
Blank - Truck Governs.

7.4.163 H20 Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to H20 live loading with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.162.

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7.4.164 H20 Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to H20 live loading without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.162.

7.4.165 H20 Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to H20 live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to the H20 truck load.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to the H20 truck load.
5. Maximum Lane - the maximum, unfactored reaction in the girder at the specified location due to the H20 lane load.
6. Minimum Lane - the minimum, unfactored reaction in the girder at the specified location due to the H20 lane load.

7.4.166 Fatigue Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to fatigue live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to fatigue live loading.

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4. Maximum Moments, Positive, LC - for fatigue live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to fatigue live loading.
6. Maximum Moments, Negative, LC - for fatigue live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to fatigue live loading.
8. Maximum Shears, Positive, LC - for fatigue live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to fatigue live loading.
10. Maximum Shears, Negative, LC - for fatigue live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to fatigue live loading.

7.4.167 Fatigue Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to fatigue live loading. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase “c” if the value is from the continuous analysis results or a lowercase “s” if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to fatigue live loading.
4. Maximum Reaction, LC - for fatigue live load analysis, this column is left blank.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to fatigue live loading.
6. Minimum Reaction, LC - for fatigue live load analysis, this column is left blank.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to fatigue live loading.
8. Maximum Rotation, LC - for fatigue live load analysis, this column is left blank.
9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to fatigue live loading.
10. Minimum Rotation, LC - for fatigue live load analysis, this column is left blank.

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7.4.168 Fatigue Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to fatigue live loading. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to fatigue truck.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to fatigue truck.
5. Maximum Lane - since fatigue live load does not include a lane loading, this value is always zero.
6. Minimum Lane - since fatigue live load does not include a lane loading, this value is always zero.

7.4.169 SLL #i Live Load Analysis (Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to special live loading number i. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the moment, shear, and deflection values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to special live loading number i.
4. Maximum Moments, Positive, LC - for special live load analysis, this column is left blank.
5. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to special live loading number i.
6. Maximum Moments, Negative, LC - for special live load analysis, this column is left blank.
7. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to special live loading number i.
8. Maximum Shears, Positive, LC - for special live load analysis, this column is left blank.
9. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to special live loading number i.

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10. Maximum Shears, Negative, LC - for special live load analysis, this column is left blank.
11. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to special live loading number i.

7.4.170 SLL #i Live Load Analysis (With Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to special live loading number i with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user and the special live load Vehicle Type is not "P". The same information is printed on this table as described in Section 7.4.169.

7.4.171 SLL #i Live Load Analysis (Without Sidewalks, Unfactored, Including Impact)

This table presents the unfactored moments, shears, and deflections due to special live loading number i without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.169.

7.4.172 SLL #i Live Load Analysis (Reactions Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to special live loading number i. All values include the effects of dynamic load allowance (impact) and distribution factors. If the continuous analysis with simple span check option is selected for multi-span structures, the reaction and rotation values will include a lowercase "c" if the value is from the continuous analysis results or a lowercase "s" if the value is from the simple span check analysis results. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to special live loading number i.
4. Maximum Reaction, LC - for special live load analysis, this column is left blank.
5. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to special live loading number i.
6. Minimum Reaction, LC - for special live load analysis, this column is left blank.
7. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to special live loading number i.
8. Maximum Rotation, LC - for special live load analysis, this column is left blank.

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9. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to special live loading number i.
10. Minimum Rotation, LC - for special live load analysis, this column is left blank.

7.4.173 SLL #i Live Load Analysis (Reactions with Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to special live loading number i with sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user and the special live load Vehicle Type is not "P". The same information is printed on this table as described in Section 7.4.172.

7.4.174 SLL #i Live Load Analysis (Reactions without Sidewalks Including Impact Dist Factors)

This table presents the unfactored reactions and rotations due to special live loading number i without sidewalks present. All values include the effects of dynamic load allowance (impact) and distribution factors. This output table is presented only if a PLD command is input by the user. The same information is printed on this table as described in Section 7.4.172.

7.4.175 SLL #i Live Load Analysis (Reactions without Impact Dist Factors)

This table presents the unfactored truck and lane load reactions due to special live loading number i. All values do not include the effects of dynamic load allowance (impact). In addition, all values do not include distribution factors. The following information is presented in this table:

1. Span No. - span number in which the reactions are presented.
2. Support - the support at which the reactions are located; supports include the following:
LEFT
RIGHT
3. Maximum Truck - the maximum, unfactored reaction in the girder at the specified location due to special truck load number i.
4. Minimum Truck - the minimum, unfactored reaction in the girder at the specified location due to special truck load number i.
5. Maximum Lane - the maximum, unfactored reaction in the girder at the specified location due to special lane load number i.
6. Minimum Lane - the minimum, unfactored reaction in the girder at the specified location due to special lane load number i.

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7.4.176 Pedestrian Live Load Analysis (Unfactored)

This table presents the unfactored moments, shears, and deflections due to pedestrian live loading. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Maximum Moments, Positive - the maximum, positive, unfactored moment in the girder at the specified location due to pedestrian live loading.
4. Maximum Moments, Negative - the maximum, negative, unfactored moment in the girder at the specified location due to pedestrian live loading.
5. Maximum Shears, Positive - the maximum, positive, unfactored shear in the girder at the specified location due to pedestrian live loading.
6. Maximum Shears, Negative - the maximum, negative, unfactored shear in the girder at the specified location due to pedestrian live loading.
7. Maximum Deflection - the maximum, unfactored deflection in the girder at the specified location due to pedestrian live loading.

7.4.177 Pedestrian Live Load Analysis (Reactions)

This table presents the unfactored reactions and rotations due to pedestrian live loading. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Support - the support at which the analysis values are located; supports include the following:
LEFT
RIGHT
3. Maximum Reaction - the maximum, unfactored reaction in the girder at the specified location due to pedestrian live loading.
4. Minimum Reaction - the minimum, unfactored reaction in the girder at the specified location due to pedestrian live loading.
5. Maximum Rotation - the maximum, unfactored rotation in the girder at the specified location due to pedestrian live loading.
6. Minimum Rotation - the minimum, unfactored rotation in the girder at the specified location due to pedestrian live loading.

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7.4.178 Factored Analysis Results

This table presents the factored moments and shears for each analysis point and for each limit state being considered. This table is computed by multiplying the values in the unfactored analysis tables by the appropriate load modifier and load factors. All values include the effects of dynamic load allowance (impact). For continuous multi-span analysis, the creep and shrinkage moments are considered when computing the maximum and minimum factored moments except within the transfer length of each abutment. The following information is presented in this table:

1. Span No. - span number in which the analysis values are presented.
2. Distance - the distance from the location of the analysis values to the left end of the span in which the analysis values are located.
3. Limit State - the limit state for which the analysis values apply; limit states for which factored analysis results are presented include the following:
 - STR-I - Strength I limit state.
 - STR-IP - Strength IP limit state.
 - STR-IA - Strength IA limit state.
 - STR-II - Strength II limit state.
 - SRV-I - Service I limit state.
 - SRV-IP - Service IP limit state.
 - SRV-III - Service III limit state.
 - SRV-IIIP - Service IIIP limit state.
 - SRV-IIIA - Service IIIA limit state.
 - SRV-IIIB - Service IIIB limit state.
4. Factored Maximum Moment, $M(u)$ - the factored, maximum moment in the girder at the specified location for the specified limit state.
5. Factored Minimum Moment, $M(u)$ - the factored, minimum moment in the girder at the specified location for the specified limit state.
6. Factored Maximum Shear, $V(u)$ - the factored, maximum shear in the girder at the specified location for the specified limit state.
7. Factored Minimum Shear, $V(u)$ - the factored, minimum shear in the girder at the specified location for the specified limit state.

7.4.179 Required Counterweight / Counterweight Check

Required Counterweight

This output table is printed when uplift has occurred at any support for the Service I Limit State and no input Counterweight force has been entered.. A note will be printed following this output table explaining the program needs to be rerun with a counterweight entered in the input. The following information is presented in this table:

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1. Support No. – The support number of the reported uplift reaction location followed by either an “L” or “R” to identify the reaction as being to the LEFT or to the RIGHT of the support.
2. Uplift Force – The Service I Limit State reaction value. This value will be negative.
3. Req'd Counterweight Force – The required counterweight force based on the Strength I Limit State reaction value. This value will be positive.

Counterweight Check

This output table is printed when uplift has occurred at any support for the Service I limit state and an input Counterweight force has been entered. The following information is presented in this table:

1. Support No. – The support number of the reported uplift reaction location followed by either an “L” or “R” to identify the reaction as being to the LEFT or to the RIGHT of the support.
2. Uplift Force without CW Load – The Service I limit state reaction value without any counterweight load. This value will be negative.
3. Required Counterweight Force – The required counterweight force based on the Strength I limit state reaction value without any counterweight load. This value will be positive.
4. Provided Coun Counterweight Force – The provided counterweight force based on the Strength I limit state reaction value. This value will be positive.
5. If Code Failure Flag – A flag to indicate when the Required Counterweight Force exceeds the Provided Counterweight Force.

If a failure flag is present, a note will be printed following this output table explaining the program needs to be rerun with an additional counterweight force entered in the input.

7.4.180 Factored Analysis Results - Reactions

This table presents the factored reactions for each analysis point and for each limit state being considered. This table is computed by multiplying the values in the unfactored analysis tables by the appropriate load modifier and load factors. All values include the effects of dynamic load allowance (impact). The following information is presented in this table:

1. Support Number - support number for which the analysis values are presented.
2. L or R – either an “L” or “R” to identify the reaction as being to the LEFT or to the RIGHT of the support.
3. Limit State - the limit state for which the analysis values apply; limit states for which factored analysis results are presented include the following:
 - STR-I - Strength I limit state.
 - STR-IP - Strength IP limit state.
 - STR-IA - Strength IA limit state.

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- STR-II - Strength II limit state.
- SRV-I - Service I limit state.
- SRV-IP - Service IP limit state.

4. Maximum Reaction - the factored, maximum reaction in the girder at the specified support for the specified limit state.
5. Minimum Reaction - the factored, minimum reaction in the girder at the specified support for the specified limit state.
6. Maximum Rotation - the factored, maximum rotation in the girder at the specified support for the specified limit state.
7. Minimum Rotation - the factored, minimum rotation in the girder at the specified support for the specified limit state.
8. * If Uplift - an asterisk (*) is printed in this column if uplift occurs at the specified support based on the factored analysis results when uplift is considered for the limit state. If uplift is not considered for the limit state the text "n/a" is printed in this column.

7.4.181 Summary - Overall Reactions Tables

A list of the overall reaction output tables printed by default is given in Section 6.4. The user can suppress all of the overall reaction table outputs by entering zero on the OAN command for the overall reaction summary parameter. The output applies to both design and analysis runs of the program. Output tables listed in sections 7.4.181.1 to 7.4.181.4 are printed under the above title. The output tables provide reaction values that could be used as an input for bearing, abutment and pier designs.

When the simple span check option for multiple span bridges has been selected, both the continuous and the simple reactions and rotations are considered. The maximum and minimum reactions are selected based on the total factored reactions considering Limit State Service I. If pedestrian is considered, then the Service IP Limit State is also considered to determine the maximum and minimum reactions. When considering continuous and simple reactions for composite dead loads and live loads, all reactions are either continuous or simple. A lower case "c" or "s" is printed to the right of the reaction or rotation to identify the value being continuous or simple. The non-composite reactions are always from a simple span analysis and therefore do not include an identifier. Likewise, for single span bridges and multiple span bridges without the simple span check, the reactions and rotations do not include an identifier.

When the Service IP Limit State results in the controlling effect, the live load effect will also include the upper case "P" to identify Service IP controlled. For this case, the live load value printed is the sum of the vehicle and pedestrian loads multiplied by the corresponding load factors for the vehicle and pedestrian loads.

For non-composite bridges the "Total DC2" label is replaced by the label "S/W DL" (Sidewalk Deadload). The "S/W DL" reactions will be zero unless pedestrian loading is considered.

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7.4.181.1 Reactions & Rotations Per Girder (Unfactored, W/O Impact, W/ Distribution) For Elastomeric Bearing Pad Design

All reactions provided in this table are per girder. Live load reactions and rotations provided in this table include distribution factors and do not include impact. The absolute value of the minimum and maximum live load rotations are compared with the larger being reported without the absolute value. Both dead load and live load reactions are provided in one table. For NEXT Beams an asterisk, “*”, appears after the reaction values to note the values need to be divided by 2 to design bearings for each stem.

The following information is reported in the output table.

1. Support No. - Support number of the reported reaction location followed by either an “L” or an “R” to identify the reaction as being to the LEFT or to the RIGHT of the support.
2. Lists load types such as Dead Load (DC1, DC2, FWS) and LL (Live Load Vehicle).
3. Minimum Reaction - Minimum reaction value for the given load type
4. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for minimum reaction
5. Maximum Reaction - Maximum reaction value for the given load type
6. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for maximum reaction
7. Live Load Rotation - Rotation for live loads only. Lists maximum of absolute value of minimum and maximum rotations for the given live load
8. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for the rotation

7.4.181.2 Reactions & Rotations Per Girder (Unfactored, W/ Impact, W/ Distribution) For Pot, Steel Or Disc Bearing Design

For this table the live load effects include impact and distribution factors. All controlling conditions are determined using live load effects with both impact and distribution factor. Refer to the previous section for a detail description of the information reported in the output table.

7.4.181.3 Reactions (Unfactored) For Abutment Design

The following two output tables, 7.4.181.3.1 and 7.4.181.3.2, are summarized for the abutment design under the above title. Dead load and live load reactions are provided in two separate output tables. These values are to be used only if the end supports are abutments. Do not use these values for the pier design at a discontinuous superstructure.

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7.4.181.3.1DL Reactions (Unfactored) per Girder

All reactions provided in this table are per girder. The user is expected to sum the reactions from each girder obtained from different runs for interior and exterior girders. The resulting value should then be divided by the skewed abutment width to obtain total dead load reaction per unit width of the abutment for the use in abutment design (refer to section 3.7.18).

The following information is reported in the output table.

1. Support No. - Support number of the reported reaction location.
2. Lists dead load types (DC1, DC2, FWS)
3. Minimum Reaction - Minimum reaction value for the given load type
4. LC - Governing multi-span analysis code for minimum reaction
5. Maximum Reaction - Maximum reaction value for the given load type
6. LC - Governing multi-span analysis code for maximum reaction

7.4.181.3.2LL Reactions per Lane (Unfactored, w/o Impact)

The user should multiply the reaction value given in the output table by the number of lanes and the multiple presence factor. The resulting value should then be divided by the skewed abutment width to obtain total live load reaction per unit width of the abutment for the use in abutment design (refer to section 3.7.18).

Minimum and maximum reaction values listed under this table is the summation of vehicle and lane reactions.

The following information is reported in the output table.

1. Support No. - Support number of the reported reaction location.
2. Lists live load vehicle for the reported reaction
3. Minimum Reaction - Minimum reaction value for the given load type
4. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for minimum reaction
5. Maximum Reaction - Maximum reaction value for the given load type
6. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for maximum reaction

7.4.181.4 Reactions (Unfactored) For Pier Design

The following two output tables, 7.4.181.4.1 and 7.4.181.4.2, are summarized for the pier design under the above title. Dead load and live load reactions are provided in two separate output tables. These output tables are only produced for interior supports. For each interior support, reactions are provided to the left and to the right of the support.

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7.4.181.4.1DL Reactions (Unfactored) per Girder

The following information is reported in the output table.

1. Support No. - Support number of the reported reaction location followed by either an "L" or an "R" to identify the reaction as being to the LEFT or to the RIGHT of the support.
2. Lists dead load types (DC1, DC2, FWS)
3. Minimum Reaction - Minimum reaction value for the given load type
4. LC - Governing multi-span analysis code for minimum reaction
5. Maximum Reaction - Maximum reaction value for the given load type
6. LC - Governing multi-span analysis code for maximum reaction

7.4.181.4.2LL Reactions per Lane (Unfactored, w/o Impact)

The following information is reported in the output table.

1. Support No. - Support number of the reported reaction location followed by either an "L" or an "R" to identify the reaction as being to the LEFT or to the RIGHT of the support
2. Lists live load run for the reported reaction
3. Minimum Reaction Truck - Minimum vehicle reaction value for the given LL
4. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for minimum vehicle reaction
5. Minimum Reaction Lane - Minimum lane reaction value for the given LL
6. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for minimum lane reaction
7. Maximum Reaction Truck - Maximum vehicle reaction value for the given LL
8. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for maximum vehicle reaction
9. Maximum Reaction Lane - Maximum lane reaction value for the given LL
10. LC - Governing loading code (for PHL-93 and HL-93 only) and multi-span analysis code for maximum lane reaction

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7.5 SPECIFICATION CHECKING OUTPUT

The specification checking output consists of results from the various specification checks. A format commonly used in the specification checking output tables is as follows:

1. Location of specification check.
2. Allowable values.
3. Actual values.
4. Code failure check, in which an asterisk (*) indicates a code failure. Stress checks apply the allowable stress tolerances specified by in DM-4 Article 5.9.2.3.7P.

A summary of the output tables for each parameter is given in Section 6.4. The user can suppress all specification checking output by entering zero for every specification checking output parameter.

7.5.1 Allowable Concrete Stresses

This table presents the allowable concrete stresses for each span at both the centerline of bearing and at all other locations. The following information is presented in this table:

1. Span No. - the span number for which the allowable concrete stresses are presented.
2. Type of Stress - the following are the various types of stress that are presented:
 - Initial Stress at Transfer of P/S
 - Final Compressive Stress Under Design DL+P/S
 - Final Stress Under Design Loads
 - Final Compressive Stress Under LL+0.5(DL+P/S)
 - Final Stresses in Slab
 - Final Stress with Creep & Shrinkage
3. Tension or Compression - the word "Tension" indicates that an allowable concrete tensile stress is presented, and the word "Compression" indicates that an allowable concrete compressive stress is presented.
4. Stress Designation - the stress designation that corresponds with the type of stress and whether the stress is tensile or compressive; the following is a legend of stress designations used in the output:
 - $f(t_i)$ = initial tensile stress at transfer of P/S.
 - $f(c_i)$ = initial compressive stress at transfer of P/S.
 - $f(c, DP)$ = final compressive stress under design DL+P/S.
 - $f(t)$ = final tensile stress under design loads.
 - $f(c)$ = final compressive stress under design loads.
 - $f(c, 1/2DP)$ = final compressive stress under LL+0.5(DL+P/S).
 - $f(cs)$ = final stresses in slab.
 - $f(t)$ = final stress with creep and shrinkage.

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5. Allow. Conc. Stresses at C.L. Bearing - the allowable concrete stress at the centerline of simple span bearing corresponding with the stress designation.
6. Allow. Conc. Stresses at All Other Locations - the allowable concrete stress at all locations other than the centerline of simple span bearing corresponding with the stress designation.

7.5.2 Initial Stresses at Transfer of Prestress

This table presents the initial stresses at transfer of prestress. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the initial stresses are presented.
2. Distance - the distance from the location of the initial stresses to the left end of the span in which the stresses are located. For debonded problems, the debonded transfer length is denoted with a "<" next to the distance value.
3. Allowable Stresses, Compressive Stress, $f(c_i)$ - the allowable compressive stress at the specified location.
4. Allowable Stresses, Tensile Stress, $f(t_i)$ - the allowable tensile stress at the specified location.
5. Actual Stresses, Top of Beam, $f(\text{top})$ - the actual stress at the top of the beam at the specified location.
6. Actual Stresses, Bot. of Beam, $f(\text{btm})$ - the actual stress at the bottom of the beam at the specified location.
7. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the actual stresses exceed the allowable stresses at the specified location. A number symbol (#) indicates that the actual stress exceeds the allowable but is within the tolerance.

7.5.3 Final Stresses Under Dead Load and Prestress

This table presents the final stresses under dead load and prestress. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located
3. Allowable Compressive Stress, $f(c,DL)$ - the allowable final compressive stress under dead load and prestress at the specified location.
4. Actual Stresses, Top of Beam, $f(\text{top},c,DL)$ - the actual final compressive stress under dead load and prestress at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.

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5. Actual Stresses, Bot. of Beam, $f_{(btm,c,DL)}$ - the actual final compressive stress under dead load and prestress at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the actual stresses exceed the allowable stress at the specified location. A number symbol (#) indicates that the actual stress exceeds the allowable but is within the tolerance. A double asterisk (**) indicates that the stress for a location within 3 ft of the centerline of bearing exceeds the allowable, but will be less due to crack control debonding.

7.5.4 Final Compressive Stresses - Design Loads

This table presents the final compressive stresses under design loads. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, f_c - the allowable final compressive stress under design loads at the specified location.
4. Total Stresses, Top of Beam, $f_{(top,c)}$ - the total final compressive stress under design loads at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the total stress if the pedestrian load case governs.
5. Total Stresses, Bot. of Beam, $f_{(btm,c)}$ - the total final compressive stress under design loads at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the total stress if the pedestrian load case governs.
6. LL Stresses, Top of Beam, $f_{(t,LL)}$ - the live load final compressive stress from the design live load vehicle(s) at the top of the beam at the specified location.
7. LL Stresses, Bot. of Beam, $f_{(b,LL)}$ - the live load final compressive stress from the design live load vehicle(s) at the bottom of the beam at the specified location.
8. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the total stresses exceed the allowable stress at the specified location. A number symbol (#) indicates that the total stress exceeds the allowable but is within the tolerance.

7.5.5 Final Compressive Stresses - Design Loads (Includes Creep and Shrinkage)

This table presents the final compressive stresses under design loads, including the effects of creep and shrinkage for continuous spans only. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

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1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, $f(c)$ - the allowable final compressive stress under design loads, including the effects of creep and shrinkage, at the specified location.
4. Total Stresses, Top of Beam, $f(\text{top},c)$ - the total final compressive stress under design loads, including the effects of creep and shrinkage, at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the total stress if the pedestrian load case governs.
5. Total Stresses, Bot. of Beam, $f(\text{btm},c)$ - the total final compressive stress under design loads, including the effects of creep and shrinkage, at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the total stress if the pedestrian load case governs.
6. LL Stresses, Top of Beam, $f(t,LL)$ - the live load final compressive stress from the design live load vehicle(s) at the top of the beam at the specified location.
7. LL Stresses, Bot. of Beam, $f(b,LL)$ - the live load final compressive stress from the design live load vehicle(s) at the bottom of the beam at the specified location.
8. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the total stresses exceed the allowable stress at the specified location. A number symbol (#) indicates that the total stress exceeds the allowable but is within the tolerance.

7.5.6 Final Tensile Stresses - Design Loads

This table presents the final tensile stresses under design loads. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Tensile Stress, $f(t)$ - the allowable final tensile stress under design loads at the specified location.
4. Total Stresses, Top of Beam, $f(\text{top},t)$ - the total final tensile stress under design loads at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
5. Total Stresses, Bot. of Beam, $f(\text{btm},t)$ - the total final tensile stress under design loads at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
6. LL Stresses, Top of Beam, $f(t,LL)$ - the live load final tensile stress from the design live load vehicle(s) at the top of the beam at the specified location.

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7. LL Stresses, Bot. of Beam, $f(b,LL)$ - the live load final tensile stress from the design live load vehicle(s) at the bottom of the beam at the specified location.
8. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the total stresses exceed the allowable stress at the specified location. A number symbol (#) indicates that the total stress exceeds the allowable but is within the tolerance. A plus sign (+) indicates the girders at interior supports are designed as reinforced concrete members at the strength limit state. The stress limits for the service limit state do not apply to this region of the girder.

7.5.7 Final Tensile Stresses - Design Loads (Includes Creep and Shrinkage)

This table presents the final tensile stresses under design loads, including the effects of creep and shrinkage for continuous spans only. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Tensile Stress, $f(t)$ - the allowable final tensile stress under design loads, including the effects of creep and shrinkage, at the specified location.
4. Total Stresses, Top of Beam, $f(top,t)$ - the total final tensile stress under design loads, including the effects of creep and shrinkage, at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
5. Total Stresses, Bot. of Beam, $f(btm,t)$ - the total final tensile stress under design loads, including the effects of creep and shrinkage, at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
6. LL Stresses, Top of Beam, $f(t,LL)$ - the live load final tensile stress from the design live load vehicle(s) at the top of the beam at the specified location.
7. LL Stresses, Bot. of Beam, $f(b,LL)$ - the live load final tensile stress from the design live load vehicle(s) at the bottom of the beam at the specified location.
8. * If Code Failure - the code failure check, in which an asterisk (*) is presented if either of the total stresses exceed the allowable stress at the specified location. A number symbol (#) indicates that the total stress exceeds the allowable but is within the tolerance. A plus sign (+) indicates the girders at interior supports are designed as reinforced concrete members at the strength limit state. The stress limits for the service limit state do not apply to this region of the girder.

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7.5.8 Final Stresses In Slab – Design Loads

This table presents the final compressive stresses in the slab. This table is presented for composite sections only. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, $f(cs)$ - the allowable final compressive stress in the slab at the specified location.
4. Total Stress at Top of Slab, $f(c,slab)$ - the total final compressive stress in the top of the slab at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
5. LL Stress at Top of Slab, $f(slab,LL)$ – the live load final compressive stress from the design live load vehicle(s) in the top of the slab at the specified location.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the total stress exceeds the allowable stress at the specified location.

7.5.9 Final Stresses in Slab – Design Loads (Includes Creep and Shrinkage)

This table presents the final compressive stresses in the slab, including the effects of creep and shrinkage for continuous spans only. This table is presented for composite sections only. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, $f(cs)$ - the allowable final compressive stress in the slab, including the effects of creep and shrinkage, at the specified location.
4. Total Stress at Top of Slab, $f(c,slab)$ - the total final compressive stress in the top of the slab, including the effects of creep and shrinkage, at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
5. LL Stress at Top of Slab, $f(slab,LL)$ – the live load final compressive stress from the design live load vehicle(s) in the top of the slab at the specified location.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the total stress exceeds the allowable stress at the specified location.

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7.5.10 Final Compressive Stresses Under $LL+1/2(DL+P/S)$

This table presents the final compressive stresses under live load plus one-half of the sum of dead load and prestress. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, $f(c, 1/2DP)$ - the allowable final compressive stress under live load plus one-half of the sum of dead load and prestress at the specified location.
4. Actual Stress at Top of Beam, $f(top, c, 1/2DP)$ - the actual final compressive stress under live load plus one-half of the sum of dead load and prestress at the top of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
5. Actual Stress at Bottom of Beam, $f(btm, c, 1/2DP)$ - the actual final compressive stress under live load plus one-half of the sum of dead load and prestress at the bottom of the beam at the specified location. For pedestrian load runs, a "P" is placed next to the actual stress if the pedestrian load case governs.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the actual stress exceeds the allowable stress at the specified location.

7.5.11 Final Compressive Stresses – Fatigue-I + $1/2(DL+P/S)$

This table presents the final compressive stresses from Fatigue I live load combination plus one-half of the sum of dead load and prestress. This table is not applicable for points between both simple span centerline of bearings at continuous supports (see Figure 3.3-1). The following information is presented in this table:

1. Span No. - the span number for which the final stresses are presented.
2. Distance - the distance from the location of the final stresses to the left end of the span in which the stresses are located.
3. Allowable Compressive Stress, $f(c, 1/2DP)$ - the allowable final compressive stress from Fatigue I live load combination plus one-half of the sum of dead load and prestress at the specified location.
4. Actual Stress at Top of Beam, $f(top, c, 1/2DP)$ - the actual final compressive stress from Fatigue I live load combination plus one-half of the sum of dead load and prestress at the top of the beam at the specified location.
5. Actual Stress at Bottom of Beam, $f(btm, c, 1/2DP)$ - the actual final compressive stress from Fatigue I live load combination plus one-half of the sum of dead load and prestress at the bottom of the beam at the specified location.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the actual stress exceeds the allowable stress at the specified location.

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7.5.12 End Block Stresses Based on Solid Section

This table presents the initial end block tensile stresses based on a solid section at the end of the beam. This table is presented only for adjacent or spread box beams with either straight or draped strands. The following information is presented in this table:

1. Span No. - the span number for which the initial stresses are presented.
2. Distance - the distance from the location of the initial stresses to the left end of the span in which the stresses are located.
3. Allowable Initial Tensile Stress, f_{ti} - the allowable initial tensile stress in the beam, based on a solid section at the end of the beam, at the specified location.
4. Actual Initial Stress at Top of Beam, f_{top} - the actual initial tensile stress in the top of the beam at the specified location.
5. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the actual stress exceeds the allowable stress at the specified location.

7.5.13 End Block Stresses Based on Solid Section with Beam Notch

This table presents the initial end block tensile stresses based on a solid section at the end of the beam, with a beam notch. This table is presented only for adjacent or spread box beams with either straight or draped strands. The following information is presented in this table:

1. Span No. - the span number for which the initial stresses are presented.
2. Distance - the distance from the location of the initial stresses to the left end of the span in which the stresses are located.
3. Beam Notch - the depth of the beam notch.
4. Allowable Initial Tensile Stress, f_{ti} - the allowable initial tensile stress in the beam, based on a solid section at the end of the beam with a beam notch, at the specified location.
5. Actual Initial Stress at Top of Beam, f_{top} - the actual initial tensile stress in the top of the beam at the specified location.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the actual stress exceeds the allowable stress at the specified location.

7.5.14 Minimum Prestressing Steel Check

This table presents the minimum prestressing steel check as a comparison of the cracking moment versus the ultimate moment capacity. The following information is presented in this table:

1. Span No. - the span number for which the cracking moment check is presented.
2. Distance - the distance from the location of the cracking moment check to the left end of the span in

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which the moments are located.

3. Cracking Moment, M_{cr} - the cracking moment in the beam at the specified location. For both pedestrian load runs and non-pedestrian load runs, the cracking moment calculation does not include sidewalk or additional future wearing surface.
4. $4/3 * M(u)$ - $4/3$ times the total factored moment at the specified location.
5. Ultimate Moment Capacity, $M(r)$ - the ultimate moment capacity in the beam at the specified location. This value is the maximum of Strength I, Strength II, and, if applicable, Strength IP.
6. $M(r)/MINVAL$ - the ultimate moment capacity in the beam divided by the minimum of the cracking moment in the beam or $4/3$ times the total factored moment at the specified location.
7. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the $M(r)/MINVAL$ ratio is less than 1.0 with a 1.5% tolerance (less than 0.985). A number symbol (#) indicates that the ratio is less than 1.0 but is within the tolerance.

7.5.15 Flexural Resistance Factors

This table presents the flexure resistance factor based on the net tensile strain at each analysis point. The following information is presented in this table:

1. Span No. – the span number for which the flexure resistance factor is presented.
2. Distance – the distance from the location of the flexure resistance factor to the left end of the span.
3. Nominal Flexural Resistance, $M(n)$ – the nominal flexural resistance of the beam at the specified location.
4. ϕ – the flexure resistance factor at the specified location.
5. Net Tensile Strain, $e(t)*1000$ – the net tensile strain in extreme tension steel at nominal resistance times one thousand.
6. $c(N.A.)$ – the distance to the neutral axis from the extreme compression fiber.

7.5.16 Service IIIA 90% Yield Stress of P/S Strands (aaaaaaaaaaaaaaaaaaaa)

This table presents the Service IIIA check of the flexural resistance of the section with the stress in the prestressing steel in the row nearest the extreme tension fiber of the member equal to 90% of the yield stress of the prestressing strands. The following information is presented in this table:

1. Span No. – the span number for which the flexure resistance is presented.
2. Distance – the distance from the location of the flexure resistance to the left end of the span.
3. SRV-3A Moment, $M(u)$ – the Service IIIA moment at the specified location.
4. Flexural Resistance, $M(r)@0.9 f_{py}$ – the resistance of the section at the 90% stress level of the strands nearest the extreme tension fiber of the member at the specified location.
5. SRV-3A LL Moment, $M(u_{LL})$ – the live load moment for Service IIIA Limit State at the specified location.

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- 6. * If Code Failure – the code failure check, in which an asterisk (*) is presented if the M(u) moment is greater than the M(r)@0.9 fpy moment.

7.5.17 Cracking Moment Service Check (aaaaaaaaaaaaaaaaaaaaa)

This table presents the cracking moment service check as computed in accordance with DM-4 Article 5.6.3.3. Values presented represent the controlling values based on "design live loading" associated with the given design or analysis live load code entered on the CTL command. The following information is presented in this table:

- 1. Span No. - the span number for which the cracking moment check is presented.
- 2. Distance - the distance from the location of the cracking moment check to the left end of the span in which the moments are located. Debonding transfer locations are denoted with a less than character (<) after the distance. Debonding cutoff locations are denoted with a backslash character (\) after the distance. Locations that are both transfer locations and cutoff locations are denoted with an amperstand character (&) after the distance.
- 3. SERV-IIIB Moment - the factored moment for the Service IIIB limit state at the specified location.
- 4. Cracking Moment, M(cr) - the cracking moment in the beam at the specified location. For both pedestrian load runs and non-pedestrian load runs, the cracking moment calculation does not include sidewalk or additional future wearing surface.
- 5. Design Controlled By M(cr) - an asterisk (*) is presented if the design is controlled by the cracking moment at the indicated location.

7.5.18 Negative Moment Capacity (aaaaaaaaaaaaaaaaaaaaa)

This table presents a check of the negative moment capacity. Values presented represent the "design live loading" associated with the given design or analysis live load code entered on the CTL command. This table is presented only for structures with more than one span. The following information is presented in this table:

- 1. Span No. - the span number for which the negative moment capacity is presented.
- 2. Distance - the distance from the location of the negative moment to the left end of the span in which the moment is located.
- 3. Limit State - the limit state for which the negative moment capacity is presented; limit states for which negative moment capacities are presented include the following:
 - STR-I - Strength I limit state.
 - STR-IP - Strength IP limit state.
 - STR-II - Strength II limit state.

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4. Factored Flexural Resistance, $M(r)$ - the factored flexural resistance in the beam at the specified location.
5. Factored Moment, $M(u)$ - the factored moment in the beam at the specified location for the specified limit state.
6. Crack Moment, $M(cr)$ – the cracking moment in the slab of the composite beam at the specified location.
7. ϕ – the flexure resistance factor at the specified location.
8. Net Tensile Strain $\epsilon_t \times 1000$ – the net tensile strain in the extreme tension steel at nominal resistance.
9. Required $A_s/Eff.$ Slab Width – for design runs the area of longitudinal slab reinforcement within the effective slab width required for the negative moment.
Provided $A_s/Eff.$ Slab Width – for analysis runs the area of longitudinal slab reinforcement within the effective slab width provided for the negative moment.
10. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the factored flexural resistance, $M(r)$, is less than the factored moment, $M(u)$.

7.5.19 Shear Reinforcement and Resistance

This table presents the shear reinforcement stirrup area and spacing, as well as the nominal shear resistance provided by the concrete, prestressing, and shear reinforcement. The following information is presented in this table:

1. Span No. - the span number for which the shear reinforcement and resistance values are presented.
2. Distance - the distance from the location of the shear values to the left end of the span in which the shear values are located; all analysis points are printed for this table; for points that are not located within the critical section, results are not printed, but the message "Not Applicable" is printed; the critical distance is denoted with a "<" next to the distance value.
3. Shear Reinforcement, Stirrup Area, $A(v)$ - the area of all legs of the shear reinforcement stirrup at the specified location.
4. Shear Reinforcement, Stirrup Spacing, s - the spacing of the shear reinforcement stirrups at the specified location.
5. Shear Reinforcement, Maximum Spacing, $s(max)$ – the maximum spacing allowed. This column is reported only for analysis problems. The AASHTO Article that controls the maximum spacing is noted by an integer in parentheses. The integer can be either 3, 5, or 6 to denote AASHTO Articles 5.7.3.3, 5.7.2.5, or 5.7.2.6, respectively.
6. Nominal Shear Resistance Provided By: Concrete, $V(c)$ - the nominal shear resistance provided by the concrete at the specified location.
7. Nominal Shear Resistance Provided By: P/S Force, $V(p)$ - the nominal shear resistance provided by the prestressing force at the specified location.

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8. Nominal Shear Resistance Provided By: Shear Reinf., $V(s)$ - the nominal shear resistance provided by the shear reinforcement at the specified location.
9. Nominal Shear Resistance Provided By: Governing Limit State - the limit state that governed nominal shear resistance; the following codes are used for governing limit state:
 - 1 - STR-I max shear, +ve mom.
 - 2 - STR-I max shear, -ve mom.
 - 3 - STR-II max shear, +ve mom.
 - 4 - STR-II max shear, -ve mom.
 - 5 - STR-IP max shear, +ve mom.
 - 6 - STR-IP max shear, -ve mom.
10. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the stirrup spacing, s , is greater than the maximum spacing, $s(\max)$. This column is reported only for analysis problems.

7.5.20 Shear Design/Analysis

This table presents the shear design or analysis results. Design results are presented for a design run, and analysis results are presented for an analysis run. The following information is presented in this table:

1. Span No. - the span number for which the shear results are presented.
2. Distance - the distance from the location of the shear results to the left end of the span in which the shear results are located; all analysis points are printed for this table; for points that are not located within the critical section, results are not printed, but the message "Not Applicable" is printed; the critical distance is denoted with a "<" next to the distance value.
3. Governing Limit State - the governing limit state and the governing loading condition (such as + mom) for which the shear results are presented.
4. Factored Shear Resistance, $V(r)$ - the factored shear resistance at the specified location. A caret symbol (^) is presented if $V(r)$ is limited by the web concrete ($0.25f_c' b_v d_v + V(p)$).
5. Factored Shear, $V(u)$ - the factored shear at the specified location corresponding with the governing limit state.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the factored shear resistance, $V(r)$, is less than 99.5% of the factored shear, $V(u)$. A pound sign (#) is presented if $V(r)$ is greater than or equal to 99.5% of $V(u)$ but less than $V(u)$. If a pound sign is printed, a note is printed directing the user to verify the shear ratings are greater than or equal to 1.00.

7.5.21 Resistance of Longitudinal Steel

This table presents the tensile resistance of longitudinal steel results. The following information is presented in this table:

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1. Span No. - the span number for which the tensile resistance values are presented.
2. Distance - the distance from the location of the tensile resistance values to the left end of the span in which the resistance values are located; all analysis points are printed for this table; for points that are not located within the critical section, results are not printed, but the message "Not Applicable" is printed; the critical distance is denoted with a "<" next to the distance value.
3. Limit State - the governing limit state for which the resistance values are presented.
4. Tensile Resistance of Longitudinal Steel - the tensile resistance of the longitudinal steel at the specified location.
5. Actual Factored Tension - the actual factored tension for the specified limit state at the specified location.
6. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the tensile resistance of longitudinal steel is less than the actual factored tension.

7.5.22 Limits On Horizontal Shear (aaaaaaaaaaaaaaaaaaaa)

This table presents the nominal shear resistance limits for each span. The following information is presented in this table:

1. Span No. - the span number for which the horizontal shear resistance values are presented.
2. $x.xx \cdot f_c \cdot A_{cv}$ – this value is an upper limit for the nominal shear resistance.
3. $x.x \cdot A_{cv}$ – this value is an upper limit for the nominal shear resistance; $x.x \cdot A_{cv}$ will be presented in the column heading and in the output data.
4. $V(n-max)$ – the minimum of the values presented in columns 2 and 3.

7.5.23 Horizontal Shear (aaaaaaaaaaaaaaaaaaaa)

This table presents the nominal shear resistance, as well as the stirrup spacing and area, for horizontal shear in the girder based on "design live loading" associated with the given design or analysis live load code entered on the CTL command. The following information is presented in this table:

1. Span No. - the span number for which the horizontal shear resistance and reinforcement values are presented.
2. Distance - the distance from the location of the horizontal shear values to the left end of the span in which the horizontal shear values are located; only analysis points that are located within the critical sections are printed; the critical distance is denoted with a "<" next to the distance value.
3. $u[A_v f_y + p_c]$ - this value is the friction component of the nominal shear resistance.
4. $c A_{cv}$ – this value is the cohesion component of the nominal shear resistance.
5. $V(n-prov)$ - the provided nominal shear resistance of the section considered. For an stirrup design this column will not be presented.
6. $V(n-req)$ - the required nominal shear resistance of the section considered.

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7. Stirrup Spacing (prov) – the user provided spacing of the horizontal shear reinforcement stirrups at the specified location. For a stirrup design this column will not be presented.
8. Stirrup Spacing (req) - the required spacing of the horizontal shear reinforcement stirrups at the specified location. If either Failure Code A or B has occurred the value will be zero.
9. Stirrup Area - the area of all legs of the horizontal shear reinforcement stirrups at the specified location.
10. Failure Code – six possible code failure checks are reported using the letters A, B, C, D, E, or F with the following meanings:
 - A - $V(n\text{-req})$ greater than $V(n\text{-max})$
 - B - $V(n\text{-prov})$ greater than $V(n\text{-max})$
 - C - $V(n\text{-prov})$ less than $V(n\text{-req})$
 - D - User-specified stirrup spacing greater than required spacing
 - E - User-specified stirrup spacing less than minimum spacing
 - F - User-specified stirrup spacing greater than maximum spacing

7.5.24 Stirrups Required for End Zone Splitting Stresses

This table presents the required area and required distribution end zone distance for transverse steel in girder end zones. The following information is presented in this table:

1. Span No. - the span number in which the end zone is located.
2. Required Area of Transverse Steel in Girder End Zones, $A(sr)$ - the required area of the transverse steel in the girder end zones.
3. Required Distribution End Zone Distance for Area of Transverse Steel, $X(sr)$ - the required distribution end zone distance for the transverse steel in the girder end zones.

7.5.25 Theta & Beta Values – Table B5.2-1

This table presents the values used to interpolate θ and β from Table B5.2-1 of LRFD Specifications Appendix B5. The following information is presented in this table:

1. Span No. – the span number in which the theta and beta values are presented.
2. Distance – the distance from the left end of the span where the values are presented.
3. v_u/f'_c – the shear stress on the concrete as computed by LRFD Specification Article 5.7.2.8 divided by the design concrete strength.
4. $\epsilon(x) \times 10^3$ – the longitudinal strain at the mid-depth of the member as computed by LRFD Specification Article B5.2 times 1000.
5. Theta – the angle of inclination of diagonal compressive stresses linearly interpolated from LRFD Specification Table B5.2-1
6. Beta – the factor indicating the ability of diagonally cracked concrete to transmit tension and shear

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linearly interpolated from LRFD Specification Table B5.2-1

7.5.26 Longitudinal Strain – Epsilon(x)

This table presents the values used to compute ϵ_x using equations from LRFD Specifications Article B5.2. The following information is presented in this table:

1. Span No. – the span number in which the values are presented.
2. Distance – the distance from the left end of the span where the values are presented.
3. Mu – the maximum of the factored moment at the section or $V_u * dv$.
4. dv – the effective shear depth.
5. V_u – the factored shear force.
6. V_p – the component of the prestressing force in the direction of the shear force.
7. Theta – the angle of inclination of diagonal compressive stresses.
8. Aps – the area of the prestressing steel on the flexural tension side of the member.
9. f_{pu} – taken as the stress in the strands when the concrete is cast around them, i.e., approximately equal to the jacking stress ($0.75 f_{pu}$ DM-4 Table 5.9.2.2-1)
10. As – the area of non-prestressed steel on the flexural tension side of the member at the section under consideration.
11. Ac – the area of the concrete on the flexural tension side of the member at the section under consideration.
12. Epsilon(x) x 10^3 – the longitudinal strain at the mid-depth of the member times 1000

7.5.27 Shear Stress on Concrete

This table presents the values used to compute v_u using LRFD Specifications Equation 5.7.2.8-1. The following information is presented in this table:

1. Span No. – the span number in which the values are presented.
2. Distance – the distance from the left end of the span where the values are presented.
3. V_u – the factored shear force.
4. V_p – the component of the prestressing force in the direction of the shear force.
5. phi – the resistance factor for shear.
6. bv – the effective web width taken as the minimum web width.
7. dv – the effective shear depth.
8. v_u – the shear stress on the concrete.

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7.5.28 Effective Shear Depth

This table presents the values used to compute d_v using the definition from LRFD Specifications Article 5.7.2.8. The following information is presented in this table:

- 1. Span No. – the span number in which the values are presented.
- 2. Distance – the distance from the left end of the span where the values are presented.
- 3. d_s – at locations controlled by negative moment, the distance from extreme compression fiber to the centroid of the longitudinal slab reinforcement. (n/a reported at locations controlled by positive moment)
- 4. d_p – at locations controlled by positive moment, the distance from extreme compression fiber to the centroid of the prestressing steel. (n/a reported at locations controlled by negative moment)
- 5. d_e – the depth of center of gravity of steel as computed by LRFD Specifications Equation 5.7.2.8-2.
- 6. h – the overall depth of the member.
- 7. $0.9d_e$ – the first lower bound on the effective shear depth.
- 8. $0.72h$ – the second lower bound on the effective shear depth.
- 9. d_{ct} – the distance between the resultants of the tensile and compressive forces due to flexure.
- 10. d_v – the effective shear depth (maximum of $0.9d_e$, $0.72h$, and d_{ct}).

7.5.29 Draped Strand (Beam Desig. <aaaaaaaa>)

This table presents the draped strand pattern for each span. The beam designation is presented in the table heading, when applicable. Table sub-headings identify whether the presented information is for Draped Strands, Straight Strands, or Straight/Draped Strands. This table presents strand data for each individual row, as well as for the entire strand pattern. This table is printed for design problems and analysis problems, without crack control debonding, when the strand pattern was entered. For design problems and analysis problems, without crack control debonding and with the SCE command entered, the draped and straight strands are presented separately in two sub-tables. For analysis problems, without crack control debonding and without the SCE command entered, the straight and draped strands are presented in a single combined table. Individual row data at the beam end and C.L. Brg is blank when the single combined table is presented. The following information is presented in this table regardless of whether the SCE command was entered:

- 1. Span No. - the span number for which the strand pattern is presented.
- 2. Row No. - the row number for which the strand data is presented; in the next to last row of this column, "Total" is presented to designate the total number of strands for the entire strand pattern, in the last row of this column, "C.G." is presented to designate strand data for the center of gravity of the entire strand pattern.
- 3. Avail. Strands - the number of available strand positions in the specified row. For user defined beams this column displays "un" to indicate this information is *unknown*. For the draped sub-table this is the

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number of available strand positions for draping. For the straight sub-table and the combined straight/draped sub-table this is the total available strand positions.

4. Beam End (xx.xxx) - this column presents both the vertical distance from the specified row to the bottom of the beam and the number of strands in the specified row at the beam end. The location of the end of the beam from the simple bearing is specified in parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.
5. C.L. Brg (xx.xxx) - this column presents both the vertical distance from the specified row to the bottom of the beam and the number of strands in the specified row at the centerline of bearing. The location of the centerline of bearing from the simple bearing is specified in parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.
6. Drape Point (xx.xxx) - this column presents both the vertical distance from the specified row to the bottom of the beam and the number of strands in the specified row at the drape point. The location of the drape point from the simple bearing is specified in parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.

When the draped and straight sub-tables are presented a third sub-table is presented for the Total Number of Strands. The following information is presented in this sub-table:

1. Span Number - the span number for which the number of strands is presented.
2. Row Number - the row number for which the number of strands is presented; in the last row of this column, "Total" is presented to designate the total number of strands.
3. Draped - this column presents the number of draped strands and the available number of draped strand positions. An asterisk will be printed next to the number of draped strands if the number of draped strand positions is exceeded.
4. Straight - this column presents the number of straight strands and the available number of straight strand positions. An asterisk will be printed next to the number of straight strands if the number of straight strand positions is exceeded.
5. Total - this column presents the total number of strands and the available number of strands positions. An asterisk will be printed next to the total number of strands if the number of strand positions is exceeded.

The distance from the bottom of the beam to the draped strand rows at the CL of Bearing is determined by similar triangles. The following figure shows the geometry used to determine the top strand row location which is used to determine the other draped strand row locations.

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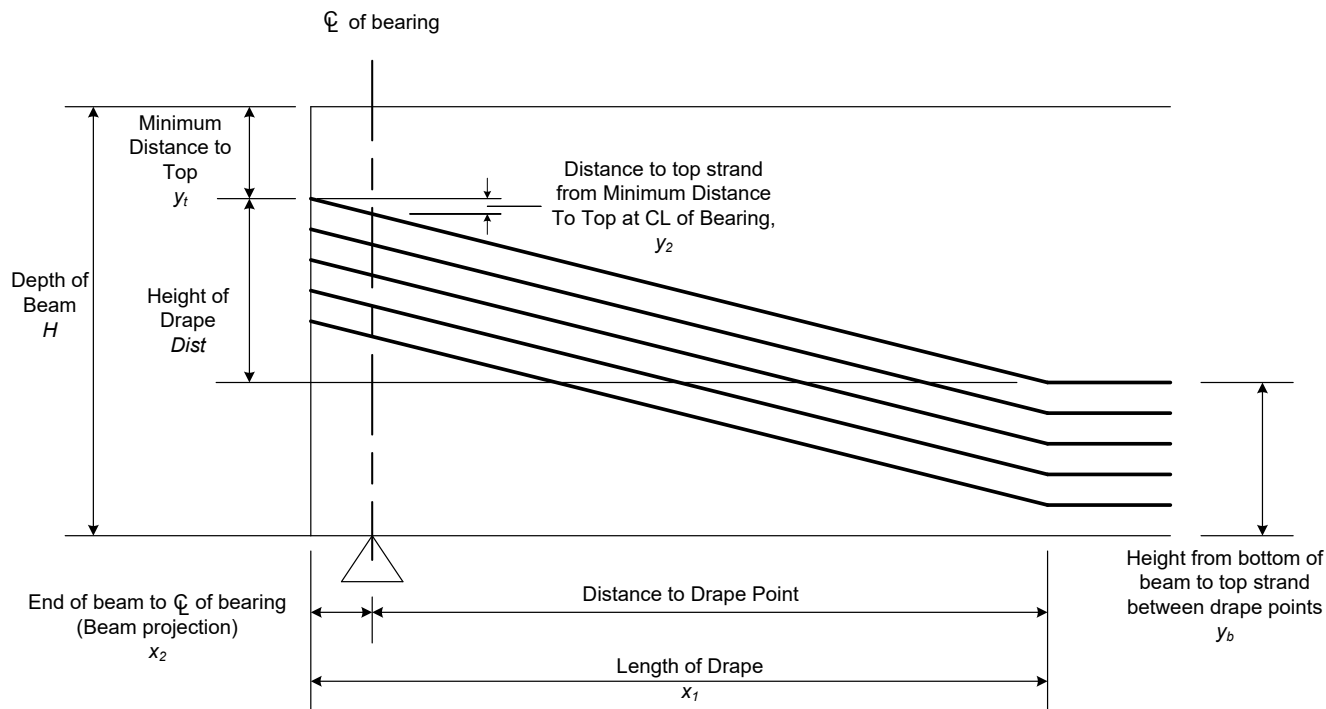


Figure 7.5-1 Draped Strand Row Location at CL of Bearing

The distance y_2 is calculated using the following equation.

$$y_2 = \frac{(H - y_t - y_b)(x_2)}{(x_1)}$$

To determine the distance from the bottom of the beam to the top row of draped strands the following equation is used.

$$Dist = H - y_2 - y_t$$

When the distance to the top of the strand from the bottom of the beam is known, the other row locations can be found by subtracting the distance between rows.

7.5.30 Debonded Strand (Beam Desig. <aaaaaaaa>)

The “Straight/Debonded Strands” table presents the number of strands being debonded at each cutoff location. The beam designation is presented in the table heading, when applicable. This table presents strand data for each individual row, as well as for the entire strand pattern. This table is printed for design and analysis problems with debonded strands and for analysis problems with straight strands and crack control debonding. The following information is presented in this table:

1. Span No. - the span number for which the strand pattern is presented.
2. Row No. - the row number for which the strand data is presented; in the last row of this column, "C.G." is presented to designate strand data for the center of gravity of the entire strand pattern.

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3. Avail. Strands - the number of available strand positions in the specified row. For user defined beams this column displays "un" to indicate this information in *unknown*.
4. **iaa Cutoff (xx.xxx) to (xx.xxx) - these columns will be created for the 1st to the 5th strand cutoff location. The values of these columns represent** the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row from the end of the beam to the **cutoff location**; in the next to last row of this column, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The last row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam. The location of the end of the beam from the simple bearing is specified in the first parentheses as part of the column heading. The location of the **cutoff** from the simple bearing is specified in the second parentheses as part of the column heading. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.
5. Mid Span (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam and the number of bonded strands in the specified row from the last cutoff location to mid span; in the next to last row of this column, the total number of bonded strands for all rows is presented with the row number labeled "Total". The last row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam. The location of the last cutoff from the simple bearing is specified in the first parentheses as part of the column heading. The location of mid span from the simple bearing is specified in the second parentheses as part of the column heading. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.

The "Strand Pattern Visualization" table presents a simplified representation of the cross section at the end of a beam. Bonded and debonded strands are arranged within the cross section to help the user validate the strand configuration. This can be particularly useful in better understanding warnings following the "Straight/Debonded Strands" table. This table will be printed for design and analysis problems unless a user defined beam is specified. To determine the strand location, the program uses a simple algorithm with the following logic:

- Strand rows are filled from the bottom to the top.
- Positions in each row are filled from the outside in.
- The outermost strand positions in each row are always reserved for bonded strands.
- Debonded strands will start to be placed in the second outermost position unless the preceding row has a debonded strand in the adjacent position, in which case the debonding will start in the next position towards the center.
- Positions continue to be filled, with every other position being available for a debonded strand, until all strands are placed or the center of the pattern is reached.

- If the user has specified more debonded strands than the alternating positions will allow, the debonded strands will start to fill positions that are normally reserved for bonded strands.
- If there is an odd number of strands and an odd number of positions in the row, the last strand will be saved for the center position to maintain symmetry.
- A second pattern is generated using the same logic but offsetting the initial debonding position by one. The two patterns are compared based on the number debonded strands placed in invalid position. The pattern with fewer invalid strands is printed in the report.

Due to the limitations of this algorithm, the generated pattern may not always be ideal. If the pattern is valid, meaning it doesn't violate any debonding guidelines, there may be other valid patterns as well. For analysis problems, there is no way to ensure that the pattern matches the as-built condition. The following information is presented in the table:

1. **Span No.** – the span number for which the strand pattern is presented.
2. **Row No.** – the row number for which the strand data is presented.
3. **Avail. Strands** – the number of available strand positions in the specified row.
4. **Pattern** – an ASCII representation of the end cross section of a beam. The character legend is as follows:

Character	Definition
–	Empty strand location
•	Bonded strand
O	Debonded Strand
/, , \	Edge borders
:	Border of web region within the flange

7.5.31 Straight Strand (Beam Desig. <aaaaaaaa>)

This table presents the straight strand pattern for each span. The beam designation is presented in the table heading, when applicable. This table presents strand data for each individual row, as well as for the entire strand pattern. This table is printed for design problems and analysis problems without crack control debonding, when the strand pattern was entered. The following information is presented in this table:

1. **Span No.** - the span number for which the strand pattern is presented.
2. **Row No.** - the row number for which the strand data is presented; in the next to last row of this column, "Total" is presented to designate the total number of strands for the entire strand pattern, in the last row of this column, "C.G." is presented to designate strand data for the center of gravity of the entire strand pattern.

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3. Avail. Strands - the number of available strand positions in the specified row. For user defined beams this column displays "un" to indicate this information in *unknown*.
4. Mid Span (xx.xxx) to (xx.xxx) - this column presents both the vertical distance from the specified row to the bottom of the beam and the number of strands in the specified row from the beam end to mid span; in the next to last row of this column, the total number of strands for all rows is presented, in the last row of this column the center of gravity of the entire strand pattern is presented. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.

7.5.32 Debonded/Draped Strand (Beam Desig. <aaaaaaaaa>)

This table presents the strand pattern for combined draped and debonded strand analysis problems or draped strands analysis problems with crack control debonding. The beam designation is presented in the table heading, when applicable. Table sub-headings identify whether the presented information is for Draped Strands, Straight/Debonded Strands, or Straight/Debonded/Draped Strands. This table presents strand data for each individual row, as well as for the entire strand pattern. For analysis problems with the SCE command entered, the draped and straight/debonded strands are presented separately in two sub-tables. For analysis problems without the SCE command entered, the straight/debonded/draped strands are presented in a single combined table. Individual row height data is blank for all columns except at Mid Span when the single combined table is presented. The number of debonded strands in the Draped sub-table will always be blank since only straight strands are considered for debonding. The following information is presented in this table regardless of whether the SCE command was entered:

1. Span No. - the span number for which the strand pattern is presented.
2. Row No. - the row number for which the strand data is presented; in the next to last row of this column, "Total" is presented to designate the total number of strands for the entire strand pattern, in the last row of this column, "C.G." is presented to designate strand data for the center of gravity of the entire strand pattern.
3. Avail. Strands - the number of available strand positions in the specified row. For user defined beams this column displays "un" to indicate this information is *unknown*. For the draped sub-table this is the number of available strand positions for draping. For the straight/debonded sub-table and the combined straight/debonded/draped sub-table this is the total available strand positions.
4. Beam End (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of strands in the specified row, and the total number of debonded strands at the beam end. The location of the end of the beam from the simple bearing is specified in parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.
5. C.L. Brg (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of strands in the specified row, and the total number of debonded strands at the centerline of bearing. The location of the centerline of bearing from the simple bearing is specified

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in parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.

6. 1st Cutoff (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row at the 1st Cutoff; after all strands rows, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The next row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam at the beam end. The next row of this column has the text "to". The final row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the left of the 1st cutoff. The location of the end of the beam from the simple bearing is specified in the first parentheses as part of the column heading. The location of the 1st Cutoff from the simple bearing is specified in the second parentheses as part of the column heading. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.
7. 2nd Cutoff (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row at the 2nd Cutoff; after all strands rows, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The next row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the right of the 1st cutoff. The next row of this column has the text "to". The final row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the left of the 2nd cutoff. The location of the 1st cutoff from the simple bearing is specified in the first parentheses as part of the column heading. The location of the 2nd Cutoff from the simple bearing is specified in the second parentheses as part of the column heading. This column is not printed if the debonding pattern has only one cutoff location. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.
8. 3rd Cutoff (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row at the 3rd Cutoff; after all strands rows, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The next row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the right of the 2nd cutoff. The next row of this column has the text "to". The final row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the left of the 3rd cutoff. The location of the 2nd cutoff from the simple bearing is specified in the first parentheses as part of the column heading. The location of the 3rd Cutoff from the simple bearing is specified in the second parentheses as part of the column heading. This column is not printed if the debonding pattern has less than three cutoff

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locations. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.

9. 4th Cutoff (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row at the 4th Cutoff; after all strands rows, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The next row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the right of the 3rd cutoff. The next row of this column has the text "to". The final row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the left of the 3rd cutoff. The location of the 3rd cutoff from the simple bearing is specified in the first parentheses as part of the column heading. The location of the 4th Cutoff from the simple bearing is specified in the second parentheses as part of the column heading. This column is not printed if the debonding pattern has less than four cutoff locations. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.
10. 5th Cutoff (xx.xxx) to (xx.xx) - this column presents the vertical distance from the specified row to the bottom of the beam, the number of bonded strands in the specified row, and the total number of debonded strands in the specified row at the 5th Cutoff; after all strands rows, the total number of bonded strands for all rows and the total number of debonded strands for all rows are presented with the row number labeled "Total". The next row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the right of the 4th cutoff. The next row of this column has the text "to". The final row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam just to the left of the 5th cutoff. The location of the 4th cutoff from the simple bearing is specified in the first parentheses as part of the column heading. The location of the 5th Cutoff from the simple bearing is specified in the second parentheses as part of the column heading. This column is not printed if the debonding pattern has less than five cutoff locations. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.
11. Drape Point (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam and the number of strands in the specified row at the drape point. The location of the last cutoff is specified in the first parentheses as part of the column heading. The location of the drape point from the simple bearing is specified in the second parentheses as part of the column heading. An asterisk will be printed between the strand height and the number of strands if the number of available strands is exceeded.
12. Mid Span (xx.xxx) to (xx.xxx) - this column presents the vertical distance from the specified row to the bottom of the beam and the number of bonded strands in the specified row from the drape point to mid span; in the next to last row of this column, the total number of bonded strands for all rows is presented with the row number labeled "Total". The last row of this column specifies the center of gravity of the entire strand pattern from the bottom of the beam. The location of the drape point from

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the simple bearing is specified in the first parentheses as part of the column heading. The location of mid span from the simple bearing is specified in the second parentheses as part of the column heading. An asterisk will be printed next to the number of strands if the number of available strands is exceeded.

When the draped and straight/debonded sub-tables are presented a third sub-table is presented for the Total Number of Strands. The following information is presented in this sub-table:

- 1. Span Number - the span number for which the number of strands is presented.
- 2. Row Number - the row number for which the number of strands is presented; in the last row of this column, "Total" is presented to designate the total number of strands.
- 3. Draped - this column presents the number of draped strands and the available number of draped strand positions. An asterisk will be printed next to the number of draped strands if the number of draped strand positions is exceeded.
- 4. Straight - this column presents the number of straight strands and the available number of straight strand positions. An asterisk will be printed next to the number of straight strands if the number of straight strand positions is exceeded.
- 5. Total - this column presents the total number of strands and the available number of strands positions. An asterisk will be printed next to the total number of strands if the number of strand positions is exceeded.

7.5.33 User Input C.G.S. (Beam Desig. <aaaaaaa>)

This table presents the center of gravity of the entire strand pattern, as input by the user. This table is printed for an analysis problem only. The following information is presented in this table:

- 1. Span Number. - the span number for which the center of gravity of the entire strand pattern is presented.
- 2. CGS at Midspan - the center of gravity of the entire strand pattern at the midspan for the specified span.
- 3. CGS at CL Brg - the center of gravity of the entire strand pattern at the centerline of bearing for the specified span.
- 4. Total No. of Strands - the total number of strands in the specified span.

7.5.34 Effective C.G.S. and Number of Strands

This table presents the effective center of gravity of the strand pattern (C.G.S.) and the effective number of strands along the structure length by accounting for the transfer length. Locations reported in this table correspond to changes in either the number of strands or the C.G.S. Between locations given in this table

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the C.G.S. and number of strands can assume to vary linearly. The following information is presented in this table:

1. Span No. - the span number for which the effective center of gravity of the strand pattern and number of strand are presented.
2. Distance - the distance from the location of the effective C.G.S. and number of strands to the left end of the span in which the effective C.G.S. and number of strands are located
3. Effective C.G.S - the center of gravity of the effective strand pattern at the specified location.
4. Effective Number of Strands - the number of effective strands in the strand pattern at the specified location.
5. Location Type - a brief description of the specified location.

7.5.35 Prestress Values Based on Losses at Midspan of Simple Span

This table presents the total area of strands, the total jacking force, the transfer prestressing force and stress, and the effective prestressing force and stress. These values are presented at the midspan of the simple span. The following information is presented in this table:

1. Span No. - the span number for which the prestress values are presented.
2. Total Area of Strands, A (strand) - the total area of prestressing strands in the girder.
3. Total Jacking Force - the force in the prestressing steel at jacking.
4. Transfer Prestress Stress, $f_{(pt)}$ - the stress in prestressing steel immediately after transfer.
5. Transfer Prestress Force, $P(t)$ - the force in prestressing steel immediately after transfer.
6. Effective Prestress Stress, $f_{(pe)}$ - the effective stress in the prestressing steel after losses.
7. Effective Prestress Force, $P(e)$ - the effective force in the prestressing steel after losses.

7.5.36 Prestress Values at Nominal Flexural Resistance

This table presents the average stress in the prestressing strands and the average force in the prestressing strands at nominal flexural resistance. The following information is presented in this table:

1. Span Number - the span number for which the prestress values are presented.
2. Average Stress in Prestressing Steel, $f_{(ps)}$, at nominal flexural resistance.
3. Average Force in Prestressing Steel, $P_{(ps)}$, at nominal flexural resistance.

7.5.37 Long-Term Time-Dependent Prestress Losses

This table presents the long-term time-dependent prestress loss component values for each span, given as percentages. The following information is presented in this table:

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1. Span Number - the span number for which the prestressing loss values are presented.
2. Concrete Shrinkage, $f(pSR)$, loss in prestressing steel stress due to shrinkage before deck placement, given as a percentage.
3. Concrete Creep, $f(pCR)$, loss in prestressing steel stress due to creep before deck placement, given as a percentage.
4. Strand Relax. Prior to Transfer, $f(pR1)$, loss in prestressing steel stress due to relaxation of steel before deck placement, given as a percentage.
5. Concrete Shrinkage, $f(pSD)$, loss in prestressing steel stress due to shrinkage after deck placement, given as a percentage.
6. Concrete Creep, $f(pCD)$, loss in prestressing steel stress due to creep after deck placement, given as a percentage.
7. Strand Relax. After Transfer, $f(pR2)$, loss in prestressing steel stress due to relaxation of steel after deck placement, given as a percentage.
8. Slab Conc Shrinkage, $f(pSS)$, loss (or gain) in prestressing steel stress due to slab concrete shrinkage, given as a percentage.

7.5.38 Total Prestress Loss

This table presents the total prestress loss values for each span, given as percentages. The following information is presented in this table:

1. Span Number - the span number for which the prestressing loss values are presented.
2. Elastic Shortening of Beam, $f(pES)$, loss in prestressing steel stress due to elastic shortening, given as a percentage.
3. Total Long-term Losses, $f(pLT)$, loss in prestressing steel stress due to the sum of all long-term time-dependent losses, given as a percentage.
4. Total Loss, $f(pT)$, total loss in prestressing steel stress, given as a percentage.

7.5.39 Ultimate Moment and Serviceability Checks

This table presents the moment resistance check at the location of maximum moment. The following information is presented in this table:

1. Span No. - the span number for which the moment resistance check is presented.
2. SRV-3A Moment - the factored moment based on the Service IIIA limit state at the location of maximum moment in the specified span.
3. $M(r) .9 f_y$ - the moment resistance based on a maximum strand stress of 0.9 times the yield stress.

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4. $SRV-3A > M(r) \cdot 0.9f_y$ - an asterisk (*) is presented if the factored moment based on the Service IIIA limit state at the location of maximum moment is greater than the moment resistance based on a maximum strand stress of 0.9 times the yield stress.
5. STRENGTH M (u) - the maximum factored moment based on the Strength I, Strength IP (if applicable) and Strength II limit states at the location of maximum moment in the specified span.
6. $M(r)$ - the moment resistance at the location of maximum moment in the specified span.
7. ϕ - the flexural resistance factor based on the net tensile strain in the tension steel.
8. $M(u) > M(r)$ - an asterisk (*) is presented if the maximum factored moment based on the Strength I, Strength IP (if applicable) and Strength II limit states is greater than the moment resistance at the location of maximum moment.
9. * If Code Failure - an asterisk (*) is presented if either of the two code checks in this table failed.

7.5.40 Transfer and Development Lengths

This table presents the transfer lengths and the development lengths for each span. The following information is presented in this table:

1. Span No. - the span number for which the transfer length and the development length are presented.
2. Transfer Length - the transfer length (the length over which the prestressing force is transferred to the concrete by bond and friction in the member) for the specified span, computed in accordance with AASHTO Article 5.9.4.3.1.
3. Development Length - the development length (the distance required to develop the specified strength of the prestressing strand) for the specified span for straight and draped strands.
4. Development Length Debonded - the development length for the specified span for debonded strands.

7.5.41 Fatigue Stress Range in Prestressing Steel

This table presents the fatigue stress range in the prestressing steel at controlling locations for each span. The following information is presented in this table:

1. Span No. - the span number for which the fatigue stress range is presented.
2. Distance - the distance from the location of the fatigue stress range to the left end of the span in which the fatigue stress range is located.
3. Location - the significance of the location is presented, as follows:
 - MAXIMUM - the location of the maximum fatigue stress range.
 - DRAPE - the location of the drape point.
4. Allowable Fatigue Stress Range, $(dF)_{TH}$ - the allowable fatigue stress range (constant-amplitude fatigue threshold) at the specified location.
5. Effective Fatigue Stress Range, $f(fp)$ - the effective fatigue stress range at the specified location.

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6. If Code Failure - the code failure check, in which an asterisk (*) is presented if the allowable fatigue stress range, $(dF)_{TH}$, is less than the effective fatigue stress range, $f(fp)$.

7.5.42 Control of Cracking by Distribution of Reinforcement

This table presents the allowable spacing and actual spacing check for distribution of the longitudinal slab reinforcement to control cracking. The following information is presented in this table:

1. Span No. – the support number for which the longitudinal slab reinforcement values are presented.
2. Distance – the distance from the location of the stress check to the left end of the span.
3. SERV-I Moment – the factored moment for the Service I limit state at the specified location.
4. Total Area – the total longitudinal slab reinforcement at the specified location based on all ranges; the area will include reductions for development length for locations within the development length of the rebar.
5. Actual Stress – the stress in the longitudinal slab reinforcement from the Service I moment; when the actual stress is greater than $0.6f_y$ a less than "<" character is printed after the stress to indicate $0.6f_y$ is used to compute the allowable spacing.
6. Top Bar Size – the top rebar size for the given longitudinal slab reinforcement.
7. Actual Spacing – the actual spacing of the longitudinal slab reinforcement.
8. Allowable Spacing – the allowable spacing of the longitudinal slab reinforcement to meet distribution of reinforcement requirements.
9. * If Code Failure – the code failure check, in which an asterisk (*) is presented if the actual spacing is greater than the allowable spacing.

7.5.43 Longitudinal Slab Reinforcement at Continuous Supports

This table presents the area of the longitudinal slab reinforcement at the continuous supports. This output table is presented only for a run with more than one span. The information presented is different for an analysis run versus a design run. For a design run one range for each continuous support is computed and output by the program. The bar number for design is always set to 6. The following information is presented in this table for a design run:

1. Support No. - the support number for which the longitudinal slab reinforcement values are presented.
2. As / Eff. Slab Width - the area of the longitudinal slab reinforcement within the effective slab width at the specified support number.
3. As / Unit Slab Width – the area of the longitudinal slab reinforcement per foot width of the slab at the specified support number.

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For an analysis run this table presents the location of the left and right cutoff points, as well as the area, of the longitudinal slab reinforcement. The user can enter as many as three ranges of reinforcement at each continuous support. The following information is presented in this table for an analysis run:

1. Support No. - the support number for which the longitudinal slab reinforcement values are presented.
2. Bar No. - the bar number for which the longitudinal slab reinforcement values are presented.
3. Left Cutoff - the distance from the centerline of the pier to the cutoff point to the left of the pier.
4. Right Cutoff - the distance from the centerline of the pier to the cutoff point to the right of the pier.
5. As/Eff. Slab Width - the area of the longitudinal slab reinforcement per effective slab width for the range.
6. As/Unit Slab Width – the area of the longitudinal slab reinforcement per foot width of the slab at the specified support number for the range.
7. Location In Slab – the location of the reinforcement in the slab. A “T” indicates the reinforcement is located in the top of the slab and a “B” indicates the reinforcement is located in the bottom of the slab. Reinforcement in the top of the slab is considered when computing distribution of reinforcement for crack control.

7.5.44 Top and Bottom Bar Spacing (aa) at Support nn

This table presents configurations of longitudinal slab reinforcement that satisfies control of cracking by distribution of reinforcement. This output table is presented only for design runs of spread beams. Each combination consists of a top reinforcement rebar at a given spacing and a bottom reinforcement rebar at a second spacing. Different combinations of rebar sizes are considered for the top and bottom reinforcement. Each column of the table corresponds to one spacing of the top reinforcement. The column heading provides the spacing value. The left column provides heading for each row of the table to identify the top and bottom rebar sizes. The following information is presented in this table:

1. Bar Pairs – the top and bottom rebar size pair
2. Top Rebar Spacing – the top rebar spacing for each column of the table
3. nn&nn – the bottom rebar spacing corresponding to the top rebar size pair
4. %Area – $(\text{Provided Area} / \text{Required Area} - 1) * 100\%$

Chapter 7 Output Description

A sample output table will be used to further explain how to interpret the information provided in the table. First, the required longitudinal slab reinforcement at each continuous support is printed for reference. For this example, only support 2 will be examined.

Required area to resist negative moment

LONGITUDINAL SLAB REINFORCEMENT AT CONTINUOUS SUPPORTS

Support No.	As/Eff. Slab Width (in ²)	As/Unit Slab Width (in ² /ft)
2	8.60	1.08
3	16.31	2.04
4	18.24	2.28

Note: For negative moment reinforcement at other analysis points, refer to the table, NEGATIVE MOMENT CAPACITY (DESIGN LIVE LOADING).

TOP AND BOTTOM REBAR SPACINGS (in) AT SUPPORT 2

BAR PAIRS (T&B)	12.0	11.5	11.0	10.5	10.0	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5
C O B R O R T S E T P S O A P M C O I N R N D E G I B N A G R	5 & 4	---	---	---	---	---	---	---	---	---	---	---	---	---	6.5	6.5
%AREA															3.5	11.
5 & 5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	10.0	10.0
%AREA															3.8	11.
6 & 4	---	---	---	---	---	---	---	---	---	---	6.5	6.5	6.5	6.5	6.5	6.5
%AREA											4.5	9.9	16.	24.	33.	43.
6 & 5	---	---	---	---	---	---	---	---	---	---	10.0	10.0	10.0	10.0	10.0	10.0
%AREA											4.8	10.	16.	24.	33.	44.
6 & 6	---	---	---	---	---	---	---	---	---	---	12.0	12.0	12.0	12.0	12.0	12.0
%AREA											11.	16.	23.	30.	39.	50.
7 & 4	---	---	---	---	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
%AREA					1.3	4.8	8.7	13.	18.	24.	30.	37.	46.	>>>	>>>	>>>
7 & 5	---	---	---	---	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
%AREA					1.6	5.1	9.0	13.	18.	24.	30.	38.	46.	>>>	>>>	>>>
7 & 6	---	---	---	---	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
%AREA					7.9	11.	15.	20.	25.	30.	37.	44.	>>>	>>>	>>>	>>>
8 & 4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
%AREA	7.8	11.	14.	18.	23.	27.	32.	38.	45.	>>>	>>>	>>>	>>>	>>>	>>>	>>>
8 & 5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
%AREA	8.1	11.	15.	19.	23.	27.	33.	38.	45.	>>>	>>>	>>>	>>>	>>>	>>>	>>>
8 & 6	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
%AREA	14.	18.	21.	25.	29.	34.	39.	45.	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>

LEGEND:

- T&B - TOP AND BOTTOM REBAR SIZE
- %AREA - (PROVIDED AREA / REQUIRED AREA - 1) * 100%
- - NO CORRESPONDING BOTTOM REBAR SPACING FOR VALID DESIGN
- >>> - GREATER THAN 50%

This table presents combinations of rebar pairs that provide the required area of longitudinal reinforcement and satisfies control of cracking by distribution of reinforcement. For this example, the rebar pairs range

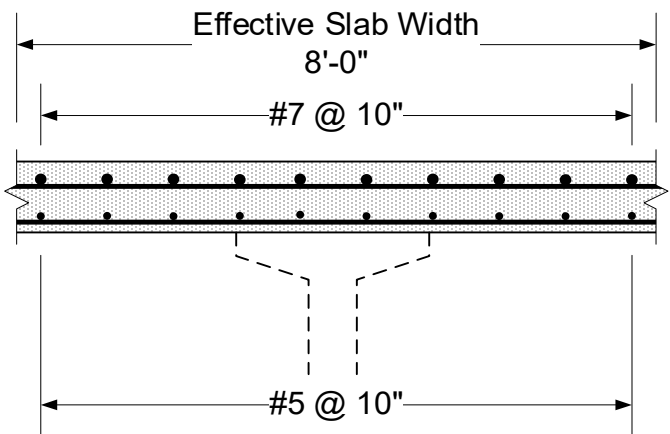
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from a #5 top rebar paired with a #4 bottom rebar to a #8 top rebar paired with a #6 bottom rebar. Each different pair of rebars results in additional rows in the output table. The number of rows in the table will vary for different problems. This example has a total of 11 rows of rebar pairs. The smallest rebar size tried is a #4 and the largest rebar size tried is a #8. The smallest pair of rebars tried is a #5 for the top and a #4 for the bottom rebar. The largest pair of rebars tried is a #8 for the top rebar and a #6 for the bottom rebar. The top rebar will always be at least as large as the bottom rebar.

Each column of the table corresponds to a different spacing of the top rebar. For this example, the top rebar spacings range from a maximum of 12.0 inches to a minimum of 4.5 inches. The program will consider a maximum spacing of 12 inches and a minimum spacing of 4.5 inches and a spacing increment of 0.5 inches. The number of columns in the output table will vary for different problems. This example has a total of 16 columns of spacings.

The percentage that the “area provided” is greater than the “required area” is printed below the spacing of the bottom rebar. If the provided area is equal to the required area this would be 0.0 in the table. If the required spacing of the bottom rebar was less than 4.5 inches the text “--+-” is printed. If the provided area exceeds the required area by more than 50%, the text “>>>” is printed. If for a given pair of rebars, the provided area exceeds the value given in the legend for all spacings in that row the row is omitted from the output table.

Scanning through the percentages, the closest provided area to required area is 1.3 for #7 @ 10” top and #4 @ 6.5” bottom. This is the intersection of row 6 and column 5 of the output table. This may be the best pair of rebars for the provided area of reinforcement, but the 10 and 6.5 inches may not be desirable spacings. Changing the bar pair to #7 top and #5 bottom would allow both bars to be spaced at 10 inches. The designer should pick a practical bar size and spacing for both the top and bottom reinforcement and rerun the problem as an analysis run. For this example, the girder spacing is 8'-0”. The following shows one possible configuration.



Chapter 7 Output Description

Now, the results of the Design output will be used for an Analysis run. The girder spacing is 8'-0" making the cross section effective slab width 96" (8'-0"). This means that the effective number of bars would be $96" / 10" \text{ per bar} = 9.6 \text{ bars}$ for the effective slab width. If we use a whole number of 10 bars for the effective slab width this configuration will provide slightly more reinforcement than was calculated in the Design output for the 10" spacing.

For the analysis run the total area of top and bottom longitudinal reinforcement in the effective slab width must be entered. Using the above sketch, the top reinforcement is 10 - #7 for an area of 6.00 in^2 ($10 * 0.60$) and the bottom reinforcement is 10 - #5 for an area of 3.10 in^2 ($10 * 0.31$). This gives a total provided area of 9.10 in^2 (105.8% of the required 8.60 in^2).

7.5.45 Bar Spacings (aa) at Support nn

This table presents configurations of longitudinal slab reinforcement that satisfies control of cracking by distribution of reinforcement. This output table is presented only for design runs of adjacent beams having a single layer of reinforcement in the slab. For each rebar size the corresponding rebar spacing is given. The following information is presented in this table:

- 1. Bar Size – the reinforcement bar size
- 2. Spacing – the reinforcement bar spacing
- 3. %Area – $(\text{Provided Area} / \text{Required Area} - 1) * 100\%$

7.5.46 Positive Moment Connect. Steel at Continuous Support (aaaaaaaaaaaaaaaaaaaaa)

This table presents the nominal flexural resistance and the required steel area for the positive moment connection at each continuous support based on the "design live loading" associated with the given design or analysis live load code entered on the CTL command. The following information is presented in this table:

- 1. Support No. - the support number for which the positive moment connection values are presented.
- 2. Nominal Flexural Resistance, $M(n)$ - the nominal flexural resistance at the specified support.
- 3. Required Steel Area Per Beam, $A(s)$ - the required steel area for the positive moment connection at the specified support.
- 4. Factored Moment, $M(u)$ - the controlling applied factored positive moment at the specified support.
- 5. Cracking Moment, $M(cr)$ – the cracking moment in the composite beam at the specified support.
- 6. ϕ – the flexural resistance factor at the specified support.
- 7. Net Tensile Strain, $\epsilon_t * 1000$ – the net tensile strain in the extreme tension steel at nominal resistance.
- 8. Limit State - the controlling limit state for $M(u)$.
- 9. $d(s)$ - the distance from the extreme compression fiber to the centroid of the non-prestressed tensile reinforcement (assumed to be at the centroid of prestressing).

Chapter 7 Output Description

7.5.47 Parapet Overhang Width

This table presents the maximum allowable overhang width approximation for each span. This output is only printed if the OVH command is input by the user. In addition, this output is not provided for a non-composite, adjacent, or exterior beam. For pedestrian load runs, this table is printed twice: once without sidewalk (unlabeled) and once with sidewalk (labeled). The following information is presented in this table:

1. Span No. - the span number for which the parapet overhang width is presented.
2. Maximum Allowable Overhang Width Approximation - the maximum allowable overhang width approximation for the specified span.

7.5.48 Shear Reinforcement for Drawings

This table presents the required shear reinforcement based on BD Standards BD-661M and BD-662M for each span. This output is only printed if the BDT command is input by the user. In addition, this output is not provided for NEXT beams or box beams (adjacent or spread) with circular voids. The first six columns are the same for all beam cross section type. The remaining columns depend on the beam cross section type. The following information is presented in this table:

Note: all stirrup spacings are measured along the centerline of beam.

1. Span No. - the span number for which the reinforcement is presented.
2. Distance - the distance from the location of the shear results to the left end of the span in which the shear results are located.
3. Vertical Stirrup Spacing – the spacing of the vertical stirrups from the Shear Reinforcement and Resistance output table.
4. Vertical Stirrup Area – the reinforcement area of the vertical stirrups from the Shear reinforcement and Resistance output table.
5. Horizontal Stirrup Spacing – the spacing of the horizontal stirrups from the Horizontal Shear output table.
6. Horizontal Stirrup Area – the reinforcement area of the horizontal stirrups from the Horizontal Shear output table.

PA I - BEAM

7. 402 Stirrup Spacing – the required spacing of the 402 stirrup bar
8. 401 Horz. Spacing – the required spacing of the 401 horizontal stirrup bar
9. 404 Confinement Spacing – the required spacing of the 404 confinement bar

AASHTO I-BEAM or PA BULB-TEE BEAM

7. 401 Stirrup Spacing – the required spacing of the 401 stirrup bar
8. 402 Horz. Spacing – the required spacing of the 402 horizontal stirrup bar

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9. 404 Confinement Spacing – the required spacing of the 404 confinement bar
ADJACENT BOX BEAMS or SPREAD BOX BEAMS
7. A1 Pairs Stirrup Spacing – the required spacing of the A1 stirrup pair bars
8. A2 Top Spacing – the required spacing of the top half of the vertical stirrup bars
9. A3 Bottom Spacing – the required spacing of the bottom half of the vertical stirrup bars
PLANK BEAMS
7. A1 Pairs Stirrup Spacing – the required spacing of the stirrup bars

7.5.49 Camber to Determine Bridge Seat Elevations

This table presents the maximum camber and deflection due to prestressing and various dead loads to determine the bridge seat elevations for each span based on an assumed prestress loss and a given creep factor. The following information is presented in this table:

1. Span No. - the span number for which the camber and deflection values are presented.
2. Prestress, Delta(P/S) - the maximum camber due to prestressing in the specified span.
3. Beam Weight, Delta(sw) - the maximum deflection due to the self-weight of the beam, including interior diaphragms, in the specified span.
4. Slab, Forms & Exterior Diaphragms, Delta(s) - the maximum deflection due to the weight of the slab, formwork, and exterior diaphragms in the specified span.
5. Superimposed Dead Load, Delta(SDL) - the maximum deflection due to the weight of the superimposed dead load (excluding the future wearing surface load) in the specified span. For pedestrian load runs, this value includes the deflections due to the sidewalk.
6. Initial Camber, C(I) - the initial camber value (at midspan) for the specified span.
7. Initial Camber, Adjusted for Creep, C(IA) - the initial camber value, adjusted for creep (at midspan) for the specified span.
8. Final Camber, C(F) - the final camber value (at midspan) for the specified span.

7.5.50 Camber to Check a Probable Sag in Bridge

This table presents the maximum camber and deflection due to prestressing and various dead loads to check a probable sag in the bridge for each span based on an assumed prestress loss and a given creep factor. The same information is printed on this table as described in Section 7.5.49.

7.5.51 Camber Based on Entered Value of Loss

This table presents the maximum camber and deflection due to prestressing and various dead loads for each span based on an entered value of prestress loss and a given creep factor. The same information is printed on this table as described in Section 7.5.49.

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7.5.52 Deflection Limits for Live Load

This table presents the allowable and the maximum actual live load deflection for each span. The following information is presented in this table:

1. Span No. - the span number for which the deflection limits are presented.
2. Location - the location of the maximum live load deflection in the specified span, as measured from the left support of that span.
3. Allowable, $L/800$ - the allowable live load deflection, which is equal to the length of the specified span divided by 800.
4. Live Load Deflection - the maximum live load deflection in the specified span.
5. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the maximum live load deflection is greater than the allowable live load deflection in the specified span.

7.5.53 Deflection Limits for Live Load with Pedestrian

This table presents the allowable and the maximum actual live load deflection, including the effects of pedestrian live loading, for each span. This output table is presented only if a PLD command is input by the user. The following information is presented in this table:

1. Span No. - the span number for which the deflection limits are presented.
2. Location - the location of the maximum live load deflection in the specified span, as measured from the left support of that span.
3. Allowable, $L/1000$ - the allowable live load deflection, which is equal to the length of the specified span divided by 1000.
4. Live Load Deflection - the maximum live load deflection, including the effects of pedestrian live loading, in the specified span.
5. * If Code Failure - the code failure check, in which an asterisk (*) is presented if the maximum live load deflection is greater than the allowable live load deflection in the specified span.

7.5.54 Strand Code Detail Checks

This table presents the vertical and horizontal strand spacing checks for each span. The following information is presented in this table:

1. Span No. - the span number for which the strand spacing checks are presented.
2. Vertical Strand Spacing, Minimum - the minimum allowable vertical strand spacing.
3. Vertical Strand Spacing, Actual - the actual vertical strand spacing for the specified span.

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4. Vertical Strand Spacing, * If Code Failure - the code failure check, in which an asterisk (*) is presented if the minimum allowable vertical strand spacing is greater than the actual vertical strand spacing for the specified span.
5. Horizontal Strand Spacing, Minimum - the minimum allowable horizontal strand spacing.
6. Horizontal Strand Spacing, Actual - the actual horizontal strand spacing for the specified span.
7. Horizontal Strand Spacing, * If Code Failure - the code failure check, in which an asterisk (*) is presented if the minimum allowable horizontal strand spacing is greater than the actual horizontal strand spacing for the specified span.

7.5.55 Available Strands Per Row

This table presents the number of available strand positions for each strand row for each span. This table is presented only for design problems. Each column starting with the second column is data for a different span. The following information is presented in this table:

1. Span – the span number for each column of data.
2. Beam – the beam designation for each span.
3. Row ii – the strand row number. Row number one is at the bottom of the beam cross section. Each column presents the available number of strands for that row number and span number.

7.5.56 Principal Stresses Due to Unfactored Loads - PHL-93

This table presents the principal stresses due to unfactored loads for each analysis point for the PHL-93 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The following information is presented in this table:

1. Span No. - the span number for which the principal stresses are presented.
2. Distance - the distance from the location of the principal stresses to the left end of the span in which the principal stresses are located.
3. Dist. from Bottom - the vertical distance from the bottom of the beam to the location of the principal stresses.
4. Stress Due to: Dead Load - the principal stress due to unfactored dead load at the specified location.
5. Stress Due to: Total - the principal stress due to unfactored total load at the specified location.
6. Angles Due to: Dead Load - the principal angle due to unfactored dead load at the specified location.
7. Angles Due to: Total - the principal angle due to unfactored total load at the specified location.

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7.5.57 Principal Stresses Due to Unfactored Loads - HL-93

This table presents the principal stresses due to unfactored loads for each analysis point for the HL-93 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.58 Principal Stresses Due to Unfactored Loads - P-82

This table presents the principal stresses due to unfactored loads for each analysis point for the P-82 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.59 Principal Stresses Due to Unfactored Loads - P-82C

This table presents the principal stresses due to unfactored loads for each analysis point for the P-82C live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.60 Principal Stresses Due to Unfactored Loads – P2016-13

This table presents the principal stresses due to unfactored loads for each analysis point for the P2016-13 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.61 Principal Stresses Due to Unfactored Loads – P2016-13C

This table presents the principal stresses due to unfactored loads for each analysis point for the P2016-13C live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.62 Principal Stresses Due to Unfactored Loads - ML-80

This table presents the principal stresses due to unfactored loads for each analysis point for the ML-80 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.63 Principal Stresses Due to Unfactored Loads - TK527

This table presents the principal stresses due to unfactored loads for each analysis point for the TK527 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

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7.5.64 Principal Stresses Due to Unfactored Loads – EV2

This table presents the principal stresses due to unfactored loads for each analysis point for the EV2 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.65 Principal Stresses Due to Unfactored Loads – EV3

This table presents the principal stresses due to unfactored loads for each analysis point for the EV3 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.66 Principal Stresses Due to Unfactored Loads – SU6TV

This table presents the principal stresses due to unfactored loads for each analysis point for the SU6TV live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.67 Principal Stresses Due to Unfactored Loads - HS20

This table presents the principal stresses due to unfactored loads for each analysis point for the HS20 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.68 Principal Stresses Due to Unfactored Loads - H20

This table presents the principal stresses due to unfactored loads for each analysis point for the H20 live loading. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.69 Principal Stresses Due to Unfactored Loads – SLL #i

This table presents the principal stresses due to unfactored loads for each analysis point for the special live loading number i. Included in this table are the stresses and angles due to unfactored dead load and unfactored total load. The same information is printed on this table as described in Section 7.5.56.

7.5.70 Principal Stresses - Controlling Factored Strength Limit State Loads - PHL-93

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the PHL-93 live loading. Included in this table are the stresses and angles due to

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controlling factored strength limit state dead and total loads. The following information is presented in this table:

1. Span No. - the span number for which the principal stresses are presented.
2. Distance - the distance from the location of the principal stresses to the left end of the span in which the principal stresses are located.
3. Dist. from Bottom - the vertical distance from the bottom of the beam to the location of the principal stresses.
4. Stress Due to: Dead Load - the principal stress due to controlling factored strength limit state dead load at the specified location.
5. Stress Due to: Total - the principal stress due to controlling factored strength limit state total load at the specified location.
6. Angles Due to: Dead Load - the principal angle due to controlling factored strength limit state dead load at the specified location.
7. Angles Due to: Total - the principal angle due to controlling factored strength limit state total load at the specified location.

7.5.71 Principal Stresses - Controlling Factored Strength Limit State Loads - HL-93

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the HL-93 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.72 Principal Stresses - Controlling Factored Strength Limit State Loads - P-82

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the P-82 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.73 Principal Stresses - Controlling Factored Strength Limit State Loads - P-82C

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the P-82C live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

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7.5.74 Principal Stresses - Controlling Factored Strength Limit State Loads - ML-80

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the ML-80 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.75 Principal Stresses - Controlling Factored Strength Limit State Loads - TK527

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the TK527 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.76 Principal Stresses - Controlling Factored Strength Limit State Loads - HS20

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the HS20 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.77 Principal Stresses - Controlling Factored Strength Limit State Loads - H20

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the H20 live loading. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

7.5.78 Principal Stresses - Controlling Factored Strength Limit State Loads – SLL #i

This table presents the principal stresses due to controlling factored strength limit state loads for each analysis point for the special live loading number i. Included in this table are the stresses and angles due to controlling factored strength limit state dead and total loads. The same information is printed on this table as described in Section 7.5.70.

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7.5.79 Girder Stability Checks

7.5.79.1 Hanging Girder – Girder Stability (Part 1)

This report presents the input data from the GSC command for hanging girders, the input from other program output and the computed output data for the Girder Stability Checks. A separate report is provided for each span that GSC input data was provided by the user. Each data item is on a separate line of the report and contains a description of the item, the units of the item and the value of the item. For items that vary depending when the wind direction is either left or right, two values are reported for each item.

7.5.79.2 Seated Girders – Girder Stability (Part 2)

This report presents data used with the GS2 command to analyze the first girder seated on bearings and multiple girders seated with inactive construction wind conditions. For the first girder seated and end bracing not specified, girder stresses are computed when the girder is rotated to equilibrium and compared to allowable stresses. Additionally, factors of safety are computed for three conditions, 1) Factor of Safety Against Cracking, 2) Factor of Safety Against Failure, and 3) Factor of Safety Against Rollover. If any of the factors of safety are less than the required value or the concrete stresses exceed the allowable, bracing is considered at the girder ends and the moment and the force resisted by the bracing is reported. When end bracing is specified for the first girder seated, the factor safety against rollover is not computed. Each data item is on a separate line of the report and contains a description of the item, the units of the item and the value of the item.

For multiple girders seated and intermediate bracings set to -1, the number of intermediate braces is determined. First the girder is checked with no intermediate bracing for concrete stresses and factors of safety. If these checks fail, the number of intermediate braces are determined so that the concrete stress check passes. With intermediate bracing provided, the factor of safety checks are not required.

7.5.79.3 Deck Casting – Girder Stability (Part 3)

This report presents data used with the GS3 command to analyze the exterior girder during casting of the concrete deck. Using input data from the GS3 command and other program output, the rotation of the girder due to the torque load applied between bracing location is determined. Based on the girder rotation, the corresponding reduction in the concrete cover is computed. Initially, the number of braces starts at two (one at each bearing) and are increased until the concrete cover reduction is $\frac{1}{4}$ " or less or until the number of braces is 8. Each data item is on a separate line of the report and contains a description of the item, the units of the item and the value of the item.

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7.6 RATING FACTORS OUTPUT

The rating factors output includes service moment ratings, service moment ratings (creep and shrinkage), strength moment ratings, strength moment ratings (creep and shrinkage), and strength shear ratings for each vehicle, at each analysis point, and for each applicable limit state. In addition, rating summary tables are available which provide a summary of ratings for each vehicle, and an overall summary table is available which provides the controlling ratings for each vehicle. Both the rating factor and the rating tonnage are presented in the summary tables. The headings for all rating tables indicate whether the rating is an inventory rating or an operating rating. A rating factor value of 999.99 presented in the rating output tables indicates that the rating factor is greater than or equal to 999.99. "n/a" indicates that particular rating factor is not applicable. The page heading indicates whether Future Wearing Surface load is included in the ratings.

A summary of the output tables for each parameter is given in Section 6.43. The user can suppress all rating factors output by entering zero for every rating factor output parameter.

7.6.1 Service Moment Rating: PHL-93

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the PHL-93 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The following information is presented in this table:

1. Span No. - the span number for which the service moment ratings are presented.
2. Dist. - the distance from the location of the service moment ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, SERV-I, Slab Compr. - the inventory rating factor in the top of the slab based on compression for the Service I limit state at the specified location. For pedestrian load runs, a "P" is placed next to the rating factor if the pedestrian load case governs.
4. Rating Factors, Inventory, SERV-I, Top Compr. - the inventory rating factor in the top of the girder based on compression for the Service I limit state at the specified location. For pedestrian load runs, a "P" is placed next to the rating factor if the pedestrian load case governs.
5. Rating Factors, Inventory, SERV-I, Btm. Compr. - the inventory rating factor in the bottom of the girder based on compression for the Service I limit state at the specified location. For pedestrian load runs, a "P" is placed next to the rating factor if the pedestrian load case governs.
6. Rating Factors, Inventory, SERV-III, Btm. Tens. - the inventory rating factor in the bottom of the girder based on tension for the Service III limit state at the specified location. For pedestrian load runs, a "P" is placed next to the rating factor if the pedestrian load case governs.

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7. Rating Factors, Inventory, SERV-III, Top Tens. - the inventory rating factor in the top of the girder based on tension for the Service III limit state at the specified location. For pedestrian load runs, a "P" is placed next to the rating factor if the pedestrian load case governs.
8. Rating Factors, Operating, SERV-IIIA, 0.9 Mfy - the operating rating factor using a moment capacity based on a stress of $0.9f_{py}$ in the bottom row of the prestressing steel for the Service IIIA limit state at the specified location.
9. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.2 Service Moment Rating: HL-93

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the HL-93 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.3 Service Moment Rating: P-82

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P-82 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The following information is presented in this table:

1. Span No. - the span number for which the service moment ratings are presented.
2. Dist. - the distance from the location of the service moment ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, SERV-I, Slab Compr. - the inventory rating factor in the top of the slab based on compression for the Service I limit state at the specified location. Not applicable for this live loading.
4. Rating Factors, Inventory, SERV-I, Top Compr. - the inventory rating factor in the top of the girder based on compression for the Service I limit state at the specified location. Not applicable for this live loading.
5. Rating Factors, Inventory, SERV-I, Btm. Compr. - the inventory rating factor in the bottom of the girder based on compression for the Service I limit state at the specified location. Not applicable for this live loading.
6. Rating Factors, Inventory, SERV-III, Btm. Tens. - the inventory rating factor in the bottom of the girder based on tension for the Service III limit state at the specified location. Not applicable for this live loading.

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7. Rating Factors, Inventory, SERV-III, Top Tens. - the inventory rating factor in the top of the girder based on tension for the Service III limit state at the specified location. Not applicable for this live loading.
8. Rating Factors, Operating, SERV-IIIA, 0.9 Mfy - the operating rating factor using a moment capacity based on a stress of $0.9 \cdot f_{py}$ in the bottom row of the prestressing steel for the Service IIIA limit state at the specified location.
9. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.4 Service Moment Rating: P-82C

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P-82C live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.5 Service Moment Rating: P2016-13

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P2016-13 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.6 Service Moment Rating: P2016-13C

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P2016-13C live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.7 Service Moment Rating: ML-80

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the ML-80 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

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7.6.8 Service Moment Rating: TK527

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the TK527 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.9 Service Moment Rating: EV2

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the EV2 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.10 Service Moment Rating: EV3

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the EV3 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.11 Service Moment Rating: SU6TV

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the SU6TV live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.12 Service Moment Rating: HS20

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the HS20 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.13 Service Moment Rating: H20

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the H20 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

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7.6.14 Service Moment Rating: SLL #i

This table presents the service moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the special live loading number i. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1 when the special live load Vehicle Type is not “P”. When the special live load Vehicle Type is “P” the same information is printed on this table as described in Section 7.6.3.

7.6.15 Service Moment Rating (Creep and Shrinkage): PHL-93

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the PHL-93 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.16 Service Moment Rating (Creep and Shrinkage): HL-93

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the HL-93 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.17 Service Moment Rating (Creep and Shrinkage): P-82

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the P-82 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.18 Service Moment Rating (Creep and Shrinkage): P-82C

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the P-82C live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.19 Service Moment Rating (Creep and Shrinkage): P2016-13

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the P2016-13 live loading. Inventory ratings are presented for Service I limit state and

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Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.20 Service Moment Rating (Creep and Shrinkage): P2016-13C

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the P2016-13C live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.21 Service Moment Rating (Creep and Shrinkage): ML-80

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the ML-80 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.22 Service Moment Rating (Creep and Shrinkage): TK527

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the TK527 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.23 Service Moment Rating (Creep and Shrinkage): EV2

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the EV2 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.24 Service Moment Rating (Creep and Shrinkage): EV3

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the EV3 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

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7.6.25 Service Moment Rating (Creep and Shrinkage): SU6TV

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the SU6TV live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.3.

7.6.26 Service Moment Rating (Creep and Shrinkage): HS20

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the HS20 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.27 Service Moment Rating (Creep and Shrinkage): H20

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the H20 live loading. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1.

7.6.28 Service Moment Rating (Creep and Shrinkage): SLL #i

This table presents the service moment ratings, including the effects of creep and shrinkage, for each analysis point for the special live loading number i. Inventory ratings are presented for Service I limit state and Service III limit state. Operating ratings are presented for Service IIIA limit state. The same information is printed on this table as described in Section 7.6.1 when the special live load Vehicle Type is not "P". When the special live load Vehicle Type is "P" the same information is printed on this table as described in Section 7.6.3.

7.6.29 Strength Moment Rating: PHL-93

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the PHL-93 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength IA limit state. Rating factors are presented for both positive and negative flexure. The following information is presented in this table:

1. Span No. - the span number for which the strength moment ratings are presented.
2. Dist. - the distance from the location of the strength moment ratings to the left end of the span in which the ratings are located.

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3. Rating Factors, Inventory, STR-I, Pos. - the inventory rating factor based on positive flexure for the Strength I limit state at the specified location.
4. Rating Factors, Inventory, STR-I, Neg. - the inventory rating factor based on negative flexure for the Strength I limit state at the specified location.
5. Rating Factors, Inventory, STR-IP, Pos. - the inventory rating factor based on positive flexure for the Strength IP limit state at the specified location.
6. Rating Factors, Inventory, STR-IP, Neg. - the inventory rating factor based on negative flexure for the Strength IP limit state at the specified location.
7. Rating Factors, Operating, STR-IA, Pos. - the operating rating factor based on positive flexure for the Strength IA limit state at the specified location.
8. Rating Factors, Operating, STR-IA, Neg. - the operating rating factor based on negative flexure for the Strength IA limit state at the specified location.
9. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.30 Strength Moment Rating: HL-93

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the HL-93 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength IA limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.29.

7.6.31 Strength Moment Rating: P-82

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P-82 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The following information is presented in this table:

1. Span No. - the span number for which the strength moment ratings are presented.
2. Dist. - the distance from the location of the strength moment ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, STR-I, Pos. - the inventory rating factor based on positive flexure for the Strength I limit state at the specified location. Not applicable for this live loading.
4. Rating Factors, Inventory, STR-I, Neg. - the inventory rating factor based on negative flexure for the Strength I limit state at the specified location. Not applicable for this live loading.
5. Rating Factors, Inventory, STR-IP, Pos. - the inventory rating factor based on positive flexure for the Strength IP limit state at the specified location. Not applicable for this live loading.

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6. Rating Factors, Inventory, STR-IP, Neg. - the inventory rating factor based on negative flexure for the Strength IP limit state at the specified location. Not applicable for this live loading.
7. Rating Factors, Operating, STR-II, Pos. - the operating rating factor based on positive flexure for the Strength II limit state at the specified location.
8. Rating Factors, Operating, STR-II, Neg. - the operating rating factor based on negative flexure for the Strength II limit state at the specified location.
9. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.32 Strength Moment Rating: P-82C

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P-82C live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.33 Strength Moment Rating: P2016-13

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P2016-13 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.34 Strength Moment Rating: P2016-13C

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the P2016-13C live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.35 Strength Moment Rating: ML-80

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the ML-80 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The following information is presented in this table:

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1. Span No. - the span number for which the strength moment ratings are presented.
2. Dist. - the distance from the location of the strength moment ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, STR-I, Pos. - the inventory rating factor based on positive flexure for the Strength I limit state at the specified location.
4. Rating Factors, Inventory, STR-I, Neg. - the inventory rating factor based on negative flexure for the Strength I limit state at the specified location.
5. Rating Factors, Inventory, STR-IP, Pos. - the inventory rating factor based on positive flexure for the Strength IP limit state at the specified location.
6. Rating Factors, Inventory, STR-IP, Neg. - the inventory rating factor based on negative flexure for the Strength IP limit state at the specified location.
7. Rating Factors, Operating, STR-II, Pos. - the operating rating factor based on positive flexure for the Strength II limit state at the specified location.
8. Rating Factors, Operating, STR-II, Neg. - the operating rating factor based on negative flexure for the Strength II limit state at the specified location.
9. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.36 Strength Moment Rating: TK527

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the TK527 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.37 Strength Moment Rating: EV2

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the EV2 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.38 Strength Moment Rating: EV3

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the EV3 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for

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both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.39 Strength Moment Rating: SU6TV

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the SU6TV live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.40 Strength Moment Rating: HS20

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the HS20 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.41 Strength Moment Rating: H20

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the H20 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.42 Strength Moment Rating: SLL #i

This table presents the strength moment ratings, excluding the effects of creep and shrinkage, for each analysis point for the special live loading number i. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35 when the special live load Vehicle Type is not "P". When the special live load Vehicle Type is "P" the same information is printed on this table as described in Section 7.6.31.

7.6.43 Strength Moment Rating (Creep and Shrinkage): PHL-93

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the PHL-93 live loading. Inventory ratings are presented for Strength I limit state and

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Strength IP limit state. Operating ratings are presented for Strength IA limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.29.

7.6.44 Strength Moment Rating (Creep and Shrinkage): HL-93

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the HL-93 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength IA limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.29.

7.6.45 Strength Moment Rating (Creep and Shrinkage): P-82

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the P-82 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.46 Strength Moment Rating (Creep and Shrinkage): P-82C

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the P-82C live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.47 Strength Moment Rating (Creep and Shrinkage): P2016-13

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the P2016-13 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.48 Strength Moment Rating (Creep and Shrinkage): P2016-13C

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the P2016-13C live loading. Inventory ratings are presented for Strength I limit state and

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Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.49 Strength Moment Rating (Creep and Shrinkage): ML-80

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the ML-80 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.50 Strength Moment Rating (Creep and Shrinkage): TK527

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the TK527 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.51 Strength Moment Rating (Creep and Shrinkage): EV2

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the EV2 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.52 Strength Moment Rating (Creep and Shrinkage): EV3

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the EV3 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.53 Strength Moment Rating (Creep and Shrinkage): SU6TV

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the SU6TV live loading. Inventory ratings are presented for Strength I limit state and

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Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.31.

7.6.54 Strength Moment Rating (Creep and Shrinkage): HS20

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the HS20 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.55 Strength Moment Rating (Creep and Shrinkage): H20

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the H20 live loading. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35.

7.6.56 Strength Moment Rating (Creep and Shrinkage): SLL #i

This table presents the strength moment ratings, including the effects of creep and shrinkage, for each analysis point for the special live loading number i. Inventory ratings are presented for Strength I limit state and Strength IP limit state. Operating ratings are presented for Strength II limit state. Rating factors are presented for both positive and negative flexure. The same information is printed on this table as described in Section 7.6.35 when the special live load Vehicle Type is not "P". When the special live load Vehicle Type is "P" the same information is printed on this table as described in Section 7.6.31.

7.6.57 Strength Shear Rating: PHL-93

This table presents the strength shear ratings for each analysis point for the PHL-93 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength IA limit state. The following information is presented in this table:

1. Span No. - the span number for which the strength shear ratings are presented.
2. Dist. - the distance from the location of the strength shear ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, STR-I - the inventory rating factor based on the Strength I limit state at the specified location.

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4. Rating Factors, Inventory, STR-IP - the inventory rating factor based on the Strength IP limit state at the specified location.
5. Rating Factors, Operating, STR-IA - the operating rating factor based on the Strength IA limit state at the specified location.
6. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.58 Strength Shear Rating: HL-93

This table presents the strength shear ratings for each analysis point for the HL-93 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength IA limit state. The same information is printed on this table as described in Section 7.6.57.

7.6.59 Strength Shear Rating: P-82

This table presents the strength shear ratings for each analysis point for the P-82 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The following information is presented in this table:

1. Span No. - the span number for which the strength shear ratings are presented.
2. Dist. - the distance from the location of the strength shear ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, STR-I - the inventory rating factor based on the Strength I limit state at the specified location. Not applicable for this live loading.
4. Rating Factors, Inventory, STR-IP - the inventory rating factor based on the Strength IP limit state at the specified location. Not applicable for this live loading.
5. Rating Factors, Operating, STR-II - the operating rating factor based on the Strength II limit state at the specified location.
6. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.60 Strength Shear Rating: P-82C

This table presents the strength shear ratings for each analysis point for the P-82C live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

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7.6.61 Strength Shear Rating: P2016-13

This table presents the strength shear ratings for each analysis point for the P2016-13 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

7.6.62 Strength Shear Rating: P2016-13C

This table presents the strength shear ratings for each analysis point for the P2016-13C live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

7.6.63 Strength Shear Rating: ML-80

This table presents the strength shear ratings for each analysis point for the ML-80 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The following information is presented in this table:

1. Span No. - the span number for which the strength shear ratings are presented.
2. Dist. - the distance from the location of the strength shear ratings to the left end of the span in which the ratings are located.
3. Rating Factors, Inventory, STR-I - the inventory rating factor based on the Strength I limit state at the specified location.
4. Rating Factors, Inventory, STR-IP - the inventory rating factor based on the Strength IP limit state at the specified location.
5. Rating Factors, Operating, STR-II - the operating rating factor based on the Strength II limit state at the specified location.
6. * If Rating Failure – an asterisk (*) is presented if any of the rating factors at this location are less than 1.0.

7.6.64 Strength Shear Rating: TK527

This table presents the strength shear ratings for each analysis point for the TK527 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.63.

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7.6.65 Strength Shear Rating: EV2

This table presents the strength shear ratings for each analysis point for the EV2 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

7.6.66 Strength Shear Rating: EV3

This table presents the strength shear ratings for each analysis point for the EV3 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

7.6.67 Strength Shear Rating: SU6TV

This table presents the strength shear ratings for each analysis point for the SU6TV live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.59.

7.6.68 Strength Shear Rating: HS20

This table presents the strength shear ratings for each analysis point for the HS20 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.63.

7.6.69 Strength Shear Rating: H20

This table presents the strength shear ratings for each analysis point for the H20 live loading. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.63.

7.6.70 Strength Shear Rating: SLL #i

This table presents the strength shear ratings for each analysis point for the special live loading number i. Inventory ratings are presented for Strength I and Strength IP limit states. Operating ratings are presented for Strength II limit state. The same information is printed on this table as described in Section 7.6.63 when the special live load Vehicle Type is not "P". When the special live load Vehicle Type is "P" the same information is printed on this table as described in Section 7.6.59.

After all service moment, strength moment, and strength shear rating tables are presented, the following note is printed in the output:

NOTE: < - A left arrow next to a distance indicates the critical distance

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7.6.71 Rating Summary: PHL-93

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength IA moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength IA shear for the PHL-93 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The following information is presented in this table:

1. Basis of Rating - the limit state and the nature of the rating; the following are the various bases of rating that are presented:
 - Strength I Moment (IR)
 - Strength IP Moment (IR)
 - Strength IA Moment (OR)
 - Service I Moment (IR)
 - Service IP Moment (IR)
 - Service III Moment (IR)
 - Service IIIP Moment (IR)
 - Service IIIA Moment (OR)
 - Strength I Shear (IR)
 - Strength IP Shear (IR)
 - Strength IA Shear (OR)
2. Controlling Rating Factor - the controlling rating factor corresponding with the specified basis of rating.
3. Controlling Location, Span No. - the span number in which the specified controlling rating factor is located.
4. Controlling Location, Distance - the distance from the location of the specified controlling rating factor to the left end of the span in which it is located.
5. Rating Tonnage - the rating tonnage corresponding with the controlling rating factor; no rating tonnage is computed for PHL-93 or HL-93.

7.6.72 Rating Summary: HL-93

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength IA moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength IA shear for the HL-93 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.72.

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7.6.73 Rating Summary: P-82

This table presents a summary of the controlling rating factors for Strength II moment, Service IIIA moment, and Strength II shear for the P-82 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The following information is presented in this table:

1. Basis of Rating - the limit state and the nature of the rating; the following are the various bases of rating that are presented:
 - Strength II Moment (OR)
 - Service IIIA Moment (OR)
 - Strength II Shear (OR)
2. Controlling Rating Factor - the controlling rating factor corresponding with the specified basis of rating.
3. Controlling Location, Span No. - the span number in which the specified controlling rating factor is located.
4. Controlling Location, Distance - the distance from the location of the specified controlling rating factor to the left end of the span in which it is located.
5. Rating Tonnage - the rating tonnage corresponding with the controlling rating factor.

7.6.74 Rating Summary: P-82C

This table presents a summary of the controlling rating factors for Strength II moment, Service IIIA moment, and Strength II shear for the P-82C live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The following information is presented in this table:

1. Basis of Rating - the limit state and the nature of the rating; the following are the various bases of rating that are presented:
 - Strength II Moment (OR)
 - Service IIIA Moment (OR)
 - Strength II Shear (OR)
2. Controlling Rating Factor - the controlling rating factor corresponding with the specified basis of rating.
3. Controlling Location, Span No. - the span number in which the specified controlling rating factor is located.
4. Controlling Location, Distance - the distance from the location of the specified controlling rating factor to the left end of the span in which it is located.
5. Rating Tonnage - the rating tonnage corresponding with the controlling rating factor; no rating tonnage is computed for this live load

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7.6.75 Rating Summary: P2016-13

This table presents a summary of the controlling rating factors for Strength II moment, Service IIIA moment, and Strength II shear for the P2016-13 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.73.

7.6.76 Rating Summary: P2016-13C

This table presents a summary of the controlling rating factors for Strength II moment, Service IIIA moment, and Strength II shear for the P2016-13C live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.74.

7.6.77 Rating Summary: ML-80

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the ML-80 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The following information is presented in this table:

1. Basis of Rating - the limit state and the nature of the rating; the following are the various bases of rating that are presented:
 - Strength I Moment (IR)
 - Strength IP Moment (IR)
 - Strength II Moment (OR)
 - Service I Moment (IR)
 - Service IP Moment (IR)
 - Service III Moment (IR)
 - Service IIIP Moment (IR)
 - Service IIIA Moment (OR)
 - Strength I Shear (IR)
 - Strength IP Shear (IR)
 - Strength II Shear (OR)
2. Controlling Rating Factor - the controlling rating factor corresponding with the specified basis of rating.
3. Controlling Location, Span No. - the span number in which the specified controlling rating factor is located.
4. Controlling Location, Distance - the distance from the location of the specified controlling rating factor to the left end of the span in which it is located.

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5. Rating Tonnage - the rating tonnage corresponding with the controlling rating factor.

7.6.78 Rating Summary: TK527

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the TK527 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.77.

7.6.79 Rating Summary: EV2

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the EV2 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.73.

7.6.80 Rating Summary: EV3

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the EV3 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.73.

7.6.81 Rating Summary: SU6TV

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the SU6TV live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.73.

7.6.82 Rating Summary: HS20

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the HS20 live loading. For each controlling rating factor, the controlling location and

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the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.77.

7.6.83 Rating Summary: H20

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the H20 live loading. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.77.

7.6.84 Rating Summary: SLL #i

This table presents a summary of the controlling rating factors for Strength I moment, Strength IP moment, Strength II moment, Service I moment, Service III moment, Service IIIA moment, Strength I shear, and Strength II shear for the special live loading number i. For each controlling rating factor, the controlling location and the corresponding rating tonnage are also presented. The same information is printed on this table as described in Section 7.6.77 when the special live load Vehicle Type is not "P". When the special live load Vehicle Type is "P" the same information is printed on this table as described in Section 7.6.73.

7.6.85 Rating Factors - Overall Summary

This table presents an overall summary of the controlling inventory and operating rating factors for each vehicle. For each vehicle and rating type, the corresponding rating factor, rating tonnage, location, and limit state are presented. The following information is presented in this table:

1. Governs - the word "FLEXURE" is presented if the specified controlling rating factor is based on flexure, and the word "SHEAR" is presented if the specified controlling rating factor is based on shear.
2. Rating Factor - the controlling rating factor corresponding with the specified basis of rating.
3. Rating Tonnage - the rating tonnage corresponding with the specified controlling rating factor; no rating tonnage is computed for PHL-93, HL-93, P-82C, and P2016-13C.
4. Span No. - the span number in which the specified controlling rating factor is located.
5. Dist. - the distance from the location of the specified controlling rating factor to the left end of the span in which it is located.
6. Limit State - the limit state corresponding with the specified controlling rating factor.

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7.6.86 Bridge Load Ratings

This table presents inventory and operating ratings for each span of the bridge and for each rating vehicle considered in a format that is consistent with DM-4 Part A Table 1.8.3-1. The following information is presented in this table:

1. Span ii - the span number for the rating summary
2. Beam Type and Size: - the beam type as defined by the Shape of Beam parameter of the CTL command and the Beam Designation
3. INVENTORY RATING Dist. Fact. - the live load distribution factor for each vehicle
4. INVENTORY RATING Loc. (ft) - the distance from the left centerline of bearing in feet to the location of the specified rating
5. INVENTORY RATING Limit State - the limit state corresponding to the given rating
6. INVENTORY RATING RESISTANCE – the resistance corresponding to the controlling rating. The units of the resistance is also reported. Locations controlled by concrete stress are reported in ksi. Locations controlled by moment are reported in kip-ft. Locations controlled by shear are reported in kips.
7. INVENTORY RATING RF - the rating factor value with either "M" or "V" to identify whether moment ("M") or shear ("V") controls
8. OPERATING RATING Dist. Fact. - the live load distribution factor for each vehicle
9. OPERATING RATING Loc. (ft) - the distance from the left centerline of bearing in feet to the location of the specified rating
10. OPERATING RATING Limit State - the limit state corresponding to the given rating
11. OPERATING RATING RESISTANCE – the resistance corresponding to the controlling rating. The units are also report, refer to INVENTORY RATING RESISTANCE.
12. OPERATING RATING RF - the rating factor value with either "M" or "V" to identify whether moment ("M") or shear ("V") controls
13. Maximum Factored Flexural Resistance (kip-ft) - the maximum moment capacity in the given span
14. Span Length(ft) - the span length measured from the left centerline of bearing (abutment or pier) to the right centerline of bearing (abutment or pier)
15. Location (ft) - the distance from the left centerline of bearing to the location of the maximum factored flexural resistance
16. Maximum Factored Shear Resistance (kips) - the maximum shear capacity in the given span
17. Location (ft) - the distance from the left centerline of bearing to the location of the maximum factored shear resistance

7.6.87 Service IIIA 90% Yield Stress of P/S Strands (ML-80: Specification Check)

This table presents the Service IIIA moment check for the ML-80 live loading. The same information is printed in this table as described in Section 7.5.16.

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7.6.88 Cracking Moment Service Check (ML-80: Specification Check)

This table presents the cracking moment check at relevant specified locations as computed in accordance with DM-4 Article 5.6.3.3 for an ML-80 live loading. The same information is printed in this table as described in Section 7.5.17.

7.6.89 Horizontal Shear (ML-80: Specification Check)

This table presents the nominal shear resistance limits, as well as the stirrup spacing and area, for horizontal shear in the girder for an ML-80 live loading. The same information is printed in this table as described in Section 7.5.23.

7.6.90 Negative Moment Capacity (ML-80: Specification Check)

This table presents a check of the negative moment capacity for an ML-80 live loading. This table is presented only for structures with more than one span. The same information is printed in this table as described in Section 7.5.18.

7.6.91 Positive Moment Connection Steel at Continuous Support (ML-80)

This table presents the nominal flexural resistance and the required steel area for the positive moment connection at each continuous support for an ML-80 live loading. The same information is printed in this table as described in Section 7.5.46.

7.6.92 Service IIIA 90% Yield Stress of P/S Strands (TK527: Specification Check)

This table presents the Service IIIA moment check for the TK527 live loading. The same information is printed in this table as described in Section 7.5.16.

7.6.93 Cracking Moment Service Check (TK527: Specification Check)

This table presents the cracking moment check at relevant specified locations as computed in accordance with DM-4 Article 5.6.3.3 for a TK527 live loading. The same information is printed in this table as described in Section 7.5.17.

7.6.94 Horizontal Shear (TK527: Specification Check)

This table presents the nominal shear resistance limits, as well as the stirrup spacing and area, for horizontal shear in the girder for a TK527 live loading. The same information is printed in this table as described in Section 7.5.23.

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7.6.95 Negative Moment Capacity (TK527: Specification Check)

This table presents a check of the negative moment capacity for a TK527 live loading. This table is presented only for structures with more than one span. The same information is printed in this table as described in Section 7.5.18.

7.6.96 Positive Moment Connection Steel at Continuous Support (TK527)

This table presents the nominal flexural resistance and the required steel area for the positive moment connection at each continuous support for a TK527 live loading. The same information is printed in this table as described in Section 7.5.46.

7.6.97 Service IIIA 90% Yield Stress of P/S Strands (HS20: Specification Check)

This table presents the Service IIIA moment check for the HS20 live loading. The same information is printed in this table as described in Section 7.5.16.

7.6.98 Cracking Moment Service Check (HS20: Specification Check)

This table presents the cracking moment check at relevant specified locations as computed in accordance with DM-4 Article 5.6.3.3 for an HS20 live loading. The same information is printed in this table as described in Section 7.5.17.

7.6.99 Horizontal Shear (HS20: Specification Check)

This table presents the nominal shear resistance limits, as well as the stirrup spacing and area, for horizontal shear in the girder for an HS20 live loading. The same information is printed in this table as described in Section 7.5.23.

7.6.100 Negative Moment Capacity (HS20: Specification Check)

This table presents a check of the negative moment capacity for an HS20 live loading. This table is presented only for structures with more than one span. The same information is printed in this table as described in Section 7.5.18.

7.6.101 Positive Moment Connection Steel at Continuous Support (HS20)

This table presents the nominal flexural resistance and the required steel area for the positive moment connection at each continuous support for an HS20 live loading. The same information is printed in this table as described in Section 7.5.46.

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7.6.102 Service IIIA 90% Yield Stress of P/S Strands (H20: Specification Check)

This table presents the Service IIIA moment check for the H20 live loading. The same information is printed in this table as described in Section 7.5.16.

7.6.103 Cracking Moment Service Check (H20: Specification Check)

This table presents the cracking moment check at relevant specified locations in accordance with DM-4 Article 5.6.3.3 for an H20 live loading. The same information is printed in this table as described in Section 7.5.17.

7.6.104 Horizontal Shear (H20: Specification Check)

This table presents the nominal shear resistance limits, as well as the stirrup spacing and area, for horizontal shear in the girder for an H20 live loading. The same information is printed in this table as described in Section 7.5.23.

7.6.105 Negative Moment Capacity (H20: Specification Check)

This table presents a check of the negative moment capacity for an H20 live loading. This table is presented only for structures with more than one span. The same information is printed in this table as described in Section 7.5.18.

7.6.106 Positive Moment Connection Steel at Continuous Support (H20)

This table presents the nominal flexural resistance and the required steel area for the positive moment connection at each continuous support for an H20 live loading. The same information is printed in this table as described in Section 7.5.46.

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7.7 SUMMARY OUTPUT

The summary output provides three sections of output reports. The TS&L Design Summary contains information typically required for a TS&L or design summary report. The Q/A - Q/C Summary contains information typically used for quality assurance and quality control. The Detailer Summary contains information typically needed for the design drawings.

7.7.1 TS&L Design Summary

This collection of reports contains information typically needed for a TS&L or design summary.

7.7.1.1 General Information

This table presents general information about each span of the bridge. The following information is presented in the table:

1. Span No. - the span number for which the information is presented.
2. Length - the span length measured from left centerline of bearing (abutment or pier) to right centerline of bearing (abutment or pier)
3. Beam Type - the beam designation for standard beams or 'USER' for non-standard beams
4. Strand Config. - the strand configuration which can be either Straight, Draped, or Debonded
5. 28 day f'_c - the compressive strength of beam concrete at 28 days
6. Initial f_{ci} - the compressive strength of beam concrete at initial prestressing
7. Slab Thick. - the actual slab thickness
8. Beam Spacing - the center-to-center beam spacing

7.7.1.2 Distribution Factors

The distribution factors are reported using the same output reports as described in the Analysis Results Output. Refer to sections 7.4.22.1.3 through 7.4.40 for details of the information presented in these tables.

7.7.1.3 Initial Stress Check

The initial stress check consists of two output tables. The data required to compute the initial stresses are provided in the first table. The second table reports the computed stress and the allowable stress. The following information is presented in the first table:

1. Span No. - the span number in which the initial stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. P_i - the initial prestress force at the specified location

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4. A_g - the gross cross section area
5. e - the eccentricity of the prestress force
6. Z_t - the section modulus of the basic beam at the top of the beam
7. MDNI - the initial non-composite dead load moment

The following information is presented in the second table:

1. Span No. - the span number in which the initial stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. $f(t_i)$ - the allowable initial tension stress at the specified location
4. $f(\text{top})$ - the computed initial stress at the specified location
5. Failure - the result of the stress comparison

7.7.1.4 Final Stress Check @ Maximum Moment

The final stress check consists of three or four output tables. The data required to compute the final stresses are provided in the first two tables. The next table reports the computed stresses with creep and shrinkage moments considered. This table is not reported for single span bridges or bridges that use the simple span check. The next table reports the computed stresses without creep and shrinkage moments considered. The following information is presented in the first table:

1. Span No. - the span number in which the final stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. P_e - the effective prestress force at the specified location
4. A_g - the gross cross section area
5. e - the eccentricity of the prestress force
6. Z_b - the section modulus of the basic beam at the bottom of the beam
7. Z_{bc} - the section modulus of the composite beam at the bottom of the beam
8. Z_{bct} - the section modulus of the composite transformed beam at the bottom of the beam

The following information is presented in the second table:

1. Span No. - the span number in which the final stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. MDNF - the final non-composite dead load moment
4. MDCF - the final composite dead load moment
5. MLCF - the final composite live load moment
6. MC&S - the creep and shrinkage moment

Chapter 7 Output Description

The following information is presented when the third table is outputted:

1. Span No. - the span number in which the final stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. $f(t)$ w/ C&S - the allowable tension stress when checking creep and shrinkage
4. $f(btm,t)$ w/ C&S - the computed tension stress with creep and shrinkage considered
5. Failure - the result of the stress comparison

The following information is presented in the fourth table:

1. Span No. - the span number in which the final stress check is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. $f(t)$ w/o C&S - the allowable tension stress
4. $f(btm,t)$ w/o C&S - the computed tension stress without creep and shrinkage considered
5. Failure - the result of the stress comparison

7.7.2 Quality Assurance / Quality Control Summary

This group of reports contains information typically needed for quality assurance and quality control. The following information is presented in the first table:

1. Span No. - the span number of the reported data
2. Length - the span length measured from centerline of bearing (abutment or pier)
3. Beam Type - the beam designation for standard beams or 'USER' for non-standard beams
4. Strand Config. - the strand configuration which can be either Straight, Draped, or Debonded
5. P/S Strand Diameter - the diameter of the prestressing strand
6. P/S Strand Area - the cross sectional area of the prestressing strand
7. Strand Type - the prestressing strand type which can be either Low relaxation or Stress relieved

7.7.2.1 Maximum Moments

This table presents the location of the maximum positive and maximum negative moment for each span. The following information is presented in the table:

1. Span No. - the span number in which the maximum moment is located
2. Type - identifies whether the moment is positive or negative
3. Location - the distance from the left centerline of bearing to the location of the maximum moment
4. Max. Unfact. Moment - the maximum unfactored moment

Chapter 7 Output Description

7.7.2.2 Final Tensile Stresses In Precomp. Tensile Zone

This table presents data related to the final tensile stresses. The following information is presented in the table:

1. Span No. - the span number in which the information is located
2. Loc - the distance from the left centerline of bearing to the location where the stress is computed
3. $f(t)$ - the final tension stress
4. Resistance - the allowable tension stress
5. Max. P/S Force - the maximum effective prestress force in the specified span
6. Ecc - the eccentricity of the prestress force
7. $M(r)$ - the factored flexure resistance
8. $M(u)$ - the factored flexure moment

7.7.3 Detailer Summary

The section contains tables with information typically needed for the design drawings.

7.7.3.1 Camber

The camber is reported using the same output reports as described in the Specification Checking Output. Refer to sections 7.5.48 through 7.5.51 for details of the information presented in these tables.

7.7.3.2 Prestress Information

This table presents the various values that define the prestressing for each span. The following information is presented in this table:

1. Span No. - the span number in which the prestress information is located
2. Loc - the distance from the left centerline of bearing to the location where the prestress information is given
3. P_i - the initial prestress force
4. CGS - the center of gravity of the prestressing steel measured from the bottom of the beam
5. Number of Strands - the number of prestressing strands at mid-span
6. 28 Day f'_c - the compressive strength of beam concrete at 28 days
7. Initial f'_c - the compressive strength of beam concrete at initial prestressing
8. Slab Steel at Support - the area of slab reinforcement at the support

Chapter 7 Output Description

7.7.3.3 Shear Reinforcement

This table presents the stirrup information for each span. The following information is presented in this table:

1. Span No. - the span number in which the stirrup information is located
2. Location - the range for the specified stirrup reinforcement given as ratios of the span length
3. Shear Reinforcement Stirrup Area, $A(v)$ - the cross section area of the stirrup reinforcement
4. Shear reinforcement Minimum Stirrup Spacing, s - the spacing of the stirrup reinforcement

7.7.3.4 Cross Section Properties at Centerline Span ii

These tables present the cross section properties of the non-composite and composite girder for both gross section and transformed section at centerline of each span. A detailed description of each data item is provided in the output.

7.7.3.5 Bridge Load Ratings

The bridge load ratings are reported using the same output reports as described in the Rating Factors Output. Refer to section 7.6.86 for details of the information presented in this table.

Chapter 7 Output Description

7.8 FORMATTED OUTPUT TABLES

The following pages contain the format (i.e. the title, output parameters, units, field width and decimal locations, and legends) for each output table described in this chapter, in the order listed in this chapter. On each table, the character "a" represents a character value for that column, and the number of "a" characters shows the number of characters possible there. The character "i" represents an integer value for that column, and the character "x" represents a real value for that column, with the decimal location indicated. The output available for every run of the program may not include all of the output tables shown. Depending on such items as the live loadings, type of run, specifications checked, and output commands and parameters chosen, the program will print different combinations of these output reports.

7.8.1 Input File Echo

Example of Input File Echo:

```
ex2.DAT
-----
!*****
! PROGRAM:
! LRFD Prestress Concrete Girder Design and Rating
! *!
! DESCRIPTION:
! Example Problem 2: 1 span adjacent box (US)
! *!
! DETAIL DESCRIPTION:
! Type: 1 span adjacent box beam, Analysis
! Units: US
! Span Lengths: 82'
! Strands: Straight Strands
! *!
! LAST UPDATED:
! B01 M.Mlynarski 7/2/96
! - Changes in SDM command.
! - Changes in CTL command.
! - User input D.F. because of change in BSP calculation of
! Torsional constant J
! - Changes in MCG/SP2 commands
! *!
!*****
TTL PROBLEM #2 - 1 Span Adjacent Box (82 feet)
!
CTL US,A,AR,E,14,1,N,U,1.0,A,1.33,1.15,1.3,,LR,2,,Y,Y,,,A
!
OIN 1,1,1
OAN
OSC
ORF
!
GEO 4.0,2.5,2,0.286,9
!
!
UDF 1, D, 0.3519144, 0., 0.5644266, 0.5644266
UDF 1, F, 0.34375, 0., 0.34375, 0.34375
!
SSI 1, ST
SPL 1, 82
```

Chapter 7 Output Description

```

SKW  1, 15, 0.0, 0.0, R
SKW  2, 15, 0.0, 0.0, L
MCS  0, 6.5, 5.5
MCA  0
!*b01 MCG  1.6, 150, 150, I, 0.9, 0.95, S
MCG  1.6, 150, 150, I, S
MPS  250, 175, 212.5, 28500, 10
MST  0, 60, 60, 1.0, 1.0, 1.0
BDM  1, 33, 48, 47.25, 5, 5.5, 3, 3, 3, 3, 3, 6, 6, 0.375, 0.750,-
      1.55, 0.00, 3.0, 0.0, 4, 4
SCA  1, 0.5, 0.153, 3.0, 2.0, 2.0, , , 2, 22, 22
STI  1, 0, .4, 12, .8, 24
SLB  6.0, , 0.0, 4.0, 150, 150, N, 60, 4
DLB  ID, 1, 0, 1, 82, 0.0193, 0.0193
DLB  DC1, 1, 0, 1, 82, 0.024, 0.024
DLB  DC2, 1, 0, 1, 82, 0.072, 0.072
DLB  FWS, 1, 0, 1, 82, 0.115, 0.115

```

7.8.2 Input Commands

Example of Input Commands:

INPUT COMMANDS

```

COMMAND:  CTL
SYSTEM OF UNITS                US
DESIGN/ANALYSIS                 A
SHAPE OF BEAM                  AR
EXTERIOR/INTERIOR              E
NUMBER OF BEAMS                14
NUMBER OF SPANS                1
SYMMETRY                      N
BEAM DESIGNATION               U
MULT. PRES. ADJ. FACTOR        1.0
LIVE LOAD                      A
DYNAMIC LOAD ALLOWANCE         1.33
FATIGUE DYN. LOAD ALLOW.       1.15
PA. TRAFFIC FACTOR             *          (computed, if necessary)
STRAND TYPE                    L          (default)
P/S LOSS TYPE                  LR
PRESTRESS TRANSFER TIME        2
RELATIVE HUMIDITY              70.0      (default)
COMPOSITE BEAM                 Y
SKEW OVERRIDE                  Y
IMPORTANCE FACTOR              1.0      (default)
DUCTILITY FACTOR               1.0      (default)
REDUNDANCY FACTOR              1.0      (default)
SHEAR DESIGN/ANALYSIS         A
SKEW ANGLE DESIGNATION         P          (default)
SHRINKAGE ONLY ANALYSIS        N          (default)
OUTPUT POINTS                  0          (default)
MULTI-SPAN ANALYSIS OPT        S          (default)
P-82 DYN. LOAD ALLOW.          1.20      (default)
DECK PLACEMENT TIME            120.0      (default)
OVERHANG-DEPTH OVERRIDE        N          (default)

COMMAND:  OIN
INPUT FILE ECHO                1
INPUT COMMANDS                 1

```

Chapter 7 Output Description

INPUT SUMMARY 1

```

COMMAND:  OAN
SECTION PROPERTIES      *      (computed, if necessary)
ANALYSIS POINTS        *      (computed, if necessary)
DISTRIBUTION FACTOR     *      (computed, if necessary)
POINTS OF CONTRAFLEXURE *      (computed, if necessary)
LOADS AND LOAD MODIFIERS *      (computed, if necessary)
DL NC FORCE-MOMENT       *      (computed, if necessary)
TOTAL NC DL FORCE-MOMENT *      (computed, if necessary)
DL COMP FORCE-MOMENT     *      (computed, if necessary)
TOTAL COMP DL FORCE-MOM. *      (computed, if necessary)
DL CREEP/SHRINKAGE MOM. *      (computed, if necessary)
LL EFFECTS              *      (computed, if necessary)
LL REACTIONS            *      (computed, if necessary)
HS20 EFFECTS/REACTIONS *      (computed, if necessary)
H20 EFFECTS/REACTIONS  *      (computed, if necessary)
FATIGUE EFFECTS/REACT. *      (computed, if necessary)
FACTORED EFFECTS       *      (computed, if necessary)
FACTORED REACTIONS     *      (computed, if necessary)

```

7.8.3 Input Summary

CONFIGURATION

```

-----
Lines      Blank Lines at
per Page   Top of Page
ii         ii

```

CONTROL PARAMETERS

```

-----
Units  Design/  Shape of  Exterior/  No.    No.    Symmetry  Beam
       Analysis Beam      Interior  Beams   Spans   aaaaaa   Desig.
       aa      aaaaaaaa aaaaaaaaaaaaaa aaaaaaaa ii     ii          a

Multiple
Presence      Live Load  Dyn. Load  Fatigue    PA        P/S
Adj. Factor   Code      Allowance  Allowance  Traffic   Strand   Loss
xxx.xx       a        xx.xxx    xx.xxx    Factor    Type    Type
              a        xx.xxx    xx.xxx    N/A       a       aa

Prestress
Transfer      Relative  Composite  Skew       Impor.    Duct.    Redun.
Time          Humidity  Beam      Override   Factor    Factor    Factor
xxx.xx       xxx.xx  a        a        xx.xxx    xx.xxx    xx.xxx

Shear        Skew      Shrinkage  Multi-Span  P-82      Deck
Design/      Angle    Analysis  Output     Analysis  Dyn. Load  Placement
Analysis     Desig.   Only     Points     Method    Allowance  Age
a            a        a        i         a        xx.xxx    xxxxx.xx

Overhang to
Beam Depth
Override
a

```

Chapter 7 Output Description

STRUCTURE IDENTIFICATION					
Program Identification =PSLRFD	County nn	State Route nnnn	Segment nnnn	Offset nnnn	Span Identification aaaa

BEAM GEOMETRY					
Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
xxx.xxx	xxx.xxx	iii	xx.xxx	xxx.xxx	xxx.xxx

BEAM GEOMETRY (SIDEWALK)	
Defl. Dist. Factor	No. of Design Lanes
xx.xxx	iii

COMPUTED DISTRIBUTION FACTORS					
CL Ext. to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
xxx.xxx	xxxx.xxx	xxxx.xxx	xxxx.xxx	xxx.xxx	xxxx.xxx

COMPUTED DISTRIBUTION FACTORS (SIDEWALK)	
CL Ext. Girder to Curb W/Sidewalks (ft)	Dist. to Outermost Wheel W/Sidewalks (ft)
xxx.xxx	xxxx.xxx

USER DEFINED DISTRIBUTION FACTOR					
Span No.	D.F. Type	Moment DF1	Moment DF2	Shear DF1	Shear DF2
i	aaaaaaa	x.xxxx	x.xxxx	x.xxxx	x.xxxx

USER DEFINED REACTION DISTRIBUTION FACTOR		
Support Number	D.F. Type	Reaction DF
i	aaaaaaa	x.xxxx

Chapter 7 Output Description

SPAN SPECIFIC INPUT

```

          Straight/
Span      Draped/
Number    Debonded
          ii      aaaaaaaaa

```

SPAN LENGTHS

```

Span No.      1      2
Length (ft) xxx.xxx xxx.xxx

```

SUPPORT INFORMATION

```

          Distance      Distance
          to left       to right
Simple Span Simple Span Skew
Support No. Angle Bearing Bearing Correction
          (deg) (ft) (ft) Application
          ii xxx.xxx xxxxx.xxx xxxxx.xxx a

```

BEAM CONCRETE MATERIAL PROPERTIES

```

Span      28 day Spec.      Initial
No.        Compr. Strength  Strength
          f'c              f'ci
          (ksi)            (ksi)
          ii xxxxx.xxx      xxxxx.xxx

```

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

```

          Final      Final
Span      Initial  Initial  Final  Final  Final DL  Compression  Slab  Tension
No.        Compr.  Tension  Compr.  Tension  Compr.  1/2 (DL+PS)+LL  Compr.  Creep
          (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)
          i   xx.xxx  x.xxx  xx.xxx  x.xxx  xx.xxx  xx.xxx  xx.xxx  x.xxx

```

(Centerline of bearing ONLY)

```

          Final      Final
Span      Initial  Initial  Final  Final  Final DL  Compression  Slab  Tension
No.        Compr.  Tension  Compr.  Tension  Compr.  1/2 (DL+PS)+LL  Compr.  Creep
          (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)   (ksi)
          i   xx.xxx  x.xxx  xx.xxx  x.xxx  xx.xxx  xx.xxx  xx.xxx  x.xxx

```

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

```

          Steam/
Creep      Beam Unit  Beam Unit  Slab Beam  Moist
Factor     Wt. for DL  Wt. for E  Interface  Cured
          (lb/ft^3)  (lb/ft^3)
          xx.xx      xxxxx.x      xxxxx.x      a      a

```

Chapter 7 Output Description

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
xxxxx.xx	xxxxx.xx	xxxxx.xx	xxxxxxxx.x	xxx.xx

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Slabs	Other Beam Ultimate Strength (ksi)
ii	xxxx.x	xxxx.x	xxx.xx	xxx.xx	xxx.xx	xxxx.x

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
ii	aaaaaaa	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
ii	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
ii	xx.x	xx.x	xx.xx	xx.xx	ii	ii

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio
a	xxxx.xx	xxxx.xx	xx.x	xx.	xx.xxa	x.xx	x.xxx

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Top Flange Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio	Bottom Flange Thickness (in)
a	xxxx.xx	xxxx.xx	xx.x	xx.	xx.xxa	x.xx	x.xxx	xx.

* NOTE: Design f'c modified for f'c optimization.

Chapter 7 Output Description

STRAND CONFIGURATION - ANALYSIS (1 OF i)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
ii	x.xxx	x.xxx	aaaaaa	aaaa	aaaa	iii	aaaaaa	aaa

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF i)

Span No.	Number of Strands in each Row at MidSpan																			
ii	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa

STRAND CONFIGURATION - DESIGN (1 OF i)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
ii	x.xxx	x.xxx	aaa	x.xx	x.xx	xx.xx	ii

STRAND CONFIGURATION - DESIGN (2 OF i)

Span No.	Available Strand Positions in each Row at MidSpan																			
ii	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa	aa

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)
xx.xxx	xx.xxx	xx.xxx	xxx.xxx	xxxx.xx	xxxx.xx	xx.xxx

SLAB PROPERTIES (2 OF 2)

Slab Concrete Type	Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)
a	xxxx.x	xx.xxx	xx.xxx	ii	xxxx.x

DIAPHRAGM DETAILS

Span No.	Location	Exterior/Interior	Weight (kip)	Thickness (in)
ii	xxxx.xx	a	aaaaaaaa	xxxxxx.xx

Chapter 7 Output Description

DRAPE POINT LOCATION

Span No.	% Drape Point Location
	Left Right
ii	xxx.xxx xxx.xxx

TENDON LOCATION

Span No.	Tendon Height (in)	1st Tendon (ft)	2nd Tendon (ft)	3rd Tendon (ft)	4th Tendon (ft)	5th Tendon (ft)
ii	xx.xx	xxx.xxxx	xxx.xxxx	xxx.xxxx	xxx.xxxx	xxx.xxxx

* NOTE: One or more draped strands interfere with the tendon pocket at the indicated tendon location.

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
ii	xx.xxx	ii	ii

DRAPING INFORMATION

Span No.	Distance to Top (in)	Row Number	Number Strands Draped
ii	xx.xx	ii	ii

PEDESTRIAN LOAD

Total Pedestrian Live Load (kips/ft)	Pedestrian Live Load (kips/ft)	Sidewalk Dead Load (kips/ft)	Addl. FWS Dead Load (kips/ft)	Addl. DC1 Dead Load (kip/ft)
xxx.xxx	xxx.xxx	xxx.xxx	xxx.xxx	xxx.xxx

LONGITUDINAL SLAB REINFORCEMENT

Support No.	Bar No.	Left Cutoff (ft)	Right Cutoff (ft)	As/Eff. Slab Width (in^2)	Location In Slab
ii	ii	xxx.xxx	xxx.xxx	xxxxx.xx	a

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in^2)	Shear Reinf. Spacing (in)	Horizontal Area (in^2)	Shear Reinf. Spacing (in)
ii	xxxx.xxx	xxxx.x	xxxxx.x	xxxx.x	xxxxx.x

Chapter 7 Output Description

Load Type	LOAD FACTORS											
	STR I	STR IP	STR IA	STR II	SRV I	SRV IP	SRV III	SRV IIIP	SRV IIIA	SRV IIIB	FAT I	DEFL
aaa	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx

CONCENTRATED LOADS			
Load Type	Span	Dist. (ft)	Start Magnitude (kips)
aaa	ii	xxx.xxx	xx.xxx

DISTRIBUTED LOADS							
Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)	
aaa	ii	xxx.xxx	ii	xxx.xxx	xx.xxxx	xx.xxxx	

SPECIAL LIVE LOAD				
LL No.	Axle Effect	Lane Load (kip/ft)	Percentage Increase	Vehicle Type
i	a	xxx.xxx	xxx.xxx	a

SPECIAL AXLE LOAD								
LL No.	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)
i	xxxx.xxx	xxx.xxx	xxxx.xxx	xxx.xxx	xxxx.xxx	xxx.xxx	xxxx.xxx	xxx.xxx

OVERHANG							
Future WS (in)	Future WS Density (lb/ft^3)	Weight of Rail (kip/ft)	Parapet Weight (kip/ft)	Width (in)	Weight of Formwork (psf)	Dist. to Curb (ft)	Overhang Gage Dist. (ft)
xxx.xx	xxxxx.x	xxx.xx	xxx.xx	xx.xx	xxx.xx	xx.xxx	xxx.xxx

BEAM DETAILING				
Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)
iaa	xx.xx	xx.xx	xx.xx	aaaaa

Chapter 7 Output Description

GIRDER STABILITY (Part 1)

Span No.	Overhang Distance (ft)	Cable Angle (deg)	Wind Pressure (psf)	Impact Factor (%)	Lifting Loops Eccentricity (in)	Lifting Loops Rigid Extension (in)	Lateral Deflection (Sweep) (in)
ii	xx.xxx	xx.x	xx.x	xx.x	xx.xxx	xx.xxx	xx.xxx
Span No.	Concrete Strength At Lift (ksi)	Camber At Lift (in)					
ii	xx.xxx	xx.xxx					

GIRDER STABILITY (Part 2)

Span No.	Concrete Strength Seating (ksi)	Camber at Seating (in)	Sweep at Seating (in)	P/S Force at Seating (kips)	Active Const. Wind Press. (psf)	Bearing Rotational Stiffness (in*kip/rad)		
ii	xx.xxx	xx.xx	xx.xxx	xxxxx.x	xx.xx	xxxxxx.x		
Span No.	Bearing Height (in)	Bearing Width (in)	Bearing Tolerance from C.L. (in)	Bearing Level Tolerance (ft/ft)	Inactive Wind Pressure (psf)	Construction Vert. Wind Pressure (psf)	End Bracing Provided	Number of Intermediate Braces
ii	xx.xxx	xx.xxx	x.xxx	x.xxx	xx.xxx	xx.xxx	a	nn

GIRDER STABILITY (Part 3)

Span No.	Concrete Strength Casting (ksi)	Formwork Extension (ft)	Screed Rail Distance (in)	Thickness Deck Overhang (in)	Weight SIP Forms (psf)	Weight Cantilever Forms (psf)	Live Load on Deck (psf)
ii	xx.xxx	xx.xx	xx.xx	xx.xx	xx.x	xx.x	xx.x
Span No.	Live Load from Screed (kips)	Live Load on Walkway (plf)	Length of Live Load on Walkway (ft)				
ii	xx.xxx	xxx.x	xxx.x				

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary		
i			i	i

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
i	i	i	i	i	i	i
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
i	i	i	i	i	i	i
Factored Reactions	Overall Reaction Summary					
i	i					

Chapter 7 Output Description

OUTPUT OF SPECIFICATION CHECKING

Design Stresses i	Final Compressive Stresses Under LL + 1/2 (DL+PS) i	End Block Stresses i	Cracking Moment i	Negative Moment Capacity i	Shear Reinforcement i	Prestressing Data i
Fatigue Stress Range i	Longitudinal Slab Reinforcement i	Positive Moment Connection i	Overhang Width i	Camber and Deflection i	Strand Code Detail i	Principal Stresses i
Girder Stability i	Rating Vehicle Stresses i					

OUTPUT OF RATING FACTORS

Detailed Rating Factors i	Live Load Rating i	Overall Rating Summary i	Rating Vehicle Specification Checking i	Ratings w/o FWS i

OUTPUT SUMMARY

TS&L Design Summary i	Q/A-Q/C Summary i	Detailer Summary i

i

7.8.4 Section Properties

EFFECTIVE SLAB DIMENSIONS

Effective Slab Width (in) xxxx.xx	Effective Slab Thickness (in) xxx.xx	Effective Slab Haunch (in) xxx.xx

SECTION PROPERTIES (BASIC BEAM, GROSS SECTION)

Span No.	Moment of Inertia (in^4) xxxxxxxx.	Dist. to Neutral Axis Bot. of Beam (in) xxxxxx.xx	Top of Beam (in) xxxxx.xx	Section Modulus Bot. of Beam (in^3) xxxxxxx.	Top of Beam (in^3) xxxxxxx.
ii	xxxxxxxx.	xxxxxx.xx	xxxxx.xx	xxxxxxx.	xxxxxxx.

SECTION PROPERTIES (BASIC BEAM, TRANSFORMED SECTION)

Span No.	Dist.	Moment of Inertia (in^4) xxxxxxx.	Dist. to Neutral Axis Bot. of Beam (in) xxx.xx	Top of Beam (in) xxx.xx	Section Modulus Bot. of Beam (in^3) xxxxxxx.	Top of Beam (in^3) xxxxxxx.
ii	xxx.xxx	xxxxxxx.	xxx.xx	xxx.xx	xxxxxxx.	xxxxxxx.

Chapter 7 Output Description

SECTION PROPERTIES (COMPOSITE BEAM, GROSS SECTION)

Span No.	Dist.	Moment of Inertia (in ⁴)	Dist. to Neutral Axis			Section Modulus		
			Bot. of Beam (in)	Top of Beam (in)	Top of Slab (in)	Bot. of Beam (in ³)	Top of Beam (in ³)	Top of Slab (in ³)
ii	xxx.xxx	xxxxxxxx.	xxxxxx.xx	xxxx.xx	xxx.xx	xxx.xxxx	xxx.xxxx	xxxxxxxx.

SECTION PROPERTIES (COMPOSITE BEAM, TRANSFORMED SECTION)

Span No.	Dist.	Moment of Inertia (in ⁴)	Dist. to Neutral Axis			Section Modulus		
			Bot. of Beam (in)	Top of Beam (in)	Top of Slab (in)	Bot. of Beam (in ³)	Top of Beam (in ³)	Top of Slab (in ³)
ii	xxx.xxx	xxxxxxxx.	xxxxxx.xx	xxxxxx.xx	xxxxxx.xx	xxxxxx.	xxx.xxxx	xxxxxxxx.

NOTE: A negative distance from top of beam to neutral axis and a negative top of beam section modulus indicates the neutral axis is above the top of beam.

ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (1 OF 2)

Span No.	Depth (in)	Area		Weight		Volume / Surface	
		Basic Beam (in ²)	Beam (in ²)	Per Unit Length (k/ft)	Volume (in ³ /ft)	Surface Area (in ² /ft)	Area Ratio (in)
ii	xxxx.xx	xxxxxx.xx	xxxxxx.xx	xxx.xx	xxxxxxxx.xx	xxxxxx.xx	xxx.xxxx

ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (1 OF 2)

Span No.	Depth (in)	Area		Weight		Volume / Surface	
		Basic Beam (in ²)	w/ Addl. Conc. Around Void Perimeter (in ²)	Per Unit Length (w/ Addl. Conc.) (k/ft)	Volume (in ³ /ft)	Surface Area (in ² /ft)	Area Ratio (in)
ii	xxx.xx	xxxxxx.xx	xxxxxx.xx	xxx.xx	xxxxxx.xx	xxxxxx.xx	xxxxxx.xx

ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (2 OF 2)

Span No.	Longitud. Stiffness Parameter (in ⁴)	Longitud.		Concrete 1/2 Area	
		Stiffness Parameter (in ⁴)	Torsional Constant (in ⁴)	Positive (in ²)	Negative (in ²)
ii	xxxxxxxx.	xxxxxxxx.	xxxxxxxx.	xxxxxx.x	xxxxxx.x

ADDITIONAL SECTION PROPERTIES FOR BASIC BEAM (2 OF 2)

Span No.	Longitud. Stiffness Parameter (in ⁴)	Area Stems (in ²)	Distance to Neutral Axis		Moment of Inertia Stems (in ⁴)	Torsional Constant (in ⁴)	Concrete 1/2 Area	
			Top of Stem (in)	Bottom of Stem (in)			Positive (in ²)	Negative (in ²)
ii	xxxxxx.	xxxx.xx	xxx.xx	xxxxxx.	xxxxxx.	xxxxxx.	xxxxxx.x	xxxxxx.x

Chapter 7 Output Description

INTERIOR BEAM SECTION PROPERTIES FOR DISTRIBUTION FACTOR

Span No.	Distance (ft)	Moment of Inertia (in ⁴)	Torsional Constant (in ⁴)
ii	xxx.xxx	xxxxxx.	xxxxxx.

MODULUS OF ELASTICITY

Span No.	Girder Concrete		Slab Concrete	Prestressing Steel	Mild Steel
	Final E(c) (ksi)	Initial E(ci) (ksi)	E(cs) (ksi)	E(p) (ksi)	E(s) (ksi)
ii	xxxxxx.	xxxxxx.	xxxxxx.	xxxxxx.	xxxxxxxx.

MODULAR RATIOS

Span No.	n(p)	n(s)	n(cs)
ii	xxx.xxx	xxx.xxx	xxx.xxx

MISCELLANEOUS STRESSES

Span No.	Prestressing Steel		Girder Concrete	Slab Concrete	
	Yield Stress f(py) (ksi)	Jacking Stress f(pj) (ksi)	28-Day Spec. Compr. Strength f'c (ksi)	Modulus of Rupture f(r) (ksi)	28-Day Spec. Compr. Strength f'c (ksi)
ii	xxxxxx.x	xxxxxx.x	xxx.xxx	xxx.xxx	xxxx.xxx

BEAM DESIGNATIONS

Beam Table Designation
(The following beams will be considered for design)

aaaaaaaaaa, aaaaaaaaaa, ...

The following beams were selected for this design:

Span ii: aaaaaaaaaa

Span ii: aaaaaaaaaa

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
ii	aaaaaaaaaa	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx

Chapter 7 Output Description

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)								

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
ii	xxx.xxx	xxx.xxx	xx.xxx	xx.xxx	xx.xxx	xx.xxx	xxx.xxx	xx.xxx

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)						

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
ii	xxxx.x	xxxx.x	xxx.xx	xxx.xx	ii	ii

7.8.5 Analysis Points

SPAN DISTANCE PRESENTED IN OUTPUT TABLES		

Span No.	Distance (ft)	Significance
ii	xxxx.xxx	aaaaaa,aaaaaa,aaaaaa...

TWENTH - Twentieth point
 SMPBRG - Simple span bearing location
 MIDSPN - Midspan of the simple span
 TRANSF - Prestressing transfer length
 DRAPE - Drape point location
 EXTSUP - Exterior or end support
 INTSUP - Interior support
 CONCEN - Concentrated load location
 TENTH - Tenth point
 STIRUP - Stirrup change location

SPAN LENGTHS AND GIRDER LENGTHS						

Span Number	Input Span Length (ft)	Left Support Distance (ft)	Right Support Distance (ft)	Simple Span Length (ft)	Beam Projection (ft)	Overall Girder Length (ft)
ii	xxx.xxx	xx.xxx	xx.xxx	xxx.xxx	xx.xxx	xxx.xxx

Note: Simple Span Length = Input Span Length - Lt. Support Distance - Rt. Support Distance
 Overall Girder Length = Simple Span Length + 2 * Beam Projection

Chapter 7 Output Description

7.8.6 Distribution Factor

```

COMPUTED DISTRIBUTION FACTORS - INTERIOR MOMENT (LANES/BEAM)
-----

NEXT BEAM DOUBLE-TEE MODEL
=====

Design Live Load Moment
-----

          D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Interior      Interior      Interior      Interior      D.Factor
          Moment        Moment        Lever Rule    Lever Rule      Interior
Span      1 Lane      2+ Lanes      1 Lane      2+ Lanes      Moment
No.      gDT(iM)^1    gDT(iM)^2+    gDT(iLR)^1  gDT(iLR)^2+    (Nb3a3)
ii       x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx

          Variables                      Range of Applicability
aa =  x.xxxxx  aaaa  xx.xxxx  <= aa <=  xx.xxx  ;  aa
aa =      ii      ii      <= aa      ;  aa
aa =  x.xxxxxxE+ii aaaa  xxxxx.  <= aa <=  x.xxxxxxE+ii;  aa

*Controlling D.F. = Max(gDT(iM)^1, gDT(iM)^2+)
*Controlling D.F. = Max( Min(gDT(iM)^1, gDT(iLR)^1),
                        Min(gDT(iM)^2+, gDT(iLR)^2+) )

Fatigue Load Moment
-----

          Control*
          D.Factor
          Fatigue
          Moment
          gDT(iM)^Fat
          x.xxxxxx

*Controlling D.F. = gDT(iM)^1 / 1.2
*Controlling D.F. = Min(gDT(iM)^1, gDT(iLR)^1) / 1.2

Design Live Load Moment (w/ Sidewalks)
-----

          D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Interior      Interior      Interior      Interior      D.Factor
          Moment        Moment        Lever Rule    Lever Rule      Interior
Span      1 Lane      2+ Lanes      1 Lane      2+ Lanes      Moment
No.      gDT(iM)^1P    gDT(iM)^2+P    gDT(iLR)^1P  gDT(iLR)^2+P    (Nb3a3)
ii       x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxx

          Variables                      Range of Applicability
aa =  x.xxxxx  aaaa  xx.xxxx  <= aa <=  xx.xxx  ;  aa

*Controlling D.F. = Max(gDT(iM)^1P, gDT(iM)^2+P)
*Controlling D.F. = Max( Min(gDT(iM)^1P, gDT(iLR)^1P),
                        Min(gDT(iM)^2+P, gDT(iLR)^2+P) )

```

Chapter 7 Output Description

NEXT BEAM SINGLE-TEE MODEL

=====

Design Live Load Moment

	D.Factor	D.Factor	Controla
	Interior	Interior	Interior
	Moment	Moment	Moment
	1 Lane	2+ Lanes	(Nb/=3)
Span No.	$gST(iM)^1$	$gST(iM)^2+$	$gST(iM)$
ii	x.xxxxx	x.xxxxx	x.xxxxx

	Variables		Range of Applicability	
aa =	x.xxxx	aaaa	xx.xxxx	<= aa <= xx.xxx ; aa

*Controlling D.F. = 2 * Max($gST(iM)^1$, $gST(iM)^2+$)

Fatigue Load Moment

Controla
D.Factor
Fatigue
Moment
$gST(iM)^{Fat}$
x.xxxxx

*Controlling D.F. = 2 * $gST(iM)^1$ / 1.2

Design Live Load Moment (w/ Sidewalks)

	D.Factor	D.Factor	Controla
	Exterior	Exterior	Exterior
	Moment	Moment	Moment
	1 Lane	2+ Lanes	(Nb/=3)
Span No.	$gST(iM)^{1P}$	$gST(iM)^{2+P}$	$gST(iM)^P$
ii	x.xxxxx	x.xxxxx	x.xxxxx

	Variables		Range of Applicability	
aa =	x.xxxx	aaaa	xx.xxxx	<= aa <= xx.xxx ; aa

*Controlling D.F. = 2 * Max($gST(iM)^{1P}$, $gST(iM)^{2+P}$)

CONTROLLING INTERIOR MOMENT DISTRIBUTION FACTOR

=====

Design Live Load Moment

	Control*
	D.Factor
	Live Load
	Moment
Span No.	$g(iM)$
ii	x.xxxxx

Fatigue Load Moment

Controla
D.Factor
Fatigue
Moment
$g(iM)^{Fat}$
x.xxxxx

Chapter 7 Output Description

```

Design Live Load Moment (w/ Sidewalks)
-----
Control*
D.Factor
Live Load
Moment
g(iM)P
x.xxxxx

*Controlling Live Load D.F. = Max(gDT(iM), gST(iM))
*Controlling Fatigue D.F. = Max(gDT(iM)^Fat, gST(iM)^Fat)

*Controlling Live Load (w/ Sidewalks) D.F. = Max(gDT(iM)P, gST(iM)P)
COMPUTED DISTRIBUTION FACTORS - INTERIOR SHEAR (LANES/BEAM)
-----

NEXT BEAM DOUBLE-TEE MODEL
=====

Design Live Load Shear
-----
D.Factor      D.Factor      Controla
Interior      Interior      D.Factor
Shear         Shear         Interior
1 Lane       2+ Lanes      Shear
Span No.    gDT(iV)^1    gDT(iV)^2+    gDT(iV)
ii DF1      x.xxxxx      x.xxxxx      x.xxxxx
ii DF2      x.xxxxx      x.xxxxx      x.xxxxx

Variables      Range of Applicability
aa =  x.xxxx   aaaa   xx.xxxx   <= aa <=   xx.xxx   ;   aa

*Controlling D.F. = Max(gDT(iV)^1, gDT(iV)^2+)

Skew Correction
-----
Support No.    Shear Factor
ii             x.xxxxxx
ii             x.xxxxxx

Variables (DF1)      Range of Applicability
--- N O N E ---

Variables (DF2)      Range of Applicability
--- N O N E ---

Fatigue Load Shear
-----
Controla
D.Factor
Fatigue
Shear
Span No.    gDT(iV)^Fat
ii DF1      x.xxxxx
ii DF2      x.xxxxx

*Controlling D.F. = gDT(iV)^1 / 1.2

```

Chapter 7 Output Description

```

                                Design Live Load Shear (w/ Sidewalks)
                                -----
                                D.Factor      D.Factor      Controla
                                Interior      Interior      D.Factor
                                Shear        Shear        Interior
                                1 Lane       2+ Lanes      Shear
Span No.  gDT(iV)^1P    gDT(iV)^2+P    gDT(iV) P
ii DF1    x.xxxxxx    x.xxxxxx    x.xxxxxx
ii DF2    x.xxxxxx    x.xxxxxx    x.xxxxxx

                                Variables                      Range of Applicability
aa =      x.xxxxx      aaaa      xx.xxxxx      <= aa <=      xx.xxx      ; aa

*Controlling D.F. = Max(gDT(iV)^1P, gDT(iV)^2+P)

                                NEXT BEAM SINGLE-TEE MODEL
                                =====

                                Design Live Load Shear
                                -----
                                D.Factor      D.Factor      Controla
                                Interior      Interior      D.Factor
                                Shear        Shear        Interior
                                1 Lane       2+ Lanes      Shear
Span No.  gST(iV)^1    gST(iV)^2+    gST(iV)
ii DF1    x.xxxxxx    x.xxxxxx    x.xxxxxx
ii DF2    x.xxxxxx    x.xxxxxx    x.xxxxxx

                                Variables                      Range of Applicability
aa =      x.xxxxx      aaaa      xx.xxxxx      <= aa <=      xx.xxx      ; aa

*Controlling D.F. = 2 * Max(gST(iV)^1, gST(iV)^2+)

                                Skew Correction
                                -----
Support No.      Shear Factor
ii              x.xxxxxx
ii              x.xxxxxx

                                Variables (DF1)                Range of Applicability
                                --- N O N E ---

                                Variables (DF2)                Range of Applicability
                                --- N O N E ---
                                Fatigue Load Shear
                                -----
                                Controla
                                D.Factor
                                Fatigue
                                Shear
Span No.      gST(iV)^Fat
ii DF1        x.xxxxxx
ii DF2        x.xxxxxx

*Controlling D.F. = 2 * gST(iV)^1 / 1.2

```

Chapter 7 Output Description

```

                                Design Live Load Shear (w/ Sidewalks)
                                -----
                                D.Factor      D.Factor      Controla
                                Interior      Interior      D.Factor
                                Shear        Shear        Interior
                                1 Lane       2+ Lanes      Shear
Span No.  gST(iV)^1P    gST(iV)^2+P    gST(iV) P
    ii DF1  x.xxxxxx    x.xxxxxx    x.xxxxxx
    ii DF2  x.xxxxxx    x.xxxxxx    x.xxxxxx

                                Variables                      Range of Applicability
aa =  x.xxxxx  aaaa    xx.xxxxx  <= aa <=  xx.xxx  ;  aa

```

*Controlling D.F. = 2 * Max(gST(iV)^1P, gST(iV)^2+P)

CONTROLLING INTERIOR SHEAR DISTRIBUTION FACTOR

=====

```

                                Design Live Load Shear      Fatigue Load Shear
                                -----
                                Controla                      Controla
                                D.Factor                      D.Factor
                                Live Load                      Fatigue
                                Shear                          Shear
Span No.  g(iV)                          g(iV)^Fat
    ii DF1  x.xxxxxx                      x.xxxxxx
    ii DF2  x.xxxxxx                      x.xxxxxx
                                Design Live Load Shear (w/Sidewalks)
                                -----

```

```

                                Controla
                                D.Factor
                                Live Load
                                Shear
Span No.  g(iV) P
    ii DF1  x.xxxxxx
    ii DF2  x.xxxxxx

```

*Controlling Live Load D.F. = Max(gDT(iV), gST(iV))

*Controlling Fatigue D.F. = Max(gDT(iV)^Fat, gST(iV)^Fat)

*Controlling Live Load (w/ Sidewalks) D.F. = Max(gDT(iV)P, gST(iV)P)

COMPUTED DISTRIBUTION FACTORS - EXTERIOR MOMENT (LANES/BEAM)

NEXT BEAM DOUBLE-TEE MODEL

=====

```

                                Design Live Load Moment
                                -----
                                D.Factor      D.Factor      D.Factor      Controla
                                Exterior      Exterior      Exterior      D.Factor
                                Moment        Lever Rule    Lever Rule    Exterior
                                2+ Lanes      1 Lane         2+ Lanes      (Nb/=3)
Span No.  gDT(eM)^2+    gDT(eLR)^1     gDT(eLR)^2    gDT(eM)
    ii     x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx

```

Chapter 7 Output Description

```

          Variables                      Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=      xx.xxx      ;      aa

*Controlling D.F. = Max(gDT(eLR)^1, gDT(eM)^2+)

          Fatigue Load Moment
          -----
          Controla
          D.Factor
          Fatigue
          Moment
          gDT(eM)^Fat
          x.xxxxx

*Controlling D.F. = gDT(eLR)^1 / 1.2

          Design Live Load Moment (w/ Sidewalks)
          -----
          D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Exterior      Exterior      Exterior      Exterior      D.Factor
          Moment      Lever Rule      Lever Rule      Moment      Exterior
          2+ Lanes      1 Lane      2+ Lanes      (Nb/=3)
Span No.  gDT(eM)^2+P  gDT(eLR)^1P  gDT(eLR)^2P  gDT(eM) P
ii        x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx
          Variables                      Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=      xx.xxx      ;      aa

*Controlling D.F. = Max(gDT(eLR)^1P, gDT(eM)^2+P)

          NEXT BEAM SINGLE-TEE MODEL
          =====

          Design Live Load Moment
          -----
          D.Factor      D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Exterior      Exterior      Interior      Interior      Exterior      D.Factor
          Moment      Lever Rule      Moment      Moment      Moment      Exterior
          2+ Lanes      1 Lane      1 Lane      2+ Lanes      Moment
Span No.  gST(eM)^2+  gST(eLR)^1  gST(iM)^1  gST(iM)2+  gST(eM)
ii        x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx    x.xxxxxx

          Variables                      Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=      xx.xxx      ;      aa

*Controlling D.F. = Max( 2 * gST(eLR)^1,
                        2 * gST(eM)^2+,
                        gST(eLR)^1 + gST(iM)^1,
                        gST(eM)^2+ + gST(iM)^2+ )

```

Chapter 7 Output Description

Fatigue Load Moment

```
-----
Controla
D.Factor
Fatigue
Moment
gST(eM)^Fat
x.xxxxx
```

*Controlling D.F. = Max(2 * gST(eLR)^1, gST(eLR)^1 + gST(iM)^1) / 1.2

Design Live Load Moment (w/ Sidewalks)

```
-----
Controla
D.Factor      D.Factor      D.Factor      D.Factor      D.Factor
Exterior      Exterior      Interior      Interior      Exterior
Moment        Lever Rule   Moment        Moment        Moment
Span 2+ Lanes 1 Lane      1 Lane      2+ Lanes
No.  gST(eM)^2+P gST(eLR)^1P gST(iM)^1P  gST(iM)^2+P  gST(eM) P
ii   x.xxxxx    x.xxxxx    x.xxxxx    x.xxxxx    x.xxxxx
Variables
aa =  x.xxxx    aaaa    xx.xxxx    <= aa <=  xx.xxx    ; aa
```

*Controlling D.F. = Max(2 * gST(eLR)^1P,
2 * gST(eM)^2+P,
gST(eLR)^1P + gST(iM)^1P,
gST(eM)^2+P + gST(iM)^2+P)

CONTROLLING EXTERIOR MOMENT DISTRIBUTION FACTOR

```
=====
Design Live Load Moment      Fatigue Load Moment
-----
Controla                      Controla
D.Factor                      D.Factor
Live Load                     Fatigue
Moment                        Moment
Span No.                      g(eM)^Fat
ii                             x.xxxxx
```

Design Live Load Moment (w/ Sidewalks)

```
-----
Controla
D.Factor
Live Load
Moment
g(eM) P
x.xxxxx
```

*Controlling Live Load D.F. = Max(gDT(eM), gST(eM))

*Controlling Fatigue D.F. = Max(gDT(eM)^Fat, gST(eM)^Fat)

*Controlling Live Load (w/ Sidewalks) D.F. = Max(gDT(eM) P, gST(eM) P)

Chapter 7 Output Description

COMPUTED DISTRIBUTION FACTORS - EXTERIOR SHEAR (LANES/BEAM)

NEXT BEAM DOUBLE-TEE MODEL

=====

Design Live Load Shear

	D.Factor Exterior Shear 2+ Lanes	D.Factor Exterior Lever Rule 1 Lane	D.Factor Exterior Lever Rule 2+ Lanes	Controla D.Factor Exterior Shear (Nb/=3)
Span No.	gDT(eV)^2+	gDT(eLR)^1	gDT(eLR)^2	gDT(eV)
ii DF1	x.xxxxx	x.xxxxx	x.xxxxx	x.xxxxx
ii DF2	x.xxxxx	x.xxxxx	x.xxxxx	x.xxxxx

	Variables		Range of Applicability	
aa =	x.xxxx	aaaa	xx.xxxx	<= aa <= xx.xxx ; aa

*Controlling D.F. = Max(gDT(eLR)^1, gDT(eV)^2+)

Skew Correction

Support No.	Shear Factor	Applies
ii	x.xxxxxx	aaa
ii	x.xxxxxx	aaa

	Variables (DF1)		Range of Applicability	
aa =	x.xxxx	aaaa	xx.xxxx	<= aa <= xx.xxx ; aa

	Variables (DF2)		Range of Applicability	
aa =	x.xxxx	aaaa	xx.xxxx	<= aa <= xx.xxx ; aa

Fatigue Load Shear

	Controla D.Factor Fatigue Shear
Span No.	gDT(eV)^Fat
ii DF1	x.xxxxx
ii DF2	x.xxxxx

*Controlling D.F. = gDT(eLR)^1 / 1.2

Chapter 7 Output Description

```

Design Live Load Shear (w/ Sidewalks)
-----
          D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Exterior      Exterior      Exterior      Exterior
          Shear        Lever Rule    Lever Rule    Shear
          2+ Lanes      1 Lane      2+ Lanes      (Nb/=3)
Span No.  gDT (eV) ^2+P  gDT (eLR) ^1P  gDT (eLR) ^2P  gDT (eV) P
ii DF1    x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx
ii DF2    x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx

          Variables                      Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=  xx.xxx      ; aa

*Controlling D.F. = Max(gDT (eLR) ^1P, gDT (eV) ^2+P)

NEXT BEAM SINGLE-TEE MODEL
=====

Design Live Load Shear
-----
          D.Factor      D.Factor      D.Factor      D.Factor      D.Factor      Controla
          Exterior      Exterior      Interior      Interior      Exterior
          Shear        Lever Rule    Shear        Shear        Shear
          2+ Lanes      1 Lane      1 Lane      2+ Lanes
Span No.  gST (eV) ^2+  gST (eLR) ^1  gST (iV) ^1  gST (iV) ^2+  gST (eV)
ii DF1    x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx
ii DF2    x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx      x.xxxxx

          Variables                      Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=  xx.xxx      ; aa

*Controlling D.F. = Max( 2 * gST (eLR) ^1,
                        2 * gST (eV) ^2+,
                        gST (eLR) ^1 + gST (iV) ^1,
                        gST (eV) ^2+ + gST (iV) ^2+ )

Skew Correction
-----
Support No.      Exterior      Interior      Applies
ii               x.xxxxxxx      x.xxxxxxx      aaa
ii               x.xxxxxxx      x.xxxxxxx      aaa

          Variables (DF1)                Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=  xx.xxx      ; aa

          Variables (DF2)                Range of Applicability
aa =      x.xxxx      aaaa      xx.xxxx      <= aa <=  xx.xxx      ; aa

```

Chapter 7 Output Description

```

                                Fatigue Load Shear
                                -----
                                Controla
                                D.Factor
                                Fatigue
                                Shear
Span No.      gST(eV)^Fat
  ii DF1      x.xxxxxx
  ii DF2      x.xxxxxx

*Controlling D.F. = Max( 2 * gST(eLR)^1, gST(eLR)^1 + gST(iV)^1) / 1.2

                                Design Live Load Shear (w/ Sidewalks)
                                -----

                                Controla
                                D.Factor
                                Exterior
                                Shear
Span      2+ Lanes
No.      gST(eV)^2+P
ii DF1   x.xxxxxx
ii DF2   x.xxxxxx

                                D.Factor
                                Exterior
                                Lever Rule
                                1 Lane
                                gST(eLR)^1P
                                x.xxxxxx

                                D.Factor
                                Interior
                                Shear
                                1 Lane
                                gST(iV)^1P
                                x.xxxxxx

                                D.Factor
                                Interior
                                Shear
                                2+ Lanes
                                gST(iV)^2+P
                                x.xxxxxx

                                D.Factor
                                Exterior
                                Shear
                                gST(eV) P
                                x.xxxxxx

                                Variables
                                Range of Applicability
aa =   x.xxxx   aaaa   xx.xxxx   <= aa <=   xx.xxx   ;   aa

*Controlling D.F. = Max( 2 * gST(eLR)^1P,
                        2 * gST(eV)^2+P,
                        gST(eLR)^1P + gST(iV)^1P,
                        gST(eV)^2+P + gST(iV)^2+P )

CONTROLLING EXTERIOR SHEAR DISTRIBUTION FACTOR
=====

                                Design Live Load Shear
                                -----
                                Control*
                                D.Factor
                                Live Load
                                Shear
                                g(eV)
Span No.      x.xxxxxx
  ii DF1      x.xxxxxx
  ii DF2      x.xxxxxx

                                Fatigue Load Shear
                                -----
                                Control*
                                D.Factor
                                Fatigue
                                Shear
                                g(eV)^Fat
                                x.xxxxxx
                                x.xxxxxx

                                Design Live Load Shear (w/Sidewalks)
                                -----

                                Controla
                                D.Factor
                                Live Load
                                Shear
                                g(eV) P
Span No.      x.xxxxxx
  ii DF1      x.xxxxxx
  ii DF2      x.xxxxxx

*Controlling Live Load D.F. = Max(gDT(eV), gST(eV))
*Controlling Fatigue D.F. = Max(gDT(eV)^Fat, gST(eV)^Fat)

*Controlling Live Load (w/ Sidewalks) D.F. = Max(gDT(eV) P, gST(eV) P)

```

Chapter 7 Output Description

```

COMPUTED DISTRIBUTION FACTORS-DESIGN LIVE LOAD(LANE FRACTION, INCL. SKEW)
-----
COMPUTED DISTRIBUTION FACTORS-FATIGUE LOAD(LANE FRACTION, INCL. SKEW)
-----
COMPUTED DISTRIBUTION FACTORS WITH SIDEWALKS (LANE FRACTION, INCL. SKEW)
-----
COMPUTED DISTRIBUTION FACTORS-P-82C LOAD(MULTI-LANE, LANE FRACTION, INCL. SKEW)
-----
COMPUTED DISTRIBUTION FACTORS-P-82C LOAD(SINGLE LANE, LANE FRACTION, INCL. SKEW)
-----
USER INPUT DISTRIBUTION FACTORS-DESIGN LIVE LOAD(LANE FRACTION, INCL. SKEW)
-----
USER INPUT DISTRIBUTION FACTORS-FATIGUE LOAD(LANE FRACTION, INCL. SKEW)
-----
USER INPUT DISTRIBUTION FACTORS WITH SIDEWALKS (LANE FRACTION, INCL. SKEW)
-----
USER INPUT DISTRIBUTION FACTORS-P-82C LOAD(MULTI-LANE, LANE FRACTION, INCL. SKEW)
-----
USER INPUT DISTRIBUTION FACTORS-P-82C LOAD(SINGLE LANE, LANE FRACTION, INCL. SKEW)
-----

```

Span No.	Moment		Shear		Deflection
	DF1	DF2	DF1	DF2	
ii	xx.xxx(a)aa	xx.xxx(a)aa	xx.xxx(i)aa	xx.xxx(i)aa	xxx.xxx
**	aaaaaaaaa	aaaaaaaaa	aaaaaaaaa	aaaaaaaaa	

LR - Distribution Factor computed by Lever Rule

EQ - Distribution Factor computed by equations, S = Single Lane, M = Multiple Lanes

EQ - Distribution Factor computed by single-lane equations divided by 1.2

EQ - Distribution Factor computed by multiple-lane equations

NOTE: The value in parentheses is the number of lanes loaded to produce the maximum live load distribution factor.

The # symbol indicates the moment distribution factor is based On the number of design lanes, i, specified on the GEO Command.

NOTE: The DISTRIBUTION FACTORS-P-82C LOAD (MULTI-LANE) are used as the "g" value in DM-4 Equation 3.4.1-3P when computing the combined live load effects of the P-82 vehicle in one lane and the PHL-93 vehicle in all other lanes.

NOTE: The DISTRIBUTION FACTORS-P-82C LOAD (SINGLE LANE) are used as the "g1/2" value in DM-4 Equation 3.4.1-3P when computing the combined live load effects of the P-82 vehicle in one lane and the PHL-93 vehicle in all other lanes. The values printed here do NOT include any multiple presence factors.

```

COMPUTED DISTRIBUTION FACTORS FOR REACTIONS AND ROTATIONS
-----

```

```

USER INPUT DISTRIBUTION FACTORS FOR REACTIONS AND ROTATIONS
-----

```

Support No.	Design Live Load		Fatigue Load	
	Reaction	Rotation	Reaction	Rotation
ii	x.xxx(i)aa	x.xxx(a)aa	x.xxx aa	x.xxx aa
**	aaaaaaaaa	aaaaaaaaa	aaaaaaaaa	aaaaaaaaa

LR - Distribution Factor computed by Lever Rule

EQ - Distribution Factor computed by equations, S = Single Lane, M = Multiple Lanes

NOTE: The value in parentheses is the number of lanes loaded to produce the maximum live load distribution factor.

The # symbol indicates the rotation distribution factor is based On the number of design lanes, i, specified on the GEO Command.

Chapter 7 Output Description

```
COMPUTED DISTRIBUTION FACTORS FOR REACTIONS AND ROTATIONS WITH SIDEWALKS
-----
USER INPUT DISTRIBUTION FACTORS FOR REACTIONS AND ROTATIONS WITH SIDEWALKS
-----
```

```
Support
No.      Reaction      Rotation
ii       x.xxx(i)aa    x.xxx(a)aa
**       aaaaaaaaaa    aaaaaaaaaa
```

LR - Distribution Factor computed by Lever Rule

EQ - Distribution Factor computed by multiple-lane equations

NOTE: The value in parentheses is the number of lanes loaded to produce the maximum live load distribution factor.

The Multiple Presence Factor is based on the number of lanes loaded plus one more to account for the pedestrian loads.

The # symbol indicates the rotation distribution factor is based on the number of design lanes, i, specified on the GEO Command.

** - Range of Applicability Warning Messages for following:

S, Spacing of beams
L, Span Length of beam
d, Depth of beam
Nb, Number of beams
de, Curb to Ext. Web of Ext. Girder distance
b, Width of beam
J, St. Venant torsional constant
I, Moment of inertia
ts, Slab thickness
Kg, Longitudinal stiffness parameter
Sk, Skew angle

7.8.7 Points of Contraflexure

POINTS OF CONTRAFLEXURE

```
-----
Dead Load
Points of
Contraflexure
Span
No.    Dist.
      (ft)
ii xxxx.xxx
```

7.8.8 Loads and Load Modifiers

LOAD MODIFIER

```
-----
Importance  Ductility  Redundancy
Factor      Factor      Factor      Calculated      Used
Ni          Nd          Nr          Ni*Nd*Nr        Load
xx.xx      xx.xx      xx.xx      xx.xxx          Modifier
xx.xx      xx.xx      xx.xx      xx.xxx          xx.xxx
```

WARNING - As per PennDOT DM-4 Sections 1.3.2 through 1.3.5,
ETA factors other than 1.0 are not permitted by PennDOT.

Chapter 7 Output Description

RESISTANCE FACTORS

Tension-Controlled Reinforced Concrete Sections	x.xxx
Tension-Controlled Prestressed Concrete Sections	x.xxx
Compression-Controlled Sections	x.xxx
Shear, phi(V)	x.xxx

For sections with net tensile strain in the transition between the compression-controlled strain limits and the tension-controlled strain limits given below, the phi value is obtained by linear interpolation of the phi value for tension-controlled sections and the phi value for compression-controlled sections.

	Tension-Controlled Strain Limit (in/in)*1000	Compression-Controlled Strain Limit (in/in)*1000
Prestress	x.xxx	x.xxx
Slab Reinf.	x.xxx	x.xxx
Beam Reinf. Fy= xx.ksi	x.xxx	x.xxx

LOAD FACTORS AND COMBINATIONS

Limit State	STR I	STR IP	STR IA	STR II	SRV I	SRV IP	SRV III	SRV IIIP	SRV IIIA	SRV IIIB	FAT I	DEFL
gamma												
gDC Max	1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00	--	1.00
Min	0.90	0.90	0.90	0.90	1.00	1.00	1.00	1.00	1.00	1.00	--	1.00
gDW Max	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00	1.00	1.00	--	1.00
Min	0.65	0.65	0.65	0.65	1.00	1.00	1.00	1.00	1.00	1.00	--	1.00
gSWK Max	--	1.25	--	--	--	1.00	--	1.00	--	--	--	1.00
Min	--	0.90	--	--	--	1.00	--	1.00	--	--	--	1.00
gAWS Max	--	1.50	--	--	--	1.00	--	1.00	--	--	--	1.00
Min	--	0.65	--	--	--	1.00	--	1.00	--	--	--	1.00
gMC1 Max	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Min	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
gMC2 Max	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Min	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
gCRSH	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.00	0.00	--	0.00
gLL	1.75	1.35	1.35	--	1.00	0.80	0.80	0.80	1.00	1.00	--	1.00
gPermit	--	--	--	1.35	--	--	--	--	1.00	1.00	--	--
gRate	1.75	1.35	--	1.35	1.00	0.80	1.00	1.00	1.00	1.00	--	--
gPL	--	1.75	--	--	--	1.00	--	1.00	--	--	--	--
gFAT	--	--	--	--	--	--	--	--	--	--	x.xx	--
gSLL1	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL2	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL3	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL4	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL5	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL6	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL7	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--
gSLL8	x.xx	x.xx	--	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx	--	--

NOTE: "gDC" applies to GIR, SLAB, ID, ED, DC1, DC2, CW1, and CW2
 "gCRSH" applies to CRP and SHR
 "gDW" applies to FWS, UT1, and UT2

Chapter 7 Output Description

LIVE LOADING SUMMARY (aaaaaaaa, Live Load Code: a)

```

Live
Load          STR  STR  STR  STR  L i m i t  S t a t e s
Vehicles      I    IP   IA   II   I    IP   III  IIIP  IIIA  IIIB  FAT  DEFL
              I    IP   IA   II   I    IP   III  IIIP  IIIA  IIIB  I    DEFL

Analysis and Rating Vehicles
aaaaaa      aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa
aa          aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa

Permit and Rating Vehicles
aaaaaa      aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa
aa          aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa

Rating Only Vehicles
aaaaaa      aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa
aa          aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa  aa

Fatigue
HS20-30      --  --  --  --  --  --  --  --  --  --  SC  --

Deflection
aaaaaa      --  --  --  --  --  --  --  --  --  --  --  SC

```

Note: Rating Applicability: I = Inventory, O = Operating
 SC = Specification Check Only, No Rating

CONCENTRATED LOADS

```

U,C
or
M*   Span      Location  Magnit.  Description
      (ft)      (kips)
a     ii  aaaa.aaa  aaa.aaa  aaaaaaaaaaaaaaaaaaaaaa
* U-User input, C-Computed by program, M-Modified by program as
  documented in User Manual Section 3.6.1.1

```

DISTRIBUTED LOADS

```

U,C          Start          End
or Start Span      Start End      Span      End
M* Span Location Magnit. Span Location Magnit. Description
      (ft) (kip/ft) (ft) (kip/ft)
a     ii xxxx.xxx  xxx.xxx ii xxxx.xxx xxxx.xxx aaaaaaaaaaaaaaaaaaaaaa
* U-User input, C-Computed by program, M-Modified by program as
  documented in User Manual Section 3.6.1.1

```

CREEP AND SHRINKAGE LOADS

```

Span      Location  Magnit.  Type  Description
      (ft)      (kips or k-ft)
ii  xxxx.xxx  xxxx.xx  aaaaaaa aaaaaaaaaaaaaaaaaaaaaa

```

7.8.9 Dead Load Noncomposite Forces and Moments

GIRDER WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```

Span No.      Distance      Moment      Shear      Deflection
              (ft)      (k-ft)      (kips)      (in)
ii  xxxx.xxx  xxxxxxxxx.x xxxxxxxxx.xx xxxxxxxx.xxx

```

Chapter 7 Output Description

GIRDER WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```
-----
Support
  No.      Reaction      Rotation
          (kips)      (radians)
ii a  xxxxx.xx      xx.xxxxxx
```

SLAB AND HAUNCH WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```
-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)      (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x      xxxxxxxxx.xx      xxxxxx.xxx
```

SLAB AND HAUNCH WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```
-----
Support
  No.      Reaction      Rotation
          (kips)      (radians)
ii a  xxxxx.xx      xx.xxxxxx
```

INTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```
-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)      (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x      xxxxxxxxx.xx      xxxxxx.xxx
```

INTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```
-----
Support
  No.      Reaction      Rotation
          (kips)      (radians)
ii a  xxxxx.xx      xx.xxxxxx
```

EXTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```
-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)      (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x      xxxxxxxxx.xx      xxxxxx.xxx
```

EXTERIOR DIAPHRAGM WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```
-----
Support
  No.      Reaction      Rotation
          (kips)      (radians)
ii a  xxxxx.xx      xx.xxxxxx
```

ADDITIONAL DC1 WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```
-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)      (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x      xxxxxxxxx.xx      xxxxxx.xxx
```

Chapter 7 Output Description

----- ADDITIONAL DC1 WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```

Support
  No.      Reaction      Rotation
          (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx

```

MISC. NONCOMP. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```

-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)        (k-ft)        (kips)        (in)
ii      xxxx.xxx      xxxxxxxxx.x  xxxxxxxxx.xx  xxxxxx.xxx

```

MISC. NONCOMP. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```

Support
  No.      Reaction      Rotation
          (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx

```

NON-COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```

-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)        (k-ft)        (kips)        (in)
ii      xxxx.xxx      xxxxxxxxx.x  xxxxxxxxx.xx  xxxxxx.xxx

```

NON-COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```

Support
  No.      Reaction      Rotation
          (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx

```

NON-COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM)

```

-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)        (k-ft)        (kips)        (in)
ii      xxxx.xxx      xxxxxxxxx.x  xxxxxxxxx.xx  xxxxxx.xxx

```

NON-COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```

Support
  No.      Reaction      Rotation
          (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx

```

7.8.10 Total Noncomposite Dead Load Forces and Moments

TOTAL NON-COMPOSITE LOAD ANALYSIS (UNFACTORED, BASIC BEAM)

```

-----
Span No.      Distance      Moment      Shear      Deflection
          (ft)        (k-ft)        (kips)        (in)
ii      xxxx.xxx      xxxxxxxxx.x  xxxxxxxxx.xx  xxxxxx.xxx

```


Chapter 7 Output Description

TOTAL NON-COMPOSITE LOAD ANALYSIS (UNFACTORED, BASIC BEAM) - REACTIONS

```
-----
Support
  No.      Reaction      Rotation
           (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx
```

7.8.11 Dead Load Composite Forces and Moments

DC2 WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)

```
-----
Span No.    Distance      Moment      Shear      Deflection
           (ft)        (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx
```

DC2 WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS

```
-----
Support      Simple      Continuous
  No.      Reaction      Rotation      Reaction      Rotation
           (kips)        (radians)      (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx      xxxx.xx      xx.xxxxxx
```

FUTURE WEARING SURF WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)

```
-----
Span No.    Distance      Moment      Shear      Deflection
           (ft)        (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx
```

FUTURE WEARING SURF WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS

```
-----
Support      Simple      Continuous
  No.      Reaction      Rotation      Reaction      Rotation
           (kips)        (radians)      (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx      xxxx.xx      xx.xxxxxx
```

MISC. COMPOSITE WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)

```
-----
Span No.    Distance      Moment      Shear      Deflection
           (ft)        (k-ft)      (kips)      (in)
ii      xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx
```

MISC. COMPOSITE WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) - REACTIONS

```
-----
Support      Simple      Continuous
  No.      Reaction      Rotation      Reaction      Rotation
           (kips)        (radians)      (kips)        (radians)
ii a  xxxxx.xx      xx.xxxxxx      xxxx.xx      xx.xxxxxx
```

Chapter 7 Output Description

```

COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)
-----
Span No.      Distance      Moment      Shear      Deflection
              (ft)          (k-ft)      (kips)      (in)
ii           xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx

```

```

COMP. COUNTER-WT. WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) -REACTIONS
-----
Support      Simple      Continuous
No.          Reaction  Rotation    Reaction    Rotation
              (kips)      (radians)    (kips)      (radians)
ii a         xxxxx.xx      xx.xxxxxxx  xxxx.xx     xx.xxxxxxx

```

```

COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)
-----
Span No.      Distance      Moment      Shear      Deflection
              (ft)          (k-ft)      (kips)      (in)
ii           xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx

```

```

COMP. UTILITY LOAD WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) -REACTIONS
-----
Support      Simple      Continuous
No.          Reaction  Rotation    Reaction    Rotation
              (kips)      (radians)    (kips)      (radians)
ii a         xxxxx.xx      xx.xxxxxxx  xxxx.xx     xx.xxxxxxx

```

```

SIDEWALK WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)
-----
Span No.      Distance      Moment      Shear      Deflection
              (ft)          (k-ft)      (kips)      (in)
ii           xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx

```

```

SIDEWALK WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) -REACTIONS
-----
Support      Simple      Continuous
No.          Reaction  Rotation    Reaction    Rotation
              (kips)      (radians)    (kips)      (radians)
ii a         xxxxx.xx      xx.xxxxxxx  xxxx.xx     xx.xxxxxxx

```

```

ADDITIONAL FWS WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM)
-----
Span No.      Distance      Moment      Shear      Deflection
              (ft)          (k-ft)      (kips)      (in)
ii           xxxx.xxx      xxxxxxxxx.x xxxxxxxxx.xx xxxxxxx.xxx

```

```

ADDITIONAL FWS WEIGHT ANALYSIS (UNFACTORED, COMPOSITE BEAM) -REACTIONS
-----
Support      Simple      Continuous
No.          Reaction  Rotation    Reaction    Rotation
              (kips)      (radians)    (kips)      (radians)
ii a         xxxxx.xx      xx.xxxxxxx  xxxx.xx     xx.xxxxxxx

```

Chapter 7 Output Description

7.8.12 Total Composite Dead Load Forces and Moments

```
TOTAL COMPOSITE LOAD ANALYSIS (UNFACTORED, COMPOSITE BEAM)
-----
TOTAL COMPOSITE LOAD ANALYSIS W/SW (UNFACTORED, COMPOSITE BEAM)
-----
TOTAL COMPOSITE LOAD ANALYSIS W/O SW (UNFACTORED, COMPOSITE BEAM)
-----
Span No.      Distance      Moment      Shear      Deflection
              (ft)          (k-ft)      (kips)      (in)
ii           xxxx.xxx      xxxxxxxx.x  xxxxxxxx.xx  xxxxxx.xxx

TOTAL COMPOSITE LOAD ANALYSIS (UNFACTORED, COMPOSITE BEAM)-REACTIONS
-----
TOTAL COMPOSITE LOAD ANALYSIS W/SW (UNFACTORED, COMPOSITE BEAM)-REACTIONS
-----
TOTAL COMPOSITE LOAD ANALYSIS W/O SW (UNFACTORED, COMPOSITE BEAM)-REACTIONS
-----
Support      Simple      Continuous
No.          Reaction   Rotation   Reaction   Rotation
              (kips)     (radians)  (kips)     (radians)
ii a        xxxxx.xx   xx.xxxxxx  xxxx.xx    xx.xxxxxx
```

Chapter 7 Output Description

7.8.13 Dead Load Creep and Shrinkage Moments

 CREEP AND SHRINKAGE MOMENTS BASED ON 30 DAYS

 CREEP AND SHRINKAGE MOMENTS BASED ON 450 DAYS

Span No.	Distance (ft)	Creep Restraint Moment (k-ft)	Final Shrinkage Moment (k-ft)	M(c&s) (k-ft)
ii	xxxx.xxx	xxxxxxx.x	xxxxxxx.xa	xxxxxxx.xa

* <WARNING>

The analysis results indicate a non-zero moment at the simply supported end of the continuous beam. This effect, resulting from the assumed shrinkage moment analysis, can be neglected up to the transfer distance (xx.x (ft) from the centerline of bearing at the simple end).

7.8.14 Live Load Effects

 PHL-93 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)

 PHL-93 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)

 PHL-93 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)

Span No.	Dist. (ft)	Maximum Moments		Maximum Shears		Maximum Deflection
		Positive L (k-ft)	Negative L (k-ft)	Positive L (kips)	Negative L (kips)	(in)
ii	xxxx.xxx	xxxxxxx.x	iaxxxxxxx.x	iaxxxxxxx.xx	iaxxxxxxx.xx	iaxxxx.xxx

 PHL-93 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)

 PHL-93 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)

 PHL-93 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)

 PHL-93 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)

 PHL-93 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)

Support No.	Maximum L Reaction C (kips)	Minimum L Reaction C (kips)	Maximum L Rotation C (radians)	Minimum L Rotation C (radians)
ii a	xxxxx.xx aa	xxxxx.xx aa	xx.xxxxxx aa	xx.xxxxxx aa

PHL93 Loading Codes:

- 1 - Tandem + Lane Governs
- 2 - Truck + Lane Governs
- 3 - Tandem Pair + Lane Governs
- 4 - Truck Pair + Lane Governs
- 5 - Truck Alone Governs
- 6 - 25% Truck + Lane Governs
- 7 - 90% (Truck Pair + Lane Governs)

Chapter 7 Output Description

```

      PHL-93 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support  Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
No.      Truck     Truck     Lane      Lane      Total     Total
        (kips)    (kips)    (kips)    (kips)    (radians) (radians)
ii a xxxxxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

```

      HL-93 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
      HL-93 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)
-----
      HL-93 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----

```

```

Span      Maximum Moments           Maximum Shears           Maximum
No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
      (ft)     (k-ft) C     (k-ft) C     (kips) C     (kips) C     (in)
ii xxxx.xxx xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

```

```

      HL-93 LL ANALYSIS (REACTIONS INCLUDING IMPACT DIST FACTORS)
-----
      HL-93 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT DIST FACTORS)
-----
      HL-93 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT DIST FACTORS)
-----
      HL-93 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
      HL-93 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support  Maximum L   Minimum L   Maximum L   Minimum L
No.      Reaction C  Reaction C  Rotation C  Rotation C
        (kips)      (kips)      (radians)  (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

HL93 Loading Codes:

- 1 - Tandem + Lane Governs
- 2 - Truck + Lane Governs
- 3 - 90% Tandem Pair + Lane Governs
- 4 - 90% Truck Pair + Lane Governs
- 5 - Truck Alone Governs
- 6 - 25% Truck + Lane Governs

```

      HL-93 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support  Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
No.      Truck     Truck     Lane      Lane      Total     Total
        (kips)    (kips)    (kips)    (kips)    (radians) (radians)
ii a xxxxxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

Chapter 7 Output Description

```

P-82 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
P-82C LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
(P-82 in one lane with PHL-93 in other lanes)
-----
P-82 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
(SINGLE LANE DISTRIBUTION FACTOR)
-----
P-82 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
P-82C LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
(P-82 in one lane with PHL-93 in other lanes)
-----
P-82 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
(SINGLE LANE DISTRIBUTION FACTOR)
-----
P2016-13 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
P2016-13C LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
(P2016-13 in one lane with PHL-93 in other lanes)
-----
P2016-13 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
(SINGLE LANE DISTRIBUTION FACTOR)
-----
P2016-13 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
P2016-13C LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
(P2016-13 in one lane with PHL-93 in other lanes)
-----
P2016-13 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
(SINGLE LANE DISTRIBUTION FACTOR)
-----
Span      Maximum Moments      Maximum Shears      Maximum
No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
      (ft)     (k-ft) C    (k-ft) C    (kips) C    (kips) C    (in)
ii xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

P-82 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
P-82 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
P-82 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
P2016-13 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
P2016-13 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
P2016-13 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support   Maximum L   Minimum L   Maximum L   Minimum L
No.       Reaction C  Reaction C  Rotation C  Rotation C
          (kips)   (kips)      (radians)   (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

Chapter 7 Output Description

P-82 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)

P2016-13 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)

Support No.	Maximum Truck (kips)	Minimum Truck (kips)	Maximum Lane (kips)	Minimum Lane (kips)	Maximum Total (radians)	Minimum Total (radians)
ii a	xxxxxx.xx aa	xxx.xx aa	xxx.xx aa	xxx.xx aa	xx.xxxxxx aa	xx.xxxxxx aa

ML-80 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)

ML-80 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)

ML-80 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)

Span No.	Dist. (ft)	Maximum Moments				Maximum Shears				Maximum Deflection (in)
		Positive L (k-ft)	Negative L (k-ft)	Positive L (kips)	Negative L (kips)	Positive L (kips)	Negative L (kips)	Positive L (kips)	Negative L (kips)	
ii	xxxx.xxx	xxxxxxx.x a	xxxxxxx.x a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	

ML-80 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)

ML-80 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)

ML-80 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)

ML-80 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)

ML-80 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)

Support No.	Maximum Reaction (kips)	Minimum Reaction (kips)	Maximum Rotation (radians)	Minimum Rotation (radians)
ii a	xxxxx.xx aa	xxxxx.xx aa	xx.xxxxxx aa	xx.xxxxxx aa

ML-80 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)

Support No.	Maximum Truck (kips)	Minimum Truck (kips)	Maximum Lane (kips)	Minimum Lane (kips)	Maximum Total (radians)	Minimum Total (radians)
ii a	xxxxxx.xx aa	xxx.xx aa	xxx.xx aa	xxx.xx aa	xx.xxxxxx aa	xx.xxxxxx aa

TK527 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)

TK527 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)

TK527 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)

Span No.	Dist. (ft)	Maximum Moments				Maximum Shears				Maximum Deflection (in)
		Positive L (k-ft)	Negative L (k-ft)	Positive L (kips)	Negative L (kips)	Positive L (kips)	Negative L (kips)	Positive L (kips)	Negative L (kips)	
ii	xxxx.xxx	xxxxxxx.x a	xxxxxxx.x a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	xxxxxx.xx a	

Chapter 7 Output Description

```

TK527 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
TK527 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
TK527 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
TK527 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
TK527 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support      Maximum L   Minimum L   Maximum L   Minimum L
  No.         Reaction C   Reaction C   Rotation C   Rotation C
              (kips)      (kips)      (radians)    (radians)
ii a         xxxxx.xx aa  xxxxx.xx aa  xx.xxxxxx aa  xx.xxxxxx aa

TK527 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support      Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
  No.        Truck    Truck    Lane     Lane     Total     Total
              (kips)    (kips)   (kips)    (kips)    (radians) (radians)
ii a         xxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

EV2 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
EV2 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)
-----
EV2 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
Span          Maximum Moments          Maximum Shears          Maximum
  No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
              (ft)      (k-ft) C    (k-ft) C    (kips) C    (kips) C    (in)
ii xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

EV2 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
EV2 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
EV2 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
EV2 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
EV2 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support      Maximum L   Minimum L   Maximum L   Minimum L
  No.         Reaction C   Reaction C   Rotation C   Rotation C
              (kips)      (kips)      (radians)    (radians)
ii a         xxxxx.xx aa  xxxxx.xx aa  xx.xxxxxx aa  xx.xxxxxx aa

EV2 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support      Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
  No.        Truck    Truck    Lane     Lane     Total     Total
              (kips)    (kips)   (kips)    (kips)    (radians) (radians)
ii a         xxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```


Chapter 7 Output Description

EV3 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)

EV3 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)

EV3 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)

Span No.	Dist. (ft)	Maximum Moments				Maximum Shears				Maximum Deflection (in)
		Positive L (k-ft)	Negative L (k-ft)	Positive L (kips)	Negative L (kips)					
ii	xxxx.xxx	xxxxxxx.x	a xxxxxx.x	a xxxxxx.xx	a xxxxxx.xx	a xxxxxx.xx	a xxxxxx.xxx			

EV3 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)

EV3 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)

EV3 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)

EV3 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)

EV3 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)

Support No.	Maximum L		Minimum L		Maximum L		Minimum L	
	Reaction C (kips)	Rotation C (radians)	Reaction C (kips)	Rotation C (radians)	Reaction C (kips)	Rotation C (radians)	Reaction C (kips)	Rotation C (radians)
ii	a	xxxxx.xx	aa	xxxxx.xx	aa	xx.xxxxxx	aa	xx.xxxxxx

EV3 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)

Support No.	Maximum		Minimum		Maximum		Minimum	
	Truck (kips)	Truck (kips)	Lane (kips)	Lane (kips)	Total (radians)	Total (radians)	Total (radians)	Total (radians)
ii	a	xxx.xx	aa	xxx.xx	aa	xxx.xx	aa	xx.xxxxxx

SU6TV LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)

SU6TV LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)

SU6TV LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)

Span No.	Dist. (ft)	Maximum Moments				Maximum Shears				Maximum Deflection (in)
		Positive L (k-ft)	Negative L (k-ft)	Positive L (kips)	Negative L (kips)					
ii	xxxx.xxx	xxxxxxx.x	a xxxxxx.x	a xxxxxx.xx	a xxxxxx.xx	a xxxxxx.xx	a xxxxxx.xxx			

Chapter 7 Output Description

```

SU6TV LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
SU6TV LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
SU6TV LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
SU6TV LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
SU6TV LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support      Maximum L   Minimum L   Maximum L   Minimum L
  No.         Reaction C   Reaction C   Rotation C   Rotation C
              (kips)       (kips)       (radians)    (radians)
ii a         xxxxx.xx aa  xxxxx.xx aa  xx.xxxxxx aa  xx.xxxxxx aa

SU6TV LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support      Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
  No.         Truck    Truck    Lane     Lane     Total     Total
              (kips)    (kips)   (kips)   (kips)   (radians) (radians)
ii a         xxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

SLL #i LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
SLL #i LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)
-----
SLL #i LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
Span          Maximum Moments          Maximum Shears          Maximum
  No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
              (ft)      (k-ft) C    (k-ft) C    (kips)  C    (kips)  C    (in)
ii xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

SLL #i LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
SLL #i LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
SLL #i LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
SLL #i LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
SLL #i LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support      Maximum L   Minimum L   Maximum L   Minimum L
  No.         Reaction C   Reaction C   Rotation C   Rotation C
              (kips)       (kips)       (radians)    (radians)
ii a         xxxxx.xx aa  xxxxx.xx aa  xx.xxxxxx aa  xx.xxxxxx aa

SLL #i LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support      Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
  No.         Truck    Truck    Lane     Lane     Total     Total
              (kips)    (kips)   (kips)   (kips)   (radians) (radians)
ii a xxxxxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

Chapter 7 Output Description

```

PEDESTRIAN LIVE LOAD ANALYSIS (UNFACTORED)
-----
Span      Maximum Moments          Maximum Shears          Maximum
No.   Dist.   Positive   Negative   Positive   Negative   Deflection
      (ft)     (k-ft)    (k-ft)    (kips)    (kips)    (in)
ii  xxxx.xxx  xxxxxxx.x  xxxxxxx.x  xxxxxx.xx  xxxxxx.xx  xxxxx.xxx

```

```

PEDESTRIAN LIVE LOAD ANALYSIS (REACTIONS)
-----
Support   Maximum L   Minimum L   Maximum L   Minimum L
No.        Reaction C Reaction C   Rotation C   Rotation C
          (kips)   (kips)      (radians)   (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

7.8.15 HS20 Effects and Reactions

```

HS20 LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
HS20 LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)
-----
HS20 LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
Span      Maximum Moments          Maximum Shears          Maximum
No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
      (ft)     (k-ft) C    (k-ft) C    (kips) C    (kips) C    (in)
ii  xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

```

```

HS20 LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
HS20 LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
HS20 LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
HS20 LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
HS20 LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support   Maximum L   Minimum L   Maximum L   Minimum L
No.        Reaction C Reaction C   Rotation C   Rotation C
          (kips)   (kips)      (radians)   (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

```

HS20 LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support   Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
No.        Truck    Truck     Lane      Lane      Total     Total
          (kips)   (kips)   (kips)    (kips)    (radians) (radians)
ii a  xxxxxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

Chapter 7 Output Description

7.8.16 H2O Effects and Reactions

```

H2O LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
H2O LIVE LOAD ANALYSIS (W/ SW, UNFACTORED, INCLUDING IMPACT)
-----
H2O LIVE LOAD ANALYSIS (W/O SW, UNFACTORED, INCLUDING IMPACT)
-----
Span      Maximum Moments      Maximum Shears      Maximum
No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
      (ft)     (k-ft) C    (k-ft) C    (kips) C    (kips) C    (in)
xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

H2O LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
H2O LL ANALYSIS (REACTIONS W/ SW INCLUDING IMPACT,DIST FACTORS)
-----
H2O LL ANALYSIS (REACTIONS W/O SW INCLUDING IMPACT,DIST FACTORS)
-----
H2O LL ANALYSIS (REACTIONS W/ SW W/O IMPACT, W/ DIST FACTORS)
-----
H2O LL ANALYSIS (REACTIONS W/O SW W/O IMPACT, W/ DIST FACTORS)
-----
Support   Maximum L   Minimum L   Maximum L   Minimum L
No.        Reaction C Reaction C Rotation C Rotation C
          (kips) (kips) (radians) (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

H2O LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)
-----
Support   Maximum   Minimum   Maximum   Minimum   Maximum   Minimum
No.        Truck    Truck    Lane     Lane     Total     Total
          (kips) (kips) (kips) (kips) (radians) (radians)
ii a xxxxxx.xx aa xxx.xx aa xxx.xx aa xxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

7.8.17 Fatigue Effects and Reactions

```

FATIGUE LIVE LOAD ANALYSIS (UNFACTORED, INCLUDING IMPACT)
-----
Span      Maximum Moments      Maximum Shears      Maximum
No.   Dist.   Positive L   Negative L   Positive L   Negative L   Deflection
      (ft)     (k-ft) C    (k-ft) C    (kips) C    (kips) C    (in)
ii xxxx.xxx  xxxxxxx.x a xxxxxxx.x a xxxxxx.xx a xxxxxx.xx a xxxxx.xxx

FATIGUE LL ANALYSIS (REACTIONS INCLUDING IMPACT,DIST FACTORS)
-----
Support   Maximum L   Minimum L   Maximum L   Minimum L
No.        Reaction C Reaction C Rotation C Rotation C
          (kips) (kips) (radians) (radians)
ii a      xxxxxx.xx aa xxxxxx.xx aa xx.xxxxxx aa xx.xxxxxx aa

```

Chapter 7 Output Description

FATIGUE LL ANALYSIS (REACTIONS W/O IMPACT,DIST FACTORS)

Support No.	Maximum Truck (kips)	Minimum Truck (kips)	Maximum Lane (kips)	Minimum Lane (kips)	Maximum Total (radians)	Minimum Total (radians)
ii a	xxxxxx.xx	aa xxx.xx	aa xxx.xx	aa xxx.xx	aa xx.xxxxxx	aa xx.xxxxxx

7.8.18 Factored Effects

FACTORED ANALYSIS RESULTS

Span No.	Limit Dist. State (ft)	Factored Maximum Moment M(u) (k-ft)	Factored Minimum Moment M(u) (k-ft)	Factored Maximum Shear V(u) (kips)	Factored Minimum Shear V(u) (kips)
ii	xxxx.xxx	aaaaaaaa	xxxxxxxx.x	xxxxxxxx.x	xxxxxx.xx

FACTORED ANALYSIS RESULTS-REACTIONS

Support No.	L or R	Limit State	Maximum Reaction (kips)	Minimum Reaction (kips)	Maximum Rotation (radians)	Minimum Rotation (radians)	* If Uplift
ii	a	aaaaaaaa	xxxxxxx.x	xxxxxxx.x	xxxx.xxxxxx	xxxx.xxxxxx	a

* <FAILURE>

Uplift is occurring at Service I Limit State. If possible, revise span and/or skew such that no uplift occurs. If this is not possible, a counterweight must be designed for the Strength I Limit State minimum reaction to prevent uplift.

REQUIRED COUNTERWEIGHT

Support No.	Uplift Force (kips)	Req'd Counterweight Force (kips)
i a	xxxx.x	xxxx.x

Note: Uplift is occurring at the Service I Limit State as shown in the Uplift Force column. A counterweight equal to the Strength I Limit State minimum reaction, shown in the Req'd Counterweight column, must be provided to prevent uplift. To eliminate this code failure, rerun the program accounting for the counterweight. If the designed counterweight extends beyond a distance equal to the depth of the girder from the centerline of bearing, it must be entered as a distributed load using the DLD command. Otherwise, it can be entered as a concentrated load using the CLD command.

Chapter 7 Output Description

COUNTERWEIGHT CHECK				
Support No.	Uplift Force without CW Load (SER-I Min)	Counterweight Force		* If Code Failure
		Required (STR-I Min)	Provided (STR-I Min)	
i a	xxx.x	xxxx.x	xxxx.x	a

Note: Uplift is occurring at the Service I Limit State as shown in the Uplift Force column. A counterweight equal to the Strength I Limit State minimum reaction, shown in the Required Counterweight Force column, must be provided to prevent uplift. To eliminate this code failure, rerun the program with additional counterweight. If the designed counterweight extends beyond a distance equal to the depth of the girder from the centerline of bearing, it must be entered as a distributed load using the DLD command. Otherwise, it can be entered as a concentrated load using the CLD command.

7.8.19 Overall Reaction Summary

REACTIONS & ROTATIONS PER GIRDER (UNFACTORED, w/o IMPACT, w/ DISTRIBUTION)
FOR ELASTOMERIC BEARING PAD DESIGN

Support No.		Minimum L Reaction C (kips)	Maximum L Reaction C (kips)	Live Load L Rotation C (radians)
ii a	Total DC1	xxxxxx.xxa	xxxxxx.xxa	
	Total DC2	xxxxxx.xxaa	xxxxxx.xxaa	
	FWS	xxxxxx.xxaa	xxxxxx.xxaa	
	Total DL	xxxxxx.xxaa	xxxxxx.xxaa	
	LL(aaaaa)	xxxxxx.xxaaaa	xxxxxx.xxaaaa	xx.xxxxxx aaa

Note: Rotation is about an axis normal to the centerline of the beam. The rotation value given is the larger of the positive rotation and absolute value of the negative rotation due to live load.

The program does not automatically calculate any dead loads past the centerline of the simple bearing and it does not automatically calculate additional load due to the end block for box beams. Therefore, the dead load reactions at the abutments do not automatically include any loads past the centerline of bearing or for the end block for box beams. The dead load reactions at piers do not automatically include the beam extension beyond the simple bearing or the end block for box beams. To include these loads, the user must specify them using the CLD (Concentrated Load) command.

* Reactions need to be divided by 2 to design bearings for each stem.

Chapter 7 Output Description

REACTIONS & ROTATIONS PER GIRDER (UNFACTORED, w/ IMPACT, w/ DISTRIBUTION) FOR POT, STEEL OR DISC BEARING DESIGN

Support No.		Minimum L Reaction C (kips)	Maximum L Reaction C (kips)	L Rotation C (radians)
ii a	Total DC1	xxxxxx.xxa	xxxxxx.xxa	xx.xxxxxx
	Total DC2	xxxxxx.xxaa	xxxxxx.xxaa	xx.xxxxxx a
	FWS	xxxxxx.xxaa	xxxxxx.xxaa	
	Total DL	xxxxxx.xxaa	xxxxxx.xxaa	xx.xxxxxx a
	LL(aaaaa)	xxxxxx.xxaaaa	xxxxxx.xxaaaa	xx.xxxxxx aaa

Note: Rotation is about an axis normal to the centerline of the beam.

* Reactions need to be divided by 2 to design bearings for each stem.

REACTIONS (UNFACTORED) FOR ABUTMENT DESIGN

DL REACTIONS (UNFACTORED) PER GIRDER				
Support No.		Minimum L Reaction C (kips)	Maximum L Reaction C (kips)	
ii	Total DC1	xxxxxx.xx	xxxxxx.xx	a
	Total DC2	xxxxxx.xx a	xxxxxx.xx	a
	FWS	xxxxxx.xx a	xxxxxx.xx	a
	Total DL	xxxxxx.xx a	xxxxxx.xx	a
LL REACTIONS PER LANE (UNFACTORED, W/O IMPACT)				
Support No.		Minimum L Reaction C (kips)	Maximum L Reaction C (kips)	
ii	aaaaaa	xxxxxx.xx	xxxxxx.xx	aaa

Note: These values are to be used only if the end supports are abutments. Do not use these values for the pier design when the end supports are used to model simple supports at piers (i.e., expansion joints at piers).

Chapter 7 Output Description

REACTIONS (UNFACTORED) FOR PIER DESIGN

DL REACTIONS (UNFACTORED) PER GIRDER				
Support No.		Minimum Reaction C (kips)	L	Maximum Reaction C (kips)
ii a	Total DC1	xxxxxx.xx		xxxxxx.xx
	Total DC2	xxxxxx.xx	a	xxxxxx.xx a
	FWS	xxxxxx.xx	a	xxxxxx.xx a
	Total DL	xxxxxx.xx	a	xxxxxx.xx a

LL REACTIONS PER LANE (UNFACTORED, W/O IMPACT)

Support No.		Minimum Reaction				Maximum Reaction			
		Truck (kips)	LC	Lane (kips)	LC	Truck (kips)	LC	Lane (kips)	LC
ii a	aaaaaa	xxxxxx.xx	aa	xxxxxx.xx	aa	xxxxxx.xx	aa	xxxxxx.xx	aa
	P-82	xxxxxx.xx	a			xxxxxx.xx	a		
	P2016-13	xxxxxx.xx	a			xxxxxx.xx	a		
	PED			xxxxxx.xx	a			xxxxxx.xx	a
				xxxxxx.xx	a			xxxxxx.xx	a

- NOTES: (1) End supports are included for simple supports at pier.
 (2) PAPIER requires that LL reactions are entered as a single bearing point. Therefore, the Left and Right bearing reactions at interior supports must be added together.
 (3) PAPIER requires that the pedestrian load be entered as a load per area. PAPIER computes the pedestrian load reaction internally assuming simple beam distribution, which underestimates the pedestrian load for piers where the superstructure is continuous for LL. Therefore, an "adjusted" pedestrian load must be entered into PAPIER. Refer to User Manual section 3.7.18 for details.

PHL-93 Loading Codes:

- 1 - Tandem + Lane Governs
- 2 - Truck + Lane Governs
- 3 - Tandem Pair + Lane Governs
- 4 - Truck Pair + Lane Governs
- 5 - Truck Alone Governs
- 6 - 25% Truck + Lane Governs
- 7 - 90% (Truck Pair + Lane) Governs

HL-93 Loading Codes:

- 1 - Tandem + Lane Governs
- 2 - Truck + Lane Governs
- 3 - Tandem Pair + Lane Governs
- 4 - Truck Pair + Lane Governs
- 5 - Truck Alone Governs
- 6 - 25% Truck + Lane Governs

Multi-Span Analysis Codes:

- 'c' - continuous span
- 's' - simple span

Multi-Span Analysis Codes:

- 'c' - continuous span
- 's' - simple span

Chapter 7 Output Description

7.8.20 Allowable and Design Load Stresses

ALLOWABLE CONCRETE STRESSES					

Span				Allow. Conc.	Stresses at:
No.	Type of Stress	Tension or Compression	Stress Designation	C.L. Bearing (ksi)	All Other Locations (ksi)
ii	Initial Stress at Transfer of P/S	Tension	f (ti)	xxxx.xxx	xxxx.xxx
		Compression	f (ci)	xxxx.xxx	xxxx.xxx
	Final Compr. Stress Under Design DL+P/S	Compression	f (c, DP)	xxxx.xxx	xxxx.xxx
	Final Stress Under Design Loads	Tension	f (t)	xxxx.xxx	xxxx.xxx
		Compression	f (c)	xxxx.xxx	xxxx.xxx
	Final Compr. Stress Under LL+1/2 (DL+P/S)	Compression	f (c, 1/2DP)	xxxx.xxx	xxxx.xxx
	Final Compr. Stress Fatigue-I + 1/2 (DL+P/S)	Compression	f (c, 1/2DP)	xxxx.xxx	xxxx.xxx
	Final Stresses In Slab	Compression	f (cs)	xxxx.xxx	xxxx.xxx
	Final Stress with Creep & Shrinkage	Tension	f (t)	xxxx.xxx	xxxx.xxx

INITIAL STRESSES AT TRANSFER OF PRESTRESS						

		Allowable Stresses		Actual Stresses		* If Code Failure
Span		Compressive	Tensile	Top of	Bot. of	
No.	Distance	Stress	Stress	Beam	Beam	
	(ft)	f (ci)	f (ti)	f (top)	f (btm)	
		(ksi)	(ksi)	(ksi)	(ksi)	
ii	xxxx.xxxx	xxxxx.xxx	xxxx.xxx	xxxxx.xxx	xxxxx.xxx	a

NOTE:

A "<" next to a distance indicates a debonding transfer location

A "\" next to a distance indicates a debonding cutoff location

A "&" indicates both debonding cutoff and transfer location

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.

Tension Tolerance = xxx.xxxksi

Compression Tolerance = xxx.xxxksi

Chapter 7 Output Description

FINAL STRESSES UNDER DEAD LOAD AND PRESTRESS

Span No.	Distance (ft)	Allowable Compressive Stress	Actual Stresses		* If Code Failure
		f(c,DL) (ksi)	Top of Beam f(top,c,DL) (ksi)	Bot. of Beam f(btm,c,DL) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx a	xxxxx.xxx a	a

NOTE: A "P" designation printed next to an actual stress indicates that the pedestrian load governed for that analysis point.

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.
Compression Tolerance (as a percent of the allowable) = xx.xx%

NOTE: A "***" symbol indicates that actual stress will be less Due to crack control debonding.

FINAL COMPRESSIVE STRESSES-DESIGN LOADS

Span No.	Distance (ft)	Allowable Compressive Stress	Total Stresses		LL Stresses		* If Code Failure
		f(c) (ksi)	Top of Beam f(top,c) (ksi)	Bot. of Beam f(btm,c) (ksi)	Top of Beam f(t,LL) (ksi)	Bot. of Beam f(b,LL) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx a	xxxxx.xxx a	xxx.xxx	xxx.xxx	a

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.
Compression Tolerance (as a percent of the allowable) = xx.xx%

FINAL COMPRESSIVE STRESSES-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE)

Span No.	Distance (ft)	Allowable Compressive Stress	Total Stresses		LL Stresses		* If Code Failure
		f(c) (ksi)	Top of Beam f(top,c) (ksi)	Bot. of Beam f(btm,c) (ksi)	Top of Beam f(t,LL) (ksi)	Bot. of Beam f(b,LL) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx a	xxxxx.xxx a	xxx.xxx	xxx.xxx	a

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.
Compression Tolerance (as a percent of the allowable) = xx.xx%

Chapter 7 Output Description

FINAL TENSILE STRESSES-DESIGN LOADS

Span No.	Distance (ft)	Allowable	Total Stresses		LL Stresses		* If Code Failure
		Tensile	Top of	Bot. of	Top of	Bot. of	
		Stress f(t) (ksi)	Beam f(top,t) (ksi)	Beam f(btm,t) (ksi)	Beam f(t,LL) (ksi)	Beam f(b,LL) (ksi)	
ii	xxxx.xxx	xxxxxx.xxx	xxxxxx.xxx	a xxxxx.xxx	a xxx.xxx	xxx.xxx	a

NOTE: The plus sign (+) indicates the girders at interior supports are designed as reinforced concrete members at the strength limit state. The stress limits for the service limit state do not apply to this region of the girder.
(Per LRFD Specifications Article 5.12.3.3.6)

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.
Compression Tolerance (as a percent of the allowable) = xx.xx%

FINAL TENSILE STRESSES-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE)

Span No.	Distance (ft)	Allowable	Total Stresses		LL Stresses		* If Code Failure
		Tensile	Top of	Bot. of	Top of	Bot. of	
		Stress f(t) (ksi)	Beam f(top,t) (ksi)	Beam f(btm,t) (ksi)	Beam f(t,LL) (ksi)	Beam f(b,LL) (ksi)	
ii	xxxx.xxx	xxxxxx.xxx	xxxxxx.xxx	a xxxxx.xxx	a xxx.xxx	xxx.xxx	a

NOTE: The plus sign (+) indicates the girders at interior supports are designed as reinforced concrete members at the strength limit state. The stress limits for the service limit state do not apply to this region of the girder.
(Per LRFD Specifications Article 5.12.3.3.6)

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

NOTE: A "#" symbol indicates a stress exceeding the allowable but within the tolerance.
Compression Tolerance (as a percent of the allowable) = xx.xx%

FINAL STRESSES IN SLAB-DESIGN LOADS

Span No.	Distance (ft)	Allowable	Total Stress	LL Stress	* If Code Failure
		Compressive	at Top	at Top	
		Stress f(cs) (ksi)	of Slab f(c,slab) (ksi)	of Slab f(slab,LL) (ksi)	
ii	xxxx.xxx	xxxxxx.xxx	xxxxxx.xxx	a xxxxx.xxx	a

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

Chapter 7 Output Description

FINAL STRESSES IN SLAB-DESIGN LOADS (INCLUDES CREEP AND SHRINKAGE)

Span No.	Distance (ft)	Allowable Compressive Stress	Total Stress at Top of Slab	LL Stress at Top of Slab	* If Code Failure
		f(cs) (ksi)	f(c,slab) (ksi)	f(slab,LL) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx a	xxxxx.xxx	a

NOTE: A "P" designation printed next to a total stress indicates that the pedestrian load governed for that analysis point.

7.8.21 Final Compressive Stresses LL + 1/2(DL+P/S)

FINAL COMPRESSIVE STRESSES UNDER LL+1/2 (DL+P/S)

Span No.	Distance (ft)	Allowable Compressive Stress	Actual Stress at Top of Beam	Actual Stress at Bottom of Beam	*If Code Failure
		f(c,1/2DP) (ksi)	f(top,c,1/2DP) (ksi)	f(btm,c,1/2DP) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx a	xxxxx.xxx a	a

NOTE: A "P" designation printed next to an actual stress indicates that the pedestrian load governed for that analysis point.

FINAL COMPRESSIVE STRESSES - FATIGUE-I + 1/2 (DL+P/S)

Span No.	Distance (ft)	Allowable Compressive Stress	Actual Stress at Top of Beam	Actual Stress at Bottom of Beam	*If Code Failure
		f(c,1/2DP) (ksi)	f(top,c,1/2DP) (ksi)	f(btm,c,1/2DP) (ksi)	
ii	xxxx.xxx	xxxxx.xxx	xxxxx.xxx	xxxxx.xxx	a

7.8.22 End Block Stresses

END BLOCK STRESSES BASED ON SOLID SECTION

Span No.	Distance (ft)	Allowable Initial Tensile Stress	Actual Initial Stress at Top of Beam	* If Code Failure
		f(ti) (ksi)	f(top) (ksi)	
ii	xxxx.xxx	xxxx.xxx	xxxx.xxx	a

* - End block stresses exceed allowables. Crack control debonding is required in accordance with Section 1107.01b Pub. 408.

Chapter 7 Output Description

END BLOCK STRESSES BASED ON SOLID SECTION WITH BEAM NOTCH

Span No.	Distance (ft)	Beam Notch (in)	Allowable Initial Tensile Stress	Actual Initial Stress at Top of Beam	* If Code Failure
			f (ti) (ksi)	f (top) (ksi)	
ii	xxxx.xxx	xxxx.xx	xxx.xxx	xxx.xxx	a

* - End block stresses exceed allowables. Crack control debonding is required in accordance with Section 1107.01b Pub. 408.

7.8.23 Cracking Moment

MINIMUM PRESTRESSING STEEL CHECK

Span No.	Distance (ft)	Cracking Moment M(cr) (k-ft)	4/3*M(u) (k-ft)	Ultimate Moment Capacity M(r) (k-ft)	M(r)/ MINVAL	* If Code Failure
				M(r) (k-ft)		
ii	xxxx.xxx	xxxxxxxx.x	xxxxxxxx.x	xxxxxxxx.x	xxxx.xx	a

NOTES: (1) MINVAL is the minimum of M(cr) or 4/3*M(u)

(2) A "#" symbol indicates a ratio is less than 1.0 but within a 1.5% tolerance.

WARNING - A failure for the MINIMUM PRESTRESSING STEEL CHECK has occurred. The most likely cause for this is a high shrinkage moment near the simple support and may be ignored at the discretion of the engineer.

FLEXURAL RESISTANCE FACTORS

Span No.	Distance (ft)	Nonimal Flexural Resistance	phi	dt/c Ratio	Net Tensile Strain	c (N.A.) (in)
		M(n) (k-ft)			e(t)*1000 (in/in)	
ii	xxx.xxx	xxxxx.x	x.xxxx	xxx.xxx	xxx.xxx	xx.xx

SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (aaaaaaaaaaaaaaaaaaaaa)

Span No.	Distance (ft)	SRV-3A Moment M(u) (k-ft)	Flexural Resistance M(r)@0.9 fpy (k-ft)	SRV-3A LL Moment M(uLL) (k-ft)	* If Code Failure
ii	xxx.xxx	xxxxx.x	xxxxx.x	xxxxx.x	a

Chapter 7 Output Description

CRACKING MOMENT SERVICE CHECK (aaaaaaaaaaaaaaaaaaaaa)

Span No.	Distance (ft)	Cracking		
		SERV-IIIB	Moment	Design Controlled
		Moment (k-ft)	M(cr) (k-ft)	By M(cr)
ii	xxxx.xxxx	xxxxxxxx.x	xxxxxxxx.x	a

NOTE:

A "<" next to a distance indicates a debonding transfer location

A "\" next to a distance indicates a debonding cutoff location

A "&" indicates both debonding cutoff and transfer location

7.8.24 Negative Moment Capacity

NEGATIVE MOMENT CAPACITY (aaaaaaaaaaaaaaaaaaaaa)

Span No.	Distance (ft)	Limit State	Factored		Cracking Moment M(cr) (k-ft)	phi	Net Tensile Strain et*1000 (in/in)	Required As/Eff. Slab Width (in^2)	* If Code Failure
			Flexural Resistance M(r) (k-ft)	Factored Moment M(u) (k-ft)					
ii	xxxx.xxx	STR-I	xxxxxxxx.x	xxxxxxxx.x	xxxxxxx.x	x.xxx	xxxx.xx	xxx.xx	a
		STR-IP		xxxxxxxx.x					a
		STR-II		xxxxxxxx.x					a

! Note: Total longitudinal slab reinforcement in the positive
Moment region as entered for the SLB "Slab Reinforcement
Area" parameter.

- Required reinforcement exceeds xx.xx (in^2) per (ft) width of
slab based on a maximum area of #8@4.5" top and #6@4.5" bottom.
Please verify slab bar size and spacing as per DM-4.

7.8.25 Shear Reinforcement

SHEAR REINFORCEMENT AND RESISTANCE

Span No.		Shear Reinforcement		Nominal Shear Resistance Provided By:			
		Stirrup Area	Stirrup Spacing	Concrete	P/S Force	Shear Reinf.	Gov. Limit
Distance		A(v)	s	V(c)	V(p)	V(s)	State
(in)		(in^2)	(in)	(kips)	(kips)	(kips)	
ii	xxxx.xxxx	xxxx.xx	xxxx.xx	xxxxxx.xx	xxxxxx.xx	xxxxxx.xx	a

SHEAR REINFORCEMENT AND RESISTANCE

		Shear Reinforcement			Nominal Shear Resistance Provided By:				
Span		Stirrup	Stirrup	Maximum		P/S	Shear	Gov.	
No.	Distance	Area	Spacing	Spacing	Concrete	Force	Reinf.	Limit	* If Code
	(ft)	A(v)	s	s(max)	V(c)	V(p)	V(s)	State	Failure
	(in^2)	(in)	(in)	(in)	(kips)	(kips)	(kips)		
ii	xxx.xxxx	xx.xx	xxx.xx	xx.xx(i)	xxxx.xx	xxx.xx	xxx.xx	i	a

Chapter 7 Output Description

NOTE:

A "<" next to a distance indicates the critical distance

Governing Limit States

- 1 - STR-I max shear, +ve mom.
- 2 - STR-I max shear, -ve mom.
- 3 - STR-II max shear, +ve mom.
- 4 - STR-II max shear, -ve mom.
- 5 - STR-IP max shear, +ve mom.
- 6 - STR-IP max shear, -ve mom.

(3) maximum stirrup spacing controlled by required V_s per AASHTO 5.7.3.3

(5) minimum transverse reinforcement controls stirrup spacing per AASHTO 5.7.2.5

(6) maximum spacing of transverse reinforcement controls stirrup spacing per AASHTO 5.7.2.6

SHEAR DESIGN/ANALYSIS

Span No.	Distance (ft)	Governing Limit State	Factored	Factored	* If Code Failure
			Shear Resistance V(r) (kips)	Shear V(u) (kips)	
ii	xxxx.xxxa	aaaaaaaaaaa	xxxxxxx.xxa	xxxxxxx.xx	a

NOTE:

A "<" next to a distance indicates the critical distance

Factored Shear is greater than Factored Shear Resistance but within a tolerance to allow a rating factor that rounds to 1.00. Refer to STRENGTH SHEAR RATING output table to verify rating factors are greater than or equal to 1.00.

^ Factored Shear Resistance, V(r), is limited by the web concrete.
V(n) must be less than or equal to $0.25 \cdot f'_c \cdot b_v \cdot d_v + V(p)$

RESISTANCE OF LONGITUDINAL STEEL

Span No.	Distance (ft)	Limit State	Tensile	Actual	* If Code Failure
			Resistance of Longitudinal Steel (kips)	Factored Tension (kips)	
ii	xxxx.xxxa	aaaaaaaaaaa	xxxxxxx.xx	xxxxxxxxx.xx	aa

NOTE:

A "<" next to a distance indicates the critical distance.

A "#" next to a code failure indicates a location where the tension in the longitudinal reinforcement controls the shear design. Verify the longitudinal slab reinforcement input in SLB and SST commands (see BD-601 S3 and S4 bars for composite positive moment region).

Chapter 7 Output Description

LIMITS ON HORIZONTAL SHEAR (aaaaaaaaaaaaaaaaaaaaa)

Span			
No.	x.xx*f'c*A(cv)	x.x*A(cv)	V(n-max)
	(kip/in)	(kip/in)	(kip/in)
ii	xxxxx.xx	xxxxx.xx	xxxxx.xx

NOTE:

V(n-max) is the lesser of x.xx*f'c*A(cv) or x.x*A(cv)

HORIZONTAL SHEAR (aaaaaaaaaaaaaaaaaaaaa)

Span	No.	Distance u[Avfy+Pc]	cAcv	V(n-prov)	V(n-req)	Stirrup		Failure Code
						Spacing (prov)	Area (req)	
ii	xxx.xxxx	xxxx.xx	xxxxx.xx	xxxx.xx	xxxx.xx	xx.x	xx.x	xxx.x a,a,a

NOTE:

A "<" next to a distance indicates the critical distance

Nominal interface shear resistance based on "u" = x.xx and "c" = x.xxx ksi.

Failure code(s):

"A" - Required nominal horizontal shear resistance greater than V(n-max).

"B" - Provided nominal horizontal shear resistance greater than V(n-max).

"C" - Provided nominal horizontal shear resistance less than V(n-req).

"D" - User-specified stirrup spacing greater than required spacing.

"E" - User-specified stirrup spacing less than min spacing of aaaaaaaa.

"F" - User-specified stirrup spacing greater than max spacing of aaaaaaaa.

STIRRUPS REQUIRED FOR END ZONE SPLITTING STRESSES

Span No.	Required Area of	Required Distribution
	Transverse Steel	End Zone Distance for
	in Girder End Zones	Area of Transverse Steel
	A(sr)	X(sr)
	(in^2)	(in)
ii	xxxx.xx	xxxx.xx

NOTE:

Use stirrup reinforcement (#4 or #5) at 3" spacing for a distance so as to provide the required area of steel reinforcement, when the steel area does not fit within the X(sr) distance.

Use stirrup reinforcement (#13 or #16) at 75mm spacing for a distance so as to provide the required area of steel reinforcement, when the steel area does not fit within the X(sr) distance.

Chapter 7 Output Description

SHEAR REINFORCEMENT FOR DRAWINGS

(All distances and spacings measured along the centerline of the beam.)

Span No.	Distance (ft)	Design / Provided		Stirrup		401	402	404
		Vertical Spacing (in)	Area (in ²)	Horizontal Spacing (in)	Area (in ²)	Stirrup Spacing (in)	Horz. Spacing (in)	Confinement Spacing (in)
ii	xxx.xxxx	xx.xx	xx.xxa	xx.xxa	xx.xxa	xx.xxa	xx.xxa	xx.xxa

Span No.	Distance (ft)	Design / Provided		Stirrup		A1 Pairs	A2	A3
		Vertical Spacing (in)	Area (in ²)	Horizontal Spacing (in)	Area (in ²)	Stirrup Spacing (in)	Top Spacing (in)	Bottom Spacing (in)
ii	xxx.xxxx	xx.xx	xx.xxa	xx.xxa	xx.xxa	xx.xxa	xx.xxa	xx.xxa

* Warning: Reinforcement based on BD-661M and BD-662M with #4 stirrup bars
Provided stirrup area expected to be 0.40 in² (2-#4 bars)

~ Warning: 6" is the smallest spacing that can be used for detailing, but
the required spacing is less than 6".

%ERROR - <OUTPUT>:

Not able to place flared bars to transition skewed bars to perpendicular bars
while processing span i. This can be caused by the vertical stirrup spacing
being near 3" or the horizontal stirrup spacing being near 6".
Check the stirrup spacing.
Stirrup spacing at xx.xxx (ft)
Required vertical stirrup spacing = x.xx (in)
Required horizontal stirrup spacing = x.xxx (in)
Not able to produce output for "Shear Reinforcement for Drawings"

NOTE:

\ - Alternate 401 with 402
\$ - Match 403 with 401 for full length of beam
& - Match 404 with 401 and 402
- Modify 402 bar as req'd to accommodate beam notch
403 @ 12" for full length of beam
& - Match 404 with 401
- Modify 401 bar as req'd to accommodate beam notch
& - Match A3 with A2
% - Match A3 with A1 pairs & Match A3 with A2
A "f" next to a spacing indicates flared bar placement. Max. and min. spacing
measured parallel to beam C.L. between bars at clear cover from edge of beam.
A1 pairs matched with A3; alt. with A2 & A3.
See Key Points for max. and min. spacing.
A "F" next to a spacing indicates the flared bar spacing is controlled by the
max. and min. A3 bar spacing limits specified in BD-661M.
A1 pairs matched with A3; alt. with A2 & A3.
See Key Points for max. and min. spacing.
A "<" next to a distance indicates the critical distance.
A "v" next to a distance indicates a draping point.
A "x" next to a distance indicates a diaphragm location.

Actual End Block Length (Obtuse corner to Void) = xx.xxx (ft) Left Beam End
Actual End Block Length (Obtuse corner to Void) = xx.xxx (ft) Right Beam End

Key Points:

xxx.xxx ft - Left Beam End
xxx.xxx ft - start splitting zone reinforcement, left beam end
xxx.xxx ft - start splitting zone reinforcement parallel to skew, left beam end
xxx.xxx ft - 3" min beyond Beam Notch, left beam end

Chapter 7 Output Description

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xxx.xxx ft - stop splitting zone reinforcement, left beam end
xxx.xxx ft - start flared end block reinforcement, left beam end
xxx.xxx ft - start aaa flared spacing, A3 max x.xx (in), A3 min x.xx (in), left beam end
xxx.xxx ft - end block ends, left beam end
xxx.xxx ft - end x.x x Beam Depth region, left beam end
xxx.xxx ft - end aaa flared stirrup placement, left beam end
xxx.xxx ft - stop end block stirrup placement, start design spacing, left beam end
xxx.xxx ft - end confinement reinforcement (1/3 x Span Length), left
xxx.xxx ft - drape point, 2-401 @ 9" centered about drape point, left
xxx.xxx ft - drape point, 2-402 @ 9" centered about drape point, left
xxx.xxx ft - drape point, 2-#4 EA. Side @ 9" centered about drape point, left
xxx.xxx ft - C.L. interior diaphragm, 4 additional 402 @ 4"
xxx.xxx ft - C.L. interior diaphragm, 4 additional 401 @ 4"
xxx.xxx ft - drape point, 2-#4 EA. Side @ 9" centered about drape point, right
xxx.xxx ft - drape point, 2-402 @ 9" centered about drape point, right
xxx.xxx ft - drape point, 2-401 @ 9" centered about drape point, right
xxx.xxx ft - end confinement reinforcement (1/3 x Span Length), right
xxx.xxx ft - end aaa flared stirrup placement, right beam end
xxx.xxx ft - stop end block stirrup placement, start design spacing, right beam end
xxx.xxx ft - end x.x x Beam Depth region, right beam end
xxx.xxx ft - end block ends, right beam end
xxx.xxx ft - start aaa flared spacing, A3 max x.xx (in), A3 min x.xx (in), right beam end
xxx.xxx ft - start flared end block reinforcement, right beam end
xxx.xxx ft - stop splitting zone reinforcement, right beam end
xxx.xxx ft - 3" min beyond Beam Notch, right beam end
xxx.xxx ft - start splitting zone reinforcement parallel to skew, right beam end
xxx.xxx ft - start splitting zone reinforcement, right beam end
xxx.xxx ft - Right Beam End

```

7.8.26 Shear Detail

THETA & BETA VALUES - TABLE B5.2-1

Span No.	Distance (ft)	$v_u/f'c^*$	Epsilon(x) $\times 10^3^*$ (in/in)	Theta* (deg)	Beta*
ii	xxx.xxx< xxx.xxx	x.xxx x.xxx	xx.xxx xx.xxx	xx.xx xx.xx	x.xxx x.xxx

* Legend of Table Column Headings:

$v_u/f'c$ = shear stress on concrete

Epsilon(x) $\times 10^3$ = longitudinal strain at mid-depth of member times 1000

Theta = angle of inclination of diagonal compressive stresses

Beta = factor indicating ability of diagonally cracked concrete to transmit tension and shear

LONGITUDINAL STRAIN - EPSILON(X)

Span No.	Distance (ft)	μ_u^* (k-ft)	d_v^* (in)	V_u^* (kips)	V_p^* (kips)	Theta* (deg)	A_{ps}^* (in ²)	f_{po}^* (ksi)	A_s^* (in ²)	A_c^* (in ²)	Epsilon(x) $\times 10^3^*$ (in/in)
ii	xxx.xxx< xxx.xxx	xxxxx.x xxxxx.x	xx.xx xx.xx	xxxx.x xxxx.x	xxx.x xxx.x	xx.xx xx.xx	xx.xxx xx.xxx	xxx.x xxx.x	xx.xx xx.xx	xxx.x xxx.x	xx.xxx xx.xxx

* Legend of Table Column Headings:

μ_u = maximum of factored moment or $V_u \times d_v$

d_v = effective shear depth

V_u = factored shear force

V_p = component of prestressing force in direction of shear force

Theta = angle of inclination of diagonal compressive stresses

A_{ps} = area of prestressing steel on flexural tension side of member

f_{po} = jacking stress in strands

A_s = mild steel area on flexural tension side of member

A_c = area of concrete on flexural tension side of member

Epsilon(x) $\times 10^3$ = longitudinal strain at mid-depth of member times 1000

Chapter 7 Output Description

					SHEAR STRESS ON CONCRETE			

Span								
No.	Distance	Vu*	Vp*	phi*	bv*	dv*	vu*	
	(ft)	(kips)	(kips)		(in)	(in)	(ksi)	
ii	xxx.xxx<	xxxx.x	xx.x	x.xxx	xx.xx	xx.xx	x.xxx	
	xxx.xxx	xxxx.x	xx.x	x.xxx	xx.xx	xx.xx	x.xxx	

* Legend of Table Column Headings:

Vu = factored shear force

Vp = component of prestressing force in direction of shear force

phi = resistance factor for shear

bv = effective web width

dv = effective shear depth

vu = shear stress on concrete

EFFECTIVE SHEAR DEPTH									

Span	No.	Distance	ds*	dp*	de*	h*	[dv = Maximum of These]		
		(ft)	(in)	(in)	(in)	(in)	0.9de*	0.72h*	dct*
ii		xxx.xxx<	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx
		xxx.xxx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx

* Legend of Table Column Headings:

ds = negative moment region: distance from compression fiber to centroid slab steel
positive moment region: not applicable

dp = positive moment region: distance from compression fiber to centroid p/s steel
negative moment region: not applicable

de = depth of center of gravity of steel

h = overall depth of member

0.9de = first lower bound on effective shear depth

0.72h = second lower bound on effective shear depth

dct = distance between resultants of tensile and compressive forces due to flexure

dv = effective shear depth

7.8.27 Prestressing Data

DRAPED STRAND (BEAM DESIG. <aaaaaaaa>)					

D r a p e d S t r a n d s					
Distance from Bottom of Beam to Draped Strand Row					
/ Number of Draped Strands					
Span	Row	Avail.	Beam	C.L.	Drape
No.	No.	Strands	End	Brg	Point
			(xx.xxx)	(0.000)	(xx.xxx)
ii	ii	[ii]	xx.xxaii	xx.xxaii	xx.xxaii
S t r a i g h t S t r a n d s					
Distance from Bottom of Beam to Straight Strand Row					
/ Number of Straight Strands					
Span	Row	Avail.	Beam	C.L.	Drape
No.	No.	Strands	End	Brg	Point
			(xx.xxx)	(0.000)	(xx.xxx)
ii	ii	[ii]	xx.xxaii	xx.xxaii	xx.xxaii
Total			ii	ii	ii
C.G. (in)			xx.xxa	xx.xxa	xx.xx

Chapter 7 Output Description

T o t a l N u m b e r S t r a n d s				
Span Number	Row Number	Number of Strands		
		Draped	Straight	Total
ii	ii	iaa[ii]	iaa[ii]	iaa[ii]
		---	---	---
	Total	iii	iii	iii
S t r a i g h t / D r a p e d S t r a n d s				
Distance from Bottom of Beam to Strand Row / Number of Straight and Draped Strands				
Span No.	Row No.	Beam		Drape Point
		Avail. Strands	End (xx.xxx)	
			C.L. Brg (0.000)	
ii	ii	[ii]		xx.xxaii
		-----	-----	-----
	Total		iii	iii
	C.G. (in)	xx.xxa	xx.xxa	xx.xx

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within the region from aaaa to aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

%WARNING - <OUTPUT>:
 Row 1 has zero strands. This is not desirable.
 Consider revising the strand pattern to have strands in the bottom row.

Chapter 7 Output Description

- NOTES: 1. The values in parentheses are locations along the beam from the left simple bearing measured in (ft).
2. The C.G. values are for the given location and include the straight and draped strands and consider any bonded strands to be fully developed.
- # 2. The C.G. value of the strand group at the beam end was computed using the draping data entered on the SCE command.
- # 2. The C.G. value of the strand group at the centerline of bearing was input on the SCA command. Use the SCE command if strand details are desired.
3. The total number of strands includes both draped and straight strands.
- ^ 3. The C.G. at the centerline of bearing is interpolated using the C.G.'s at the beam end and the drape point.
- ^ 3. The C.G. at the beam end is extrapolated using the C.G.'s at the centerline of bearing and the drape point.
4. The values in brackets [] are the available number of strands for each row.
5. For beam design runs, the shear calculations assume crack control debonding of ii strands within aaaaaaa from the end of the beam; and ii strands within the region from aaaaaaa to aaaaaaa from the end of the beam.
- * i. The number of actual strands exceeds the number of available strand locations for some rows.

WARNING: A "U" character denotes an unsymmetrical strand row (An odd number of strands in a row with an even number of available strands.)

DEBONDED STRAND (BEAM DESIG. <aaaaaaaaaa>)							

S t r a i g h t / D e b o n d e d S t r a n d s							
Distance from Bottom of Beam to Strand Row / Number of Bonded Strands in each region							
Span	Row	Avail.	1st	2nd	3rd	4th	5th
No.	No.	Strands	Cutoff	Cutoff	Cutoff	Cutoff	Cutoff
			(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)
			to	to	to	to	to
			(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)
ii	ii	[ii]	xx.xxaiiaaaaa	xx.xxaiiaaaaa	xx.xxaiiaaaaa	xx.xxaiiaaaaa	xx.xxaiiaaaaa
			-----	-----	-----	-----	-----
Total			iii{ii}	iii{ii}	iii{ii}	iii{ii}	iii{ii}
C.G. (in)			xx.xx	xx.xx	xx.xx	xx.xx	xx.xx
Span	Row	Avail.	6th	7th	8th	Mid	
No.	No.	Strands	Cutoff	Cutoff	Cutoff	Span	
			(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)	
			to	to	to	to	
			(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)	
ii	ii	[ii]	xx.xxaiiaaaaa	xx.xxaiiaaaaa	xx.xxaiiaaaaa	xx.xxaii	
			-----	-----	-----	-----	
Total			iii{ii}	iii{ii}	iii{ii}	iii	
C.G. (in)			xx.xx	xx.xx	xx.xx	xx.xx	

Chapter 7 Output Description

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within the region from aaaa to aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

WARNING - Total number of debonded strands (ii) in the region starting aaaa from the beam end to mid-span, exceeds the allowable maximum of ii (ii % of the total number of strands per Pub 408 Section 1107.01 (b)).

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the total number of debonded strands (ii) exceeds the 50% maximum allowed per row (ii) in row ii.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the number of debonded strands (ii) in row ii results in an asymmetrical configuration.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the total number of debonded strands (ii) in exceeds the maximum allowed per row (ii) in row ii when strands in the outermost position of flange rows and/or within the horizontal limits of the web must remain bonded.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft), the number of debonded strands (ii) in row ii requires debonding within the web region to avoid an asymmetrical configuration.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the debonding in consecutive rows (ii and ii) causes adjacent strands in the same row and/or column to be debonded when strands in the outermost position of flange rows and/or within the horizontal limits of the web must remain bonded.

- Row ii has ii strands with ii debonded.
- Row ii has ii strands with ii debonded.

%WARNING - <INPUT POST PROCESSING>:

Row ii has a total of ii bonded strands at mid-span. In the region from xx.xx(ft) to xx.xx(ft), Row ii has (ii) bonded strands (an even number) and the DBS command is requesting that an odd number of strands (ii) be debonded out of those (ii) bonded strands. This will result in an unsymmetrical strand pattern for span ii.

Please review the input for the DBS command.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the debonding in consecutive rows (ii and ii) causes adjacent strands in the same row and/or column to be debonded.

- Row ii has ii strands with ii debonded.
- Row ii has ii strands with ii debonded.

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the number of strands (ii) **being debonded** is less than the allowable minimum of ii.

Chapter 7 Output Description

%WARNING - <DEBONDING ANALYSIS>:

In span ii for the cutoff located in the region from xx.xx(ft) to xx.xx(ft) the **total** number of strands **being debonded in this region** (ii) exceeds the allowable maximum of ii.

%WARNING - <DEBONDING ANALYSIS>:

Debonding length exceeds maximum in span ii. Cutoff located in the region from xx.xx(ft) to xx.xx(ft) is too close to mid-span to allow strands to be fully developed.

Actual Cutoff Location: xx.xx(ft)

Max Allowable Cutoff Location: xx.xx(ft)

%WARNING - <DEBONDING ANALYSIS>:

Debonded cutoff region from xx.xx(ft) to xx.xx(ft) in span ii is too short.

Actual Cutoff Region Length: xx.xx(ft)

Minimum Allowable Cutoff Region Length: xx.xx(ft)

%INFO - <DEBONDING ANALYSIS>:

Debonding cutoff region from xx.xx(ft) to xx.xx(ft) in span ii is less than recommended minimum from C.L. simple bearing.

Recommended Cutoff Distance from C.L. Brg: xx.xx (ft)

Recommended cutoff region is from xx.xx(ft) to xx.xx(ft)

%WARNING - <OUTPUT>:

Row 1 has zero strands. This is not desirable.

Consider revising the strand pattern to have strands in the bottom row.

%WARNING - <OUTPUT>:

Row 1 has zero strands. This is not desirable. Revise the input commands to use one of the following alternate strand patterns that has the same or slightly less CGS at Mid-Span and the suggested debonding has the same CGS at each Cutoff.

The original Debonded Length on the DBS command may need to be increased to avoid over stresses at initial transfer of prestress.

Pattern i

SCA i, x.x, x.xxx,,,,, i, i, i, i, i, i, i

DBS i, x.x, i, i, i, i

- NOTES: 1. The values in parentheses are locations along the beam from the left simple bearing measured in (ft).
2. The C.G. values are for the given region and consider any bonded strands to be fully developed.
3. The values in braces {} are the total number of strands debonded in each cutoff region.
4. For beam design runs, the shear calculations assume crack control debonding of ii strands within aaaaaaa from the end of the beam; and ii strands within the region from aaaaaaa to aaaaaaa from the end of the beam.
* i. The number of actual strands exceeds the number of available strand locations for some rows.

WARNING: A "U" character denotes an unsymmetrical strand row (An odd number of strands in a row with an even number of available strands.)

Strand Pattern Visualization

Span	Row	Avail.	Actual	
No.	No.	Strands	{Debonded}	Pattern
ii	ii	[ii]	ii {ii}	aaaaaaaaaaaaaaaaaaaaaaaaaaaaa

- NOTES: 1. This is only a guide to help identify a valid configuration, it may not represent a valid configuration if none are available.
2. If this configuration is valid, there may be other valid configurations.
3. This does not necessarily represent the strand configuration as-built.

STRAIGHT STRAND (BEAM DESIG. <aaaaaaaa>)				

Distance from Bottom of Beam to Strand Row				
/ Number of Straight Strands				
Mid				
Span	Row	Avail.	Span	
No.	No.	Strands	(xx.xxx)	
			to	
			(xx.xxx)	
ii	ii	[ii]	xx.xxaii	

Total			iii	
C.G.(in)			xx.xx	

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

WARNING - Total number of debonded strands (ii) exceeds the allowable maximum of ii (ii % of the total number of strands debonded within the region from aaaa to aaaa from the end of beam per Pub 408 Section 1107.01 (b)).

%WARNING - <OUTPUT>:
Row 1 has zero strands. This is not desirable.
Consider revising the strand pattern to have strands in the bottom row.

- NOTES: 1. The values in parentheses are locations along the beam from the left simple bearing measured in (ft).
2. The C.G. values are for the given region and consider any bonded strands to be fully developed.
3. For beam design runs, the shear calculations assume crack control debonding of ii strands within aaaaaa from the end of the beam; and ii strands within the region from aaaaaa to aaaaaa from the end of the beam.
* i. The number of actual strands exceeds the number of available strand locations for some rows.

WARNING: A "U" character denotes an unsymmetrical strand row (An odd number of strands in a row with an even number of available strands.)

Chapter 7 Output Description

DEBONDED/DRAPED STRAND (BEAM DESIG. <aaaaaaaa>)

D r a p e d S t r a n d s

Distance from Bottom of Beam to Draped Strand Row
/ Number of Draped Strands

Span No.	Row No.	Avail. Strands	Beam End (xx.xxx)	C.L. Brg (0.000)	1st Cutoff (xx.xxx)	2nd Cutoff (xx.xxx)	3rd Cutoff (xx.xxx)
ii	ii	[ii]	xx.xxaii	xx.xxaii	xx.xxaii	xx.xxaii	xx.xxaii
Span No.	Row No.	Avail. Strands	4th Cutoff (xx.xxx)	5th Cutoff (xx.xxx)	6th Cutoff (xx.xxx)	Drape Point (xx.xxx)	Mid Span (xx.xxx)
ii	ii	[ii]	xx.xxaii	xx.xxaii	xx.xxaii	xx.xxaii	xx.xxaii

S t r a i g h t / D e b o n d e d S t r a n d s

Distance from Bottom of Beam to Strand Row
/ Number of Bonded Strands in each region

Span No.	Row No.	Avail. Strands	Beam End (xx.xxx)	C.L. Brg (0.000)	1st Cutoff (xx.xxx)	2nd Cutoff (xx.xxx)	3rd Cutoff (xx.xxx)
ii	ii	[ii]	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaiiaaaa
Total			iii{ii}	iii{ii}	iii{ii}	iii{ii}	iii{ii}
C.G. (in)			xx.xxa	xx.xxa	xx.xx to xx.xx	xx.xx to xx.xx	xx.xx to xx.xx
Span No.	Row No.	Avail. Strands	4th Cutoff (xx.xxx)	5th Cutoff (0.000)	6th Cutoff (xx.xxx)	Drape Point (xx.xxx)	Mid Span (xx.xxx)
ii	ii	[ii]	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaiiaaaa	xx.xxaii
Total			iii{ii}	iii{ii}	iii{ii}	iii{ii}	iii
C.G. (in)			xx.xx to xx.xx	xx.xx to xx.xx	xx.xx to xx.xx	xx.xx to xx.xx	xx.xx

T o t a l N u m b e r S t r a n d s

Span Number	Row Number	Number of Strands		
		Draped	Straight	Total
ii	ii	iaa[ii]	iaa[ii]	iaa[ii]
Total		iii	iii	iii

Chapter 7 Output Description

S t r a i g h t / D e b o n d e d / D r a p e d S t r a n d s

			Distance from Bottom of Beam to Strand Row / Number of Bonded Strands in each region				
Span	Row	Avail.	Beam	C.L.	1st	2nd	3rd
No.	No.	Strands	End	Brg	Cutoff	Cutoff	Cutoff
			(xx.xxx)	(0.000)	(xx.xxx)	(xx.xxx)	(xx.xxx)
					to	to	to
					(xx.xxx)	(xx.xxx)	(xx.xxx)
ii	ii	[ii]	aiaaaaa	aiaaaaa	aiaaaaa	aiaaaaa	aiaaaaa
Total			iii{ii}	iii{ii}	iii{ii}	iii{ii}	iii{ii}
C.G. (in)			xx.xxa	xx.xxa	xx.xx	xx.xx	xx.xx
					to	to	to
					xx.xx	xx.xx	xx.xx

Span	Row	Avail.	4th	5th	6th	Drape	Mid
No.	No.	Strands	Cutoff	Cutoff	Cutoff	Point	Span
			(xx.xxx)	(0.000)	(xx.xxx)	(xx.xxx)	(xx.xxx)
			to	to	to	to	to
			(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)	(xx.xxx)
ii	ii	[ii]	aiaaaaa	aiaaaaa	aiaaaaa	aiaaaaa	xx.xxaii
Total			iii{ii}	iii{ii}	iii{ii}	iii{ii}	iii
C.G. (in)			xx.xx	xx.xx	xx.xx	xx.xx	xx.xx
			to	to	to	to	
			xx.xx	xx.xx	xx.xx	xx.xx	

%WARNING - <OUTPUT>:

Row 1 has zero strands. This is not desirable.

Consider revising the strand pattern to have strands in the bottom row.

- NOTES: 1. The values in parentheses are locations along the beam from the left simple bearing measured in (ft).
- # 2. The C.G. value of the strand group at the beam end was computed using the draping data entered on the SCE command.
- # 2. The C.G. value of the strand group at the centerline of bearing was input on the SCA command with all strands considered bonded.
3. Two(2) C.G. values, at the start and end of each region, are given where the C.G. varies due to the draped strands. Within each region all bonded strands are considered to be fully developed.
- ^ 4. The C.G.'s at the centerline of bearing and each cutoff are interpolated using the C.G.'s at the beam end and the drape point.
- ^ 4. The C.G. at the beam end is extrapolated using the C.G.'s at the centerline of bearing and the drape point.
5. The values in braces {} are the total number of strands debonded in each cutoff region.
6. The values in brackets [] are the available number of strands for each row.
- * i. The number of actual strands exceeds the number of available strand locations for some rows.

USER INPUT C.G.S (BEAM DESIG. <aaaaaaa>)

Span	CGS at	CGS at	Total
Number	MidSpan	CL Brg	No.
	(in)	(in)	of Strands
ii	xx.xxx	xx.xxx	iii

Chapter 7 Output Description

EFFECTIVE C.G.S. AND NUMBER OF STRANDS

Span		Effective	Effective	Location
No.	Distance	C.G.S.	Number of	Type
	(ft)	(in)	Strands	
ii	xxxx.xxx	xxx.xxx	xxx.xxx	aaaaaaaaaaaa

Note: CGS values consider crack control debonding and partial development of strands within the transfer length.

PRESTRESS VALUES BASED ON LOSSES AT MIDSPAN OF SIMPLE SPAN

Span	Total Area	Total	Transfer	Transfer	Effective	Effective
Number	of Strands	Jacking	Prestress	Prestress	Prestress	Prestress
	A(strand)	Force	Stress	Force	Stress	Force
	(in^2)	(kips)	f(pt)	P(t)	f(pe)	P(e)
			(ksi)	(kips)	(ksi)	(kips)
ii	xxxxx.xx	xxxxxxx.x	xxxxx.xx	xxxxxxx.x	xxxxx.xx	xxxxxxx.x

PRESTRESS VALUES AT NOMINAL FLEXURAL RESISTANCE

Span	Average Stress in	Average Force in
Number	Prestressing Steel	Prestressing Steel
	f(ps)	P(ps)
	(ksi)	(kips)
ii	xxxx.xx	xxxxx.x

LONG-TERM TIME-DEPENDENT PRESTRESS LOSSES

Span	-Transfer to Deck Placement-			----- Deck Placement to Final -----			
Number	Concrete Shrinkage	Concrete Creep	Strand Relax.	Concrete Shrinkage	Concrete Creep	Strand Relax.	Slab Conc Shrinkage
	f(pSR)	f(pCR)	f(pR1)	f(pSD)	f(pCD)	f(pR2)	f(pSS)
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
ii	xx.xx	xx.xx	xx.xxa	xx.xx	xx.xx	xx.xxa	xx.xx

"#" - Total relaxation loss controlled by 3 ksi minimum (DM-4 5.9.3.4.3c)

NOTE: The long-term time-dependent losses based on:

Concrete age at transfer, $t(i) =$ ii day(s)

Concrete age at deck placement, $t(d) =$ ii day(s)

Concrete age at final stage, $t(f) =$ ii day(s)

Chapter 7 Output Description

TOTAL PRESTRESS LOSS

Span Number	Elastic Shortening of Beam f (pES) (%)	Total Long-term Losses f (pLT) (%)	Total Loss f (pT) (%)
ii	xxx.xx	xxx.xx	xxx.xxa

"#" - Total losses controlled by minimum required loss.

ULTIMATE MOMENT AND SERVICEABILITY CHECKS

Span No.	SRV-3A Moment (k-ft)	M(r) .9 fy (k-ft)	SRV-3A> M(r).9fy a	STRENGTH M(u) (k-ft)	M(r) (k-ft)	phi	M(u)> M(r) a	* If Code Failure a
ii	xxxxx.x	xxxxx.x		xxxxx.x	xxxxxxx.x	x.xxx		

TRANSFER AND DEVELOPMENT LENGTHS

Span No.	Transfer Length (ft)	Development Length (ft)	Development Length Debonded (ft)
ii	xxxx.xxx	xxxx.xxx	xxxx.xxx

7.8.28 Fatigue Stress Range

FATIGUE STRESS RANGE IN PRESTRESSING STEEL

Span No.	Distance (ft)	Location	Allowable Fatigue Stress Range (dF) TH (ksi)	Effective Fatigue Stress Range f (fp) (ksi)	* If Code Failure
ii	xxxx.xxx	MAXIUMUM	xxxxx.xx	xxxxx.xx	a
	xxxx.xxx	DRAPE	xxxxx.xx	xxxxx.xx	a

7.8.29 Longitudinal Slab Reinforcement

LONGITUDINAL SLAB REINFORCEMENT AT CONTINUOUS SUPPORTS

Support No.	As/Eff. Slab Width (in^2)	As/Unit Slab Width (in^2/ft)
ii	xxxxxxx.xx	xxxxxxx.xx

Note: For negative moment reinforcement at other analysis points, refer to the table, NEGATIVE MOMENT CAPACITY (DESIGN LIVE LOADING).

Chapter 7 Output Description

BAR SPACINGS (in) AT SUPPORT ii

```

-----
Bar Size      ii   ii   ii   ii   ii
Spacing      xxx. xxx. xxx. xxx. xxx.
Spacing      xx.x xx.x xx.x xx.x xx.x
%AREA        xx.  xx.  xx.  xx.  xx.

```

LEGEND:

```

%AREA - (PROVIDED AREA / REQUIRED AREA - 1) * 100%
---+ - NO REBAR SPACING FOR VALID DESIGN
--+- - NO REBAR SPACING FOR VALID DESIGN
>>> - GREATER THAN ii%

```

TOP AND BOTTOM BAR SPACINGS (in) AT SUPPORT ii

```

-----
BAR      T O P      R E B A R      S P A C I N G (in)
PAIRS    x.x  x.x  x.x  x.x  x.x  x.x  x.x
(T&B)

C      ii&ii  --+-  --+-  --+-  --+-  x.x  x.x  x.x
O B    %AREA                x.x  x.x  x.x
R O
R T S  ii&ii  x.x  x.x  x.x  x.x  x.x  x.x  x.x
E T P  %AREA  x.x  x.x  x.x  x.x  x.x  x.x  x.x
S O A
P M C  ii&ii  --+-  x.x  x.x  x.x  x.x  xx.x  xx.x
O I    %AREA                x.x  x.x  x.x  x.x  x.x  x.x
N R N
E E G  ii&ii  x.x  x.x  x.x  xx.x  xx.x  xx.x  xx.x
D B    %AREA  x.x  x.x  x.x  x.x  x.x  x.x  >>>
I A
N R    ii&ii  x.x  x.x  xx.x  xx.x  xx.x  xx.x  xx.x
G      %AREA  x.x  x.x  x.x  >>>  >>>  >>>  >>>

      ii&ii  x.x  xx.x  xx.x  xx.x  xx.x  xx.x  xx.x
      %AREA  x.x  x.x  x.x  x.x  >>>  >>>  >>>

      ii&ii  xx.x  xx.x  xx.x  xx.x  xx.x  xx.x  xx.x
      %AREA  x.x  >>>  >>>  >>>  >>>  >>>  >>>

```

LEGEND:

```

T&B - TOP AND BOTTOM REBAR SIZE
%AREA - (PROVIDED AREA / REQUIRED AREA - 1) * 100%
--+- - NO CORRESPONDING BOTTOM REBAR SPACING FOR VALID DESIGN
>>> - GREATER THAN ii%

```

Note: Design area of reinforcement controlled by 1% of slab area
 1% of slab area = xx.xx (in²/ft)

Chapter 7 Output Description

CONTROL OF CRACKING BY DISTRIBUTION OF REINFORCEMENT

Longitudinal Slab Reinforcement								*
Span No.	Distance (ft)	SERV-I Moment (k-ft)	Total Area (in^2)	Actual Stress (ksi)	Top Bar Size	Actual Spacing (in)	Allowable Spacing (in)	If Code Failure
ii	xxx.xxx	xxxxx.x	xx.xx	xxx.xxa	#ii @	xxx.xx	xxx.xx	a

NOTE: A "<" following an actual stress indicates 0.6*fy used in allowable space calculation.

7.8.30 Positive Moment Connection

POSITIVE MOMENT CONNECT. STEEL AT CONTINUOUS SUPPORT (aaaaaaaaaaaaaaaaaaaaa)

Support No.	Nominal Flexural Resistance M(n) (k-ft)	Required Steel Area A(s) (in^2)	Factored Moment M(u) (k-ft)	Cracking Moment M(cr) (k-ft)	phi	Net Tensile Strain et*1000 (in/in)	Limit State	d(s) (in)
ii	xxxxxxxx.x	xxxxx.xx	xxxxxxxx.x	xxxxxx.x	x.xxx	xxxx.xx	aaaaaaaaa	xxx.x

7.8.31 Overhang Width

PARAPET OVERHANG WIDTH

Span No.	Maximum Allowable Overhang Width Approximation (ft)
ii	xxxxx.xxx

PARAPET OVERHANG WIDTH (W/ SIDEWALK)

Span No.	Maximum Allowable Overhang Width Approximation (ft)
ii	xxxxx.xxx

7.8.32 Camber and Deflection

CAMBER TO DETERMINE BRIDGE SEAT ELEVATIONS

Camber and deflection based on an assumed loss of xx.xx% and a creep factor of xx.xx

Span No.	Prestress Delta (P/S) (in)	Beam Weight Delta (sw) (in)	Slab, Forms & Ext. Diaph Delta (s) (in)	Super. Dead Load Delta (SDL) (in)	Initial Camber C (I) (in)	Init. Creep C (IA) (in)	Final Camber C (F) (in)
ii	xxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx

Chapter 7 Output Description

CAMBER TO CHECK A PROBABLE SAG IN BRIDGE

Camber and deflection based on an assumed loss of xx.xx%
and a creep factor of xx.xx

Span No.	Prestress Delta (P/S) (in)	Slab, Forms		Super. Dead Load Delta (SDL) (in)	Initial Camber C (I) (in)	Init.	
		Beam Weight Delta (sw) (in)	& Ext. Diaph Delta (s) (in)			Camber, Creep C (IA) (in)	Final Camber C (F) (in)
ii	xxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx

CAMBER BASED ON ENTERED VALUE OF LOSS

Camber and deflection based on an input loss of xx.xx%
and a creep factor of xx.xx

Span No.	Prestress Delta (P/S) (in)	Slab, Forms		Super. Dead Load Delta (SDL) (in)	Initial Camber C (I) (in)	Init.	
		Beam Weight Delta (sw) (in)	& Ext. Diaph Delta (s) (in)			Camber, Creep C (IA) (in)	Final Camber C (F) (in)
ii	xxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx	xxxx.xx

DEFLECTION LIMITS FOR LIVE LOAD

Span No.	Location	Allowable L/800 (in)	Live Load Deflection (in)	* If Code Failure
ii	xxxx.xxx	xxxx.xx	xxxxxx.xx	a

DEFLECTION LIMITS FOR LIVE LOAD WITH PEDESTRIAN

Span No.	Location	Allowable L/1000 (in)	Live Load Deflection (in)	* If Code Failure
ii	xxxx.xxx	xxxx.xx	xxxxxx.xx	a

7.8.33 Strand Detail Checks

STRAND CODE DETAIL CHECKS

Span No.	Vertical Strand Spacing			Horizontal Strand Spacing		
	Minimum (in)	Actual (in)	* If Code Failure	Minimum (in)	Actual (in)	* If Code Failure
ii	xxxxxx.xx	xxxxxx.xx		xxxxxx.xx	xxxxxx.xx	a

Chapter 7 Output Description

	AVAILABLE STRANDS PER ROW						
	ii	ii	ii	ii	ii	ii	ii
Span	ii	ii	ii	ii	ii	ii	ii
Beam	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa
Row ii	iii	iii	iii	iii	iii	iii	iii
	---	---	---	---	---	---	---
Total	iii	iii	iii	iii	iii	iii	iii

7.8.34 Principal Stresses

```

PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - PHL-93
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - HL-93
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P-82
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P-82C
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P2016-13
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - P2016-13C
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - ML-80
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - TK527
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - EV2
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - EV3
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - SU6TV
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - HS20
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - H20
-----
PRINCIPAL STRESSES DUE TO UNFACTORED LOADS - SLL #i
-----

```

Span	Dist.	Dist. from	Stress Due to:		Angles Due to:	
No.	(ft)	Bottom	Dead Load	Total	Dead Load	Total
	(ft)	(in)	(ksi)	(ksi)	(Degrees)	(Degrees)
ii	xxxx.xxx	xxxxxx.xx	xxxxx.xxx	xxxxx.xxx	xxxxx.xxx	xxxxx.xxx

Chapter 7 Output Description

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-PHL-93

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-HL-93

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-P-82

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-P-82C

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-P2016-13

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-P2016-13C

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-ML-80

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-TK527

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-EV2

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-EV3

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-SU6TV

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-HS20

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-H20

PRINCIPAL STRESSES-CONTROLLING FACTORED STRENGTH LIMIT STATE LOADS-SLL #i

Span No.	Dist. (ft)	Dist. from Bottom (in)	Stress Due to:		Angles Due to:	
			Dead Load (ksi)	Total (ksi)	Dead Load (Degrees)	Total (Degrees)
ii	xxxx.xxx	xxxxxx.xx	xxxxx.xxx	xxxxx.xxx	xxxxx.xxx	xxxxx.xxx

7.8.35 Girder Stability

HANGING GIRDER (SPAN i)

Span ii
Girder Type and Size: aaaaaaaaaaaaaaaaaa

Input Data from GSC Command (Hanging Girder)

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaa: xxxxxxxx

Input Data from other PSLRFD output

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaa: xxxxxxxx

Output Data GSC Command (Hanging Girder)
=====

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	aaaaaaaaa:	xxxxxxx	

Girder stresses at midspan
Girder stresses at xDB = xx.xx ft
Girder stresses at drape point

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	aaaaaaaaa:	xxxxxxx	Wind Left	Wind Right
			xxxxxxx	xxxxxxx

Chapter 7 Output Description

```

Girder stresses at lifting loops
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  Wind Left  Wind Right
xxxxxxxxxx  xxxxxxxx

Check Factor of Safety Against Cracking (Midspan)
Check Factor of Safety Against Cracking (Drape Point)
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  Wind Left  Wind Right
xxxxxxxxxx  xxxxxxxx

Check Factor of Safety Against Failure
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  Wind Left  Wind Right
xxxxxxxxxx  xxxxxxxx

```

NOTE: Concrete Compressive stress is Negative, Tensile stress is Positive

```

                                FIRST GIRDER SEATED ON BEARINGS (SPAN i)
                                -----
Span i
Girder Type and Size:          aaaaaaaaaaaaaaaaaa

Concrete Properties
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Prestress Force
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Other Configuration Parameters
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Other Loading Parameters
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Girder Eccentricities
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Check Girder Stresses at Drape Point - 1st Girder Seated
Check Girder Stresses at xDB = xx.xx ft
Check Girder Stresses at Midspan - 1st Girder Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Check Factor of Safety Against Cracking at Midspan - 1st Girder Seated
Check Factor of Safety Against Cracking at Drape Point - 1st Girder Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Check Factor of Safety Against Failure - 1st Girder Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Check Factor of Safety Against Rollover - 1st Girder Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

Add Bracing at Girder Ends
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaa:  xxxxxxxxxx

```

```

*****
* NOTE: END BRACING IS REQUIRED TO PROVIDE ADEQUATE FACTOR OF SAFETY FOR GIRDER STABILITY. *
*****

```

NOTE: Concrete Compressive stress is Negative, Tensile stress is Positive

Chapter 7 Output Description

```

                                MULTIPLE GIRDERS SEATED - INACTIVE CONSTRUCTION (SPAN i)
                                -----
Span i
Girder Type and Size:          aaaaaaaaaaaaaaaaaa

Concrete Properties
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Prestress Force
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Other Configuration Parameters
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Other Loading Parameters
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Girder Eccentricities
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Check Stresses (No Bracing) at Drape Point - Multiple Girders Seated
Check Stresses (No Bracing) at - xDB = xx.xx ft
Check Stresses (No Bracing) at Midspan - Multiple Girders Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Check Factor of Safety Against Cracking at Midspan - Multiple Girders Seated
Check Factor of Safety Against Cracking at Drape Point - Multiple Girders Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Check Factor of Safety Against Failure - Multiple Girders Seated
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Check Bearing Pad Effectiveness Under Service Loads
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Design of Bracing (with End and Intermediate Bracing)
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

*****
* ERROR: CONCRETE STRESSES EXCEED ALLOWS. BRACING IS NOT ADEQUATE. *
*****

NOTE: Concrete Compressive stress is Negative, Tensile stress is Positive
```

```

                                DECK (ACTIVE) CONSTRUCTION - DECK CASTING (SPAN i)
                                -----
Span i
Girder Type and Size:          aaaaaaaaaaaaaaaaaa

Weight and Torque Calculations
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Pattern Live Load over Cantilever
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx

Other Live Loads
-----
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  aaaaaaaaaaaaa: xxxxxxxxxxxx
```

Chapter 7 Output Description

Service Loads

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaa: xxxxxxxxxxxx

Check Rotation of Girder

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaa: xxxxxxxxxxxx

* ERROR: BRACING IS NOT ADEQUATE. CONCRETE COVER REDUCTION EXCEEDS ALLOWABLE. *

NOTE: Concrete Compressive stress is Negative, Tensile stress is Positive

7.8.36 Detailed Rating Factors

SERVICE MOMENT RATING: PHL-93

SERVICE MOMENT RATING: HL-93

SERVICE MOMENT RATING: P-82

SERVICE MOMENT RATING: P-82C

SERVICE MOMENT RATING: P2016-13

SERVICE MOMENT RATING: P2016-13C

SERVICE MOMENT RATING: ML-80

SERVICE MOMENT RATING: TK527

SERVICE MOMENT RATING: EV2

SERVICE MOMENT RATING: EV3

SERVICE MOMENT RATING: SU6TV

SERVICE MOMENT RATING: HS20

SERVICE MOMENT RATING: H20

SERVICE MOMENT RATING: SLL #i

Rating Factors								
		Inventory		Inventory		Operating		
		SERV-I		SERV-III		SERV-IIIA		* If
Span	Slab	Top	Btm.	Btm.	Top	0.9 Mfy	Rating	
No.	Dist.	Compr.	Compr.	Compr.	Tens.	Tens.	Failure	
(ft)								
ii	xxx.xxx	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xx	a

NOTE: A "P" to the right of a rating indicates pedestrian load governed for that analysis point.

Chapter 7 Output Description

```

SERVICE MOMENT RATING (CREEP AND SHRINKAGE): PHL-93
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): HL-93
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P-82
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P-82C
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P2016-13
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): P2016-13C
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): ML-80
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): TK527
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): EV2
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): EV3
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): SU6TV
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): HS20
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): H20
-----
SERVICE MOMENT RATING (CREEP AND SHRINKAGE): SLL #i
-----

```

Rating Factors								
Span No.	Dist. (ft)	Slab Compr.	Inventory SERV-I		Inventory SERV-III		Operating SERV-IIIA 0.9 Mfy	* If Rating Failure
			Top Compr.	Btm. Compr.	Btm. Tens.	Top Tens.		
ii	xxx.xxx	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xx	a

NOTE: A "P" to the right of a rating indicates pedestrian load governed for that analysis point.

```

STRENGTH MOMENT RATING: PHL-93
-----

```

```

STRENGTH MOMENT RATING: HL-93
-----

```

Rating Factors								
Span No.	Dist. (ft)	Inventory STR-I		Inventory STR-IP		Operating STR-IA		* If Rating Failure
		Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	
ii	xxx.xxx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	a

Chapter 7 Output Description

STRENGTH MOMENT RATING: P-82

STRENGTH MOMENT RATING: P-82C

STRENGTH MOMENT RATING: P2016-13

STRENGTH MOMENT RATING: P2016-13C

STRENGTH MOMENT RATING: ML-80

STRENGTH MOMENT RATING: TK527

STRENGTH MOMENT RATING: EV2

STRENGTH MOMENT RATING: EV3

STRENGTH MOMENT RATING: SU6TV

STRENGTH MOMENT RATING: HS20

STRENGTH MOMENT RATING: H20

STRENGTH MOMENT RATING: SLL #i

		Rating Factors						* If Rating Failure
Span No.	Dist. (ft)	Inventory		Inventory		Operating		
		STR-I Pos.	STR-I Neg.	STR-IP Pos.	STR-IP Neg.	STR-II Pos.	STR-II Neg.	
ii	xxx.xxx	n/a	n/a	n/a	n/a	xxx.xx	xxx.xx	a

STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): PHL-93

STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): HL-93

		Rating Factors						* If Rating Failure
Span No.	Dist. (ft)	Inventory		Inventory		Operating		
		STR-I Pos.	STR-I Neg.	STR-IP Pos.	STR-IP Neg.	STR-IA Pos.	STR-IA Neg.	
ii	xxx.xxx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	a

Chapter 7 Output Description

STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P-82

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P-82C

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P2016-13

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): P2016-13C

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): ML-80

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): TK527

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): EV2

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): EV3

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): SU6TV

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): HS20

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): H20

 STRENGTH MOMENT RATING (CREEP AND SHRINKAGE): SLL #i

				Rating Factors				* If Rating Failure
Span No.	Dist. (ft)	Inventory		Inventory		Operating		
		STR-I Pos.	STR-I Neg.	STR-IP Pos.	STR-IP Neg.	STR-II Pos.	STR-II Neg.	
ii	xxx.xxx	n/a	n/a	n/a	n/a	xxx.xx	xxx.xx	a

STRENGTH SHEAR RATING: PHL-93

 STRENGTH SHEAR RATING: HL-93

		Rating Factors			* If Rating Failure
Span No.	Dist. (ft)	Inventory STR-I	Inventory STR-IP	Operating STR-IA	
ii	xxx.xxxa	xxx.xxa	xxx.xxa	xxx.xxa	a

Chapter 7 Output Description

```

STRENGTH SHEAR RATING: P-82
-----
STRENGTH SHEAR RATING: P-82C
-----
STRENGTH SHEAR RATING: P2016-13
-----
STRENGTH SHEAR RATING: P2016-13C
-----
STRENGTH SHEAR RATING: ML-80
-----
STRENGTH SHEAR RATING: TK527
-----
STRENGTH SHEAR RATING: HS20
-----
STRENGTH SHEAR RATING: H20
-----
STRENGTH SHEAR RATING: SLL #i
-----

```

Span No.	Dist. (ft)	Rating Factors			* If Rating Failure
		Inventory STR-I	Inventory STR-IP	Operating STR-II	
ii	xxx.xxxa	n/a	n/a	xxx.xxa	a

NOTE:

- < - A left arrow next to a distance indicates the critical distance
- * - A asterisk next to a rating indicates tension in longitudinal steel
Controlled the shear rating

7.8.37 Live Loading Rating Summary

```

RATING SUMMARY: PHL-93
-----

```

```

RATING SUMMARY: HL-93
-----

```

Basis of Rating		Rating Factor	Controlling		Rating Tonnage (ton)
			Span No.	Location Distance (ft)	
Strength I Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Strength IP Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Strength IA Moment	(OR)	xxx.xx	ii	xxxx.xxx	
Service I Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Service IP Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Service III Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Service IIIP Moment	(IR)	xxx.xx	ii	xxxx.xxx	
Service IIIA Moment	(OR)	xxx.xx	ii	xxxx.xxx	
Strength I Shear	(IR)	xxx.xx	ii	xxxx.xxx	
Strength IP Shear	(IR)	xxx.xx	ii	xxxx.xxx	
Strength IA Shear	(OR)	xxx.xx	ii	xxxx.xxx	

Chapter 7 Output Description

RATING SUMMARY: P-82

RATING SUMMARY: P2016-13

		Controlling			
Basis of Rating		Rating	Controlling	Location	Rating
		Factor	Span No.	Distance	Tonnage
				(ft)	(ton)
Strength II Moment	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service IIIA Moment	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength II Shear	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x

RATING SUMMARY: P-82C

RATING SUMMARY: P2016-13C

		Controlling			
Basis of Rating		Rating	Controlling	Location	Rating
		Factor	Span No.	Distance	Tonnage
				(ft)	(ton)
Strength II Moment	(OR)	xxx.xx	ii	xxxx.xxx	
Service IIIA Moment	(OR)	xxx.xx	ii	xxxx.xxx	
Strength II Shear	(OR)	xxx.xx	ii	xxxx.xxx	

NOTE: The P-82C live load option is a combination of multiple live loads, so there is no rating tonnage associated with it. Please see DM-4 3.4.1 for more information.

RATING SUMMARY: ML-80

RATING SUMMARY: TK527

RATING SUMMARY: EV2

RATING SUMMARY: EV3

RATING SUMMARY: SU6TV

RATING SUMMARY: HS20

RATING SUMMARY: H20

RATING SUMMARY: SLL #i

		Controlling			
Basis of Rating		Rating	Controlling	Location	Rating
		Factor	Span No.	Distance	Tonnage
				(ft)	(ton)
Strength I Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength IP Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength II Moment	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service I Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service IP Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service III Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service IIIP Moment	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Service IIIA Moment	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength I Shear	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength IP Shear	(IR)	xxx.xx	ii	xxxx.xxx	xxxx.x
Strength II Shear	(OR)	xxx.xx	ii	xxxx.xxx	xxxx.x

Chapter 7 Output Description

7.8.38 Overall Rating Summary

RATING FACTORS - OVERALL SUMMARY						
Governs		Rating Factor	Rating Tonnage (ton)	Span No.	Dist (ft)	Limit State
PHL-93						

Inventory	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
HL-93						

Inventory	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
P-82						

Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
P-82C						

Operating	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
NOTE: The P-82C live load option is a combination of multiple live loads, so there is no rating tonnage associated with it. Please see DM-4 3.4.1 for more information.						
P2016-13						

Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
P2016-13C						

Operating	aaaaaaa	xxx.xx		ii	xxxx.xxx	aaaaaaaa
NOTE: The P2016-13C live load option is a combination of multiple live loads, so there is no rating tonnage associated with it. Please see DM-4 3.4.1 for more information.						
ML-80						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
TK527						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
EV2						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
EV3						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
SU6TV						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
HS20						

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaaa

Chapter 7 Output Description

H20

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaa

SLL #i

Inventory	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaa
Operating	aaaaaaa	xxx.xx	xxxxx.x	ii	xxxx.xxx	aaaaaaa

BRIDGE LOAD RATINGS WITH FWS

BRIDGE LOAD RATINGS WITHOUT FWS

Span	ii	Beam Type and Size: aaaaaaaaaaaaaaaaaaaaaa					
		aaaaaa	aaaaaa	aaaaaa	aaaaaa	aaaaaa	aaaaaa
INVENTORY	Dist. Fact.	x.xxx	x.xxx	x.xxx	x.xxx	x.xxx	x.xxx
RATING	Loc. (ft)	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx
(IR)	Limit State	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa
	RESISTANCE	xxxxxx	aaa	xxxxxx	aaa	xxxxxx	aaa
	RF	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa
		aaaaaa	aaaaaa	aaaaaa	aaaaaa	aaaaaa	aaaaaa
OPERATING	Dist. Fact.	x.xxx	x.xxx	x.xxx	x.xxx	x.xxx	x.xxx
RATING	Loc. (ft)	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx	xxx.xx
(OR)	Limit State	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa	aaaaaaaa
	RESISTANCE	xxxxxx	aaa	xxxxxx	aaa	xxxxxx	aaa
	RF	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa	xxx.xxa

Maximum Factored Flexural Resistance (kip-ft) xxxxxx.xx Span Length(ft) = xxx.xx
Location (ft) xxx.xx

Maximum Factored Shear Resistance (kips) xxxx.xx
Location (ft) xxx.xx

NOTES:

GIVEN DISTRIBUTION FACTOR IS THE VEHICULAR LIVE LOAD DISTRIBUTION FACTOR USED TO PRODUCE THE GIVEN RATING. FOR THE STR-IP LIMIT STATE, THE VEHICULAR LIVE LOAD DISTRIBUTION FACTOR ACCOUNTS FOR THE PRESENCE OF PEDESTRIAN LOADS, IF APPLICABLE.

THE LIVE LOAD EFFECTS OF THE P-82C COMBINATION USE SEVERAL DIFFERENT LIVE LOAD DISTRIBUTION FACTORS. AS SUCH, A SINGLE DISTRIBUTION FACTOR CANNOT BE REPORTED HERE. PLEASE SEE THE "DISTRIBUTION FACTORS FOR P-82C COMBINATION" OUTPUT REPORTS FOR THE RELEVANT DISTRIBUTION FACTORS AND DM-4 EQUATION 3.4.1-3P FOR HOW THEY ARE COMBINED.

THE LIVE LOAD EFFECTS OF THE P-82C AND P2016-13C COMBINATION USE SEVERAL DIFFERENT LIVE LOAD DISTRIBUTION FACTORS. AS SUCH, A SINGLE DISTRIBUTION FACTOR CANNOT BE REPORTED HERE. PLEASE SEE THE "DISTRIBUTION FACTORS FOR P-82C COMBINATION" OUTPUT REPORTS FOR THE RELEVANT DISTRIBUTION FACTORS AND DM-4 EQUATION 3.4.1-3P FOR HOW THEY ARE COMBINED.

ALL RATINGS ARE BASED ON THE INCLUSION OF THE DESIGN FUTURE WEARING SURFACE.
ALL RATINGS ARE BASED ON THE EXCLUSION OF THE DESIGN FUTURE WEARING SURFACE.

SYMBOL DESIGNATION FOR RATING FACTORS:

M - MOMENT RATING FACTOR CONTROLS

V - SHEAR RATING FACTOR CONTROLS

Chapter 7 Output Description

7.8.39 Summary Output

```

                                TS&L DESIGN SUMMARY
                                -----
GENERAL INFORMATION
-----
Span
No.      Length      Beam Type      Strand      28 day      Initial      Slab      Beam
          (ft)                Config.      f'c          f'ci          Thick      Spacing
                      (ksi)          (ksi)          (in)          (ft)
iii      xxxx.x      aaaaaaaaaa      aaaaaaaa      xxx.xxx      xxxx.xxx      xxx.xx      xxx.xxx

INITIAL STRESS CHECK
-----
Span
No.      Loc          Pi          Ag          e          Zt          MDNI
          (ft)          (kips)      (in^2)      (in)        (in^3)      (k-ft)
iii      xxx.xxa      xxxx.x      xxxx.x      xxx.xx      xxxxx.x      xxxxx.x

Span
No.      Loc          f (ti)      f (top)      Failure
          (ft)          (ksi)      (ksi)
iii      xxx.xxa      xx.xxx      xx.xxx      aaaaaaaaaaaaaaaaaaaaaa

+ - drape point location
< - debonding cutoff location
\ - debonding transfer location
& - debonding cutoff and transfer location

FINAL STRESS CHECK @ MAXIMUM MOMENT
-----
Span
No.      Loc          Pe          Ag          e          Zb          Zbc          Zbct
          (ft)          (kips)      (in^2)      (in)        (in^3)      (in^3)      (in^3)
iii      xxx.xx      xxxx.x      xxxx.x      xxx.xx      xxxxx.x      xxxxx.x      xxxxx.x

Span
No.      Loc          MDNF          MDCF          MLCF          MC&S
          (ft)          (k-ft)      (k-ft)      (k-ft)      (k-ft)
iii      xxx.xx      xxxxx.x      xxxxx.x      xxxxx.x      xxxxx.x

Span
No.      Loc          f (t)      f (btm,t)      Failure
          (ft)          (ksi)      (ksi)
iii      xxx.xx      xxx.xxx      xxx.xxx      aaaaaaaaaaaaaaaaaaaaaa

Span
No.      Loc          f (t)      f (btm,t)      Failure
          (ft)          (ksi)      (ksi)
iii      xxx.xx      xxx.xxx      xxx.xxx      aaaaaaaaaaaaaaaaaaaaaa

```

Chapter 7 Output Description

QUALITY ASSURANCE/QUALITY CONTROL SUMMARY

Span No.	Length (ft)	Beam Type	Strand Config.	P/S Strand Diameter (in)	P/S Strand Area (in ²)	Strand Type
iii	xxx.x	aaaaaaaaa	aaaaaaa	xx.xxx	xx.xxx	aaaaaaaaaaaaaaaaaaaaa

MAXIMUM MOMENTS

Span No.	Type	Location (ft)	Max. Unfact. Moment (k-ft)
iii	Positive	xxx.xx	xxxxxx.x
	Negative	xxx.xx	xxxxxx.x

FINAL TENSILE STRESSES IN PRECOMP. TENSILE ZONE

Span No.	Loc (ft)	f(t) (ksi)	Resistance (ksi)	Max. P/S Force (kips)	Ecc (in)	M(r) (k-ft)	M(u) (k-ft)
iii	xxx.xx	xx.xxx	xx.xxx	xxxxx.x	xxx.xx	xxxxxx.x	xxxxxx.x

DETAILER SUMMARY

PRESTRESS INFORMATION

Span No.	Loc (ft)	Pi (kips)	CGS (in)	Number of Strands	28 Day f'c (ksi)	Initial f'c (ksi)	Slab Steel at Support (in ²)
iii	xxx.xxa	xxxxx.x	xxx.xx	iii	xx.xxx	xx.xxx	aaaaaaa

s - simple bearing location
t - transfer location
+ - drape point location

Note: CGS - Center of gravity of prestressing steel measured from the bottom of the beam.

SHEAR REINFORCEMENT

Span No.	Location	Shear Reinforcement Area A(v) (in ²)	Minimum Stirrup Spacing s (in)
iii	0.00 L - 0.10 L	xx.xx	xxx.xx
	0.10 L - 0.25 L	xx.xx	xxx.xx
	0.25 L - 0.40 L	xx.xx	xxx.xx
	0.40 L - 0.50 L	xx.xx	xxx.xx

Chapter 7 Output Description

CROSS SECTION PROPERTIES AT CENTERLINE SPAN ii

NON-COMPOSITE	GROSS SECTION	TRANSFORMED SECTION
Area of Basic Beam, in ²	xxxxxxx.xx	xxxxxxx.xx
Moment of Inertia, in ⁴	xxxxxxx.xx	xxxxxxx.xx
Neutral Axis to Top of Beam, in	xxxxxxx.xx	xxxxxxx.xx
Neutral Axis to Bottom of Beam, in	xxxxxxx.xx	xxxxxxx.xx
Section Modulus to Top of Beam, in ³	xxxxxxx.xx	xxxxxxx.xx
Section Modulus to Bottom of Beam, in ³	xxxxxxx.xx	xxxxxxx.xx
COMPOSITE	GROSS SECTION	TRANSFORMED SECTION
Moment of Inertia, in ⁴	xxxxxxx.xx	xxxxxxx.xx
Neutral Axis to Top of Slab, in	xxxxxxx.xx	xxxxxxx.xx
Neutral Axis to Top of Beam, in	xxxxxxx.xx	xxxxxxx.xx
Neutral Axis to Bottom of Beam, in	xxxxxxx.xx	xxxxxxx.xx
Section Modulus to Top of Slab, in ³	xxxxxxx.xx	xxxxxxx.xx
Section Modulus to Top of Beam, in ³	xxxxxxx.xx	xxxxxxx.xx
Section Modulus to Bottom of Beam, in ³	xxxxxxx.xx	xxxxxxx.xx

7.8.40 Cracking Moment

SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (ML-80:SPECIFICATION CHECK)

SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (TK527:SPECIFICATION CHECK)

SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (HS20:SPECIFICATION CHECK)

SERVICE IIIA 90% YIELD STRESS OF P/S STRANDS (H20:SPECIFICATION CHECK)

Span No.	Distance (ft)	SRV-3A Moment M(u) (k-ft)	Flexural Resistance M(r)@0.9 fpy (k-ft)	SRV-3A LL Moment M(uLL) (k-ft)	* If Code Failure
ii	xxx.xxx	xxxxx.x	xxxxx.x	xxxxx.x	a

CRACKING MOMENT SERVICE CHECK (ML-80:SPECIFICATION CHECK)

CRACKING MOMENT SERVICE CHECK (TK527:SPECIFICATION CHECK)

CRACKING MOMENT SERVICE CHECK (HS20:SPECIFICATION CHECK)

CRACKING MOMENT SERVICE CHECK (H20:SPECIFICATION CHECK)

Span No.	Distance (ft)	SERV-IIIB Moment (k-ft)	Cracking Moment M(cr) (k-ft)	Design Controlled By M(cr)
ii	xxxx.xxx	xxxxxxxx.x	xxxxxxxx.x	a

Chapter 7 Output Description

7.8.41 Shear Reinforcement

```

LIMITS ON HORIZONTAL SHEAR (ML-80:SPECIFICATION CHECK)
-----
LIMITS ON HORIZONTAL SHEAR (TK527:SPECIFICATION CHECK)
-----
LIMITS ON HORIZONTAL SHEAR (HS20:SPECIFICATION CHECK)
-----
LIMITS ON HORIZONTAL SHEAR (H20:SPECIFICATION CHECK)
-----
Span
No.    0.2*f'c*A(cv)  5.5*A(cv)    V(n-max)
No.    0.2*f'c*A(cv)  0.8*A(cv)    V(n-max)
        (kip/in)      (kip/in)      (kip/in)
ii     xxxxx.xx      xxxxx.xx      xxxxx.xx

```

NOTE:

V(n-max) is the lesser of $0.2 \cdot f'c \cdot A(cv)$ or $5.5 \cdot A(cv)$

V(n-max) is the lesser of $0.2 \cdot f'c \cdot A(cv)$ or $0.8 \cdot A(cv)$

```

HORIZONTAL SHEAR (ML-80:SPECIFICATION CHECK)
-----
HORIZONTAL SHEAR (TK527:SPECIFICATION CHECK)
-----
HORIZONTAL SHEAR (HS20:SPECIFICATION CHECK)
-----
HORIZONTAL SHEAR (H20:SPECIFICATION CHECK)
-----

```

Span No.	Distance (ft)	u[Avfy+Pc] (kip/in)	cAcv (kip/in)	V(n-prov) (kip/in)	V(n-req) (kip/in)	Stirrup		Failure Code
						Spacing (in)	Area (in ²)	
ii	xxx.xxxx	xxxx.xx	xxxxxx.xx	xxxx.xx	xxxx.xx	xx.x	xx.x	xxx.x a,a,a

7.8.42 Negative Moment Capacity

```

NEGATIVE MOMENT CAPACITY (ML-80:SPECIFICATION CHECK)
-----
NEGATIVE MOMENT CAPACITY (TK527:SPECIFICATION CHECK)
-----
NEGATIVE MOMENT CAPACITY (HS20:SPECIFICATION CHECK)
-----
NEGATIVE MOMENT CAPACITY (H20:SPECIFICATION CHECK)
-----

```

Span No.	Distance (ft)	Limit State	Factored		Required As/ Eff. Slab Width (in ²)	* If Code Failure
			Flexural Resistance M(r) (k-ft)	Factored Moment M(u) (k-ft)		
ii	xxxx.xxx	STR-I	xxxxxxxxx.x	xxxxxxxxx.x	xxxxxx.xx a	a
		STR-IP		xxxxxxxxx.x	xxxxxx.xx a	a
		STR-II		xxxxxxxxx.x	xxxxxx.xx a	a

! Note: Minimum temperature reinforcement in the top layer of longitudinal slab reinforcement.

Chapter 7 Output Description

7.8.43 Positive Moment Connection

POSITIVE MOMENT CONNECT. STEEL AT CONTINUOUS SUPPORT (ML-80)

POSITIVE MOMENT CONNECT. STEEL AT CONTINUOUS SUPPORT (TK527)

POSITIVE MOMENT CONNECT. STEEL AT CONTINUOUS SUPPORT (HS20)

POSITIVE MOMENT CONNECT. STEEL AT CONTINUOUS SUPPORT (H20)

Support	Nominal Flexural Resistance	Required Steel Area Per Beam	Factored Moment	Limit	
No.	M(n) (k-ft)	A(s) (in^2)	M(u) (k-ft)	State	d(s) (in)
ii	xxxxxxxx.x	xxxxxx.xx	xxxxxxxx.x	aaaaaaaaa	xxx.x

7.8.44 Summary – Specification Checks

SPECIFICATION CHECK WARNINGS

For the live loadings input by the user, the program encountered one or more specification check warnings. Specification check warnings indicate conditions that do not fail a specification check, but may need to be reviewed by the user. The following is a list of output table headings for which warnings have occurred. It should be noted that the program does not perform specification checking corresponding to commands that have not been input by the user.

THE FOLLOWING TABLES OR PAGES HAVE SPEC. CHECK WARNINGS

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa*

* - An asterisk indicates the table was not printed

SPECIFICATION CHECK FAILURES

For the live loadings input by the user, the program encountered one or more specification check failures. The following is a list of output table headings for which failures have occurred. It should be noted that the program does not perform specification checking corresponding to commands that have not been input by the user.

THE FOLLOWING TABLES HAVE SPEC. CHECK ERRORS

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa*

* - An asterisk indicates the table was not printed

Chapter 7 Output Description

7.8.45 f'c Optimization

f'c OPTIMIZATION MESSAGES

NOTE: The following messages are for the f'c optimizaton. If the optimization fails, disregard these pages. If the optimization passes, the following output represents values with the adjusted f'c.

Attempting f'c optimization with f'c = x.xx (ksi)

The f'c optimization has failed for this iteration.
The previous value of f'c (x.xxx (ksi)) will be used.

Chapter 7 Output Description

7.9 SPECIFICATION CHECK WARNINGS

This output table gives a summary of the titles of all of the output tables, which contain a specification check warning or any warning messages requiring approval by the Chief Bridge Engineer. Even if a specification checking output table and/or an analysis point is not printed (i.e. if the user only desires output at 10th points or user-defined points only), the specification check is done, and if a warning occurs, the output table title will appear on this report. For Chief Bridge Engineer messages the output page number is reported. This table prints for both design and analysis runs, and will still print, even if all other output is turned off.

A sample specification check warning table is shown in Figure 1.

```
LRFD P/S Concrete Girder Design and Rating, Version 2.0.1.0(TEST)  PAGE  40
Input File: scd_test.dat                                03/10/2004  10:24:55
-----
                          79 A04 OVER NS & SEMERAD
                        SUMMARY - SPECIFICATION CHECKS
-----

                        SPECIFICATION CHECK WARNINGS
                        -----
For the live loadings input by the user, the program encountered
one or more specification check warnings. Specification check
warnings indicate conditions that do not fail a specification
check, but may need to be reviewed by the user. The following is a
list of output table headings for which warnings have occurred.
It should be noted that the program does not perform specification
checking corresponding to commands that have not been input by the
user.

THE FOLLOWING TABLES OR PAGES HAVE SPEC. CHECK WARNINGS
-----
%WARNING: **THIS MUST BE APPROVED BY CHIEF BRIDGE ENGINEER** on Page 9
NEGATIVE MOMENT CAPACITY (DESIGN LIVE LOADING)
SLAB STEEL AT CONTINUOUS SUPPORTS
```

Figure 7.9-1 Specification Check Warnings Page

Chapter 7 Output Description

7.10 SPECIFICATION CHECK FAILURES

This output table gives a summary of the titles of all of the output tables, which contain a specification check failure. Even if a specification checking output table and/or an analysis point is not printed (i.e. if the user only desires output at 10th points or user-defined points only), the specification check is done, and if a failure occurs, the output table title will appear on this report. This table prints for both design and analysis runs, and will still print, even if all other output is turned off.

A sample specification check failure table is shown in Figure 1.

LRFD P/S Concrete Girder Design and Rating, Version 1.4	PAGE 39
Input File: EX2.DAT	08/19/1999 11:10:32

PROBLEM #2 - 1 Span Adjacent Box (82 feet)	
SUMMARY - SPECIFICATION CHECKS	

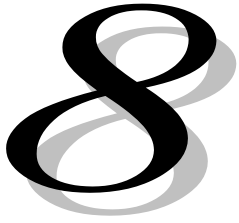
SPECIFICATION CHECK FAILURES	

For the live loadings input by the user, the program encountered one or more specification check failures. The following is a list of output table headings for which failures have occurred. It should be noted that the program does not perform specification checking corresponding to commands that have not been input by the user.	
THE FOLLOWING TABLES HAVE SPEC. CHECK ERRORS	

INITIAL STRESSES AT TRANSFER OF PRESTRESS	
FINAL TENSILE STRESSES-DESIGN LOADS	
* - An asterisk indicates the table was not printed	

Figure 7.10-1 Specification Check Failures Page

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EXAMPLE PROBLEMS

8.1 EXAMPLE PROBLEMS

This chapter contains the example problems used to test and verify this program. Table 1 shows the example problem matrix, which lists each example problem and the key input items used to differentiate the problems. For each example problem, the following information is given: a brief narrative description of the problem; sketches which illustrate the unique characteristics of the problem; the input items from the example problem matrix; and additional assumptions and input items required to create the input data file. The actual input data file for each example problem is not listed in this manual but is included electronically along with the executable program.

Chapter 8 Example Problems

Table 8.1-1 Example Problem Matrix

Input Item	Example Problem					
	1	2	3	4	5	6
Multi-Span Analysis Opt.	S	S	S	S	S	S
Number of Spans	2	1	1	1	1	3
System of Units	US	US	US	US	US	US
Span Lengths (ft)	141, 141	82	110	20	115	120, 130, 120
Symmetry Option	N	N	Y	N	N	N
Beam Designation ⁽¹⁾	P	U	U	U	P	P
Shape of Beam ⁽²⁾	I	AR	S	P	I	I
Composite/Non-composite	C	C	C	N	C	C
Slab Thickness (in)	8.0	6.0	8.0	N/A	10.0	9.0
Design/Analysis Indicator	D	A	D	A	A	D
Actual Width of Beam (in)	N/A	48	48	36	N/A	N/A
Interior/Exterior Girder	I	E	I	I	E	E
Girder Spacing (ft)	8.0	4.0	11.0	3.0	12.0	9.25
Beam Conc. Comp. Strength (ksi)	8.0	6.5	8.0	5.0	8.0	8.0
Slab Conc. Comp. Strength (ksi)	4.0	4.0	4.0	N/A	4.0	4.0
Type of Strands ⁽³⁾	L	L	L	L	L	L
Configuration of Strands ⁽⁴⁾	DR	ST	DR	ST	ST	ST, DE, ST
P/S Steel Ultimate Strength (ksi)	270	250	270	250	270	270
PennDOT Skew Angle (degree)	90	75	60	75	68	63
Live Load Type ⁽⁵⁾	LRFD	LRFD	LRFD	SPVH	LRFD	LRFD
Strand Pattern Given	N	Y	N	Y	Y	N

(1) P - PennDOT Beam, U - User Specified Beam

(2) I - I Beam, AR - Adjacent Box with Rectangular Opening, AC - Adjacent Box with Circular Opening, S - Spread Box, P - Adjacent Plank Beam, F - Type F NEXT Beam, D - Type D NEXT Beam

(3) L - Low Relaxation Strands, S - Stress Relieved Strands

(4) DR - Draped, ST - Straight, DE - Debonded

(5) LRFD - Live Load Specified by LRFD, SPVH - Live Load due to Special Vehicle

Chapter 8 Example Problems

Table 8.1-1 Example Problem Matrix (Cont.)

Input Item	Example Problem					
	7	8	9	10	11	12
Multi-Span Analysis Opt.	S	S	S	S	S	S
Number of Spans	4	2	1	3	1	1
System of Units	US	US	US	US	US	US
Span Lengths (ft)	92, 115, 98, 82	60, 70	125	80, 80, 80	66	64
Symmetry Option	N	N	N	N	N	N
Beam Designation ⁽¹⁾	U	P	P	U	P	P
Shape of Beam ⁽²⁾	S	S	I	AR	F	D
Composite/Non-composite	C	C	C	C	C	N
Slab Thickness (in)	9.0	8.0	10.0	6.0	8.0	0.0
Design/Analysis Indicator	A	D	A	A	D	A
Actual Width of Beam (in)	48	48	N/A	36	106	96
Interior/Exterior Girder	I	I	E	E	I	E
Girder Spacing (ft)	11.83	12.0	9.17	3.0	8.875	8.75
Beam Conc. Comp. Strength (ksi)	8.0	8.0	8.0	8.0	8.0	8.0
Slab Conc. Comp. Strength (ksi)	4.0	4.0	4.0	4.0	4.0	N/A
Type of Strands ⁽³⁾	L	L	L	L	L	L
Configuration of Strands ⁽⁴⁾	DR,DR,DR,DR	ST	DE	DR	DE	DE
P/S Steel Ultimate Strength (ksi)	270	270	270	250	270	270
PennDOT Skew Angle (degree)	60	75	75	68	90	90
Live Load Type ⁽⁵⁾	LRFD	LRFD	LRFD	LRFD	LRFD	LRFD
Strand Pattern Given	Y	N	Y	Y	N	Y

⁽¹⁾ P - PennDOT Beam, U - User Specified Beam

⁽²⁾ I - I Beam, AR - Adjacent Box with Rectangular Opening, AC - Adjacent Box with Circular Opening, S - Spread Box, P – Adjacent Plank Beam, F – Type F NEXT Beam, D – Type D NEXT Beam

⁽³⁾ L - Low Relaxation Strands, S - Stress Relieved Strands

⁽⁴⁾ DR - Draped, ST - Straight, DE - Debonded

⁽⁵⁾ LRFD - Live Load Specified by LRFD, SPVH - Live Load due to Special Vehicle

Chapter 8 Example Problems

8.2 EXAMPLE 1

Example 1 is a two-span problem with span lengths of 141 feet each. This example is a design of a composite, interior girder. A PennDOT I-beam is used with low relaxation strands, with a draped strand configuration. A girder spacing of 8 feet is used with no skew. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the design.

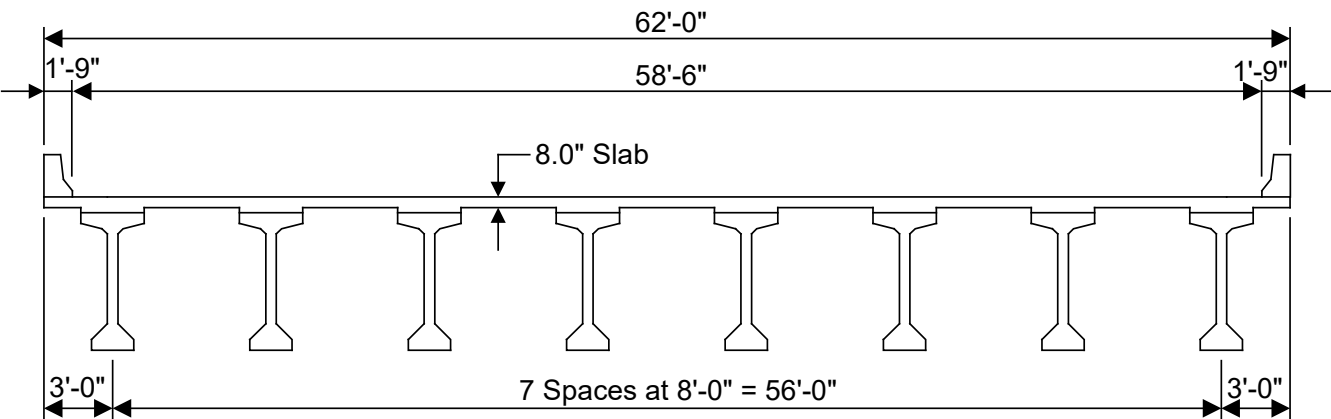
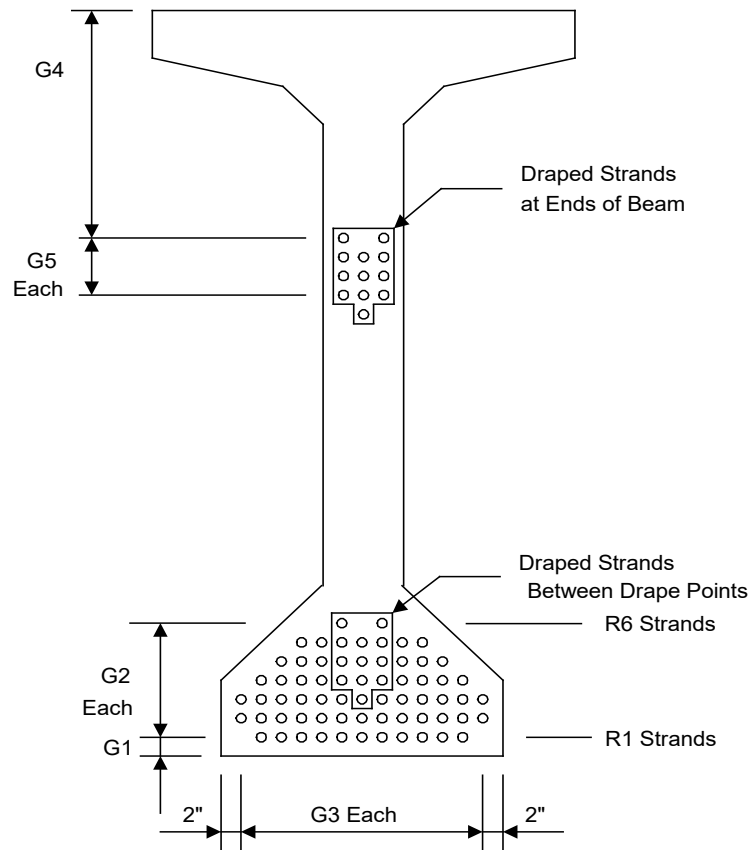


Figure 8.2-1 Example 1 Deck Cross Section

Chapter 8 Example Problems



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program

Figure 8.2-2 Example 1 Beam Strand Pattern

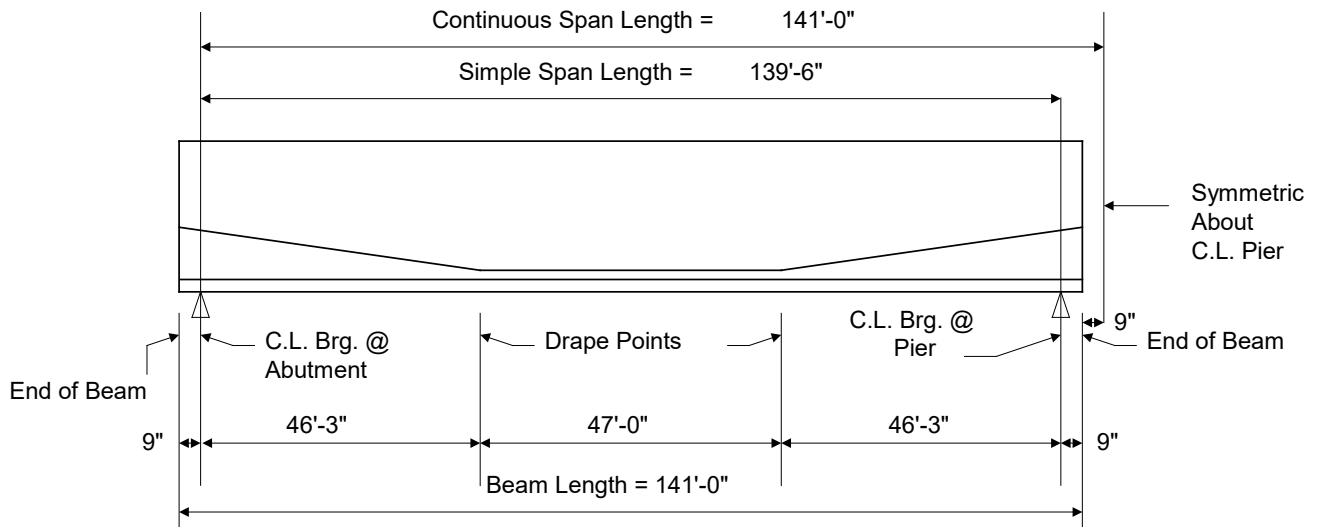


Figure 8.2-3 Example 1 Beam Elevation

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	IBeam-AASHTO	INTERIOR	8	2	NO	P

Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type
Adj. Factor						
1.00	E	1.330	1.150	N/A	L	LR

Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor
1.00	70.00	Y	N	1.000	1.000	1.000

Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age
D	P	N	2	S	1.200	120.00

Overhang to Beam Depth Override	Allow Use of Center Line Strands For Spread Box Beams
N	N

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
8.000	3.000	4	0.500	9.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext. Girder to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
0.000	0.000	12.000	6.000	4.000	0.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DRAPED
2	DRAPED

SPAN LENGTHS

Span No.	1	2
Length (ft)	141.000	141.000

Chapter 8 Example Problems

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left	Distance to right	Skew Correction Application
		Simple Span Bearing (ft)	Simple Span Bearing (ft)	
1	90.000	0.000	0.000	R
2	90.000	1.500	1.500	B
3	90.000	0.000	0.000	L

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	U	S

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	189.00	243.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0
2	60.0	60.0	1.00	1.00	1.00	90.0

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio
N	66.00	96.00	0.0	0.	8.00	0.50	0.850

Chapter 8 Example Problems

STRAND CONFIGURATION - DESIGN (1 OF 3)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in ²)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	12.00	32
2	0.500	0.153	n/a	2.00	2.00	12.00	32

STRAND CONFIGURATION - DESIGN (2 OF 3)

Span No.	Available Strand Positions in each Row at MidSpan																			
	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
1	11	13	13	11	9	7	5	3	3	3	3	3	3	3	3	3	3	3	3	3
2	11	13	13	11	9	7	5	3	3	3	3	3	3	3	3	3	3	3	3	3

STRAND CONFIGURATION - DESIGN (3 OF 3)

Span No.	Available Strand Positions in each Row at MidSpan											
	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32
1	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft ³)	Density Ec (lb/ft ³)	Haunch Depth for Section Prop (in)	Slab Concrete Type
8.000	7.500	0.500	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in ² /ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	3.750	0.500	5	90.0	B

DRAPE POINT LOCATION

Span No.	% Drap	Point Location Left	Point Location Right
1		33.154	66.846
2		33.154	66.846

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in ²)	Shear Reinf. Spacing (in)	Horizontal Area (in ²)	Shear Reinf. Spacing (in)
1	0.000	0.4	0.0	0.4	0.0
	139.500	0.4	0.0	0.4	0.0
2	0.000	0.4	0.0	0.4	0.0
	142.500	0.4	0.0	0.4	0.0

Chapter 8 Example Problems

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
DC1	1	0.000	1	139.500	0.1100	0.1100
DC1	2	1.500	2	141.000	0.1100	0.1100
ED	1	0.000	1	139.500	0.0600	0.0600
ED	2	1.500	2	141.000	0.0600	0.0600
FWS	1	0.000	2	141.000	0.2195	0.2195
DC2	1	0.000	2	141.000	0.1265	0.1265

OVERHANG

Future WS (in)	Future WS Density (lb/ft^3)	Weight of Rail (kip/ft)	Parapet Weight (kip/ft)	Parapet Width (in)	Weight of Formwork (psf)	Dist. to Curb (ft)	Overhang Gage Dist. (ft)
2.00	179.7	0.00	0.50	21.00	13.75	2.000	6.000

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	0.00	0.00	0.00	n/a	N
1R	0.00	0.00	0.00	n/a	N
2L	0.00	0.00	0.00	n/a	N
2R	0.00	0.00	0.00	n/a	N

GIRDER STABILITY (Part 1)

Span No.	Overhang Distance (ft)	Cable Angle (deg)	Wind Pressure (psf)	Impact Factor (%)	Lifting Loops Eccentricity (in)	Lifting Loops Rigid Extension (in)	Lateral Deflection (Sweep) (in)
1	8.500	90.0	2.5	0.0	0.500	0.000	1.763
2	8.500	90.0	2.5	0.0	0.500	0.000	1.763

Span No.	Concrete Strength At Lift (ksi)	Camber At Lift (in)
1	6.800	2.500
2	6.800	2.500

GIRDER STABILITY (Part 2)

Span No.	Concrete Seating (ksi)	Camber at Seating (in)	Sweep at Seating (in)	P/S Force at Seating (kips)	Active Const. Wind Press. (psf)	Bearing Rotational Stiffness (in*kip/rad)
1	8.000	2.40	1.763	1917.1	2.50	50000.0
2	8.000	2.40	1.763	1917.1	2.50	50000.0

Span No.	Bearing Height (in)	Bearing Width (in)	Bearing Tolerance from C.L. (in)	Bearing Level Tolerance (ft/ft)	Inactive Wind Pressure (psf)	Construction Vert. Wind Pressure (psf)	End Bracing Provided	Number of Intermediate Braces
1	4.000	24.000	0.500	0.005	40.000	10.000	Y	6
2	4.000	24.000	0.500	0.005	40.000	10.000	Y	6

Chapter 8 Example Problems

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non- Composite	Total DL Non-Composite
1	1	1	0	1	0	1

DL Creep/ Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
0	1	0	1	1	0	0

Factored Reactions	Overall Reaction Summary
0	1

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	1	1	1

Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	1	0	1	1	1	0

Girder Stability	Rating Vehicle Stresses	Shear Detail
1	0	0

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	1	1	0	0

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.3 EXAMPLE 2

Example 2 is a single-span problem with a span length of 82 feet. This example is an analysis of a composite, exterior girder. A user-specified, adjacent box beam with a rectangular opening is used with low relaxation strands, with a straight strand configuration. A girder spacing of 4 feet is used with a PennDOT skew angle of 75 degrees. The beam concrete strength is 6.5 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 250 ksi. A PHL-93 live loading is used in the analysis.

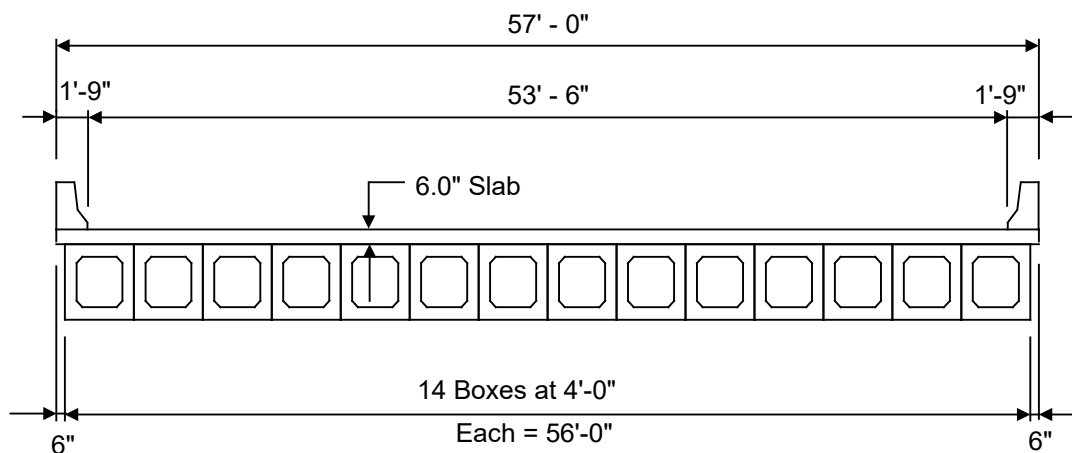
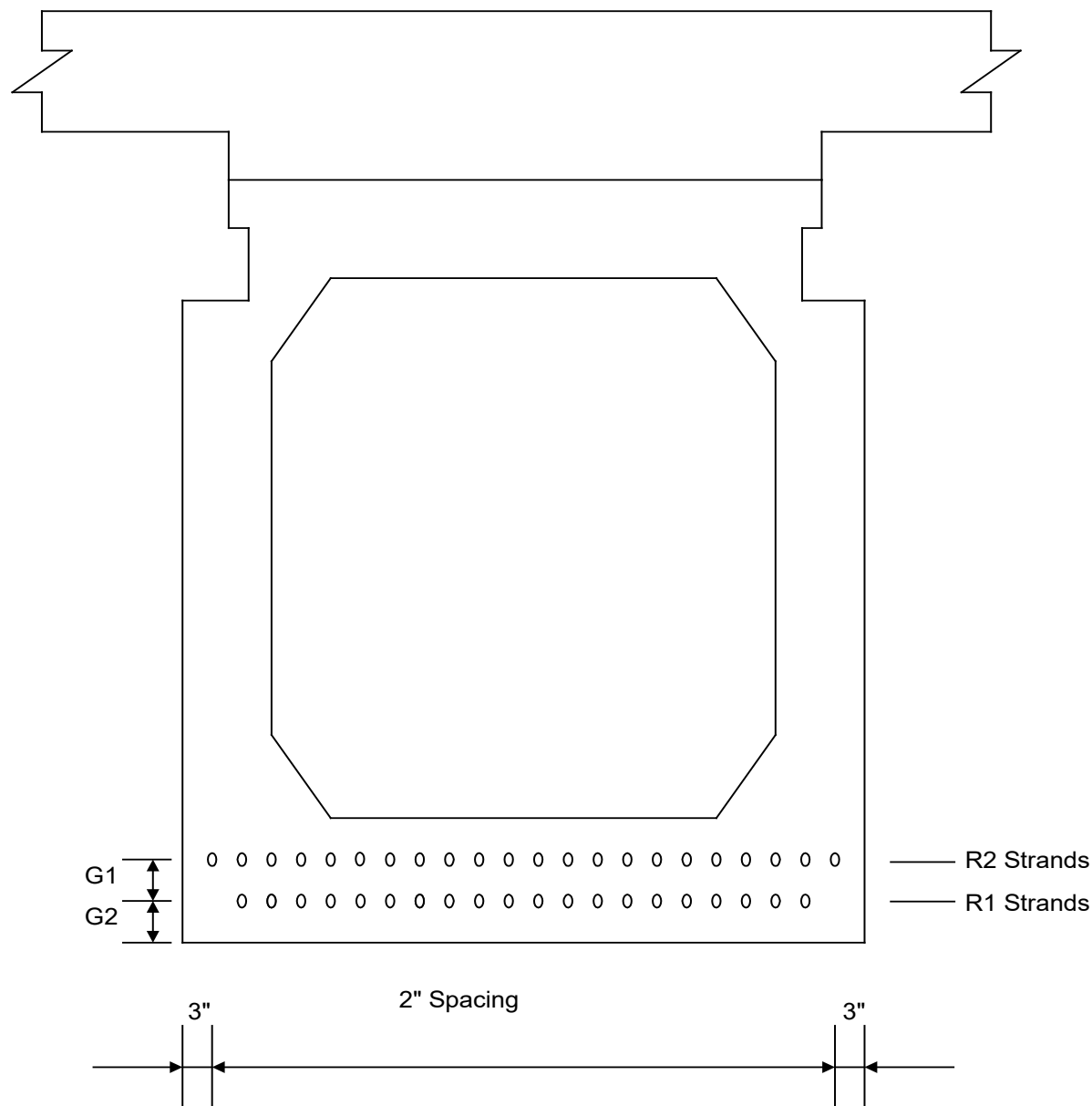


Figure 8.3-1 Example 2 Deck Cross Section



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.3-2 Example 2 Beam Strand Pattern

CONFIGURATION	

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Chapter 8 Example Problems

CONTROL PARAMETERS							

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	ADJ BOX RECT	EXTERIOR	14	1	NO	U
Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type	
Adj. Factor							
1.00	A	1.330	1.150	N/A	L	LR	
Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor	
2.00	70.00	Y	Y	1.000	1.000	1.000	
Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age	
A	P	N	2	S	1.200	120.00	
Overhang to Beam Depth Override	Allow Use of Center Line Strands For Spread Box Beams						
N	N						

BEAM GEOMETRY						

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)	
4.000	2.500	4	0.286	9.000	20.250	

USER DEFINED DISTRIBUTION FACTOR					

Span No.	D.F. Type	Moment DF1	Moment DF2	Shear DF1	Shear DF2
1	Design	0.3519	0.3519	0.5644	0.5644
1	Fatigue	0.3437	0.3437	0.3437	0.3437

USER DEFINED REACTION DISTRIBUTION FACTOR		

Support Number	D.F. Type	Reaction DF
1	Design	0.5644
1	Fatigue	0.3437

SPAN SPECIFIC INPUT	

Span Number	Straight/ Draped/ Debonded
1	STRAIGHT

SPAN LENGTHS	

Span No.	Length (ft)
1	82.000

Chapter 8 Example Problems

SUPPORT INFORMATION				
Support No.	Angle (deg)	Distance to left Simple Span Bearing	Distance to right Simple Span Bearing	Skew Correction Application
		(ft)	(ft)	
1	75.000	0.000	0.000	R
2	75.000	0.000	0.000	L

BEAM CONCRETE MATERIAL PROPERTIES		
Span No.	28 day Spec. Compr. Strength f'c (ksi)	Initial Strength f'ci (ksi)
1	6.500	5.500

CONCRETE MATERIAL ALLOWABLE								
(All locations except centerline of bearing)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-3.300	0.222	-3.900	0.242	-2.600	-2.600	-2.400	0.490

(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-3.300	0.222	-3.900	0.242	-2.600	-2.600	-2.400	0.490

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)				
Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	I	S

PRESTRESSING STEEL MATERIAL PROPERTIES				
P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
250.00	175.00	212.50	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES						
Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)						
Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)
1	USER	33.000	48.000	47.250	5.000	5.500
						T2 (in)
						3.000

Chapter 8 Example Problems

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	3.000	3.000	3.000	3.000	6.000	6.000	0.375	0.750

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	1.5	0.0	3.00	0.00	4	4

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	44c	n/a	2

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span No.	Number of Strands in each Row at MidSpan	
	R01	R02
1	22	22

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
6.000	5.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	4.000	0.200	5	90.0	B

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	-0.250	1	6
		2	6
	2.250	1	4
		2	4

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Shear Reinf. Area (in^2)	Vertical Shear Reinf. Spacing (in)	Horizontal Shear Reinf. Area (in^2)	Horizontal Shear Reinf. Spacing (in)
1	0.000	0.4	12.0	0.8	24.0
	82.000	0.4	12.0	0.8	24.0

Chapter 8 Example Problems

CONCENTRATED LOADS								

		Load Type	Span	Dist. (ft)	Start Magnitude (kips)			
		ID	1	41.000	1.000			
DISTRIBUTED LOADS								

		Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
		ID	1	0.000	1	82.000	0.0193	0.0193
		DC1	1	0.000	1	82.000	0.0240	0.0240
		DC2	1	0.000	1	82.000	0.0720	0.0720
		FWS	1	0.000	1	82.000	0.1150	0.1150
BEAM DETAILING								

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	End Substructure Type			
1L	21.00	6.00	6.00	33.00	N			
1R	21.00	6.00	6.00	33.00	N			
OUTPUT OF INPUT DATA								

		Input File Echo	Input Commands	Input Summary				
		1	0	1				
OUTPUT OF ANALYSIS RESULTS								

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite		
1	1	1	0	1	0	1		
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects		
0	1	0	1	1	0	0		
Factored Reactions	Overall Reaction Summary							
0	1							
OUTPUT OF SPECIFICATION CHECKING								

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data		
1	0	0	1	0	1	1		
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses		
0	0	0	0	1	0	0		
Girder Stability	Rating Vehicle Stresses	Shear Detail						
0	1	0						

Chapter 8 Example Problems

OUTPUT OF RATING FACTORS				

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	0	1	0	1

OUTPUT SUMMARY		

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.4 EXAMPLE 3

Example 3 is a single-span problem with a span length of 110 feet and using the symmetry option. This example is a design of a composite, interior girder. A user-specified spread box beam is used with low relaxation strands, with a draped strand configuration. A girder spacing of 11 feet is used with a PennDOT skew angle of 60 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the design.

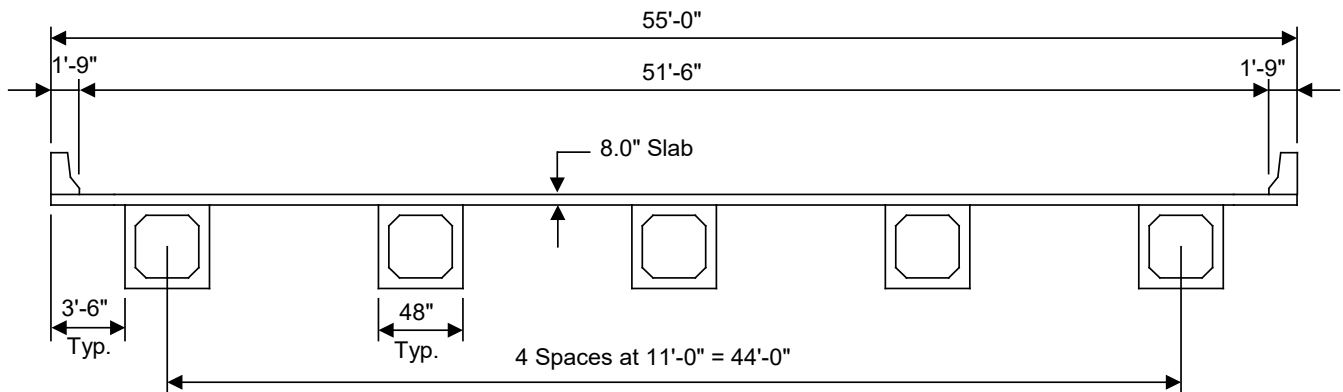
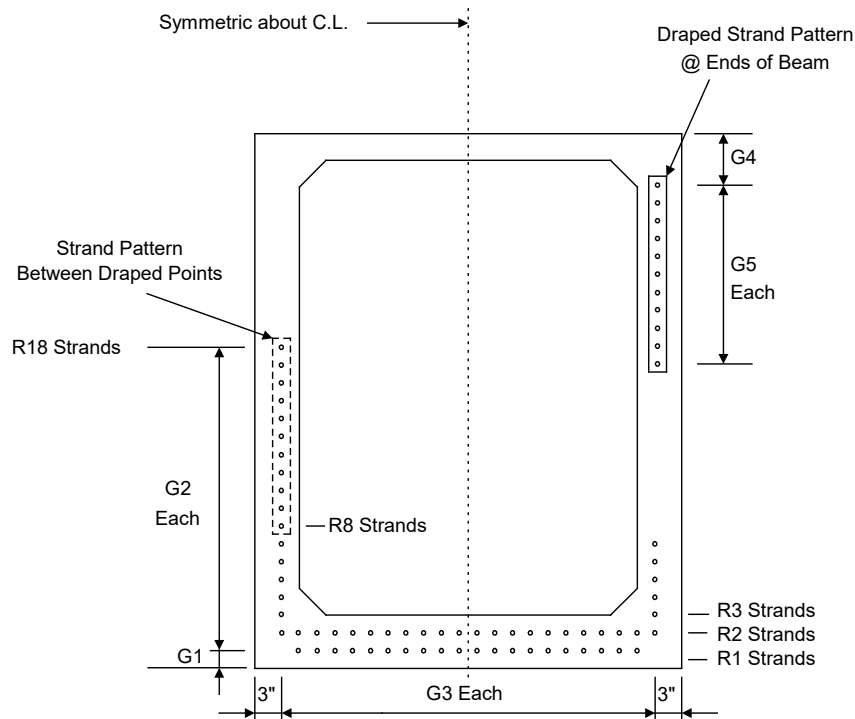


Figure 8.4-1 Example 3 Deck Cross Section



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.4-2 Example 3 Beam Strand Pattern

Chapter 8 Example Problems

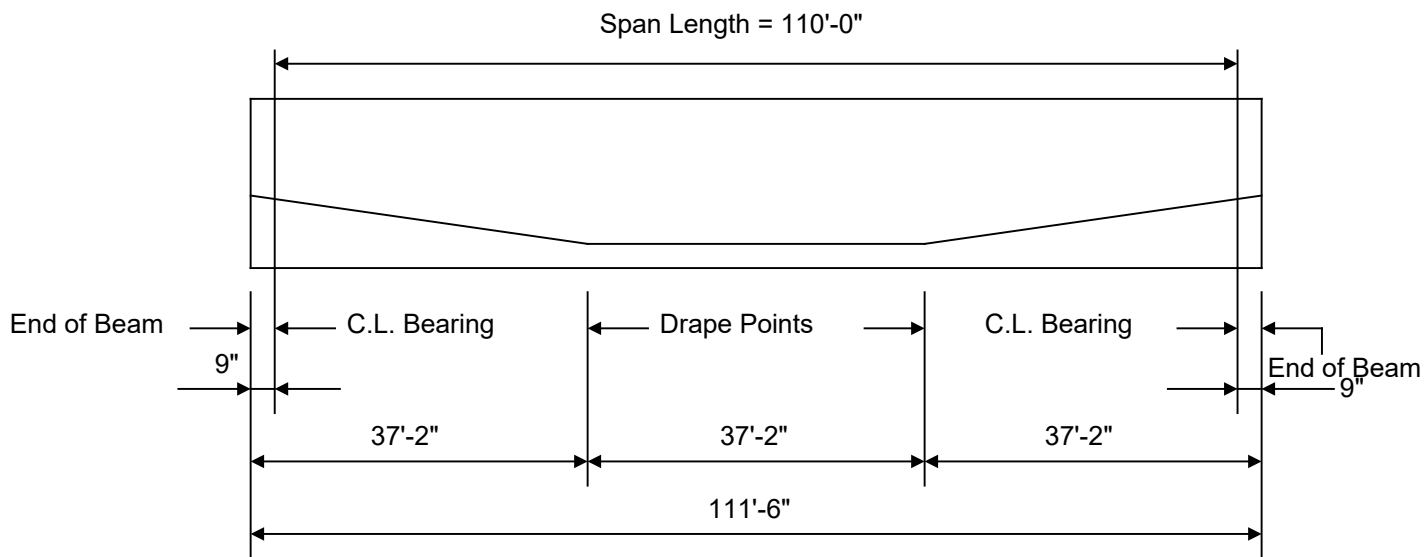


Figure 8.4-3 Example 3 Beam Elevation

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	SPR BOX RECT	INTERIOR	5	1	YES	U
Multiple Presence Adj. Factor	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type	
1.00	E	1.330	1.150	N/A	L	LR	
Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor	
30.00	70.00	Y	N	1.000	1.000	1.000	
Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age	
D	P	N	2	S	1.200	120.00	
Overhang to Beam Depth Override	Allow Use of Center Line Strands For Spread Box Beams						
N	N						

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
11.000	5.500	4	1.000	9.000	20.250

Chapter 8 Example Problems

USER DEFINED DISTRIBUTION FACTOR

Span No.	D.F. Type	Moment DF1	Moment DF2	Shear DF1	Shear DF2
1	Design	0.7200	0.7200	1.0180	1.0180
1	Fatigue	0.3490	0.3490	0.7950	0.7950

USER DEFINED REACTION DISTRIBUTION FACTOR

Support Number	D.F. Type	Reaction DF
1	Design	1.0180
1	Fatigue	0.7950

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DRAPED

SPAN LENGTHS

Span No.	1
Length (ft)	110.000

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application
1	60.000	0.000	0.000	N
2	60.000	0.000	0.000	N

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.200	0.251	-4.800	0.268	-3.200	-3.200	-2.400	0.543

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.200	0.251	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lbf/ft^3)	Beam Unit Wt. for E (lbf/ft^3)	Slab Beam Interface	Steam/Moist Cured
1.60	150.0	145.0	I	M

Chapter 8 Example Problems

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio
N	66.00	66.00	6.0	48.	8.00	0.50	0.875

STRAND CONFIGURATION - DESIGN (1 OF 3)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	10.00	28

STRAND CONFIGURATION - DESIGN (2 OF 3)

Span	Available Strand Positions in each Row at MidSpan																
No.	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17
1	20	22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

STRAND CONFIGURATION - DESIGN (3 OF 3)

Span	Available Strand Positions in each Row at MidSpan							
No.	R21	R22	R23	R24	R25	R26	R27	R28
1	2	2	2	2	2	2	2	2

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
8.000	7.500	0.500	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	7.000	0.370	6	90.0	B

DRAPE POINT LOCATION

Span No.	% Drape Left	Point Location Right
1	33.106	66.894

Chapter 8 Example Problems

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in ²)	Shear Reinf. Spacing (in)	Horizontal Area (in ²)	Shear Reinf. Spacing (in)
1	0.000	0.4	0.0	0.4	0.0
	110.000	0.4	0.0	0.4	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ID	1	0.000	1	55.000	0.0260	0.0260
ED	1	0.000	1	55.000	0.0640	0.0640
DC1	1	0.000	1	55.000	0.1100	0.1100
DC2	1	0.000	1	55.000	0.2530	0.2530
FWS	1	0.000	1	55.000	0.3300	0.3300

OVERHANG

Future WS (in)	Future WS Density (lb/ft ³)	Weight of Rail (kip/ft)	Parapet Weight (kip/ft)	Parapet Width (in)	Weight of Formwork (psf)	Dist. to Curb (ft)	Overhang Gage Dist. (ft)
0.50	130.0	0.00	0.51	21.00	10.00	2.000	6.000

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. Block Length (in)	End Substructure Type
1L	15.50	3.50	3.50	30.00	N
1R	15.50	3.50	3.50	30.00	N

OUTPUT OF INPUT DATA

Input File	Input Echo	Input Commands	Input Summary
1	1	0	1

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	1	0	1	0	1
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
0	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
0	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	0	1	1

Chapter 8 Example Problems

Fatigue Stress Range 0	Longitudinal Slab Reinforcement 0	Positive Moment Connection 0	Overhang Width 1	Camber and Deflection 1	Strand Code Detail 1	Principal Stresses 0
Girder Stability 0	Rating Vehicle Stresses 0	Shear Detail 0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors 0	Live Load Rating 1	Overall Rating Summary 1	Rating Vehicle Specification Checking 0	Ratings w/o FWS 0

OUTPUT SUMMARY

TS&L Design Summary 0	Q/A-Q/C Summary 0	Detailer Summary 0

Chapter 8 Example Problems

8.5 EXAMPLE 4

Example 4 is a single-span problem with a span length of 20 feet. This example is an analysis of a Non-composite, interior girder. A user-specified adjacent plank beam is used with low relaxation strands, with a straight strand configuration. A girder spacing of 3 feet is used with a PennDOT skew angle of 75 degrees. The beam concrete strength is 5.0 ksi, there is no slab, and the prestressing steel ultimate strength is 250 ksi. A special vehicle live loading is used in the analysis. The special vehicle consists of four axles, with axle weights of 13.70 kips, 20.60 kips, 20.60 kips, and 20.60 kips. The spacing between the 13.70 kip axle and the next axle is 10 feet. The remaining two axle spacings are 4 feet each.

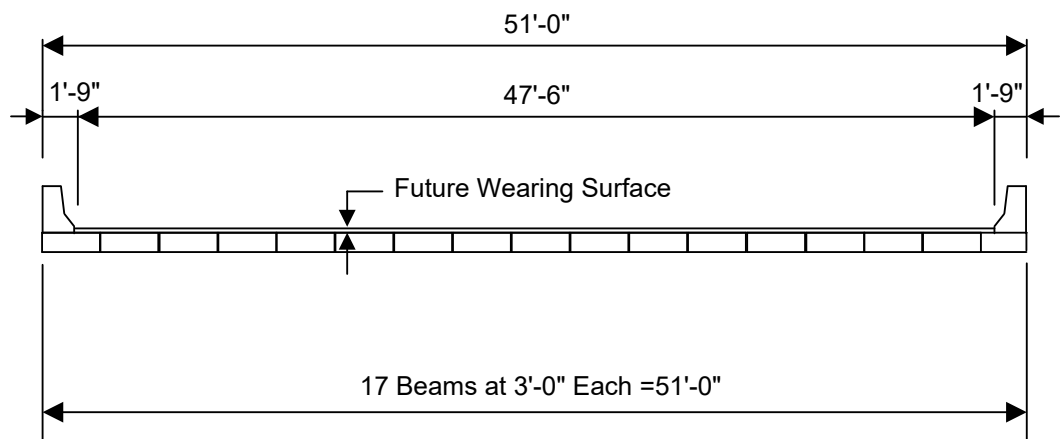
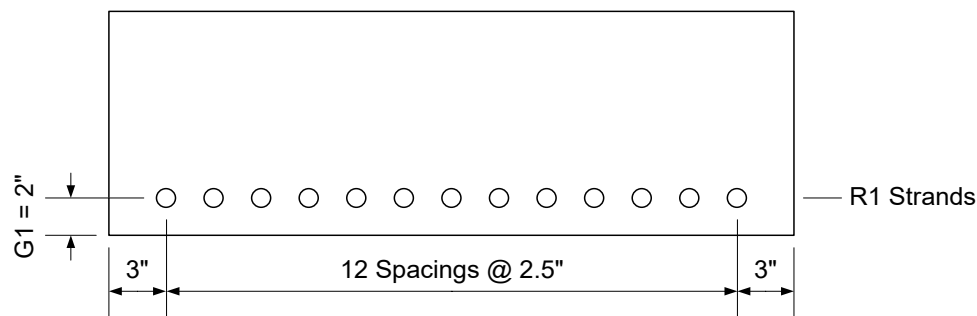


Figure 8.5-1 Example 4 Superstructure Cross Section



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern used by the current version of the program.

Figure 8.5-2 Example 4 Beam Strand Pattern

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	PLANK	INTERIOR	17	1	NO	U

Multiple Presence	Live Load	Dyn. Load	Fatigue	PA		P/S
Adj. Factor	Code	Allowance	Dyn. Load	Traffic	Strand	Loss
1.00	E	1.330	Allowance	Factor	Type	Type
			1.150	N/A	L	LR

Prestress						
Transfer	Relative	Composite	Skew	Impor.	Duct.	Redun.
Time	Humidity	Beam	Override	Factor	Factor	Factor
1.00	70.00	N	N	1.000	1.000	1.000

Shear	Skew	Shrinkage		Multi-Span	Permit	Deck
Design/ Analysis	Angle Desig.	Analysis Only	Output Points	Analysis Method	Dyn. Load Allowance	Placement Age
D	P	N	2	S	1.200	120.00

Overhang to Beam Depth	Allow Use of Center Line Strands
Override	For Spread Box Beams
N	N

BEAM GEOMETRY

Girder	Deck	No. of	Defl.		
Spacing	Overhang	Design	Dist.	Beam	Parapet
(ft)	(ft)	Lanes	Factor	Projection	Width
3.000	1.500	3	0.176	9.000	21.000

USER DEFINED DISTRIBUTION FACTOR

Span	D.F.	Moment	Moment	Shear	Shear
No.	Type	DF1	DF2	DF1	DF2
1	Design	0.2860	0.2860	0.4970	0.4970
1	Fatigue	0.2380	0.2380	0.4140	0.4140

USER DEFINED REACTION DISTRIBUTION FACTOR

Support	D.F.	Reaction
Number	Type	DF
1	Design	0.4970
1	Fatigue	0.4140

SPAN SPECIFIC INPUT

	Straight/ Draped/ Debonded
Span Number	
1	STRAIGHT

Chapter 8 Example Problems

SPAN LENGTHS

Span No. 1
Length (ft) 20.000

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application
1	75.000	0.000	0.000	N
2	75.000	0.000	0.000	N

BEAM CONCRETE MATERIAL PROPERTIES

Span No.	28 day Spec. Compr. Strength f'c (ksi)	Initial Strength f'ci (ksi)
1	5.500	5.000

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-3.000	0.212	-3.300	0.222	-2.200	-2.200	-0.001	0.450

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-3.000	0.212	-3.300	0.222	-2.200	-2.200	-0.001	0.450

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/Moist Cured
1.60	150.0	145.0	U	S

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
250.00	187.50	212.50	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

Chapter 8 Example Problems

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
1	USER	12.000	36.000	35.250	0.000	0.000	0.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	0.000	0.000	0.000	0.000	3.000	4.000	0.375	0.750

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	10.00	10.00	4	4

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.520	0.167	n/a	2.00	2.00	10c	n/a	2

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span No.	Number of Strands in each Row at MidSpan	
1	R01	R02
1	6	4

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	2.250	1	2

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in^2)	Shear Reinf. Spacing (in)	Horizontal Area (in^2)	Shear Reinf. Spacing (in)
1	0.000	0.2	0.0	0.0	0.0
	20.000	0.2	0.0	0.0	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
FWS	1	0.000	1	20.000	0.0900	0.0900

SPECIAL LIVE LOAD

LL No.	Axle Effect	Lane Load (kip/ft)	Percentage Increase	Vehicle Type
1	N	0.000	3.000	D

Chapter 8 Example Problems

SPECIAL AXLE LOAD								
LL No.	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)	Axle Load (kip)	Spacing (ft)
1	13.700	10.000	20.600	4.000	20.600	4.000	20.600	0.000

BEAM DETAILING					
Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	0.00	0.00	0.00	n/a	N
1R	0.00	0.00	0.00	n/a	N

OUTPUT OF INPUT DATA		
Input File	Input Echo	Input Commands
1	1	0

OUTPUT OF ANALYSIS RESULTS						
Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	1	0	1	1	1
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
1	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
1	1					

OUTPUT OF SPECIFICATION CHECKING						
Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	0	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
1	0	0	0	1	0	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
0	1	0				

OUTPUT OF RATING FACTORS					
Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS	
1	1	1	0	1	

Chapter 8 Example Problems

OUTPUT SUMMARY		

TS&L		
Design	Q/A-Q/C	Detailer
Summary	Summary	Summary
0	0	0

Chapter 8 Example Problems

8.6 EXAMPLE 5

Example 5 is a single-span problem with a span length of 115 feet. This example is an analysis of a composite, exterior girder. A PennDOT I-beam is used with low relaxation strands, with a straight strand configuration. A girder spacing of 12 feet is used with a PennDOT skew angle of 68 degrees. The beam concrete strength is 9.8 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the analysis.

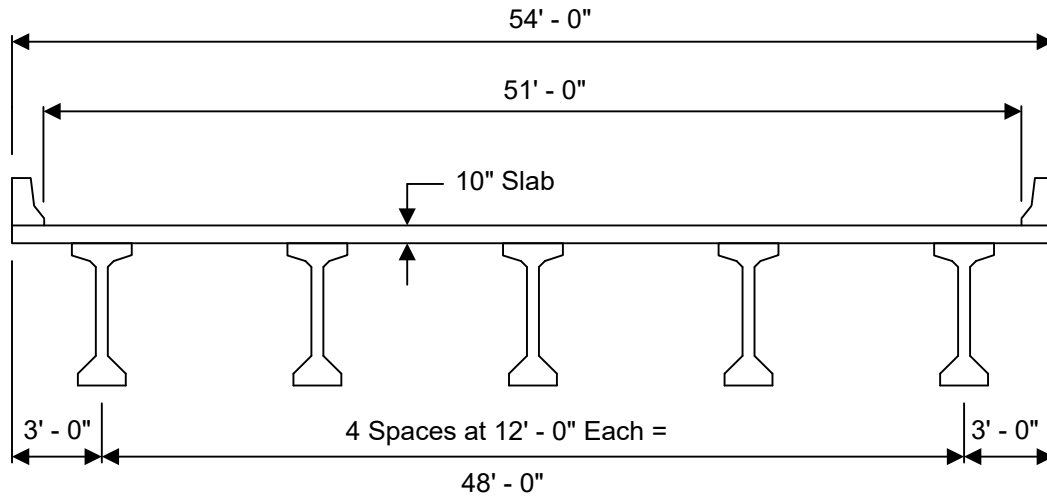


Figure 8.6-1 Example 5 Deck Cross Section

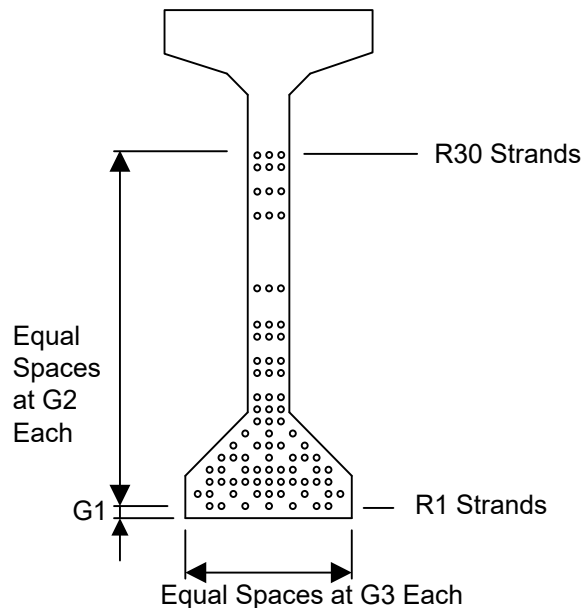


Figure 8.6-2 Example 5 Beam Strand Pattern

NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern used by the current version of the program.

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	IBeam-AASHTO	EXTERIOR	5	1	NO	P

Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type
Adj. Factor						
1.00	A	1.330	1.150	N/A	L	LR

Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor
1.00	70.00	Y	N	1.000	1.000	1.000

Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age
A	P	N	2	S	1.200	90.00

Overhang to Beam Depth	Allow Use of Center Line Strands
Override	For Spread Box Beams
N	N

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
12.000	3.000	4	0.800	9.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext. Girder to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
1.500	-0.500	12.000	6.000	2.000	0.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	STRAIGHT

SPAN LENGTHS

Span No.	1
Length (ft)	115.000

Chapter 8 Example Problems

SUPPORT INFORMATION				
Support No.	Angle (deg)	Distance to left Simple Span Bearing	Distance to right Simple Span Bearing	Skew Correction Application
		(ft)	(ft)	
1	68.000	0.000	0.000	R
2	68.000	0.000	0.000	L

BEAM CONCRETE MATERIAL PROPERTIES		
Span No.	28 day Spec. Compr. Strength f'c (ksi)	Initial Strength f'ci (ksi)
1	8.000	6.800

CONCRETE MATERIAL ALLOWABLE								
(All locations except centerline of bearing)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)				
Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	U	S

PRESTRESSING STEEL MATERIAL PROPERTIES				
P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES						
Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)						
Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)
1	2890	90.000	28.000	42.000	8.000	8.000
						T2 (in)
						5.000

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PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	10.000	10.000	4.000	4.000	3.000	0.000	13.000	0.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	0.00	0.00	3	3

STRAND CONFIGURATION - ANALYSIS (1 OF 3)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	77c	n/a	30

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF 3)

Span No.	Number of Strands in each Row at MidSpan																			
1	7	7	9	7	5	3	3	3	3	3	0	3	3	0	3	3	0	0	3	0

STRAND CONFIGURATION - ANALYSIS (3 OF 3)

Span No.	Number of Strands in each Row at MidSpan									
1	0	0	0	0	3	0	3	0	3	3

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
10.000	9.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	5.000	0.398	6	90.0	B

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	-0.250	1	3
		2	4
		3	3
		4	4

Chapter 8 Example Problems

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in ²)	Shear Reinf. Spacing (in)	Horizontal Area (in ²)	Shear Reinf. Spacing (in)
1	0.000	0.4	12.0	0.4	16.0
	115.000	0.4	12.0	0.4	16.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ED	1	0.000	1	115.000	0.0600	0.0600
DC1	1	0.000	1	115.000	0.3800	0.3800
DC2	1	0.000	1	115.000	0.2500	0.2500
FWS	1	0.000	1	115.000	0.3000	0.3000

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	End Substructure Type
1L	0.00	0.00	0.00	n/a	N
1R	0.00	0.00	0.00	n/a	N

GIRDER STABILITY (Part 1)

Span No.	Overhang Distance (ft)	Cable Angle (deg)	Wind Pressure (psf)	Impact Factor (%)	Lifting Loops Eccentricity (in)	Lifting Loops Rigid Extension (in)	Lateral Deflection (Sweep) (in)
1	8.000	90.0	2.5	0.0	0.500	0.000	1.456

Span No.	Concrete Strength At Lift (ksi)	Camber At Lift (in)
1	6.800	2.000

GIRDER STABILITY (Part 2)

Span No.	Concrete Strength Seating (ksi)	Camber at Seating (in)	Sweep at Seating (in)	P/S Force at Seating (kips)	Active Const. Wind Press. (psf)	Bearing Rotational Stiffness (in*kip/rad)
1	8.000	2.20	1.456	1908.5	2.50	50000.0

Span No.	Bearing Height (in)	Bearing Width (in)	Bearing Tolerance from C.L. (in)	Bearing Level Tolerance (ft/ft)	Inactive Wind Pressure (psf)	Construction Vert. Wind Pressure (psf)	End Bracing Provided	Number of Intermediate Braces
1	3.000	24.000	0.500	0.005	45.000	10.000	Y	2

GIRDER STABILITY (Part 3)

Span No.	Concrete Strength Casting (ksi)	Formwork Extension (ft)	Screed Rail Distance (in)	Thickness Deck Overhang (in)	Weight SIP Forms (psf)	Weight Cantilever Forms (psf)	Live Load on Deck (psf)
1	8.000	2.00	2.50	12.00	15.0	20.0	25.0

Chapter 8 Example Problems

Span	Live Load		Length of
No.	from	Live Load	Live Load
	Screed	on Walkway	on Walkway
	(kips)	(lbf/ft)	(ft)
1	5.000	75.0	20.0

OUTPUT OF INPUT DATA

Input	Input	Input
File Echo	Commands	Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS

Section	Analysis	Distribution	Points of	Loads/Load	DL Non-	Total DL
Properties	Points	Factors	Contraflexure	Modifiers	Composite	Non-Composite
1	1	1	0	1	1	1

DL Creep/ Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
1	1	0	1	1	1	1

Factored Reactions	Overall Reaction Summary
1	1

OUTPUT OF SPECIFICATION CHECKING

Design	Final Compressive			Negative		
Stresses	Stresses Under	End Block	Cracking	Moment	Shear	Prestressing
1	LL + 1/2 (DL+PS)	Stresses	Moment	Capacity	Reinforcement	Data
	1	0	1	0	1	1

Fatigue	Longitudinal	Positive			Strand	
Stress	Slab	Moment	Overhang	Camber and	Code	Principal
Range	Reinforcement	Connection	Width	Deflection	Detail	Stresses
1	0	0	0	1	0	0

Girder	Rating	
Stability	Vehicle	Shear
1	Stresses	Detail
	1	0

OUTPUT OF RATING FACTORS

Detailed	Live	Overall	Rating Vehicle	Ratings
Rating	Load	Rating	Specification	w/o
Factors	Rating	Summary	Checking	FWS
1	1	1	1	1

OUTPUT SUMMARY

TS&L		
Design	Q/A-Q/C	Detailer
Summary	Summary	Summary
0	0	0

Chapter 8 Example Problems

8.7 **EXAMPLE 6**

Example 6 is a three-span problem with span lengths of 120 feet, 130 feet, and 120 feet. This example is a design of a composite, exterior girder. A PennDOT I-beam is used with low relaxation strands, with debonded strands. A girder spacing of 9.25 feet is used with a PennDOT skew angle of 63 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the design.

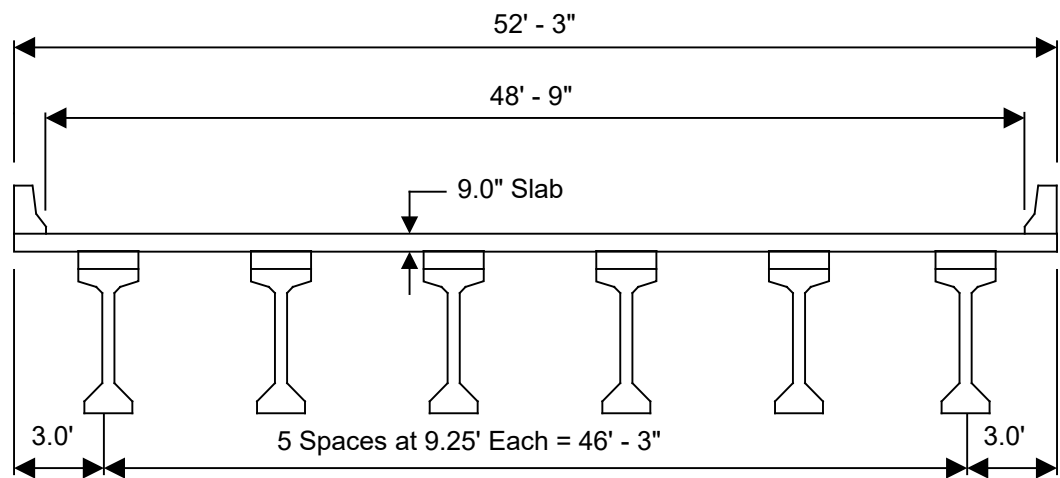
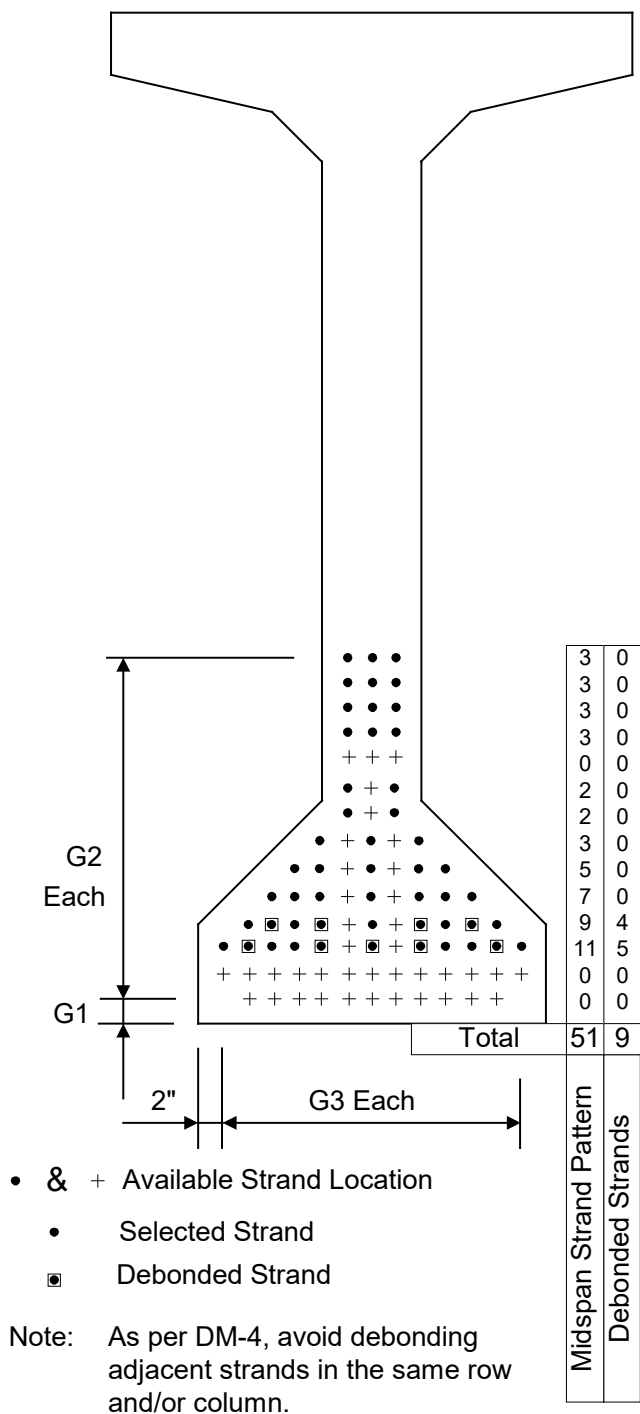


Figure 8.7-1 Example 6 Deck Cross Section



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.7-2 Example 6 Beam Strand Pattern of Second Span Beam

Chapter 8 Example Problems

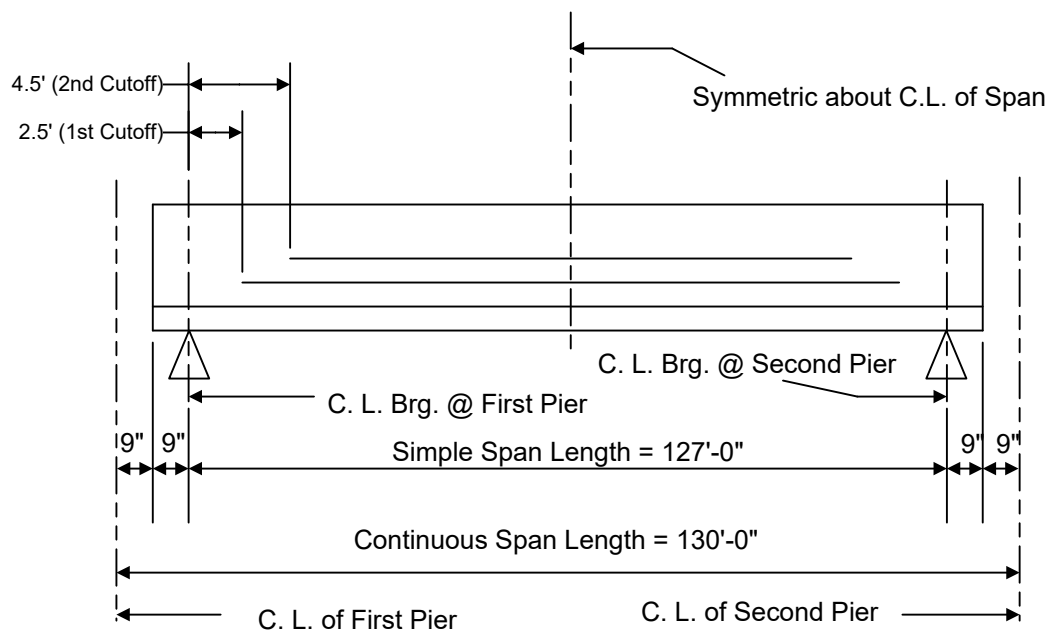


Figure 8.7-3 Example 6 Elevation of Second Span Beam

CONFIGURATION							
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CONTROL PARAMETERS							
Units	Design/Analysis	Shape of Beam	Exterior/Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	IBEAM-AASHTO	EXTERIOR	6	3	NO	P
Multiple Presence		Live Load	Dyn. Load	Fatigue Dyn. Load	PA Traffic	Strand Type	P/S Loss
Adj. Factor		Code	Allowance	Allowance	Factor	Type	Type
1.00		E	1.330	1.150	N/A	L	LR
Prestress Transfer Time							
Relative Humidity		Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor	
70.00		Y	Y	1.000	1.000	1.000	
Shear Design/Analysis	Skew Angle	Shrinkage Analysis	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age	
D	P	N	2	S	1.200	120.00	
Overhang to Beam Depth		Allow Use of Center Line Strands					
Override		For Spread Box Beams					
N		N					

Chapter 8 Example Problems

BEAM GEOMETRY								
Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)			
9.250	3.000	4	0.667	9.000	20.250			
COMPUTED DISTRIBUTION FACTORS								
CL Ext. to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)			
1.250	-0.750	12.000	6.000	4.000	0.000			
SPAN SPECIFIC INPUT								
Span Number	Straight/ Draped/ Debonded							
1	STRAIGHT							
2	DEBONDED							
3	STRAIGHT							
SPAN LENGTHS								
Span No.	1	2	3					
Length (ft)	120.000	130.000	120.000					
SUPPORT INFORMATION								
Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application				
1	63.000	0.000	0.000	R				
2	63.000	1.500	1.500	B				
3	63.000	1.500	1.500	B				
4	63.000	0.000	0.000	L				
CONCRETE MATERIAL ALLOWABLE								
(All locations except centerline of bearing)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.600

Chapter 8 Example Problems

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/Moist Cured
1.60	150.0	145.0	I	S

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0
2	60.0	60.0	1.00	1.00	1.00	90.0
3	60.0	60.0	1.00	1.00	1.00	90.0

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/f'c Ratio
N	90.00	90.00	0.0	0.	8.00	0.50	0.850

STRAND CONFIGURATION - DESIGN (1 OF 3)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	n/a	36
2	0.500	0.153	1	2.00	2.00	n/a	36
3	0.500	0.153	n/a	2.00	2.00	n/a	36

STRAND CONFIGURATION - DESIGN (2 OF 3)

Span No.	Available Strand Positions in each Row at MidSpan																			
	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
1	11	13	13	11	9	7	5	3	3	3	3	3	3	3	3	3	3	3	3	3
2	11	13	13	11	9	7	5	3	3	3	3	3	3	3	3	3	3	3	3	3
3	11	13	13	11	9	7	5	3	3	3	3	3	3	3	3	3	3	3	3	3

STRAND CONFIGURATION - DESIGN (3 OF 3)

Span No.	Available Strand Positions in each Row at MidSpan																			
	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	R33	R34	R35	R36				
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3				
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3				
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3				

Chapter 8 Example Problems

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
9.000	8.500	0.500	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	3.000	0.385	6	90.0	B

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in^2)	Shear Reinf. Spacing (in)	Horizontal Area (in^2)	Shear Reinf. Spacing (in)
1	0.000	0.4	0.0	0.4	0.0
	118.500	0.4	0.0	0.4	0.0
2	0.000	0.4	0.0	0.4	0.0
	130.000	0.4	0.0	0.4	0.0
3	0.000	0.4	0.0	0.4	0.0
	121.500	0.4	0.0	0.4	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ED	1	0.000	1	118.500	0.0430	0.0430
ED	2	1.500	2	128.500	0.0430	0.0430
ED	3	1.500	3	118.500	0.0430	0.0430
DC1	1	0.000	1	118.500	0.1920	0.1920
DC1	2	1.500	2	128.500	0.1920	0.1920
DC1	3	1.500	3	118.500	0.1920	0.1920
DC2	1	0.000	1	120.000	0.2525	0.2525
DC2	2	0.000	2	130.000	0.2525	0.2525
DC2	3	0.000	3	120.000	0.2525	0.2525
FWS	1	0.000	1	120.000	0.2435	0.2435
FWS	2	0.000	2	130.000	0.2435	0.2435
FWS	3	0.000	3	120.000	0.2435	0.2435

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	0.00	0.00	0.00	n/a	N
1R	0.00	0.00	0.00	n/a	N
2L	0.00	0.00	0.00	n/a	N
2R	0.00	0.00	0.00	n/a	N
3L	0.00	0.00	0.00	n/a	N
3R	0.00	0.00	0.00	n/a	N

Chapter 8 Example Problems

GIRDER STABILITY (Part 1)

Span No.	Overhang Distance (ft)	Cable Angle (deg)	Wind Pressure (psf)	Impact Factor (%)	Lifting Loops Eccentricity (in)	Lifting Loops Rigid Extension (in)	Lateral Deflection (Sweep) (in)
1	8.000	90.0	2.5	0.0	0.500	0.000	1.500
2	8.000	90.0	2.5	0.0	0.500	0.000	1.606
3	8.000	90.0	2.5	0.0	0.500	0.000	1.500

Span No.	Concrete Strength At Lift (ksi)	Camber At Lift (in)
1	6.800	1.500
2	6.800	1.500
3	6.800	1.500

GIRDER STABILITY (Part 2)

Span No.	Concrete Seating (ksi)	Camber at Seating (in)	Sweep at Seating (in)	P/S Force at Seating (kips)	Active Const. Wind Press. (psf)	Bearing Rotational Stiffness (in*kip/rad)
1	8.000	1.80	1.500	1511.9	2.50	25000.0
2	8.000	1.80	1.606	1635.9	2.50	25000.0
3	8.000	1.80	1.500	1511.9	2.50	25000.0

Span No.	Bearing Height (in)	Bearing Width (in)	Bearing Tolerance from C.L. (in)	Bearing Level Tolerance (ft/ft)	Inactive Construction Wind Pressure (psf)	End Bracing Provided	Number of Intermediate Braces
1	4.000	20.000	0.500	0.005	40.000	Y	4
2	4.000	20.000	0.500	0.005	40.000	Y	4
3	4.000	20.000	0.500	0.005	40.000	Y	4

GIRDER STABILITY (Part 3)

Span No.	Concrete Strength Casting (ksi)	Formwork Extension (ft)	Screed Rail Distance (in)	Thickness Deck Overhang (in)	Weight SIP Forms (psf)	Weight Cantilever Forms (psf)	Live Load on Deck (psf)
1	8.000	3.00	6.00	10.50	15.0	20.0	25.0
2	8.000	3.00	6.00	10.50	15.0	20.0	25.0
3	8.000	3.00	6.00	10.50	15.0	20.0	25.0

Span No.	Live Load from Screed (kips)	Live Load on Walkway (lbf/ft)	Length of Live Load on Walkway (ft)
1	5.500	75.0	20.0
2	5.500	75.0	20.0
3	5.500	75.0	20.0

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	1	0	1	0	1

Chapter 8 Example Problems

DL Creep/ Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
1	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
0	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	1	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	1	0	0	1	1	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
1	0	0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	1	1	0	0

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.8 EXAMPLE 7

Example 7 is a four-span problem with span lengths of 92 feet, 115 feet, 98 feet, and 82 feet, without using the symmetry option. This example is an analysis of a composite, interior girder. A user-specified spread box beam is used with low relaxation strands, with a draped strand configuration. A girder spacing of 11.83 feet is used with a PennDOT skew angle of 60 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. PHL-93, ML-80, and TK527 live loadings are used in the analysis.

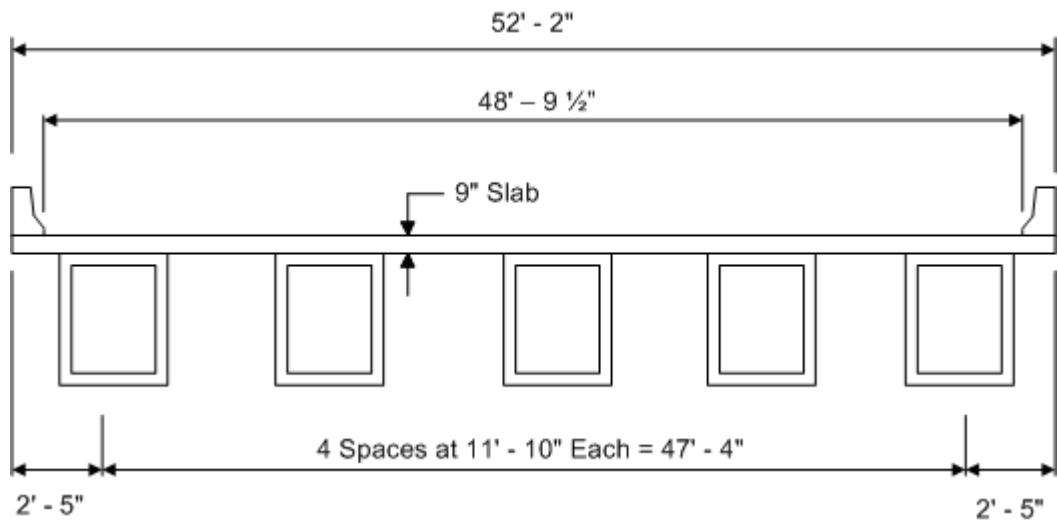


Figure 8.8-1 Example 7 Deck Cross Section

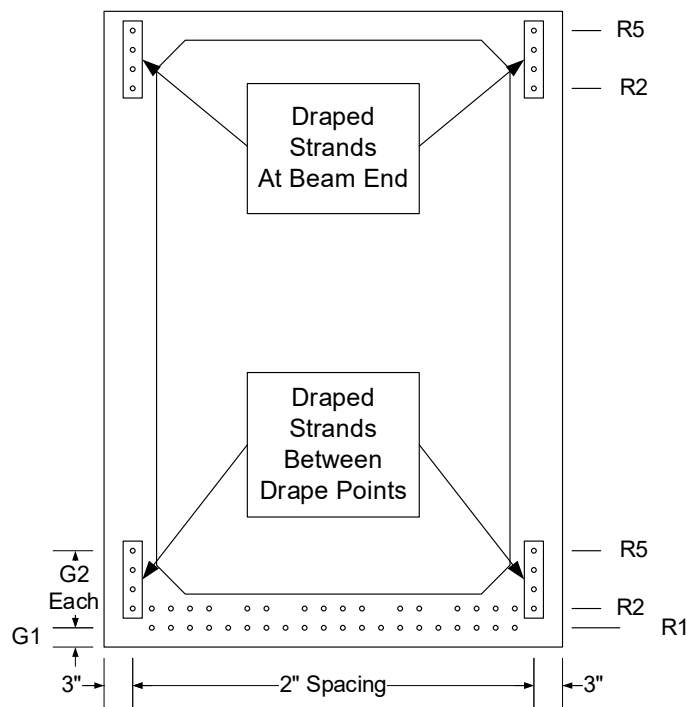


Figure 8.8-2 Example 7, Spans 1 and 3 Beam Strand Pattern

Chapter 8 Example Problems

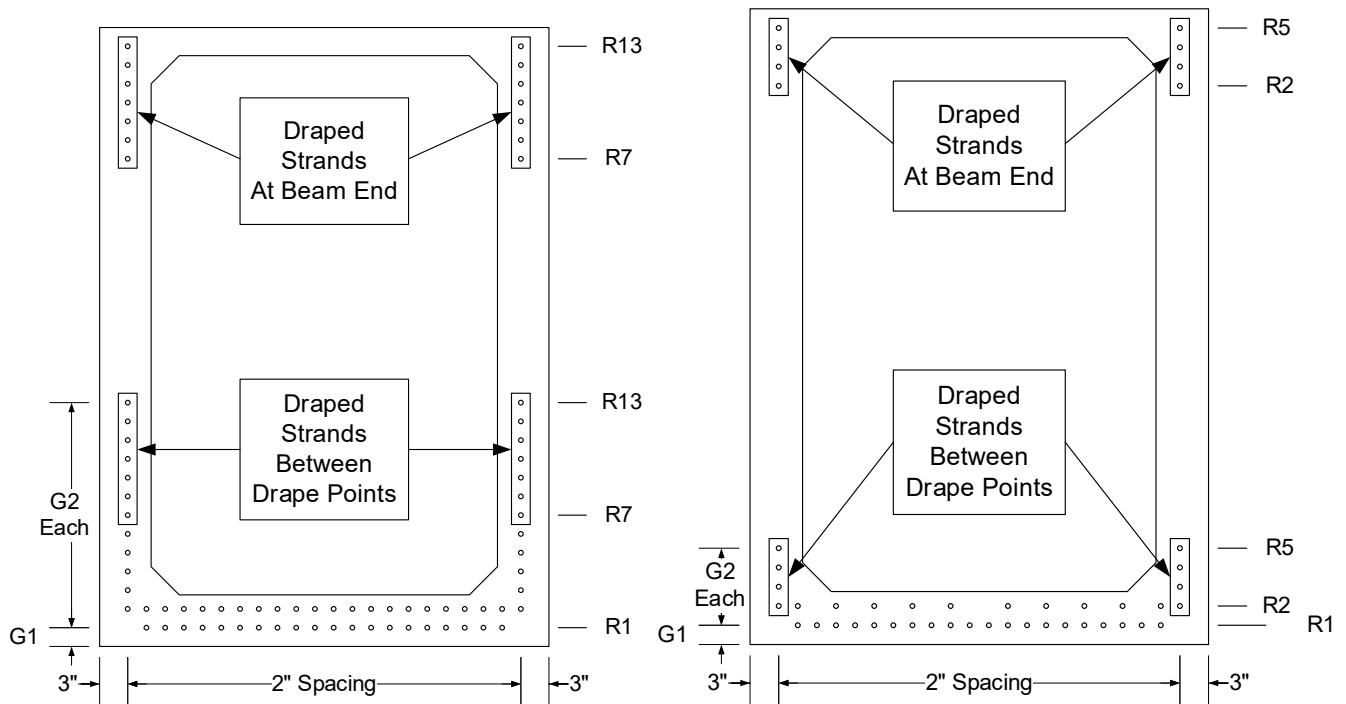


Figure 8.8-3 Example 7, Spans 2 and 4 Beam Strand Pattern

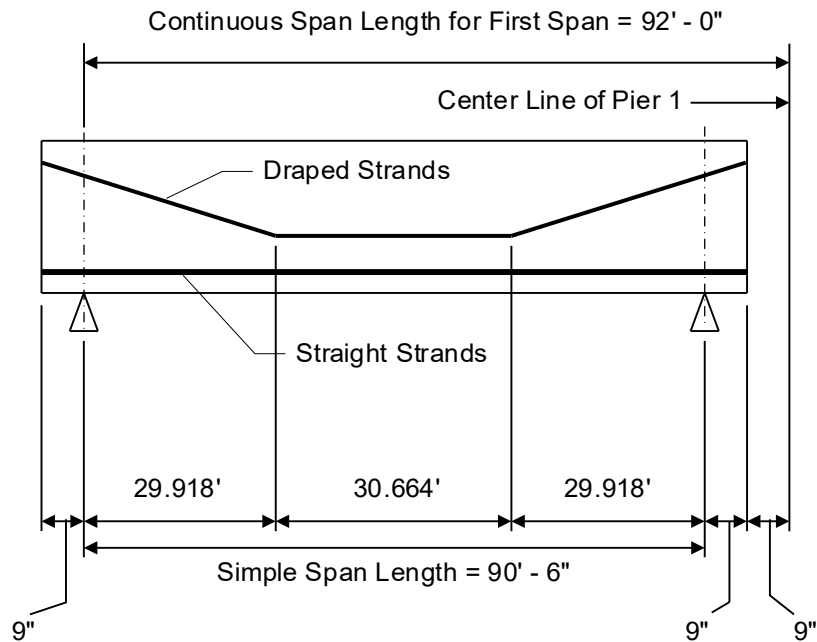


Figure 8.8-4 Example 7 Elevation of First Span Beam

Chapter 8 Example Problems

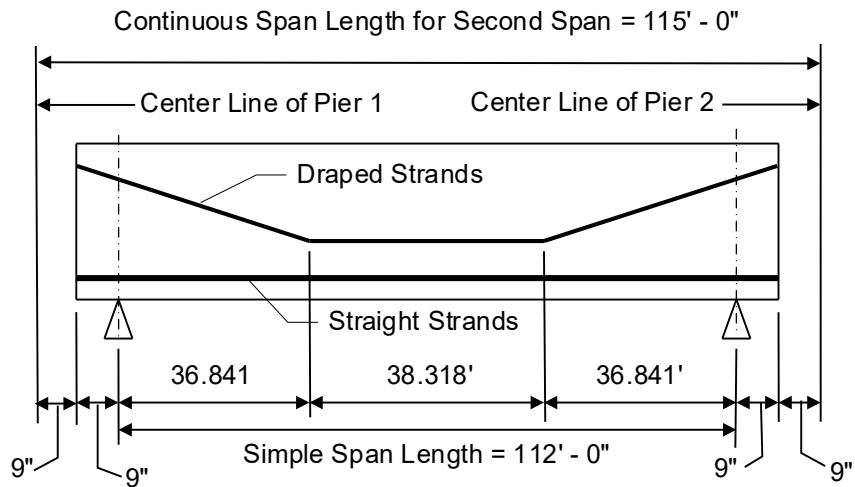


Figure 8.8-5 Example 7 Elevation of Second Span Beam

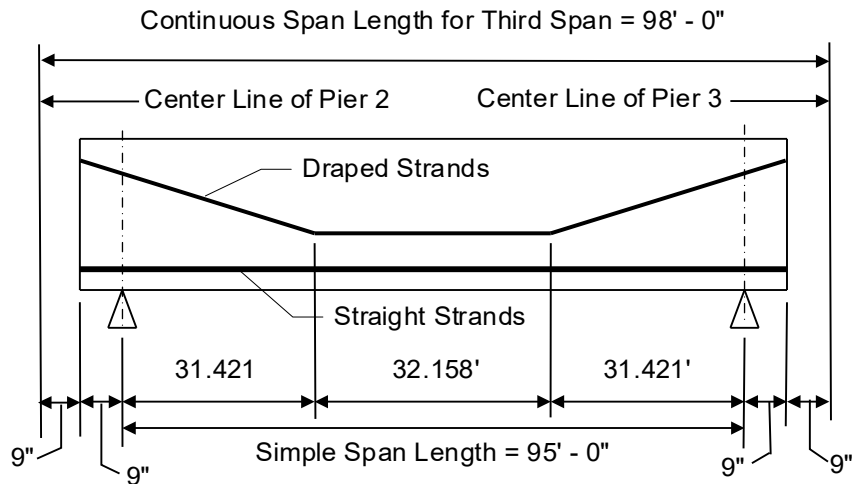


Figure 8.8-6 Example 7 Elevation of Third Span Beam

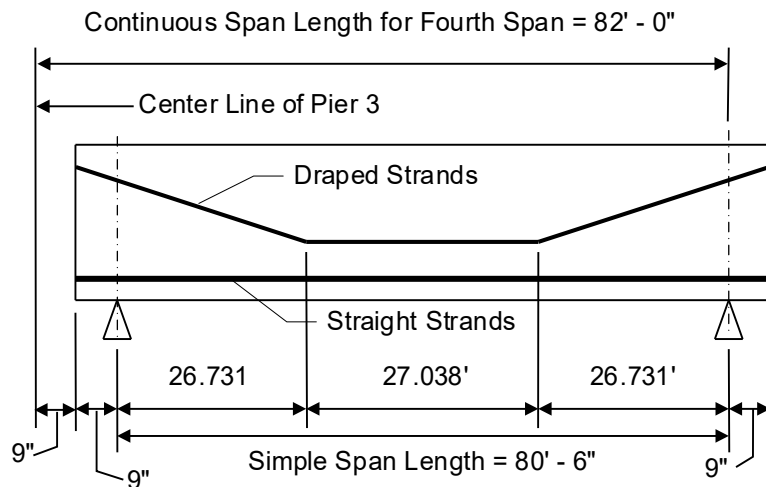


Figure 8.8-7 Example 7 Elevation of Fourth Span Beam

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	SPR BOX RECT	INTERIOR	5	4	NO	U
Multiple				Fatigue	PA	P/S	
Presence	Live Load	Dyn. Load	Dyn. Load	Traffic	Strand	Loss	
Adj. Factor	Code	Allowance	Allowance	Factor	Type	Type	
1.00	A	1.330	1.150	N/A	L	LR	
Prestress							
Transfer	Relative	Composite	Skew	Impor.	Duct.	Redun.	
Time	Humidity	Beam	Override	Factor	Factor	Factor	
2.00	70.00	Y	N	1.000	1.000	1.000	
Shear	Skew	Shrinkage	Multi-Span		Permit	Deck	
Design/ Analysis	Angle Desig.	Analysis Only	Output Points	Analysis Method	Dyn. Load Allowance	Placement Age	
A	P	N	2	S	1.200	120.00	
Overhang to Beam Depth		Allow Use of Center Line Strands					
Override		For Spread Box Beams					
N		N					

BEAM GEOMETRY

Girder	Deck	No. of	Defl.		
Spacing	Overhang	Design	Dist.	Beam	Parapet
(ft)	(ft)	Lanes	Factor	Projection	Width
11.830	2.420	4	0.800	9.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext.	Dist. to				
Girder	Outermost	Lane	Gage	Passing	Deck
to Curb	Wheel	Width	Distance	Distance	Width
(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
0.000	0.000	12.000	6.000	2.000	0.000

SPAN SPECIFIC INPUT

	Straight/ Draped/ Debonded
Span	
Number	
1	DRAPED
2	DRAPED
3	DRAPED
4	DRAPED

SPAN LENGTHS

Span No.	1	2	3	4
Length (ft)	92.000	115.000	98.000	82.000

Chapter 8 Example Problems

SUPPORT INFORMATION				
Support No.	Angle (deg)	Distance to left	Distance to right	Skew Correction Application
		Simple Span Bearing (ft)	Simple Span Bearing (ft)	
1	60.000	0.000	0.000	R
2	60.000	1.500	1.500	B
3	60.000	1.500	1.500	B
4	60.000	1.500	1.500	B
5	60.000	0.000	0.000	L

BEAM CONCRETE MATERIAL PROPERTIES		
Span No.	28 day Spec. Compr. Strength f' _c (ksi)	Initial Strength f' _{ci} (ksi)
1	8.000	6.800
2	8.000	6.800
3	8.000	6.800
4	8.000	6.800

CONCRETE MATERIAL ALLOWABLE								
(All locations except centerline of bearing)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.000	0.248	-4.800	0.270	-3.200	-3.200	-2.000	0.580
2	-4.000	0.248	-4.800	0.270	-3.200	-3.200	-2.000	0.543
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543
4	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.000	0.248	-4.800	0.270	-3.200	-3.200	-2.400	0.543
2	-4.000	0.248	-4.800	0.270	-3.200	-3.200	-2.400	0.543
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543
4	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)					
Creep Factor	Beam Unit Wt. for DL (lb/ft ³)	Beam Unit Wt. for E (lb/ft ³)	Slab Beam Interface	Steam/ Moist Cured	
1.60	150.0	145.0	I	M	

PRESTRESSING STEEL MATERIAL PROPERTIES				
P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	10.00

Chapter 8 Example Problems

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0
2	60.0	60.0	1.00	1.00	1.00	90.0
3	60.0	60.0	1.00	1.00	1.00	90.0
4	60.0	60.0	1.00	1.00	1.00	90.0

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
1	USER	66.000	48.000	48.000	5.000	5.500	3.000
2	USER	66.000	48.000	48.000	5.000	5.500	3.000
3	USER	66.000	48.000	48.000	5.000	5.500	3.000
4	USER	66.000	48.000	48.000	5.000	5.500	3.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	3.000	3.000	3.000	3.000	0.000	0.000	0.000	0.000
2	3.000	3.000	3.000	3.000	0.000	0.000	0.000	0.000
3	3.000	3.000	3.000	3.000	0.000	0.000	0.000	0.000
4	3.000	3.000	3.000	3.000	0.000	0.000	0.000	0.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	0.00	0.00	3	3
2	0.0	0.0	0.00	0.00	3	3
3	0.0	0.0	0.00	0.00	3	3
4	0.0	0.0	0.00	0.00	3	3

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.520	0.167	n/a	2.00	2.00	44c	n/a	5
2	0.520	0.167	n/a	2.00	2.00	64c	n/a	13
3	0.520	0.167	n/a	2.00	2.00	44c	n/a	5
4	0.520	0.167	n/a	2.00	2.00	38c	n/a	5

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span No.	Number of Strands in each Row at MidSpan												
	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
1	20	18	2	2	2								
2	20	22	2	2	2	2	2	2	2	2	2	2	2
3	20	18	2	2	2								
4	20	12	2	2	2								

Chapter 8 Example Problems

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
9.000	8.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	3.000	0.377	6	90.0	A

DRAPE POINT LOCATION

Span No.	% Drape Left	Point Location Right
1	33.059	66.941
2	32.894	67.106
3	33.075	66.925
4	33.026	66.974

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	-0.250	1	6
		2	4
2	-0.250	1	6
		2	4
3	-0.250	1	6
		2	4
4	-0.250	1	6
		2	4

DRAPING INFORMATION

Span No.	Distance to Top (in)	Row Number	Number Strands Draped
1	2.00	5	2
		4	2
		3	2
		2	2
		2	2
2	2.00	13	2
		12	2
		11	2
		10	2
		9	2
		8	2
		7	2
3	2.00	5	2
		4	2
		3	2
		2	2
4	2.00	5	2
		4	2
		3	2
		2	2

Chapter 8 Example Problems

LONGITUDINAL SLAB REINFORCEMENT

Support No.	Bar No.	Left Cutoff (ft)	Right Cutoff (ft)	As/Eff. Slab Width (in^2)	Location In Slab
2	6	46.000	34.500	13.95	T
3	6	34.400	29.500	13.95	T
4	6	29.500	32.800	13.95	T

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Shear Reinf. Area (in^2)	Vertical Shear Reinf. Spacing (in)	Horizontal Shear Reinf. Area (in^2)	Horizontal Shear Reinf. Spacing (in)
1	0.000	0.3	3.0	0.6	18.0
	90.500	0.3	3.0	0.6	18.0
2	0.000	0.3	3.0	0.6	18.0
	115.000	0.3	3.0	0.6	18.0
3	0.000	0.3	3.0	0.6	18.0
	98.000	0.3	3.0	0.6	18.0
4	0.000	0.3	3.0	0.6	18.0
	83.500	0.3	3.0	0.6	18.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ID	1	0.000	1	90.000	0.0200	0.0200
ID	2	1.500	2	113.350	0.0200	0.0200
ID	3	1.500	3	97.000	0.0200	0.0200
ID	4	1.500	4	82.000	0.0200	0.0200
ED	1	0.000	1	90.000	0.0600	0.0600
ED	2	1.500	2	113.350	0.0600	0.0600
ED	3	1.500	3	97.000	0.0600	0.0600
ED	4	1.500	4	82.000	0.0600	0.0600
DC1	1	0.000	1	90.000	0.0660	0.0660
DC1	2	1.500	2	113.350	0.0660	0.0660
DC1	3	1.500	3	97.000	0.0660	0.0660
DC1	4	1.500	4	82.000	0.0660	0.0660
DC2	1	0.000	4	82.000	0.2020	0.2020
FWS	1	0.000	4	82.000	0.2920	0.2920

OVERHANG

Future WS (in)	Future WS Density (lb/ft^3)	Weight of Rail (kip/ft)	Parapet Weight (kip/ft)	Parapet Width (in)	Weight of Formwork (psf)	Dist. to Curb (ft)	Overhang Gage Dist. (ft)
2.50	150.0	0.00	0.50	21.00	15.00	2.000	6.000

Chapter 8 Example Problems

BEAM DETAILING					
Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	15.50	3.50	3.50	30.00	N
1R	15.50	3.50	3.50	30.00	N
2L	15.50	3.50	3.50	30.00	N
2R	15.50	3.50	3.50	30.00	N
3L	15.50	3.50	3.50	30.00	N
3R	15.50	3.50	3.50	30.00	N
4L	15.50	3.50	3.50	30.00	N
4R	15.50	3.50	3.50	30.00	N

OUTPUT OF INPUT DATA		
Input File Echo	Input Commands	Input Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS							
Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite	
1	1	1	0	1	0	1	
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects	
0	1	0	1	1	0	0	
Factored Reactions	Overall Reaction Summary						
0	1						

OUTPUT OF SPECIFICATION CHECKING							
Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data	
1	0	0	1	1	1	1	
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses	
0	1	0	1	1	0	0	
Girder Stability	Rating Vehicle Stresses	Shear Detail					
0	1	0					

OUTPUT OF RATING FACTORS					
Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS	
1	1	1	0	1	

Chapter 8 Example Problems

OUTPUT SUMMARY		

TS&L		
Design	Q/A-Q/C	Detailer
Summary	Summary	Summary
0	0	0

Chapter 8 Example Problems

8.9 EXAMPLE 8

Example 8 is a two-span problem with span lengths of 60 feet and 70 feet, without using the symmetry option. This example is a design of a composite, interior girder. A PennDOT spread box beam is used with low relaxation strands, with a straight strand configuration. A girder spacing of 12 feet is used with a PennDOT skew angle of 75 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the design.

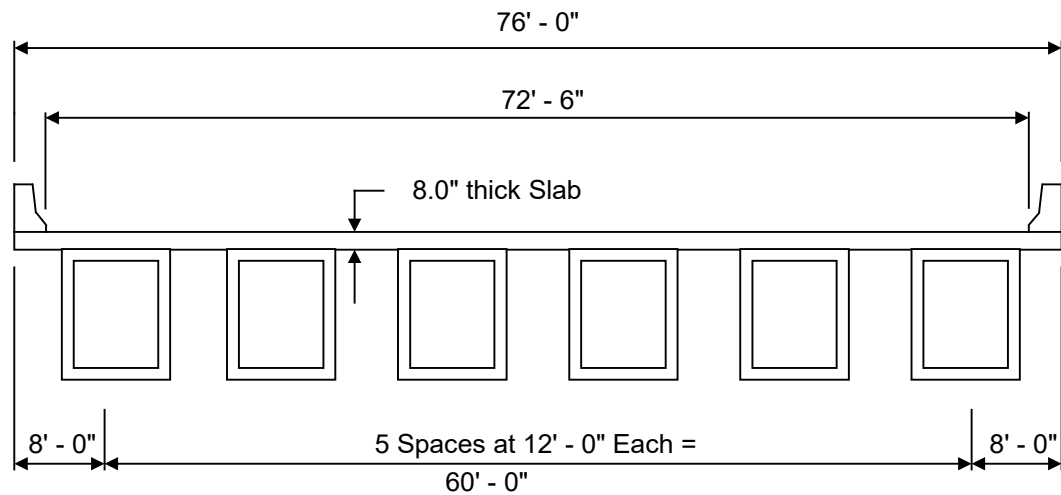


Figure 8.9-1 Example 8 Deck Cross Section

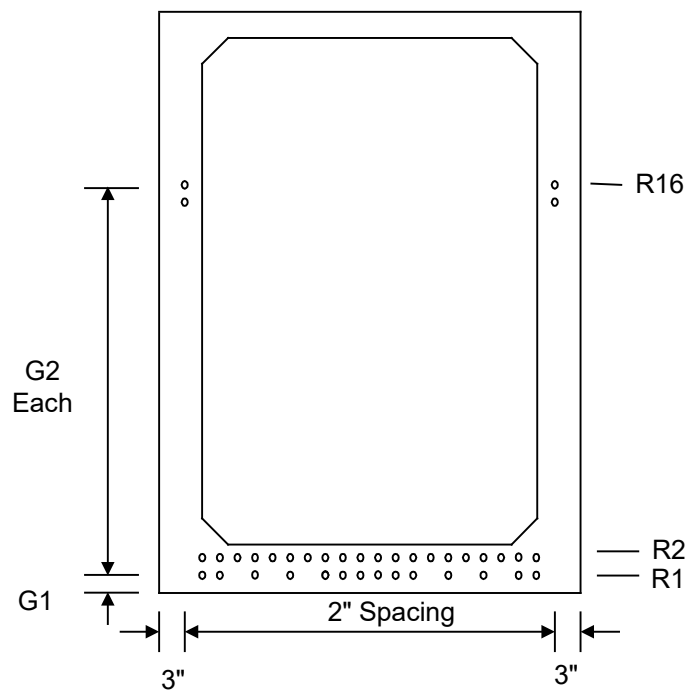


Figure 8.9-2 Example 8 Beam Strand Pattern at Support

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	SPR BOX RECT	INTERIOR	6	2	NO	P

Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type
Adj. Factor						
1.00	E	1.330	1.150	N/A	L	LR

Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor
2.00	70.00	Y	N	1.000	1.000	1.000

Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age
D	P	N	2	S	1.200	120.00

Overhang to Beam Depth Override	Allow Use of Center Line Strands For Spread Box Beams
N	N

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
12.000	8.000	6	1.000	9.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext. Girder to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
0.000	0.000	12.000	6.000	4.000	0.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	STRAIGHT
2	STRAIGHT

SPAN LENGTHS

Span No.	1	2
Length (ft)	60.000	70.000

Chapter 8 Example Problems

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left	Distance to right	Skew Correction Application
		Simple Span Bearing (ft)	Simple Span Bearing (ft)	
1	75.000	0.000	0.000	R
2	75.000	1.500	1.500	B
3	75.000	0.000	0.000	L

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.250	-4.800	0.269	-3.200	-3.200	-2.000	0.600
2	-4.080	0.250	-4.800	0.269	-3.200	-3.200	-2.000	0.600

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.250	-4.800	0.300	-3.200	-3.200	-2.000	0.600
2	-4.080	0.250	-4.800	0.300	-3.200	-3.200	-2.000	0.600

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	U	M

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	0.96	0.96	0.96	90.0
2	60.0	60.0	0.96	0.96	0.96	90.0

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio
N	42.00	66.00	0.0	48.	8.00	0.50	0.850

Chapter 8 Example Problems

STRAND CONFIGURATION - DESIGN (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	n/a	20
2	0.500	0.153	n/a	2.00	2.00	n/a	20

STRAND CONFIGURATION - DESIGN (2 OF 2)

Span No.	Available Strand Positions in each Row at MidSpan																			
	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
1	20	22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	20	22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
8.000	7.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. (ksi)	Transverse Reinforcement Location
60.0	3.000	0.378	6	90.0	B

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Shear Reinf. Area (in^2)	Vertical Shear Reinf. Spacing (in)	Horizontal Shear Reinf. Area (in^2)	Horizontal Shear Reinf. Spacing (in)
1	0.000	0.4	0.0	0.8	0.0
	58.500	0.4	0.0	0.8	0.0
2	0.000	0.4	0.0	0.8	0.0
	71.500	0.4	0.0	0.8	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ID	1	0.000	2	70.000	0.0100	0.0100
ED	1	0.000	2	70.000	0.0270	0.0270
DC2	1	0.000	2	70.000	0.2525	0.2525
DC1	1	0.000	2	70.000	0.2230	0.2230
FWS	1	0.000	2	70.000	0.3625	0.3625

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	15.50	3.50	3.50	30.00	N
1R	15.50	3.50	3.50	30.00	N
2L	15.50	3.50	3.50	30.00	N
2R	15.50	3.50	3.50	30.00	N

Chapter 8 Example Problems

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non- Composite	Total DL Non-Composite
1	1	1	0	1	0	1

DL Creep/ Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
0	1	0	1	1	0	0

Factored Reactions	Overall Reaction Summary
0	1

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	1	1	1

Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	1	0	0	1	1	0

Girder Stability	Rating Vehicle Stresses	Shear Detail
0	0	0

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	1	1	0	0

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.10 EXAMPLE 9

Example 9 is a single-span problem with a span length of 125 feet. This example is an analysis of a composite, exterior girder. A PennDOT I-beam is used with low relaxation strands, with debonded strands. A girder spacing of 9'-2" is used with a PennDOT skew angle of 75 degrees. The beam concrete strength is 9.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. A PHL-93 live loading is used in the analysis.

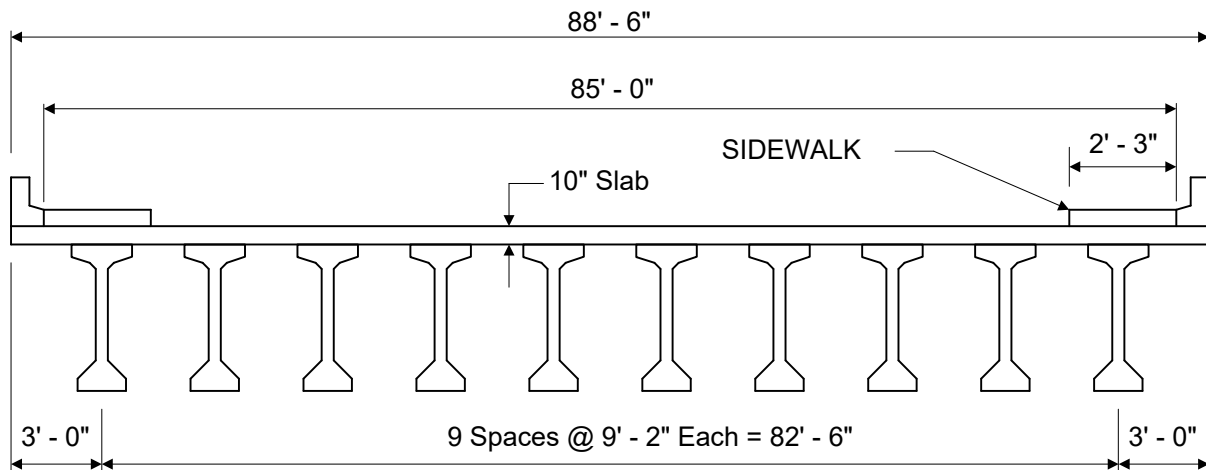
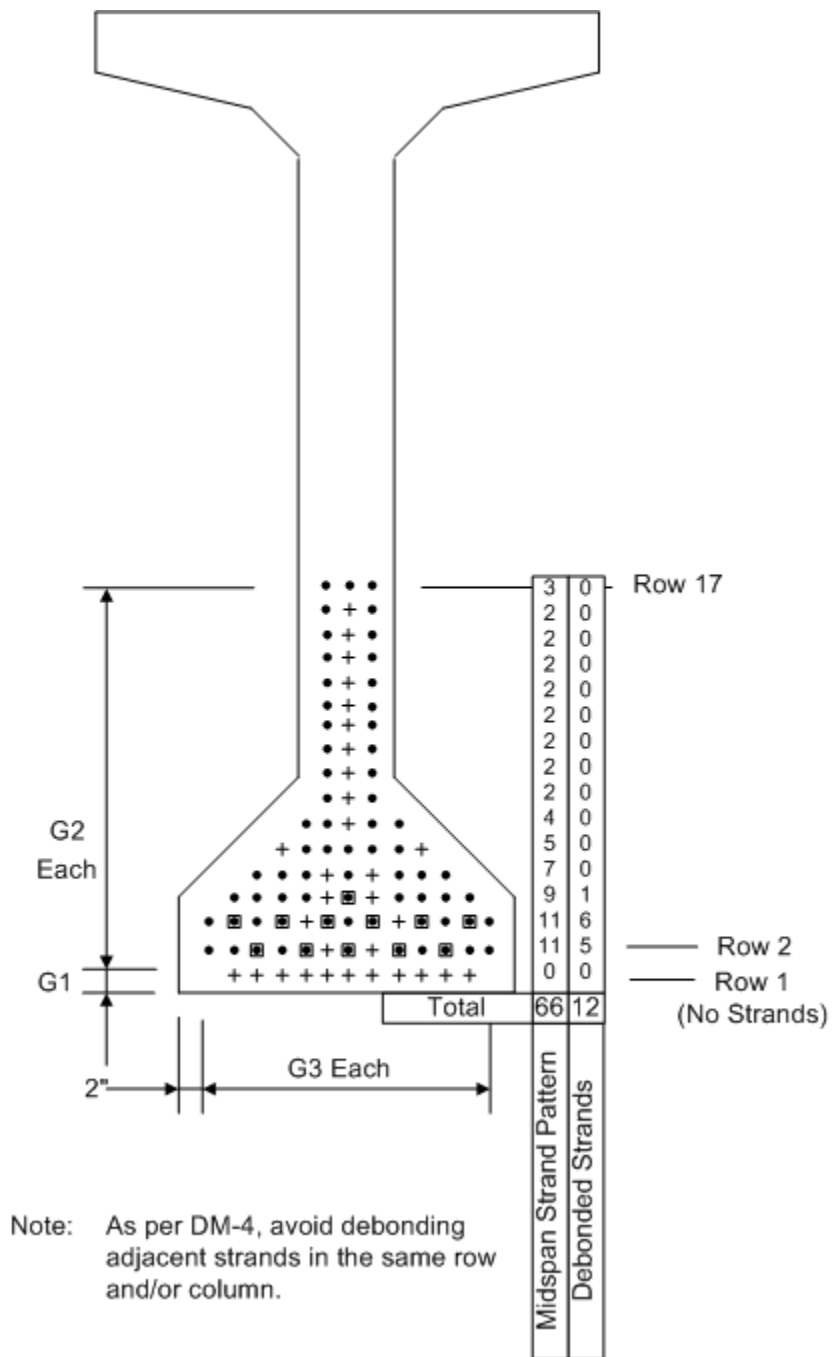


Figure 8.10-1 Example 9 Deck Cross Section

Chapter 8 Example Problems



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.10-2 Example 9 Beam Strand Pattern

Chapter 8 Example Problems

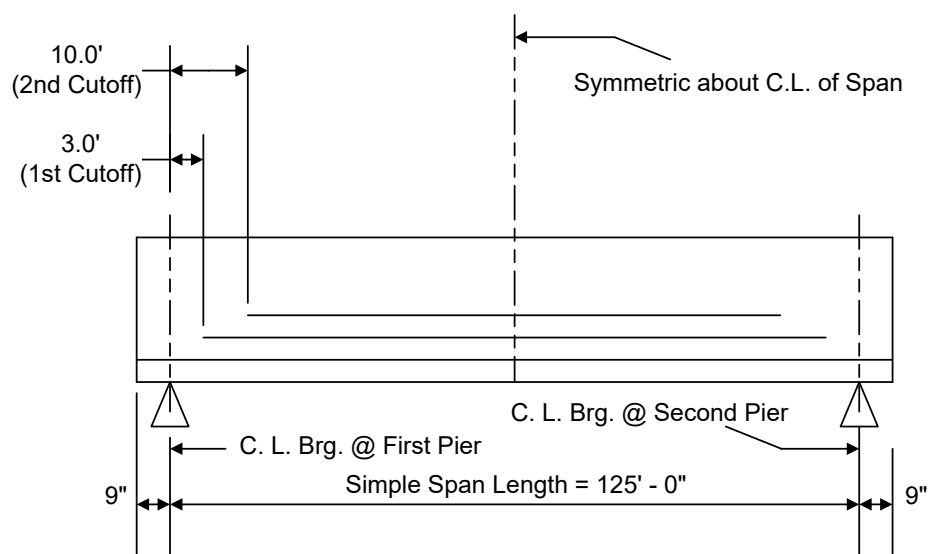


Figure 8.10-3 Example 9 Beam Elevation

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	IBeam-AASHTO	EXTERIOR	10	1	NO	P
Multiple							
Presence	Live Load	Dyn. Load	Fatigue	PA			P/S
Adj. Factor	Code	Allowance	Dyn. Load	Traffic	Strand	Loss	Type
1.00	A	1.330	1.150	N/A	L	LR	
Prestress							
Transfer	Relative	Composite	Skew	Impor.	Duct.	Redun.	
Time	Humidity	Beam	Override	Factor	Factor	Factor	
1.00	70.00	Y	N	1.000	1.000	1.000	
Shear	Skew	Shrinkage		Multi-Span	Permit	Deck	
Design/ Analysis	Angle	Analysis	Output	Analysis	Dyn. Load	Placement	
A	P	Only	Points	Method	Allowance	Age	
		N	2	S	1.200	120.00	
Overhang to Beam Depth	Allow Use of Center Line Strands						
Override	For Spread Box Beams						
N	N						

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
9.170	3.000	7	0.700	9.000	21.000

Chapter 8 Example Problems

BEAM GEOMETRY (SIDEWALK)

Defl.	No. of
Dist.	Design
Factor	Lanes
0.600	6

COMPUTED DISTRIBUTION FACTORS

CL Ext. to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
1.250	-0.750	12.000	6.000	4.000	0.000

COMPUTED DISTRIBUTION FACTORS (SIDEWALK)

CL Ext. Girder to Curb W/Sidewalks (ft)	Dist. to Outermost Wheel W/Sidewalks (ft)
-1.000	-3.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DEBONDED

SPAN LENGTHS

Span No.	1
Length (ft)	125.000

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application
1	75.000	0.000	0.000	R
2	75.000	0.000	0.000	L

BEAM CONCRETE MATERIAL PROPERTIES

Span No.	28 day Spec. Compr. Strength f'c (ksi)	Initial Strength f'ci (ksi)
1	8.000	6.800

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

Chapter 8 Example Problems

(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lbf/ft^3)	Beam Unit Wt. for E (lbf/ft^3)	Slab Beam Interface	Steam/Moist Cured
1.60	150.0	145.0	I	M

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	20.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
1	2884	84.000	28.000	42.000	8.000	8.000	5.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	10.000	10.000	4.000	4.000	3.000	0.000	13.000	0.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel				Bar No.	
	Area		CGS		Pos.	Neg.
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)		
1	0.0	0.0	0.00	0.00	4	4

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	68c	n/a	17

Note: A "c" indicates the value was computed from input on the SCA command

Chapter 8 Example Problems

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span Number of Strands in each Row at MidSpan

No.	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17
1	0	11	11	9	7	5	4	2	2	2	2	2	2	2	2	2	3

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft ³)	Density Ec (lb/ft ³)	Haunch Depth for Section Prop (in)	Slab Concrete Type
10.000	9.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in ² /ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. (ksi)	Transverse Reinforcement Location
60.0	3.000	0.385	6	90.0	B

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	3.000	4	3
		2	1
		3	4
	10.000	2	4
		3	2

PEDESTRIAN LOAD

Total Pedestrian Live Load (kip/ft)	Pedestrian Live Load (kip/ft)	Sidewalk Dead Load (kip/ft)	Addl. FWS Dead Load (kip/ft)	Addl. DC1 Dead Load (kip/ft)
2.050	0.200	0.033	-0.014	0.000

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Shear Reinf.		Horizontal Shear Reinf.	
		Area (in ²)	Spacing (in)	Area (in ²)	Spacing (in)
1	0.000	0.4	12.0	0.4	21.0
	125.000	0.4	12.0	0.4	21.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ED	1	0.000	1	125.000	0.0460	0.0460
DC1	1	0.000	1	125.000	0.1900	0.1900
DC2	1	0.000	1	125.000	0.2500	0.2500
FWS	1	0.000	1	125.000	0.2600	0.2600

Chapter 8 Example Problems

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	0.00	0.00	0.00	n/a	N
1R	0.00	0.00	0.00	n/a	N

GIRDER STABILITY (Part 1)

Span No.	Overhang Distance (ft)	Cable Angle (deg)	Wind Pressure (psf)	Impact Factor (%)	Lifting Loops Eccentricity (in)	Lifting Loops Rigid Extension (in)	Lateral Deflection (Sweep) (in)
1	10.000	90.0	2.5	0.0	0.500	0.000	1.581
Span No.	Concrete Strength At Lift (ksi)	Camber At Lift (in)					
1	6.800	1.750					

GIRDER STABILITY (Part 2)

Span No.	Concrete Strength Seating (ksi)	Camber at Seating (in)	Sweep at Seating (in)	P/S Force at Seating (kips)	Active Const. Wind Press. (psf)	Bearing Rotational Stiffness (in*kip/rad)		
1	8.000	2.00	1.581	1685.4	2.50	95000.0		
Span No.	Bearing Height (in)	Bearing Width (in)	Bearing Tolerance from C.L. (in)	Bearing Level Tolerance (ft/ft)	Inactive Construction Wind Pressure (psf)	Construction Vert. Wind Pressure (psf)	End Bracing Provided	Number of Intermediate Braces
1	2.500	26.000	0.500	0.005	25.000	10.000	N	3

GIRDER STABILITY (Part 3)

Span No.	Concrete Strength Casting (ksi)	Formwork Extension (ft)	Screed Rail Distance (in)	Thickness Deck Overhang (in)	Weight SIP Forms (psf)	Weight Cantilever Forms (psf)	Live Load on Deck (psf)
1	8.000	2.00	2.50	12.00	15.0	20.0	25.0
Span No.	Live Load from Screed (kips)	Live Load on Walkway (lb/ft)	Length of Live Load on Walkway (ft)				
1	8.000	75.0	20.0				

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary
1	0	1

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	1	0	1	0	1

Chapter 8 Example Problems

DL Creep/ Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
0	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
0	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	0	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	0	0	0	1	0	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
1	1	0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	0	1	1	1

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.11 EXAMPLE 10

Example 10 is a three-span problem with span lengths of 80 feet each. This example is an analysis of a composite, exterior girder. A user-specified adjacent box beam with a rectangular opening is used with low relaxation strands, with a draped strand configuration. A girder spacing of 3 feet is used with a PennDOT skew angle of 68 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 250 ksi. A PHL-93 live loading is used in the analysis.

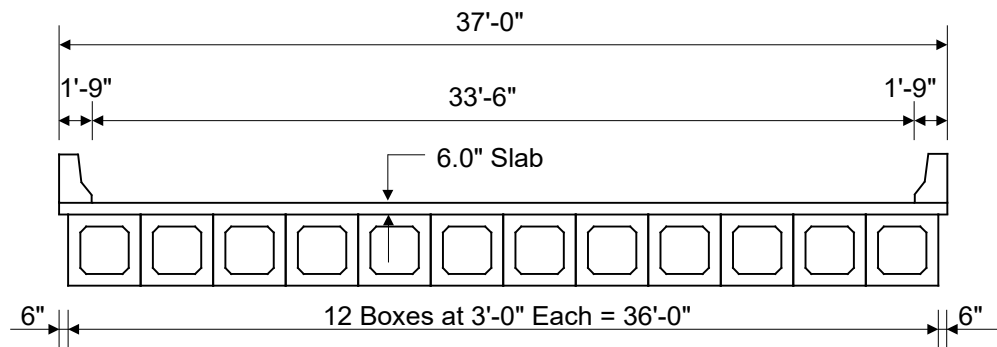
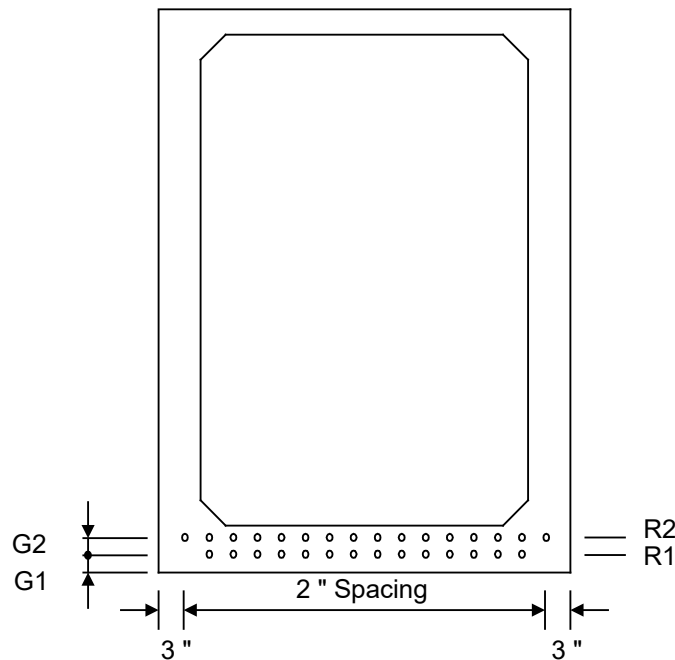
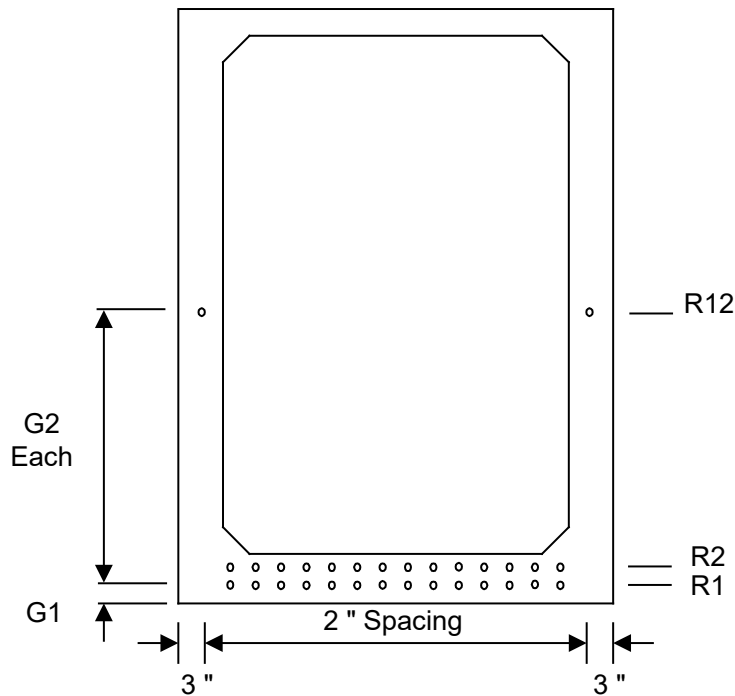


Figure 8.11-1 Example 10 Deck Cross Section



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.11-2 Example 10 Beam Strand Pattern Between Drape Points



NOTE: The strand pattern shown is a typical pattern and may not be the strand pattern produced by the current version of the program.

Figure 8.11-3 Example 10 Beam Strand Pattern at End of Beam

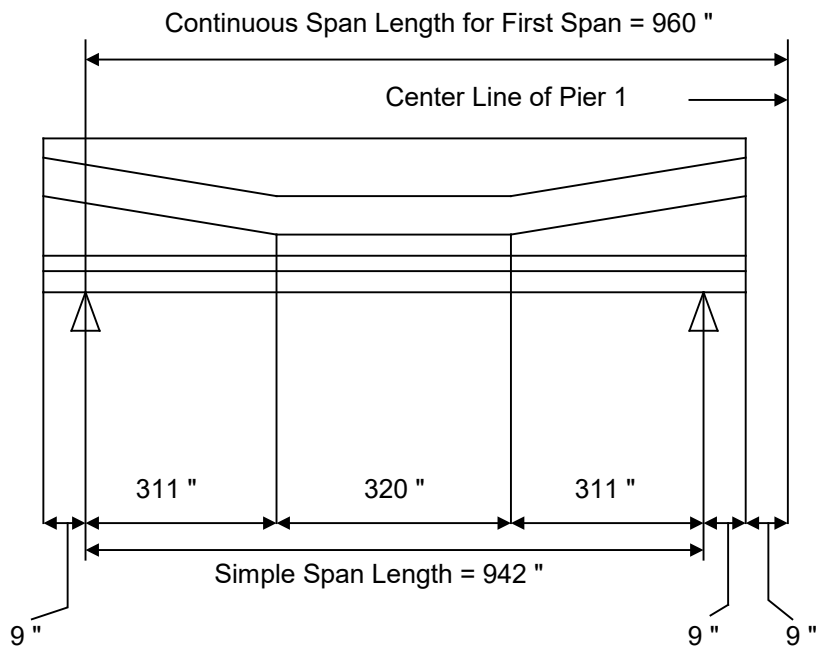


Figure 8.11-4 Example 10 Elevation of First Span Beam

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	ADJ BOX RECT	EXTERIOR	12	3	NO	U
Multiple				Fatigue	PA		P/S
Presence	Live Load	Dyn. Load	Dyn. Load	Traffic	Strand	Loss	
Adj. Factor	Code	Allowance	Allowance	Factor	Type	Type	
1.00	A	1.330	1.150	N/A	L	LR	
Prestress							
Transfer	Relative	Composite	Skew	Impor.	Duct.	Redun.	
Time	Humidity	Beam	Override	Factor	Factor	Factor	
2.00	70.00	Y	Y	1.000	1.000	1.000	
Shear	Skew	Shrinkage		Multi-Span	Permit	Deck	
Design/ Analysis	Angle Desig.	Analysis Only	Output Points	Analysis Method	Dyn. Load Allowance	Placement Age	
D	P	N	2	S	1.200	120.00	
Overhang to							
Beam Depth	Allow Use of						
Override	Center Line Strands						
N	For Spread Box Beams						
	N						

BEAM GEOMETRY

Girder	Deck	No. of	Defl.		
Spacing	Overhang	Design	Dist.	Beam	Parapet
(ft)	(ft)	Lanes	Factor	Projection	Width
3.000	2.000	2	0.167	9.000	20.250

USER DEFINED DISTRIBUTION FACTOR

Span	D.F.	Moment	Moment	Shear	Shear
No.	Type	DF1	DF2	DF1	DF2
1	Design	0.2784	0.2784	0.5212	0.5212
1	Fatigue	0.2083	0.2083	0.2083	0.2083
2	Design	0.2784	0.2784	0.5212	0.5212
2	Fatigue	0.2083	0.2083	0.2083	0.2083
3	Design	0.2784	0.2784	0.5212	0.5212
3	Fatigue	0.2083	0.2083	0.2083	0.2083

USER DEFINED REACTION DISTRIBUTION FACTOR

Support	D.F.	Reaction
Number	Type	DF
1	Design	0.5212
1	Fatigue	0.2083
2	Design	0.5212
2	Fatigue	0.2083
3	Design	0.5212
3	Fatigue	0.2083

Chapter 8 Example Problems

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DRAPED
2	DRAPED
3	DRAPED

SPAN LENGTHS

Span No.	1	2	3
Length (ft)	80.000	80.000	80.000

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application
1	68.000	0.000	0.000	R
2	68.000	1.500	1.500	B
3	68.000	1.500	1.500	B
4	68.000	0.000	0.000	L

BEAM CONCRETE MATERIAL PROPERTIES

Span No.	28 day Spec. Compr. Strength f'c (ksi)	Initial Strength f'ci (ksi)
1	8.000	6.800
2	8.000	6.800
3	8.000	6.800

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.000	0.543
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.000	0.543
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.000	0.543

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543
2	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543
3	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	I	S

Chapter 8 Example Problems

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
250.00	187.50	225.00	28500.0	10.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0
2	60.0	60.0	1.00	1.00	1.00	90.0
3	60.0	60.0	1.00	1.00	1.00	90.0

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
1	USER	33.000	36.000	35.250	5.000	5.500	3.000
2	USER	33.000	36.000	35.250	5.000	5.500	3.000
3	USER	33.000	36.000	35.250	5.000	5.500	3.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	3.000	3.000	3.000	3.000	3.000	4.000	0.375	0.750
2	3.000	3.000	3.000	3.000	3.000	4.000	0.375	0.750
3	3.000	3.000	3.000	3.000	3.000	4.000	0.375	0.750

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	0.00	0.00	3	3
2	0.0	0.0	0.00	0.00	3	3
3	0.0	0.0	0.00	0.00	3	3

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.500	0.153	n/a	2.00	2.00	32c	n/a	3
2	0.500	0.153	n/a	2.00	2.00	32c	n/a	3
3	0.500	0.153	n/a	2.00	2.00	32c	n/a	3

Note: A "c" indicates the value was computed from input on the SCA command

Chapter 8 Example Problems

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span Number of Strands in each Row at MidSpan

No.	R01	R02	R03
1	14	16	2
2	14	16	2
3	14	16	2

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
6.000	5.500	0.000	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	4.000	0.200	5	90.0	B

DRAPE POINT LOCATION

Span No.	% Drape Point Left	Point Location Right
1	33.008	66.992
2	33.008	66.992
3	33.008	66.992

TENDON LOCATION

Span No.	Tendon Height (in)	1st Tendon (ft)	2nd Tendon (ft)	3rd Tendon (ft)	4th Tendon (ft)	5th Tendon (ft)
1	16.50	2.500	76.000			
2	16.50	2.500	74.500			
3	16.50	2.500	76.000			

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	-0.250	1	4
		2	4
	2.250	1	2
		2	4
2	-0.250	1	4
		2	4
	2.250	1	2
		2	4
3	-0.250	1	4
		2	4
	2.250	1	2
		2	4

Chapter 8 Example Problems

DRAPING INFORMATION

Span No.	Distance to Top (in)	Row Number	Number Strands Draped
1	5.00	3	2
		2	2
2	5.00	3	2
		2	2
3	5.00	3	2
		2	2

LONGITUDINAL SLAB REINFORCEMENT

Support No.	Bar No.	Left Cutoff (ft)	Right Cutoff (ft)	As/Eff. Slab Width (in^2)	Location In Slab
2	3	25.000	25.000	7.00	T
3	3	25.000	25.000	7.00	T

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in^2)	Shear Reinf. Spacing (in)	Horizontal Area (in^2)	Shear Reinf. Spacing (in)
1	0.000	0.2	0.0	0.4	0.0
	78.500	0.2	0.0	0.4	0.0
2	0.000	0.2	0.0	0.4	0.0
	80.000	0.2	0.0	0.4	0.0
3	0.000	0.2	0.0	0.4	0.0
	81.500	0.2	0.0	0.4	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
ID	1	0.000	3	80.000	0.0100	0.0100
DC1	1	0.000	3	80.000	0.0180	0.0180
FWS	1	0.000	3	80.000	0.0840	0.0840
DC2	1	0.000	3	80.000	0.0840	0.0840

BEAM DETAILING

Span No.	Beam Notch Width (in)	Beam Notch Depth (in)	Notch Slope Width (in)	Min. End Block Length (in)	Substructure Type
1L	21.00	6.00	6.00	33.00	N
1R	21.00	6.00	6.00	33.00	N
2L	21.00	6.00	6.00	33.00	N
2R	21.00	6.00	6.00	33.00	N
3L	21.00	6.00	6.00	33.00	N
3R	21.00	6.00	6.00	33.00	N

OUTPUT OF INPUT DATA

Input File	Input Echo	Input Commands	Input Summary
1	1	0	1

Chapter 8 Example Problems

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	1	0	1	0	1
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
0	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
0	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	1	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	1	0	0	1	0	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
0	1	0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	0	1	0	1

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.12 EXAMPLE 11

Example 11 is a single-span problem with a span length of 62 feet. This example is a design of an interior girder with an 8-in. composite deck and the typical concrete barrier. A PennDOT Type F NEXT beam is used with 0.52-in.-diameter low relaxation strands. Four strands are in the top flange and the remaining strands fill each available position beginning with the bottom row. Six strands are debonded for 2 ft 0 in. from the end of the beam or 1 ft 6 in. from the centerline of bearing. Six additional strands are debonded for 5 ft 6 in. from the end of the beam or 5 ft 0 in. from the centerline of bearing. A girder spacing of 8.875 feet is used with a PennDOT skew angle of 90 degrees. The beam concrete strength is 8.0 ksi, the slab concrete strength is 4.0 ksi, and the prestressing steel ultimate strength is 270 ksi. PHL-93, ML-80, and TK527 live loadings are used in the analysis.

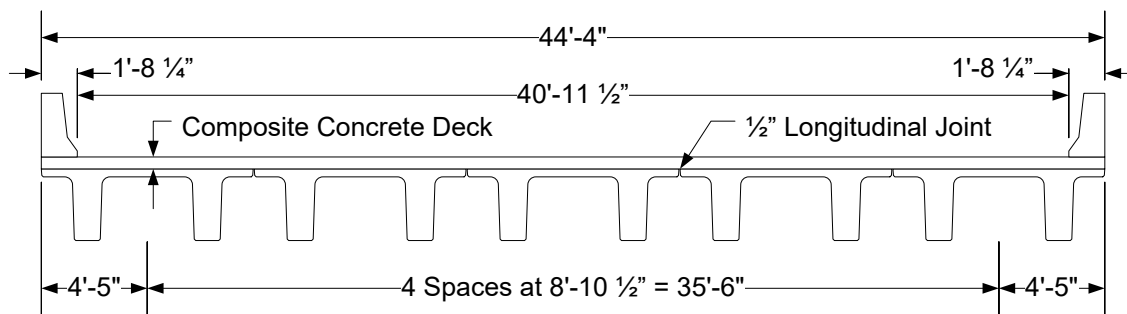


Figure 8.12-1 Example 11 Deck Cross Section

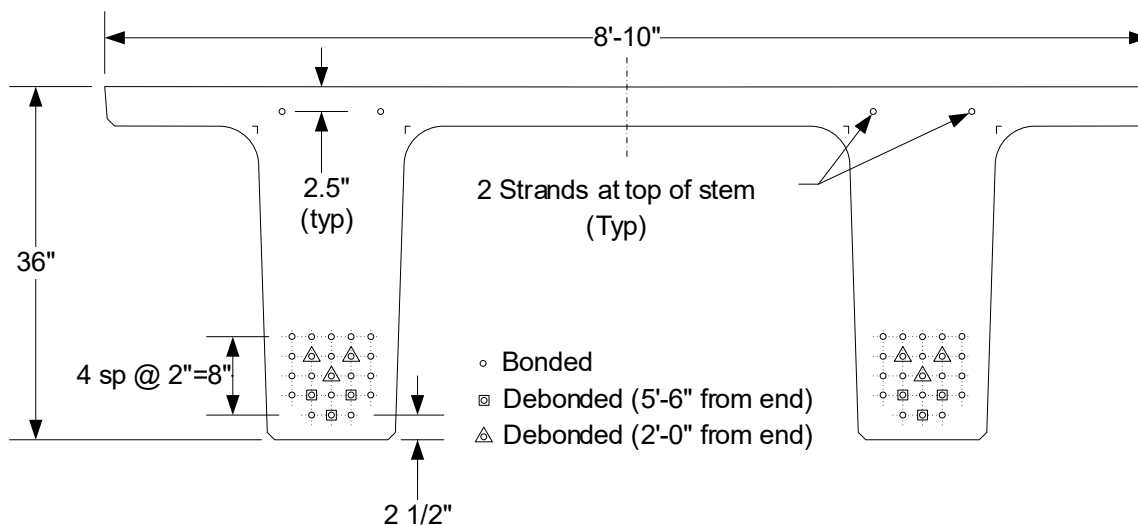


Figure 8.12-2 Example 11 Beam Strand Pattern

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	DESIGN	TYPE F NEXT	INTERIOR	5	1	NO	P

Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type
Adj. Factor 1.00	E	1.330	1.150	N/A	L	LR

Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor
1.00	70.00	Y	N	1.000	1.000	1.000

Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age
D	P	N	2	S	1.200	120.00

Overhang to Beam Depth	Allow Use of Center Line Strands
Override	For Spread Box Beams
N	N

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
8.875	4.417	3	0.510	6.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext. Girder to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
0.000	0.000	12.000	6.000	4.000	0.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DEBONDED

SPAN LENGTHS

Span No.	1
Length (ft)	62.000

Chapter 8 Example Problems

SUPPORT INFORMATION

Support No.	Angle (deg)	Distance to left	Distance to right	Skew Correction Application
		Simple Span Bearing (ft)	Simple Span Bearing (ft)	
1	90.000	0.000	0.000	N
2	90.000	0.000	0.000	N

CONCRETE MATERIAL ALLOWABLE

(All locations except centerline of bearing)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

(Centerline of bearing ONLY)

Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-2.400	0.543

CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured
1.60	150.0	145.0	C	S

PRESTRESSING STEEL MATERIAL PROPERTIES

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss
270.00	202.50	243.00	28500.0	0.00

MILD STEEL MATERIAL PROPERTIES

Span No.	Beam Stirrups Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)
1	60.0	60.0	1.00	1.00	1.00	90.0

DESIGN PARAMETERS

f'c Optim.	Minimum Depth (in)	Maximum Depth (in)	Depth Difference (in)	Box Beam Width (in)	Design f'c (ksi)	f'c Increment (ksi)	f'ci/ f'c Ratio
N	36.00	36.00	0.0	0.	8.00	0.50	0.850

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)
1	NEXT36F	36.000	60.000	106.000	13.000	0.000	4.000

Chapter 8 Example Problems

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	15.000	4.000	0.750	0.250	2.500	0.000	0.000	0.500

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	0.00	0.00	3	3

STRAND CONFIGURATION - DESIGN (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	Row to Start Debonding	Distance to 1st Row (in)	Vertical Row Spacing (in)	Minimum Distance to Top (in)	No. Strand Rows at MidSpan
1	0.520	0.167	1	2.50	2.00	n/a	6

STRAND CONFIGURATION - DESIGN (2 OF 2)

Span No.	Available Strand Positions in each Row at MidSpan					
	R01	R02	R03	R04	R05	R06
1	6	10	10	10	10	4

SLAB PROPERTIES (1 OF 2)

Actual Slab Thickness (in)	Effective Slab Thickness (in)	Haunch Depth for DL (in)	Concrete Strength (ksi)	Concrete Loads (lb/ft^3)	Density Ec (lb/ft^3)	Haunch Depth for Section Prop (in)	Slab Concrete Type
8.000	7.500	0.500	4.000	150.00	145.00	0.000	N

SLAB PROPERTIES (2 OF 2)

Slab Reinforcement Strength (ksi)	Slab Reinforcement CGS (in)	Slab Reinforcement Area (in^2/ft)	Transverse Reinforcement Size	Slab Reinforcement Ult. Ten. Str. (ksi)	Transverse Reinforcement Location
60.0	0.000	0.467	5	90.0	B

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Shear Reinf. Area (in^2)	Spacing (in)	Horizontal Shear Reinf. Area (in^2)	Spacing (in)
1	0.000	0.8	0.0	0.8	0.0
	62.000	0.8	0.0	0.8	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
DC2	1	0.000	1	62.000	0.3250	0.3250
FWS	1	0.000	1	62.000	0.2660	0.2660

OUTPUT OF INPUT DATA

Input File Echo	Input Commands	Input Summary
1	0	1

Chapter 8 Example Problems

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	4	0	1	1	1
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
1	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
1	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	0	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	0	0	0	1	1	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
0	0	0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	1	1	0	0

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0

Chapter 8 Example Problems

8.13 EXAMPLE 12

Example 12 is a single-span problem with a span length of 60 feet. The superstructure consists of five beams spaced at 8 ft 9 in. centers, as shown in Figure 1. A 3-in.-thick bituminous surfacing will be placed on the beams as a wearing surface. Provisions also include an additional future wearing surface. The beams are connected with a 9-in. longitudinal joint. This example is an analysis of an exterior girder. A PennDOT Type D NEXT beam is used with 0.52-in.-diameter low relaxation strands. Four strands are in the top flange and the remaining strands are arranged in the pattern shown in Figure 2. Six strands are debonded for a distance of 6 ft 6 in. from the end of the beam or 6 ft 0 in. from the centerline of bearing. Four additional strands are debonded for a distance of 3 ft 0 in. from the end of the beam or 2 ft 6 in. from the centerline of bearing. A girder spacing of 8 ft 9 in. is used with a PennDOT skew angle of 90 degrees. The beam concrete strength is 8.0 ksi and the prestressing steel ultimate strength is 270 ksi. PHL-93, ML-80, and TK527 live loadings are used in the analysis.

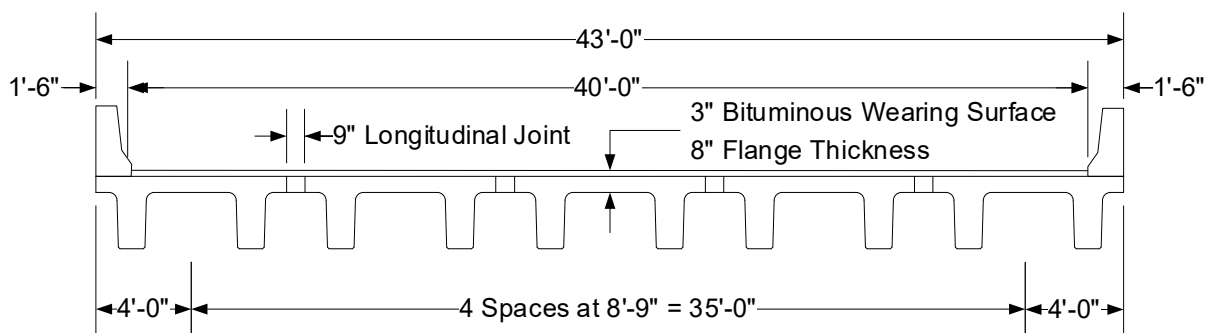


Figure 8.13-1 Example 12 Deck Cross Section

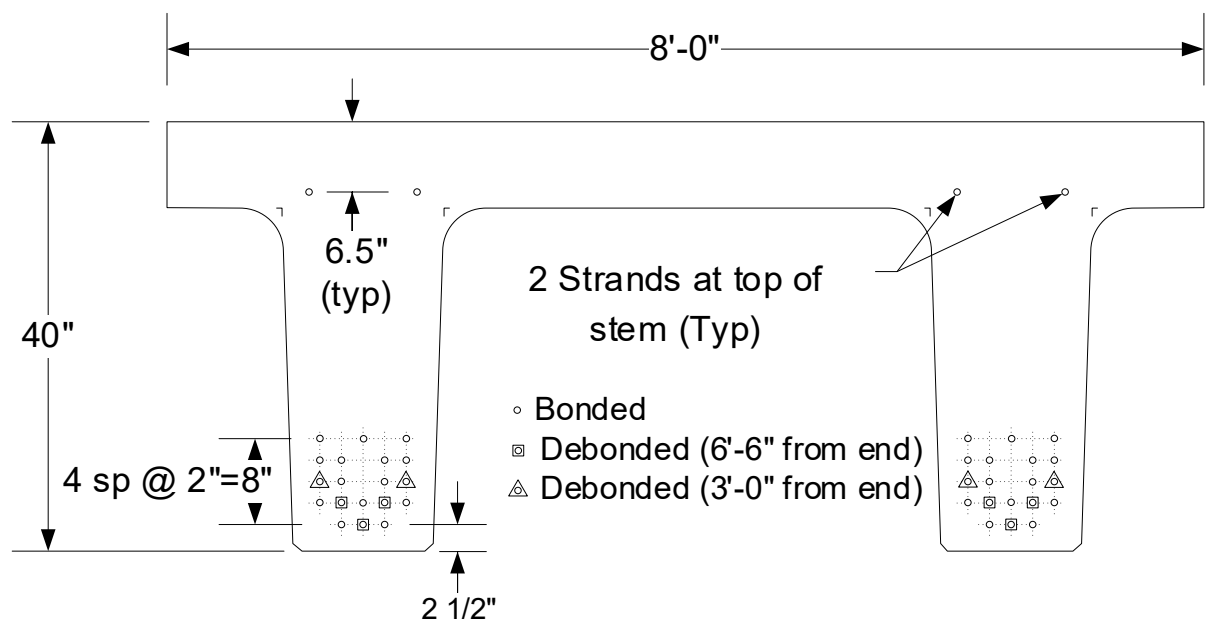


Figure 8.13-2 Example 12 Beam Strand Pattern

Chapter 8 Example Problems

CONFIGURATION

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CONTROL PARAMETERS

Units	Design/ Analysis	Shape of Beam	Exterior/ Interior	No. Beams	No. Spans	Symmetry	Beam Desig.
US	ANALYSIS	TYPE D NEXT	EXTERIOR	5	1	NO	P

Multiple Presence	Live Load Code	Dyn. Load Allowance	Fatigue Dyn. Load Allowance	PA Traffic Factor	Strand Type	P/S Loss Type
1.00	A	1.330	1.150	N/A	L	LR

Prestress Transfer Time	Relative Humidity	Composite Beam	Skew Override	Impor. Factor	Duct. Factor	Redun. Factor
1.00	70.00	N	N	1.000	1.000	1.000

Shear Design/ Analysis	Skew Angle Desig.	Shrinkage Analysis Only	Output Points	Multi-Span Analysis Method	Permit Dyn. Load Allowance	Deck Placement Age
D	P	N	2	S	1.200	120.00

Overhang to Beam Depth	Allow Use of Center Line Strands
Override	For Spread Box Beams
N	N

BEAM GEOMETRY

Girder Spacing (ft)	Deck Overhang (ft)	No. of Design Lanes	Defl. Dist. Factor	Beam Projection (in)	Parapet Width (in)
8.750	4.000	3	0.510	6.000	20.250

COMPUTED DISTRIBUTION FACTORS

CL Ext. Girder to Curb (ft)	Dist. to Outermost Wheel (ft)	Lane Width (ft)	Gage Distance (ft)	Passing Distance (ft)	Deck Width (ft)
2.500	0.500	12.000	6.000	4.000	0.000

SPAN SPECIFIC INPUT

Span Number	Straight/ Draped/ Debonded
1	DEBONDED

SPAN LENGTHS

Span No.	1
Length (ft)	60.000

Chapter 8 Example Problems

SUPPORT INFORMATION								

Support No.	Angle (deg)	Distance to left Simple Span Bearing (ft)	Distance to right Simple Span Bearing (ft)	Skew Correction Application				
1	90.000	0.000	0.000	N				
2	90.000	0.000	0.000	N				
BEAM CONCRETE MATERIAL PROPERTIES								

Span No.	28 day Spec. Compr. Strength f'c (ksi)		Initial Strength f'ci (ksi)					
1	8.000		6.800					
CONCRETE MATERIAL ALLOWABLE								

(All locations except centerline of bearing)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-0.001	0.543
(Centerline of bearing ONLY)								
Span No.	Initial Compr. (ksi)	Initial Tension (ksi)	Final Compr. (ksi)	Final Tension (ksi)	Final DL Compr. (ksi)	Compression 1/2 (DL+PS)+LL (ksi)	Final Slab Compr. (ksi)	Final Tension Creep (ksi)
1	-4.080	0.247	-4.800	0.268	-3.200	-3.200	-0.001	0.543
CONCRETE MATERIAL PROPERTIES (ALL GIRDERS)								

Creep Factor	Beam Unit Wt. for DL (lb/ft^3)	Beam Unit Wt. for E (lb/ft^3)	Slab Beam Interface	Steam/ Moist Cured				
1.60	150.0	145.0	C	S				
PRESTRESSING STEEL MATERIAL PROPERTIES								

P/S Ultimate Strength (ksi)	Init. P/S Tension (ksi)	P/S Yield Strength (ksi)	P/S Modulus Elasticity (ksi)	Est. Percent Loss				
270.00	202.50	243.00	28500.0	0.00				
MILD STEEL MATERIAL PROPERTIES								

Span No.	Beam Stirrup Yield Strength (ksi)	Other Beam Yield Strength (ksi)	Devel. Length Factor Pos.	Devel. Length Factor Neg.	Devel. Length Factor Slabs	Other Beam Ultimate Strength (ksi)		
1	60.0	60.0	1.00	1.00	1.00	90.0		
PRESTRESS CONCRETE BEAM DIMENSIONS (PART 1 OF 3)								

Span No.	Desig.	D (in)	W1 (in)	W2 (in)	W3 (in)	T1 (in)	T2 (in)	
1	NEXT40D	40.000	60.000	96.000	13.000	0.000	8.000	

Chapter 8 Example Problems

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 2 OF 3)

Span No.	B1 (in)	B2 (in)	B3 (in)	B4 (in)	D1 (in)	D2 (in)	X1 (in)	X2 (in)
1	15.000	4.000	0.750	0.000	6.500	0.000	0.000	9.000

PRESTRESS CONCRETE BEAM DIMENSIONS (PART 3 OF 3)

Span No.	Beam Longitudinal Steel					
	Area		CGS		Bar No.	
	Pos. (in^2)	Neg. (in^2)	Pos. (in)	Neg. (in)	Pos.	Neg.
1	0.0	0.0	0.00	0.00	3	3

STRAND CONFIGURATION - ANALYSIS (1 OF 2)

Span No.	P/S Strand Diameter (in)	P/S Strand Area (in^2)	CL CGS Draped Strand (in)	Distance to 1st Row (in)	Vertical Row Spacing (in)	Total No. of Strands	CGS at MidSpan (in)	No. Strand Rows at MidSpan
1	0.520	0.167	n/a	2.50	2.00	42c	n/a	6

Note: A "c" indicates the value was computed from input on the SCA command

STRAND CONFIGURATION - ANALYSIS (2 OF 2)

Span No.	Number of Strands in each Row at MidSpan					
	R01	R02	R03	R04	R05	R06
1	6	10	8	8	6	4

DEBONDING INFORMATION

Span No.	Debonding Location (ft)	Strand Row	Number Strands Debonded
1	2.500	3	4
	6.000	1	2
		2	4

STIRRUP LOCATIONS

Span No.	Location (ft)	Vertical Area (in^2)	Shear Spacing (in)	Reinf. Area (in^2)	Horizontal Area (in^2)	Shear Spacing (in)	Reinf. Area (in^2)
1	0.000	0.8	0.0	0.0	0.0	0.0	0.0
	60.000	0.8	0.0	0.0	0.0	0.0	0.0

DISTRIBUTED LOADS

Load Type	Start Span	Start Dist. (ft)	End Span	End Dist. (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)
DC1	1	0.000	1	60.000	0.1500	0.1500
UT1	1	0.000	1	60.000	0.2400	0.2400
FWS	1	0.000	1	60.000	0.2400	0.2400

OUTPUT OF INPUT DATA

Input File	Input Echo	Input Commands	Input Summary
1		0	1

Chapter 8 Example Problems

OUTPUT OF ANALYSIS RESULTS

Section Properties	Analysis Points	Distribution Factors	Points of Contraflexure	Loads/Load Modifiers	DL Non-Composite	Total DL Non-Composite
1	1	4	0	1	1	1
DL Creep/Shrinkage	Live Load Effects	Live Load Reactions	HS20 Effects /Reactions	H20 Effects /Reactions	Fatigue Effects /Reactions	Factored Effects
1	1	0	1	1	0	0
Factored Reactions	Overall Reaction Summary					
1	1					

OUTPUT OF SPECIFICATION CHECKING

Design Stresses	Final Compressive Stresses Under LL + 1/2 (DL+PS)	End Block Stresses	Cracking Moment	Negative Moment Capacity	Shear Reinforcement	Prestressing Data
1	0	0	1	0	1	1
Fatigue Stress Range	Longitudinal Slab Reinforcement	Positive Moment Connection	Overhang Width	Camber and Deflection	Strand Code Detail	Principal Stresses
0	0	0	0	1	0	0
Girder Stability	Rating Vehicle Stresses	Shear Detail				
0	1	0				

OUTPUT OF RATING FACTORS

Detailed Rating Factors	Live Load Rating	Overall Rating Summary	Rating Vehicle Specification Checking	Ratings w/o FWS
0	0	1	0	1

OUTPUT SUMMARY

TS&L Design Summary	Q/A-Q/C Summary	Detailer Summary
0	0	0



TECHNICAL QUESTIONS AND REVISION REQUEST

This chapter contains a reply form to make it easier for users to convey their questions, problems, or comments to the proper unit within the Department. General procedures for using this form are given. Users should keep the form in the manual as a master copy which can be reproduced as needed. It is also included as a Word template as part of the program installation.

Technical questions related to the interpretations of the design specifications as implemented in this program, why certain assumptions are made, applicability and limitations of this program, and other questions not related to the operation of this program can be directed to the appropriate person in PennDOT using the form or the information provided on the form. Please review the information provided in this User's Manual and the references given in Chapter 1 before submitting this form for processing or calling for assistance.

The form can also be used to report suspected program malfunctions that may require revisions to the program or to request revisions that may be required due to changes in specifications and for the enhancement of the program. Unexpected or incorrect output, rejection of input data, endless program cycling, and program abortion are examples of program malfunctions. Users are requested to review their input data and the program User's Manual before submitting the form for processing.

The form may also be used to submit suggestions for improving the User's Manual for this program. Suggestions might include typographical error correction, clarification of confusing sections, expansion of certain sections, changes in format, and the inclusion of additional information, diagrams, or examples.

The completed form should be sent to Highway Applications Division via e-mail.

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PSLRFD

TECHNICAL QUESTION / REVISION REQUEST

This form is to be used to report suspected program malfunctions, or to request revisions to the program or its documentation. Users are requested to review their input data and the program User's Manual before submitting this form.

CONTACT PERSON: _____ DATE: _____
ORGANIZATION: _____ PHONE: _____
E-MAIL ADDRESS: _____ PROGRAM VERSION: _____

Define your problem and attach samples and/or documentation you feel would be helpful in correcting the problem. If the input data is more than 4 or 5 lines, please provide the input data file as an e-mail attachment. If you require more space, use additional 8½ x 11 sheets of plain paper.

FORWARD COMPLETED FORM TO: Pennsylvania Office of Administration
Infrastructure and Economic Development
Bureau of Solutions Management
Highway Applications Division
E-MAIL: PenndotBisEngineer@pa.gov
PHONE: (717) 783-8822

RECEIVED BY: _____ FOR DEPARTMENT USE ONLY
ASSIGNED TO: _____ DATE: _____

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