USER'S MANUAL FOR

# *LFD PRESTRESSED CONCRETE GIRDER DESIGN AND RATING*

# (PS3)

pennsylvania

DEPARTMENT OF TRANSPORTATION

# USER'S MANUAL FOR

# COMPUTER PROGRAM PS3

# LFD PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

# Version 3.6.0.5

Prepared by:

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Bureau of Solution Management
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**LFD PRESTRESSED CONCRETE GIRDER DESIGN AND RATING**

**SUMMARY OF AUGUST 1993 REVISIONS - VERSION 3.0**

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.0.

1. The input forms for this program have been extensively revised to incorporate input items from the Department's Bridge Analysis and Rating program, BAR6, which will no longer be supported by the Department. However, the program will accept input from the existing BAR6 files for prestressed concrete girder bridges. No conversion of input is required. This feature is to be used only for running existing BAR6 files. The new input forms provided with this program must be used for all new input files. Changes to input forms are as follows.

    a. Under DEAD LOADS, dead load due to future wearing surface can now be entered as a separate input item. The input item SDL is now referred to as DL2.

    b. Prestressing force and eccentricity do not have to be entered for an analysis problem. The program will compute values based on the actual strand pattern entered.

    c. The LIVE LOAD input item was revised to agree with the BAR6 program. The default live loads are now H20, HS20, and ML80 loadings. Input item LIVE LOAD equal to "0" in Version 2 was changed to "F" in Version 3. Input item LIVE LOAD equal to "9" in Version 2 was changed to "G" with an ML80 loading added. Input item LIVE LOAD PLUS IMPACT MOMENT in Version 2 has been removed from Version 3.

    d. The Beam Properties line was removed.

    e. The DESIGN input item has been expanded to accept an "A" for an analysis problem and an "R" for a rating problem.

    f. The BEAM PROJECTION is added as an input item.

2. More input items have been added to the default values table including final allowable stresses, live and dead load factors, and steel initial and yield stresses.

3. Shear values for ratings or for an analysis can be analyzed based on the 1979 AASHTO Interim method or on Article 9.20 of the current AASHTO Specifications. The program will design stirrup spacings using the current AASHTO specifications. Shear values for the quarter point of the beam and unfactored live load shear without impact were added to the shear output data. The horizontal shear reinforcement equations have been revised.

4. Prestressed plank beams are considered a solid box beam for computing minimum losses and required number of strands. Beam properties for a plank beam now deduct the area of the shear key.

5. The formula for computing exterior diaphragm weight has been revised.

6. For a design problem, an actual strand pattern based on the design eccentricity is included in the output.

7. Beam dimensions for 80 different beams listed in BD-600 are stored in the program.

8. A correction has been made to the routine for computing the shear distribution factor.

9. The formula for computing Ultimate Moment Capacity has been revised.

10. Box beams with circular voids can now be input.

11. For debonded problems, the beam projection is considered for computing the transfer and development length at the centerline of bearing and moment capacity at operating rating from the centerline of bearing to the development length.

12. The moment capacity for operating rating at an analysis point is calculated as per DM-4 Figures 9.27.4P(A) and 9.27.5P(A).

13. Special live load data can be entered.

14. The rating section of the program output has been revised to include all output from the BAR6 program. Ratings with and without future wearing surface can be printed in the output.

15. The number of additional stirrups near the end of the beam is computed in accordance with AASHTO 9.21.3.

16. For a debonded design, debonding in the bottom row of strands is not allowed.

17. The creep and shrinkage movement data that was added to this program in Release 2.4 has been removed.

18. End block stresses at release in a box beam are computed based on a solid section both with and without the paving notch included.

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**SUMMARY OF NOVEMBER 1994 REVISIONS - VERSION 3.1**

The following revisions were made to the Department's Prestressed Concrete Girder program. This version was incorporated into BRADD2 and was not released to the user community. The revised program is referred to as Version 3.1.

1. The revisions correct the allowable stress check for final stresses at top fiber of the beam. Version 3.0 was using an incorrect allowable stress value.

2. The revisions correct the allowable stress used for the end block stress check.

3. The multiple lane load reduction factor is not used for computing the shear distribution factor.

4. The span limits for default interior diaphragm placement now agree with BD-651.

5. The sign convention in the rating section of the output now correctly reads "(TENSION + COMPRESSION -)".

6. The calculations of shear ratings and shear capacities for box beams with circular voids have been corrected.

7. When ratings are computed with and without future wearing surface loads, a note is printed after the rating summary that the controlling ratings are computed without considering future wearing surface.

8. A new OUTPUT option "P" has been added. This is for an APRAS permit load and will produce a one-line output that includes BMS ID, Span, Critical Member, Rating and Rating Code.

9. Final Design Load Stresses have been corrected to include the input DL1 loads.

10. The program now requires Stirrup Details to be entered for rating problems.

11. The output, concerning the additional stirrups required in the end block in accordance with AASHTO Article 9.21.3, has been removed. Standard end block details address this requirement.

12. Prestressing strand development in accordance with DM-4 Figure 9.27.5(A) is considered when computing moment capacities for straight and draped strand beams at all analysis locations. Previously this was done just for debonded strands. Additionally, moment capacities for draped strand beams are computed using actual eccentricities. The program previously used the midspan eccentricity to compute moment capacities at all analysis locations.

13. The program will terminate if compressive stresses exceed allowable stresses in a design problem. A message is printed to suggest possible solutions to the problem.

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**SUMMARY OF MARCH 1995 REVISIONS - VERSION 3.2**

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.2. Version 3.2 also includes the previously unreleased revisions from Version 3.1.

1. Flexural Operating Ratings are now computed using the Load Factor method in accordance with 1994 AASHTO Manual for Condition Evaluation of Bridges.

2. Flexural Inventory Ratings are now computed using the Load Factor method and then compared to the existing working stress rating for the serviceability requirement in accordance with 1994 AASHTO Manual for Condition Evaluation of Bridge.

3. The moment capacity at a specified stress ($M_{fy}$) computation has been corrected to consider the initial concrete strain due to the prestressing force.

4. Ultimate moment capacities computed at critical sections for the ultimate moment capacity to cracking moment ratio check in debonded problems only consider those prestressing strands that have reached full development at the previous critical section.

5. A reduced moment capacity at midspan is computed if the prestressing strands are not fully developed at midspan. This occurs when the development length for fully bonded strands minus the beam projection is greater than one-half the span length.

6. The Shear Distribution Factor computation has been revised to correctly place wheel loads in 10 ft. to 12 ft. lanes in accordance with AASHTO Articles 3.6 and 3.7.

7. A program error in the computation of camber due to prestressing force in debonded problems has been corrected.

8. A program error in the computation of the ultimate moment capacity for box beams with circular voids has been corrected.

9. A program error that prevented the use of a 24-axle special live load in the PC version has been corrected.

10. Interior diaphragms weights for box beams with circular voids have been corrected.

11. The input value for the allowable tension in the concrete in the pre-compressed tensile zone under design loads after losses, TENS ft, can now be entered as zero.

12. The example problems have been revised and the output is included in this documentation. The complete manual has been reprinted.

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## SUMMARY OF DECEMBER 1995 REVISIONS - VERSION 3.3

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.3.

1. The moment capacity at a specified stress ($M_{fy}$) computation for a non-composite plank beam has been corrected. Previous program versions could result in a "divide by zero" error for this beam type.

2. The ultimate moment capacity ($M_{UC}$) computation for a composite box beam with circular voids has been corrected. Previous program versions produced an incorrect capacity when the compression block depth was greater than the slab thickness.

3. The shear due to interior and exterior diaphragms for beams with more than one diaphragm is now computed correctly.

4. The program was revised to count the number of input diaphragm location correctly.

5. The maximum concrete strain is checked with greater precision.

6. A warning message for an "ultimate moment capacity to moment capacity at operating rating" ratio check was removed. The check does not apply to the rating revisions made in Version 3.2.

7. The "STRESSES AT RELEASE" output was revised to print the "EXCEEDS ALLOWABLE" warning messages when release stresses based on a basic box (non-solid) section exceed allowable stresses.

8. A one-half inch tolerance, corresponding to the open joint between adjacent box beams required in BD-654, was added to the beam spacing to beam width comparison to determine if box beams are adjacent.

9. The default DESIGN MODULAR RATIO was modified to consider differing concrete weights.

10. A program error, which could inadvertently change the input eccentricity at the centerline of bearings for an analysis problem, has been corrected.

11. The moment capacity of beams with draped strands at analysis points between the point of full development of the strands and the draped point was revised to consider the change in eccentricity of the strands. This revision originally appeared in Version 3.1. However, Version 3.2 revisions inadvertently used the midspan capacity for analysis points in this range.

12. An initial prestressing force exceeding 2500 kips will result in a warning message referring the user to DM-4 Section 9.15.

13. The maximum allowable debonding length check and the bottom row debonded strand restriction were removed for debonded strand design and analysis.

14. Default values were added for the creep factor and the allowable horizontal shear stress.

15. The example problems have NOT been revised in this documentation.

## SUMMARY OF NOVEMBER 1996 REVISIONS - VERSION 3.4

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.4.

1. The special live load input was modified to add new input items for uniform lane load, concentrated load for moment, concentrated load for shear, gage distance, passing distance, and variable last axle distance. In addition, the maximum number of special live loads that can be input was increased from five to eight.

2. The capability to read the special live load data from a separate input file for the PC version was added.

3. The final allowable tension stress at the centerline of bearing is no longer taken as $6\sqrt{f'_c}$ as per DM-4 Change No.2 issued August 1995.

4. The "Crack Control Debonding" message for stresses in the end block has been corrected. In addition, the message when final design stresses exceed allowable stresses at the centerline of bearing has been revised to reflect reduced stresses due to crack control debonding.

5. The minimum prestress loss check was corrected as per DM-4 Article 9.16.

6. The beam spacing tolerance for an adjacent box beam was corrected.

7. A program error, which caused an incorrect prestress loss to be applied to the prestressing force when the actual prestress loss was input, was corrected.

8. The beam dimension table was revised to correct the "T2" dimension for I-beam "24/63".

9. The horizontal shear stress computation was corrected to use the eccentricity at the centerline of bearing instead of the midspan eccentricity.

10. The program was revised to perform a straight strand design if the initial stresses at the centerline of bearing are less than the allowable initial stresses for debonded strands ($f_{tfd}$ and $f_{ci}$) for a debonded design. Previously, the program execution would terminate.

11. The user's manual procedure to calculate the uniform dead load from formwork (UDLF) for an exterior beam was corrected to remove the haunch weight. The haunch weight is computed by the program.

12. A convergence problem in the procedure used to compute the moment capacity at a specified stress ($M_{fy}$) for shallow beams was corrected.

13. Output codes in the rating section of the output have been more clearly defined.

14. The example problems have been revised and the output is included in this documentation.

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**SUMMARY OF JUNE 2002 REVISIONS - VERSION 3.5**

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.5.

1. The program will no longer be supported on the Department's mainframe computer system.

2. The program has been converted to the Compaq Visual Fortran Version 6.1.A compiler as a Win32 application. It will run on Windows 95, Windows 98, Windows NT Version 4.0, Windows 2000, and Windows XP operating systems. It will NOT run under DOS Version 6.22 or lower operating system.

3. All dates have been modified to display a 4-digit year in the output.

4. The rating procedure was revised in accordance with the 1994 AASHTO Manual for Condition Evaluation of Bridges including the 1996 and 2000 Interim Revisions. Changes include the additional Inventory rating check for prestressing steel tension (at 0.8 $f_y$ stress level) and reduction of the section's flexural strength when it is less than 1.2 times the cracking moment. Provisions were added to check concrete compression stresses for both the full design load case and the live load plus one-half the sum of the prestress and permanent (dead) loads case. Since PennDOT DM-4 only allows a final compression stress of 0.4 $f'_c$ for all load combinations, the check for the latter load combination is not required. An option is available to check both load combinations using AASHTO allowable compression stresses for use in other jurisdictions.

5. Although PennDOT has not adopted the 1996 Interim Revisions to the AASHTO Standard Specifications, an option is provided to use the 1996 Interim Revision for Article 9.15.2.2 concerning allowable compression stresses. If this option is selected, the program will check compressive stresses for two additional load combinations using an allowable compressive stress of 0.4 $f'_c$. (1) effective prestress plus permanent (dead) loads, and (2) live loads plus one-half the sum of prestress and permanent (dead) loads. An allowable compressive stress of 0.6 $f'_c$ is used for the full design load combination.

6. A new input item, SKEW CORRECTION FACTOR, was added to account for increased shear due to skew. This factor is applied to the distribution factors used to compute live load shear.

7. The program no longer attempts to place exterior diaphragms at default location for adjacent box beams with an input beam spacing accounting for a one-half inch gap between beams.

8. The allowable initial tension stress for beams with draped strands has been corrected to use the input DRP/DBND ftfd value for the centerline of bearing location and the input TENS fti value for all other locations.

9. The design procedure was corrected so that the loss used for final design is the same loss that is computed for an analysis run using the results of the design run.

10. The correct load factor for the P-82 live load is now applied when computing shear strength.

11. The shear analysis output table now prints the controlling shear value based on the minimum factored live load (including impact) shear to the shear strength ratio.

12. An error causing an incorrect strand pattern to be printed for design runs when the permit load controls was corrected.

13. A new output option was added to print the detailed rating analysis data. The normal (default) output will only contain a rating summary. A new "Rating Summary" output table containing all rating live loads was created. It is printed along with the "Controlling Ratings" output table for this output option.

14. Erroneously reported inventory rating codes of "C" were eliminated.

15. Several array dimensions were reset to eight (the maximum number of special live loads) to allow the program run with more than five special live loads. Previously, runs with more than five special live loads would result in a "exceeds array subscript" runtime error.

16. Individual shear distribution factors are now correctly computed for each special live load.

17. Several input checks were added for the special live load input.

18. Comment lines can now be used in a Special Live Load Data file.

19. Several input checks were added to check the consistency of prestressing strand input for analysis runs. A warning message is printed to notify the user of any inconsistent input and what value the program will use to continue. The program requires that the prestressing strand information for an analysis run be entered using one of the following combinations:

    a. INITIAL PRESTRESSING FORCE, MIDSPAN ECCENTRICITY, and G1.
    b. G1, G2, and the actual strand pattern in R1 to R20.
    c. G1, the center of gravity of the prestressing strand in G2, and the total number of strands in R1.

20. An input check was added to require BEAM CONC f′cb to be entered. In addition, a default value of 85% of $f'_{cb}$ was added for the CONC INIT f′ci input.

21. An input check was added to require positive values for debonded lengths.

22. The input check restricting STIRRUP AREA input to only values corresponding to #3, 4 and 5 bars was removed. Instead, a warning message is printed if STIRRUP AREA is less than the value corresponding to a #3 bar area or greater than the value corresponding to a #5 bar area.

23. Live load plus impact deflections are printed for all applicable live loads.

24. The Safe Load Capacity (SLC) rating is reported in the APRAS output, when applicable.

25. The new PA legal load configuration for the 5 to 7 axle dump truck (designated TK527) has been added to all live load groups, which currently include the ML80 loading. In addition, the TK527 load can be analyzed or rated alone.

26. The axle weights for the ML-80 and TK527 loadings shown in Figure 2.3.1 include the 3% scale tolerance allowed by the vehicle code. When computing the gross vehicle weight of these vehicles for determining the rating in tons, the 3% tolerance is removed. This also applies to special live loads when "Y" is entered for the 3% INCR parameter.

27. The User's Manual was revised for the above listed revisions. In addition, the manual's format was changed and the manual is available in PDF format.

## SUMMARY OF DECEMBER 2003 REVISIONS - VERSION 3.5.0.1

The following revisions are made to the Department's Prestressed Concrete Girder program. The revised program is referred to as Version 3.5.0.1.

1. The program was corrected to continue computing composite section properties when the composite neutral axis is located in the slab. Previously, such an occurrence would result in an error message and termination of the run – (R3.5.01).

2. The iterative procedure used to compute the moment strength at a specified stress level, $M_{fy}$, was revised to accommodate a negative haunch depth – (R3.5.02).

3. New input checks were added for the G1 and G2 fields on the STRAND DETAILS input line. G1 must always be entered, and G2 must be entered if both the INITIAL PRESTRESSING FORCE field and the MIDSPAN ECCECTRICITY field are not entered. Additionally, the center of gravity of the strands is no longer required as input for G2 when the initial prestressing force and eccentricity are entered – (R3.5.03).

4. A revision in version 3.5, which corrected a problem causing an incorrect strand pattern to be printed when the permit load controls the design, resulted in the program using the input G1 value as the center of gravity of the prestressing strands when computing $M_{fy}$ for analysis runs with unknown strand patterns. This results in an inflated $M_{fy}$, and, in turn, an inflated (non-conservative) moment rating. The program has been revised to address both issues – (R3.5.04).

5. A version 3.5 input check for the DEBONDED LENGTH field on the DEBONDED STRAND DETAILS input line was revised to allow zero or blank to be entered. This enables the program to compute the required debonded lengths – (R3.5.05).

6. The program has been corrected to use the AASTHO allowable compressive stress only at the final state. In version 3.5, additional stress checks were being performed for the initial prestress condition using the AASTHO final allowable compressive stress requirements when “Y” is entered in the AASHTO fc field. This resulted in several unsuccessful debonded design runs – (R3.5.06).

7. When the composite neutral axis is located in the slab, the slab concrete below the neutral axis is considered cracked and therefore, is neglected in the composite section property calculations – (R3.5.07).

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**SUMMARY OF AUGUST 2013 REVISIONS - VERSION 3.6.0.0**

PS3 v3.6.0.0 contains the following revisions and enhancements.

General Program Revisions

1. The program code was converted for use with the Intel Visual Fortran compiler. (Request 001)

2. The program has been converted to run as a Windows DLL allowing a seamless interface with Engineering Assistant (EngAsst) and APRAS. (Request 002)

3. The program code was upgraded to current programming standards. (Request 003)

4. The program has been enhanced to provide a PDF output file in addition to the text output file. The PDF file makes it easier to print and paginate the program output. (Request 008)

Input Revisions

5. The maximum number of input axle loads for special live loads was increased from 24 axles to 80 axles. (Request 004)

6. A default was added for the Strand Area input field for design runs. For analysis/rating runs, both the Strand Area and Strand Diameter input fields must now be entered. This corrects a problem for rating runs with the Strand Area was left blank resulting in the program attempting to run in design mode. (Request 006)

7. The input Strand Diameter and Strand Area are checked against standard strand sizes. If the input values do not correspond to a standard strand size, a warning message is printed. A warning message will also be printed if the input Strand Diameter and Strand Area do not correspond to the same standard strand size. (Request 007)

8. For design runs, the defaults for the Strand Diameter and Strand Area have been revised. If the Strand Diameter is entered and the Strand Area is left blank, the Strand Area will default to a standard strand area based on the input strand diameter and the Grade of the prestressing strand. Likewise, if the Strand Area is entered and the Strand Diameter is left blank, the Strand Diameter will default to a standard strand diameter based on the input strand area and the Grade of the prestressing strand. If both are left blank or the input Strand Diameter or Strand Area do not correspond to a standard strand size, the defaults for the Strand Area and the Strand Diameter are now set to 0.167 $in^2$ and 0.52 in. (½" special strand) for Grade 270 and 0.144 $in^2$ and 0.50 in. (½" strand) for Grade 250, respectively. (Request 007)

9. The Shear Distribution Factor input description now clearly states that one-half the wheel load distribution factor needs to be entered. (Request 011)

10. The DL1 input description was amended to include wearing surface, parapet and sidewalk loads for non-composite adjacent box and plank beams. (Request 013)

<u>Beam Section Revisions</u>

11. Bulb-tee sections can now be designed and analyzed by the program. The dimensions for all standard PA Bulb-tee section listed in BD-652M are provided by the program. (Request 009)

12. The effective slab width is determined in accordance with the 2002 AASHTO Standard Specification Article 9.8.3. (Request 012)

<u>Specification Check Revisions</u>

13. The iterative procedure used to compute the moment strength at a specified stress level, $M_{fy}$, is stopped when the strain due to the prestressing force is greater than the maximum allowable strain since the procedure will not converge. $M_{fy}$ is then reported as -9999.9 indicating that the section has no reserve resistance. Also, a detailed description of the iterative procedure used to compute $M_{fy}$ was added to Section 3.8 of the User's Manual. (Request 005)

14. The maximum debonded length check, removed in v3.3, was reinstated to avoid a possible infinite loop problem during debonding design trials. (Request 010)

<u>Load Ratings</u>

15. A new SLC LEVEL option was added, which will produce a rating factor based on a percentage of the Operating rating factor. (Request 014)

## SUMMARY OF DECEMBER 2014 REVISIONS - VERSION 3.6.0.1

PS3 v3.6.0.1 contains the following revisions and enhancements.

Input Revisions

1. The BRIDGE CROSS SECTION & LOAD DATA input descriptions were revised to clarify that the wearing surface, parapet, and sidewalk loads for non-composite adjacent box and plank beams can be included in either the UDLF or DL1 input fields. (Request 015)

2. The input beam designations for BT33/31.25 and BT33/31.50 were corrected in the User's Manual and Engineering Assistant configuration files. (Request 017)

Load Ratings

3. The Safe Load Capacity (SLC) and Risk-based Ratings have been added to the Controlling Rating output table when applicable. (Request 016)

## SUMMARY OF DECEMBER 2016 REVISIONS - VERSION 3.6.0.3

PS3 v3.6.0.3 contains the following revisions and enhancements.

General Program Revisions

1. A correction was made to prevent an infinite loop when an End-of-File or format READ error occurs. (Request 018)

2. Stirrup spacings are now correctly determined when the distance between input stirrup locations is less than the distance between analysis points. Previously, the program assumed the distance between input stirrup locations are greater than the distance between analysis points. This could lead to incorrect stirrup spacings at analysis point in these regions. (Request 019)

3. Beginning with PS3 v3.6.0.0, the “Special Live Loads from a Separate File?” prompt no longer appeared when running PS3.exe from a Command Prompt or a console run by clicking on PS3.exe. A correction was made to re-enable the prompt. (Request 021)

Load Ratings

4. A new Live Load group was added that includes FAST Act Emergency Vehicles (EV2 and EV3) and Heavy-Duty Tow Vehicle (SU6TV). (Request 020)

## SUMMARY OF JANUARY 2024 REVISIONS - VERSION 3.6.0.5

PS3 v3.6.0.5 contains the following revisions and enhancements.

General Program Revisions

1. The program has been upgraded to Microsoft Visual Studio Professional 2019 version 16.11.27, Microsoft .NET Framework Version 4.8.04084, and Intel® Parallel Studio XE2019 Update 5 Composer Edition for Fortran Windows Package ID: w_comp_lib_2019.0.5.281. (Request 023)

Load Ratings

2. For rating runs, the Emergency Vehicles (EV2 and EV3) have been added to the default Lice Load group that is used when the LIVE LOAD field is left blank on the PROJECT IDENTIFICATION input line. (Request 022).

# 1 GENERAL DESCRIPTION

## 1.1 PROGRAM IDENTIFICATION

**Program Title**: LFD Prestressed Concrete Girder Design and Rating

**Program Name**: PS3

**Version**: 3.6.0.5

**Subsystem:** Superstructure

**Authors:** Engineering Software Section
Highway/Engineering Applications Division
Bureau of Business Solutions and Services
Pennsylvania Department of Transportation

**ABSTRACT:**

The Prestressed Concrete Girder Design and Rating program analyzes, designs, or rates a simple span pre-tensioned prestressed concrete beam used in a highway bridge. The program analyzes and/or rates a beam of known cross section (box beam with rectangular or circular voids, plank beam, or I beam) for a given span length, beam spacing and prestressing force. The program will design a beam for a strand pattern and the required prestressing force. The program will also design a beam for required debonded lengths for a given strand pattern and a prestressing force. The criteria used for design are in accordance with the Pennsylvania Department of Transportation Design Manual Part 4. The input consists of span length, beam spacing, strand details, stirrup details, beam dimensions, dead loads, prestress losses or the method used for computing losses, and allowable stresses. The computed values include section properties, moments, shears, stresses, prestress losses, inventory and operating ratings, cambers, deflections, and reactions. The program will analyze, rate, or design a beam for a set of standard live loadings or special live loadings. The flexural and shear rating analysis is performed in accordance with the 1994 AASHTO Manual for Condition Evaluation of Bridges as revised by the 1995, 1996, 1998 and 2000 Interim revisions using the Load Factor method. The shear strengths are computed in accordance with either the 1992 AASHTO Specifications for Highway Bridges or the 1979 AASHTO Interim specifications.

## 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.

AASHTO Specifications - AASHTO Standard Specifications for Highway Bridges, Fifteenth Edition, 1992. This publication can be ordered from:

American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W., Suite 249
Washington, D.C. 20001

AASHTO Manual - AASHTO Manual for Condition Evaluation of Bridges, Second Edition, 1994 as revised by the 1995, 1996, 1998 and 2000 Interim Revisions. This publication can be ordered from:

American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W., Suite 249
Washington, D.C. 20001

BD Standards - Standards for Bridge Design, Prestressed Concrete, Reinforced Concrete and Steel Structures, January 1989 Edition, Pennsylvania Department of Transportation.

DM-4 - Pennsylvania Department of Transportation Design Manual Part 4, August 1993 Edition. This publication can be ordered from:

Pennsylvania Department of Transportation
Publication Sales
P.O. Box 2028
Harrisburg, PA 17105

PennDOT - Pennsylvania Department of Transportation.

PS3 - LFD Prestressed Concrete Girder Design and Rating Program.

# 2 PROGRAM DESCRIPTION

## 2.1 GENERAL

The Prestressed Concrete Girder program analyzes, designs, or rates a prestressed concrete beam of a highway bridge in accordance with the Pennsylvania Department of Transportation Design Manual Part 4. The program will analyze and/or rate a beam if the prestressing force is known or will design a beam's strand pattern and required prestressing force.

## 2.2 PROGRAM FUNCTIONS

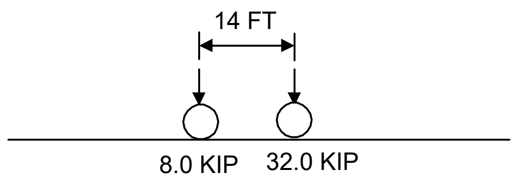
The input consists of span length, lateral beam spacing, dead loads, live loads, distribution factors, stress criteria, prestress losses or the method to be used for computing losses, strand details and other options. For standard beams, box beams with rectangular and circular voids, plank beams (solid box beams), or I-beams, beam designation or beam dimensions are input.

The program computes and outputs basic beam, composite section properties, and dead loads acting on the girder; maximum design moments, design ultimate moment, moment capacities, tensile stress at Operating Rating, cracking moment, live load factor of safety, and the ratio of moment strength to cracking moment; prestressing force, number of strands, eccentricity of prestressing force, strand pattern, percentage loss of prestressing force, transfer and development length; debonding pattern, debonding lengths and at each debonding length: the ratio of effective prestressing force to the ultimate strength of all strands, moment strength, cracking moment and the ratio of moment strength to cracking moment; stresses at pertinent sections and maximum parapet overhang, shear values and stirrup spacings; inventory and operating ratings for flexure and shear; camber and deflection values and principal stresses.

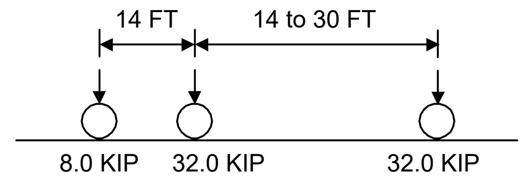
## 2.3 LIVE LOADINGS

Eleven standard live loadings are built into the program. These are designated as H20, HS20, ML80, TK527, AML (Alternate Military Load), HS25, IML (Increased Military Load), P-82 (204 kips Permit Vehicle), EV2, EV3, and SU6TV. See Figure1 for load configurations. The loadings H20 and HS20 are described in the AASHTO Specifications. ML80 and TK527 are the maximum legal loads in Pennsylvania. EV2 and EV3 are FAST Act Emergency Vehicles. SU6TV is a FAST Act Heavy-Duty Tow and Recovery Vehicle. For each loading, one unit of truck is considered in each lane that is loaded. The HS25 loading is a 25% higher loading than the HS20 loading. For loadings H20, HS20 and HS25, an equivalent lane loading (uniform load and one or two concentrated floating loads) is also considered and the governing effects are stored. Equivalent lane loadings for loadings H20 and HS20 are shown in the AASHTO Specifications. Like an HS25 truck, an HS25 lane loading is also 25% higher than the HS20 lane loading. The program provides options to analyze, design or rate a bridge for different groups of these loadings. These options are explained in the Input Data Requirements Section of this manual.

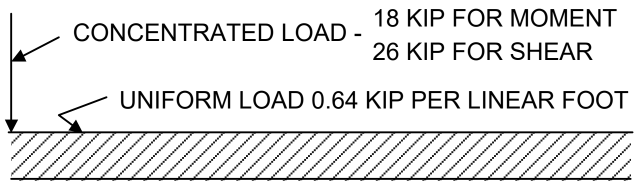
In place of standard loadings described above, the bridge can also be analyzed, designed or rated for a maximum of eight special loadings by entering various live load parameters. This may be useful in analyzing a permit load or when it may be necessary to consider more than one unit of standard loading in a lane. A special live load may have up to a maximum of 80 axles and an associated lane loading.



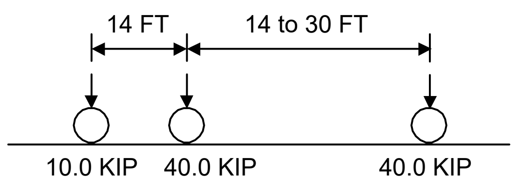

H20 Truck



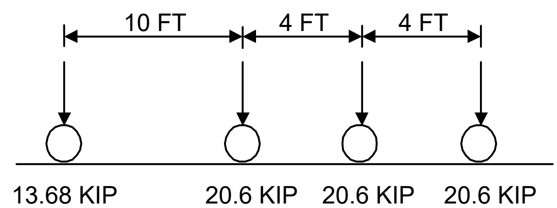

HS20 Truck



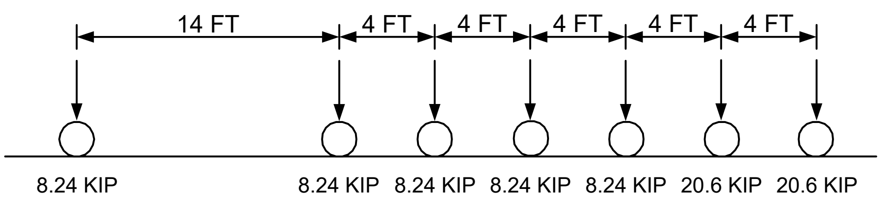

HS20 and H20 Lane Load



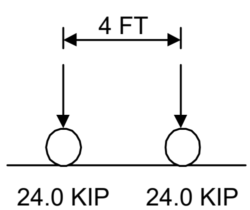

HS25 Truck



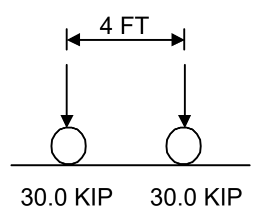

ML-80 Rating Truck



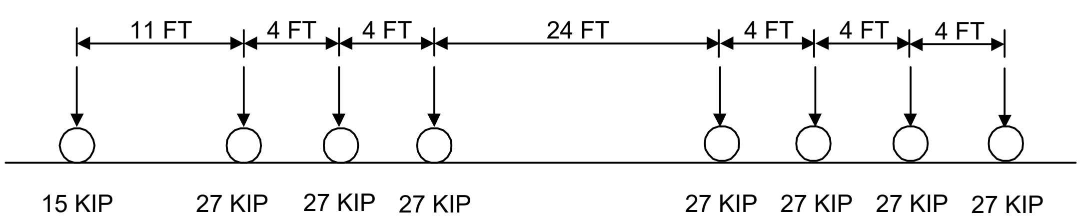

TK527 Rating Truck




Alternate Military Load

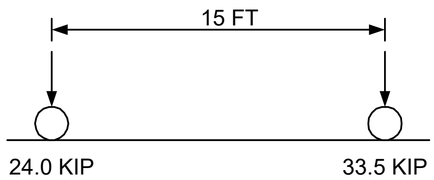



Increased Military Load

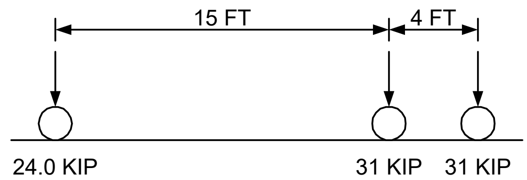



P-82 Permit Load (US)

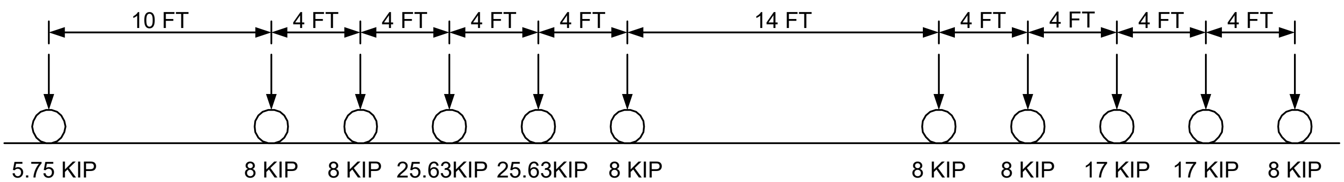
Figure 2.3.1 Standard Live Loads




EV2 Emergency Vehicle




EV3 Emergency Vehicle




SU6TV Heavy-Duty Tow and Recovery Vehicle

Figure 2.3.2 Standard Live Loads (cont.)

## 2.4 RATINGS DEFINITION

The rating of a bridge is determined using a group of specified loads at two rating levels, Inventory and Operating levels, as defined in AASHTO Manual Articles 6.3.1 and 6.3.2. The program uses the Load Factor Method as defined in AASHTO Manual Article 6.4.2 and the Rating Equation given in AASHTO Manual Article 6.5.1.

The ratings are computed based on ultimate flexural and shear strengths including the effects of prestressing. The flexural inventory ratings are computed based on the Load Factor Design method with a working stress check for serviceability. The flexural operating ratings and the shear ratings (inventory and operating) are computed based on the Load Factor Design method.

The program computes three types of ratings for a bridge. These ratings are based on different load factor combinations. The first two ratings are as per requirements of the AASHTO Manual. The last rating is given as an option. The three types of ratings are defined below.

### 2.4.1 Inventory Rating

The Inventory Rating is the load that can be carried by the structure for an indefinite period. This rating is based on the Inventory stress or strength and the number of design traffic lanes positioned and loaded as specified in the AASHTO Manual. This is printed as IR in the rating summary.

2.4.2 Operating Rating

The Operating Rating is the maximum permissible live load to which the structure may be subjected. This rating is based on the Operating strength and the number of design traffic lanes positioned and loaded as specified in the AASHTO Manual. This is printed as OR in the rating summary.

2.4.3 Safe Load Capacity

The Safe Load Capacity is the load that can be safely carried by the structure under actual traffic conditions. This rating is based on the stress or strength level and load distribution that is determined by the engineer. This is printed as SLC in the rating summary.

## 2.5 ASSUMPTIONS AND LIMITATIONS

The following is a list of basic assumptions and limitations for PS3:

1. The program is applicable to only simple span pretensioned concrete beams.

2. Strand diameter used in debonding calculations is assumed 0.52” for all type beams unless a value is entered on the STRAND DETAILS line.

3. The unit weight of concrete for a beam is assumed 150 lbs/ft$^3$. The unit weight of concrete for the slab of a composite beam is 150 lbs/ft$^3$ unless a value is input.

4. The areas of the fillets of the shear keys for adjacent box beams and plank beams are neglected when computing section properties.

5. Prestress loss is computed by the Modified BPR formula assuming low relaxation strands unless a value is input for P/S LOSS %.

6. The modulus of elasticity of concrete $E_c$ of computed by the following formula:

$$E_c = w_b^{1.5}\ 33.0 \sqrt{1000\ f'_{cb}}$$

7. The live load impact factor for moment and shear is computed in accordance with AASHTO Specifications unless a value is entered.

8. The live load distribution factor for shear is computed as per AASHTO Specifications, Article 3.23.1, assuming an interior beam unless a value is entered. The multiple lane load reduction factor is not applied to the shear distribution factor as per DM-4 3.12.

9. Two-legged #4 bars, $f_y$ of 60 ksi, are assumed for stirrup spacing unless values are input under STIRRUP details. For horizontal shear reinforcement, two-legged #4 bars, $f_y$ of 60 ksi, are assumed.

10. If not input, dead load factor is assumed to be 1.3 and live load factor is assumed to be 2.17.

11. An interior beam is assumed if a value is not input.

12. For debonded members, the moment strength for rating is calculated according to Figure 9.27.4p of DM-4. For all members, the moment strength for rating is computed based on the development of stresses in the prestress strands as shown in DM-4 Figure 9.27.5(A).

13. For stress computations, the point of maximum moment is assumed as a point where the maximum live load moment occurs. However, the dead load moment used in stress computations is the dead load moment at midspan.

14. One interior diaphragm is assumed for spans forty-five feet through ninety feet in length. Three interior diaphragms are assumed for spans greater than ninety feet. One exterior diaphragm is assumed for I beams and plank beams greater than forty feet. One exterior diaphragm is assumed for box beams greater than eighty feet.

15. For shear calculations, the distance from extreme compressive fiber to centroid of prestressing force, d, includes slab and haunch thickness for a composite beam. Live load shear caused by the loading combination that produced the maximum moment is used in the computation of $V_{ci}$.

16. Only one unit of truck is considered in a lane for a standard loading. In addition, when two or more lanes are loaded, only one unit of truck is considered in each lane.

17. For input item LIVE LOAD, for a design live load, the 204-Kip Permit Loading (P-82) is used only for an Operating Rating check. This program will not design a beam for a P-82 loading unless it is entered as a special live load. However, P-82 loading will be used for shear design or analysis using the factor DLF in computations in place of LLF.

18. For debonded members only, the maximum debonding length of a member is assumed equal to one half of the span length minus the development length, $L_d$ plus six feet. A distance of six feet is added since the maximum enveloping moment does not occur at midspan, but at a distance approximately six feet from

midspan. In addition, a nine-inch beam projection is assumed for computing the transfer and development length at the centerline of bearing.

19. Ratings are calculated at twentieth points starting at a distance of H/2 from the support to the midspan for if the current AASHTO Specifications are used, and they are calculated at twentieth points starting at the quarter point to the midspan if the 1979 AASHTO Interim Specifications are used.

20. For a span length, less than two times the development length ($L_D$), a reduced Moment Strength is used for computing ratings. The reduced Moment Strength is computed based on the development of stresses in the prestress strands as shown in DM-4 Figure 9.27.5(A).

21. For computing moment strength, the beta reduction factor is based on the concrete strength of the slab ($f'_{cs}$) for a composite section and on the concrete strength of the beam ($f'_{cb}$) for a non-composite section. The gamma factor is assumed to be 0.28 for low relaxation strands. If P/S LOSS % is entered as "0008" or L OR S is entered as "S" on the P/S CROSS SECTION AND LOAD DATA line, the gamma factor is assumed to be 0.40 for stress relieved strands.

22. Maximum live load plus impact deflection is computed for each the live loads in the live load grouping.

23. The program will terminate if compressive stresses exceed allowable stresses in a design problem. A message is printed to suggest possible solutions to the problem.

24. When the composite neutral axis is located in the slab, the slab is to be assumed cracked and, therefore, the slab concrete below the neutral axis is not be considered effective when computing the composite section properties.

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# 3 METHOD OF SOLUTION

The primary purpose of this program is to design or perform the load rating analysis of a prestressed concrete beam in accordance with DM-4, AASHTO Specifications, and AASHTO Manual. The program performs the above calculations using the classical method of structural analysis and design of a prestressed concrete beam. The program uses the theory of prestressed concrete and the criteria set forth in DM-4. The program performs the following calculations:

1. Calculate Section Properties.
2. Calculate Dead Load Effects.
3. Calculate Live Load Effects.
4. Solve for Prestressing Force and Eccentricity.
5. Calculate Stresses and Ratings.

Live load analysis is performed using the influence line method. Stresses are computed based on the Working Stress method. Shears are computed based on the Load Factor Design method.

## 3.1 NOTATION

The following are the meanings of equation notations used in various expressions throughout this document. These notations may not necessarily agree with the notations used in the AASHTO Specifications or DM-4.

$A_b$ = Cross sectional area of basic beam – in$^2$. (The area for the additional ¼" concrete around inner voids for a box beam is not included).

$A^*_s$ = Area of prestressing steel of fully bonded strand – in$^2$.

$A_v$ = Total area of steel of web reinforcement – in$^2$. This is equal to two times the stirrup area entered on the STIRRUP DETAILS line.

$b'$ = Width of a web of a flanged member - in.

$b_v$ = Width of cross section at the contact surface being investigated for horizontal shear - in.

$B_1$ = Maximum downward deflection for a non-composite section - in.

$B_2$ = Maximum downward deflection for a composite section - in.

C = Final camber - in.

Cr = Estimated creep factor.

d = Distance from extreme compressive fiber to centroid of prestressing force - in.

DEFLF = Input factor for computing deflection for individual girders.

DLF = Factor by which the dead load moment or shear is to be multiplied for design factored moment or shear.

e = Eccentricity of the centroid of the prestressing strands at the point of investigation, measured from neutral axis of basic beam - in.

$E_c$ = Modulus of elasticity of concrete at 28 days - ksi.

$E_{ci}$ = Modulus of elasticity of concrete at time of initial prestress (release) - ksi.

$e_n$ = Eccentricity of the prestressing strands centroid at the ends of the beam, measured from the basic beam neutral axis - in.

$e_s$ = Eccentricity of the prestressing strands centroid at the straight portion of the strands, measured from the basic beam neutral axis - in.

$f_b$ = Bottom fiber stress at midspan due to all external loads (used for parapet overhang) - ksi.

$f_{ci}$ = Allowable compression in concrete before losses - ksi.

$f'_{cb}$ = Compressive strength of concrete in beam at 28 days.

$f'_{cs}$ = Compressive strength of concrete in slab at 28 days.

$f_d$ = Stress due to unfactored dead loads acting on basic beam at extreme fiber of section - ksi.

$f_{pc}$ = Compressive stress in concrete after losses at centroid of cross section resisting externally applied loads or at junction of web and flange when centroid lies within the flange - ksi.

$f_{pe}$ = Compressive stress in concrete due to effective prestress forces only at extreme fiber of section where tensile stress is caused by externally applied loads - ksi.

$f'_s$ = Ultimate tensile strength of prestressing steel - ksi.

$f_{se}$ = Effective steel prestress after losses - ksi.

$f_{si}$ = Initial tensile stress in prestressing steel, usually 70% of f's - ksi.

$f^*_{su}$ = Average stress in prestressing steel at maximum factored load - ksi.

$f_{sy}$ = Yield strength of shear reinforcement - ksi.

$f_t$ = Input allowable tension in concrete in precompressed tensile zone - ksi. See the note on page 3-7 for explanation.

$f_{tf,d}$ = For beams with draped strands or debonded strands, allowable tension in top fiber of concrete at centerline of bearing - ksi.

$f_{ti}$ = Input initial tension in top fiber of concrete – ksi. See the note on page 3-7 for explanation.

$g_e$ = Center of gravity of prestressing strands at support from the bottom fiber of beam - in.

$g_m$ = Center of gravity of prestressing strands at midspan from the bottom fiber of beam - in.

H = Overall depth of member - in. This is equal to the beam depth plus the slab thickness plus the haunch thickness.

I = Moment of inertia of basic beam – $in^4$.

$I_c$ = Moment of inertia of for composite beam or non-composite beam – $in^4$.

IMPCT = Moment and shear coefficient for maximum live load plus impact.

j = 0.875

L = Span, centerline to centerline of bearings - in.

$L_D$ = Minimum strand development length for fully bonded strands - ft.

$L_d$ = Minimum strand development length for debonded strands - ft.

LLDF = Live load distribution factor.

LLF = Factor by which the live load moment or shear is to be multiplied for design factored moment or shear.

$L_t$ = Transfer length over which prestressing force is transferred to concrete by bond - in.

$L_x$ = Actual debonded length - in.

$M_{CR}$ = Cracking moment computed as per DM-4 - kip-in.

$M_{cr}$ = Moment causing flexural cracking at section due to externally applied loads computed as per AASHTO Article 9.20 - kip-in.

$M_{De}$ = Unfactored moment at section due to exterior diaphragm acting as a concentrated load - kip-in.

$M_{DIA}$ = Unfactored moment at section due to weight of diaphragms acting as concentrated load - kip-in.

$M_{Di}$ = Unfactored moment at section due to interior diaphragm acting as a concentrated load - kip-in.

$M_{DL}$ = Total unfactored dead load moment ($M_{DL1}$ + $M_{DL2}$) - kip-in.

$M_{DL1}$ = Unfactored moment at section due to input non-composite dead load - kip-in.

$M_{DL2}$ = Unfactored moment at section due to input superimposed dead load - kip-in.

$M_{FWS}$ = Unfactored moment at section due to input future wearing surface - kip-in.

$M_{fy}$ = Moment strength at specified stress in the bottom layer of steel - kip-in.

$M_{fy(IR)}$ = Moment strength at specified stress in the bottom layer of steel for Inventory rating - kip-in.

$M_{fy(OR)}$ = Moment strength at specified stress in the bottom layer of steel for Operating rating - kip-in.

$M_G$ = Unfactored moment at section due to uniform beam weight and interior diaphragm(s) acting as concentrated load(s) - kip-in. (An additional ¼" concrete around inner perimeter of voids for box beams is considered for computing beam moment).

$M_{INDR}$ = Unfactored moment at drape point due to interior diaphragm acting as a concentrated load - kip-in.

$M_{LL+I}$ = Unfactored moment at section due to live load plus impact - kip-in.

$M_{LOC}$ = Maximum available live load moment at Operating Strength - kip-in.

$M_{MAX}$ = Factored moment at section due to externally applied dead load plus live load - kip-in.

$M_n$ = Nominal moment strength - kip-in.

$M_{OC}$ = Operating moment strength at point of investigation - kip-in.

$M_{PERM}$ = Maximum live load plus impact moment for the 204-Kip Permit (P-82) load - kip-in.

$M_{SLB}$ = Moment at section due to slab plus formwork weight - kip-in.

$M_u$ = Factored moment at the section – kip-in.

$M_{UDLF}$ = Unfactored moment at point of investigation due to wearing surface (non-composite) - kip-in.

n = Ratio of modulus of elasticity of concrete in beam and slab, $E_{beam}$ / $E_{slab}$ (1.0 for non-composite beams).

$P_i$ = Initial prestressing force per beam (no losses assumed) - kips.

P = Final prestressing force after all losses - kips. $P = \beta \; P_i$

S = Beam spacing - ft.

s = Stirrup spacing - in.

SDIA = Nominal strand diameter of prestressing steel - in.

SL = Safe load capacity level.

SLC = Safe load capacity rating factor.

SPAN = Span length - ft.

T = Slab thickness - ft.

t = Interior or exterior diaphragm thickness - in.

v = Horizontal shear stress at section - ksi.

$V_c$ = Nominal shear strength provided by concrete - kips.

$V_{ci}$ = Nominal shear strength provided by concrete when diagonal cracking results from combined shear and moment - kips.

$V_{cw}$ = Nominal shear strength provided by concrete when diagonal cracking results from excessive principal tensile stress in web - kips.

$V_d$ = Unfactored shear force at section due to dead loads acting on the basic beam - kips.

$V_{DIA}$ = Unfactored shear force at section due to weight of diaphragm(s) acting as concentrated load(s) - kips.

$V_{DL}$ = Total unfactored dead load shear force at section ($V_{DL1}$ + $V_{DL2}$) - kips.

$V_{DL1}$ = Unfactored shear force at section due to input dead load - kips.

$V_{DL2}$ = Unfactored shear force at section due to input superimposed dead load - kips.

$V_{FWS}$ = Unfactored shear force at section due to input future wearing surface - kips.

$V_G$ = Unfactored shear force at section due to weight of girder - kips.

$V_i$ = Factored shear force at section due to externally applied dead load plus live load occurring simultaneously with $M_{MAX}$ - kips.

$V_{LL+I}$ = Unfactored shear force at point of investigation due to live load plus impact - kips.

$V_{nh}$ = Nominal horizontal shear strength - kips.

$V_p$ = Vertical component of effective prestressing force - kips.

$V_s$ = Nominal shear strength provided by shear reinforcement - kips.

$V_{SLB}$ = Unfactored shear force at section due to slab plus formwork weight - kips.

$V_u$ = Factored shear force at section - kips.

$V_{UDLF}$ = Unfactored shear force at section due to wearing surface (non-composite) - kips.

w = Weight of girder - kips/ft.

$w_b$ = Unit weight of beam concrete - kips/ft$^3$.

$w_s$ = Unit weight of slab concrete - kips/ft$^3$.

x = Distance from end of the beam to the point of investigation - in.

$x_{drape}$ = Input decimal part of span length at which strands are draped, measured from centerline of bearing.

Y = Vertical distance to the bottom fiber of beam from the junction of top web and flange - in.

$Y_b$ = Vertical distance to the bottom fiber of beam from neutral axis - in.

$Y_{bc}$ = Vertical distance to the bottom fiber of beam from neutral axis of composite section - in.

$Z_b$ = Basic beam section modulus for measuring stress at bottom fiber – in$^3$.

$Z_{bc}$ = Composite beam section modulus for measuring stress at bottom beam fiber – in$^3$.

$Z_{sc}$ = Composite beam section modulus for measuring stress at top fiber of slab – in$^3$.

$Z_t$ = Basic beam section modulus measuring stress at top beam fiber – in$^3$.

$Z_{tc}$ = Composite beam section modulus for measuring stress at top beam fiber – in$^3$.

$\alpha$ = Percent of prestress loss.

$\beta$ = Remaining fraction of prestressing force after percent loss has been deducted. A starting value of 0.772 for I-beams or 0.80 for box and plank beams is used.

$\Delta f_s$ = Estimated percent loss in prestressing force for computing camber.

$\Delta_1$ = Camber at transfer of initial prestress.

$\Delta_2$ = Deflection due to weight of beam and interior diaphragm.

$\Delta_3$ = Total camber at transfer of prestressing.

$\delta$ = Maximum parapet overhang - ft.

| | | | | |
|---|---|---|---|---|
| $\phi$ | = | Strength capacity reduction factor (AASHTO 9.14). | | |
| | | For moment: | $\phi$ | = 1.0 |
| | | For shear: | $\phi$ | = 1.0 (1979 AASHTO Interim) |
| | | | $\phi$ | = 0.9 (1992 AASHTO) |
| | | | $\phi$ | = 0.85 (Horizontal Shear) |
| $\sigma$ | = | Maximum principal stress - ksi. | | |
| $\tau_{xy}$ | = | Shearing stress in xy-plane – ksi. | | |

## 3.2 SECTION PROPERTIES

The program first computes all basic beam and composite section properties. The dimensions of 80 beams listed in BD-652 are stored in the program. The program calculates the area, moment of inertia, and section modulli of the beam neglecting the area of strands. The weight of the beam and interior diaphragms (if not input) are calculated from the section properties. Refer to a standard textbook on prestressed concrete structures.

## 3.3 DEAD LOAD ANALYSIS

For analysis, uniform dead loads are divided into two categories. The first load, DL1, is the dead load that acts on the non-composite section of the member. DL1 includes the load due to the weight of beam, deck, permanent formwork, haunch, median, railings and other hardware attached to the main member. The second load, DL2, is the dead load that acts on the composite section of the member. DL2 includes the load due to the weight of parapet, sidewalk, future wearing surface, other structures permanently attached to the deck, and the sidewalk live load. Some of these loads are entered by the engineer and some are computed by the program. This will be explained in detail later in this manual.

For analysis, the girder span is divided into twenty (20) equal segments and a section is considered at each end of the segment (total of 21 sections in each span). The moments due to DL1 and DL2 are computed by applying the principles of statics.

Unless diaphragm information is input for dead load moments, the program assumes no interior diaphragms for spans less than or equal to 45 feet, one interior diaphragm at midspan for spans 45 feet through 90 feet, and three interior diaphragms at the quarter points and midspan for spans greater than 90 feet. For I-beams, the program assumes no exterior diaphragms for spans less than or equal to 40 feet and one exterior diaphragm at midspan for spans greater than 40 feet. For box beams, the program assumes no exterior diaphragms for spans less than or equal to 80 feet and one exterior diaphragm at midspan for spans greater than 80 feet. These limits are provided for torsional rigidity and are to be used for design purposes only. These limits may not agree with the limits specified in BD-651. The moments due to interior and exterior diaphragms acting as concentrated loads are then computed.

## 3.4 LIVE LOAD ANALYSIS

The program uses the following techniques for live load analysis. The girder is analyzed for a live load using the influence line method. For this purpose, the girder is divided into twenty (20) equal segments. A unit vertical load is applied at each twentieth point one at a time and various effects (support reaction, shear, moment and deflection) are calculated at each analysis point across the girder. In calculating these effects, principles of statics are used for simple spans. These effects at a section due to a unit load at other positions constitute an influence line. Each influence line is then separately analyzed for the maximum live load effect. The method used for analyzing an influence line for the maximum live load effect is explained later in this section.

### 3.4.1 Influence Line

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 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.

The procedure described above is applicable for a truck load. However, for H or HS loading or a special live load with a specified lane 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. In addition, 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.

3.4.2 Live Load Distribution

The live load distribution factor for a girder is computed in accordance with the AASHTO Manual and the AASHTO Specifications based on the input value of girder spacing or the input values of distribution factors. This distribution factor is multiplied by the live load effect calculated above to calculate actual live load effect on the girder. A skew correction factor can be input to account for increased shear due to skew.

3.4.3 Impact

The impact factors are computed in accordance with the formula given in the AASHTO Specifications. The loaded length used in the AASHTO impact formula is that given in the AASHTO Specifications.

## 3.5 DESIGN OF PRESTRESSING FORCE

For design problems, the following procedures are used to calculate initial prestressing force $P_i$ and eccentricity e. If the percent loss in prestressing force α (alpha) is not input, minimum losses are initially assumed.

1. The following two simultaneous equations are solved for a theoretical value of $P_i$. The unknowns are $P_i$ and e.

a. $$-\frac{P_i}{A_b}+\frac{P_i\,e}{Z_t}-\frac{M_G}{Z_t}-\frac{M_{INDR}}{Z_t} = f_{ti}$$

b. $$-\frac{P}{A_b}-\frac{P\,e}{Z_b}+\frac{M_G+M_{DIA}+M_{SLB}+M_{DL1}}{Z_b}+\frac{M_{LL+I}+M_{FWS}+M_{DL2}}{Z_{bc}} = f_t$$

Note: Equation a is the stress equation for the top fiber of the basic beam under initial prestressing conditions, before any losses occur. The equation is applied at the centerline of bearing for straight strands and at the drape point for draped strands.

Equation b is the stress equation for the bottom fiber of the composite beam under final load conditions, after losses occur. It is applied at the point of maximum moment for beams with straight, draped or debonded strands assuming maximum dead load moments occur at the same point as maximum live load moments.

For both equations, compression is negative (-) and tension is positive (+).

2. The theoretical $P_i$ is then rounded to the value that corresponds to the nearest whole strand for beams with single webs, such as I-beams or to the nearest even number of strands for beams with double webs, such as box beams.

3. Using the chosen $P_i$ value, equations a and b are solved again, this time for the design eccentricity e. The program uses the least of the two values.

4. The adjusted value of $P_i$ and the design e are then used to compute the cracking moment, $M_{CR}$ and the moment strength, $\phi M_n$, described in Section 3.8, page 3-14. If the minimum steel condition in the following equation is not met, one strand is added to single web beams, two to double web beams, and computations are repeated beginning with step 3.

$$\frac{\phi M_n}{M_{CR}} \geq 1.2$$

5. The maximum practical eccentricity is calculated next by positioning the prestressing strands (the number of strands is based on the design $P_i$) in the bottommost strand rows (as defined by G1, G2, R1, R2, … input) and determining the c.g. of the strands. For example, if the design $P_i$ requires 36 strands, and the input R1 value is 23 strands and the input R2 value is at least 13, then the maximum practical eccentricity will be based on 23 strands in the bottom rows and 13 strands in the second row.

   When the maximum practical eccentricity is less than the design eccentricity, one strand is added to single web beams, two to double web beams, and computations are repeated beginning with step 3. This process continues until the maximum practical eccentricity is greater than or equal to the design eccentricity. If the input does not specify enough strands to satisfy this condition, the design is terminated and the message "THIS JOB TERMINATED SINCE NO. OF STRANDS REQ'D EXCEEDS AVAILABLE" is printed.

   When minimum steel conditions control a design, the design eccentricity e is replaced by the maximum practical eccentricity, to keep the strands from being grouped near the center of the beam. However, if the maximum practical eccentricity is so large that overstresses occur, it is reduced in ¼" increments until there is no overstress.

## 3.6 DEBONDING

The following criteria, taken from DM-4, have been established to control the number and length of strands. The purpose is to prevent a bond failure and ensure a section with strength comparable to a fully bonded section. The equations in this section are for design and analysis only. Refer to Section 3.11 on page 3-24 for rating factors. 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 actual strand pattern used for all computations.

2. The transfer length ($L_t$) and development lengths ($L_D$ and $L_d$) are computed next. The above lengths include the beam projection beyond the centerline of bearing. Refer to Figure 1 on page 3-12.

$$L_t = \tfrac{1}{3}\, f_{se}\ \text{SDIA}$$

$$L_D = 1.6\left[f^*_{su} - \tfrac{2}{3}\, f_{se}\right]\text{SDIA}$$

$$L_d = 2.0\left[f^*_{su} - \tfrac{2}{3}\, f_{se}\right]\text{SDIA}$$

3. For a design problem, the program assumes that two strands are to be debonded.

4. For a design problem, a trial pattern is selected for the lowest eccentricity at centerline of bearing. The debonding pattern and number of debonding lengths are selected based on the following criteria and by the suggested number of strands from Table 1 on page 3-11.

   a. The maximum number of debonded strands is limited to 25% of the total number of strands, not to exceed 24 strands.

   b. The maximum number of debonded strands in a row is 50%. 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 except for a row having three or less strands. For example, for a row of 13 strands, the maximum number of strands available for debonding is 7.

   c. For rows having three or less strands successively, select 2 or 1 debonded strands for a row of three strands; 2 or 0 for a row of two strands; and 1 or 0 for a row of one strand alternately.

      For example:

      | | |
      |---|---|
      | Strands | 3 3 3 3 3 3 2 2 2 2 2 2 1 1 1 1 1 1 |
      | Debonded Strands | 2 1 2 1 2 1 2 0 2 0 2 0 1 0 1 0 1 0 |

   d. The number of debonded strands cut off at a section is limited to a minimum of two and a maximum of six.

   e. The number of debonding points is limited to a maximum of 4.

   f. Selection of debonding of strands is from bottom up successively. Selection of debonding points is from top row down successively to ensure increasing eccentricity at each debonding point.

   g. Avoid debonding corner strands in the bottom row and adjacent strands in the same row and/or column.

   h. Debonded strand pattern should be symmetrical about the vertical axis of the beam.

5. $P_i$ and e are computed from the input (analysis problem) or selected (design problem) strand pattern at each debonding length.

6. For a design problem, the top and bottom fiber stresses in the beam at centerline of bearing are computed and compared to the input $f_{tf,d}$ and $f_{ci}$ values, respectively.

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

$$f_{bot} = -\frac{P_i}{A_b} - \frac{P_i\ e}{Z_t}$$

   If the calculated stresses exceed the allowables, two strands are added to the total number of debonded strands and computations are repeated beginning with step 4.

7. If required debonded lengths are not input, the program assumes the first debonded length, $L_x$, is 6 inches for single web (I and plank) beams and 30 inches for double web (box) beams.

8. The top and bottom fiber stresses in the beam under design loads at $L_x$ and at [$L_x$ + $L_t$] are computed and compared to the input $f_t$ and $f_c$ values.

$$f_{t,top} = -\frac{P}{A_b} + \frac{P\ e}{Z_t} - \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_t} - \frac{M_{LL+I} + M_{FWS} + M_{DL2}}{Z_{tc}}$$

$$f_{t,bot} = -\frac{P}{A_b} - \frac{P\ e}{Z_b} + \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_b} + \frac{M_{LL+I} + M_{FWS} + M_{DL2}}{Z_{bc}}$$

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

9. The next debonding length is assumed equal to the previous debonding length plus one foot and computations in step 8 are repeated for each debonding length.

10. At each debonding length, 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 equal to the debonded length, $L_x$ plus $L_d$.

11. At each critical section, the cracking moment, $M_{CR}$, (see formula in Section 3.8) and the moment strength, $\phi M_n$, are computed considering only those prestressing strands that have reached full development at the previous critical section.

12. For a design problem, the following condition is checked:

$$\phi M_n \geq 1.2\, M_{CR}$$

If this condition is not met, the entire design process is repeated starting with the equations in Section 3.5 using a revised value of $f_{ti}$. The revised $f_{ti}$ is calculated by:

$$f_{ti\,new} = \left[\frac{f_{ti}}{\sqrt{f'_{ci}}} - 1\right]\sqrt{f'_{ci}}$$

Table 3.6-1 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 |
| 2 * | 2 | | | |
| 3 | 3 | | | |
| 4 | 4 | | | |
| 5 | 5 | | | |
| 6 | 6 | | | |
| 7 | 5 | 2 | | |
| 8 | 6 | 2 | | |
| 9 | 6 | 3 | | |
| 10 | 6 | 4 | | |
| 11 | 6 | 5 | | |
| 12 | 6 | 6 | | |
| 13 | 6 | 5 | 2 | |
| 14 | 6 | 6 | 2 | |
| 15 | 6 | 6 | 3 | |
| 16 | 6 | 6 | 4 | |
| 17 | 6 | 6 | 5 | |
| 18 | 6 | 6 | 6 | |
| 19 | 6 | 6 | 5 | 2 |
| 20 | 6 | 6 | 6 | 2 |
| 21 | 6 | 6 | 6 | 3 |
| 22 | 6 | 6 | 6 | 4 |
| 23 | 6 | 6 | 6 | 5 |
| 24 ** | 6 | 6 | 6 | 6 |
| *Minimum number of strands debonded is 2.<br>**Maximum number of strands debonded is 24 | | | | |

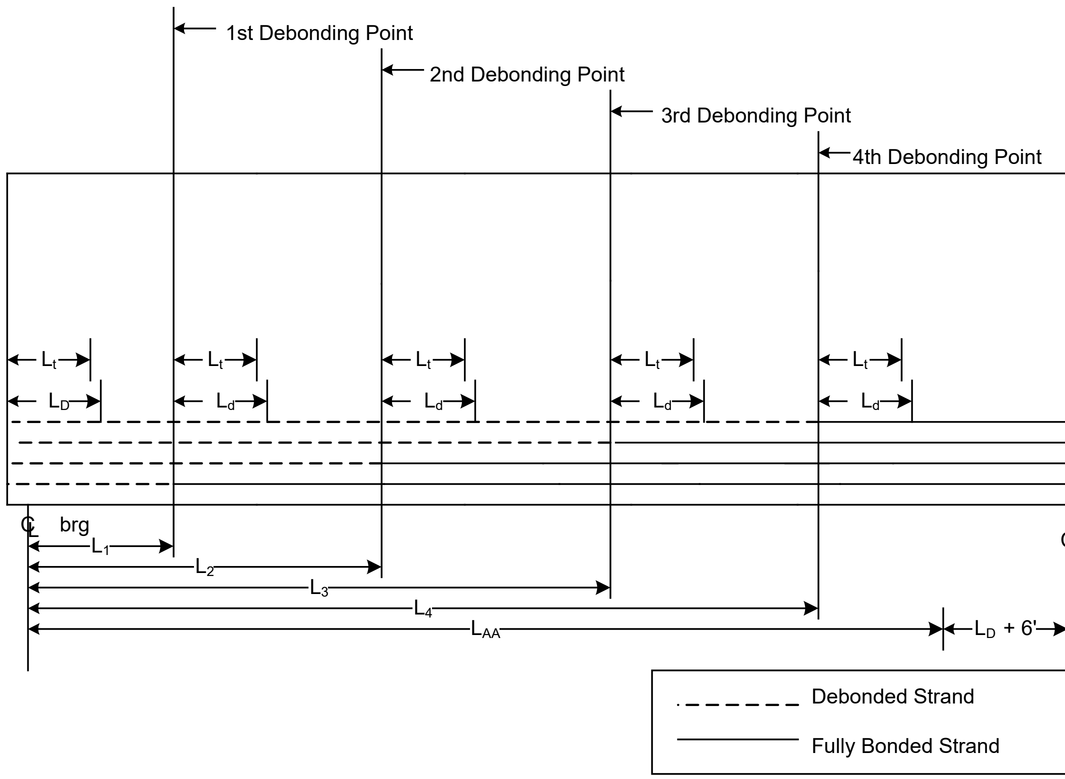


Figure 3.6.1 Debonded Strand Design Details

## 3.7 PRESTRESS LOSSES

The program next calculates α (alpha), the percent of prestress loss, depending on the method chosen. If losses are known and a value is entered for α, the program checks for the minimum losses explained in this section.

If the losses are to be computed by the Modified BPR Formula, the following formula is used.

$$\alpha = \left[ \frac{6.0 + K\, f_{si} + 16 \left[ \frac{P_i}{A_b} + \frac{P_i\, e^2}{I} - \frac{\left[M_G + M_{D,i}\right] e}{I} \right]}{f_{si}} \right] 100$$

Where: K = 0.04 if low relaxation strands are used.

K = 0.08 if stress-relieved strands are used.

If the Lehigh Loss Method is specified, the program uses the generalized computer procedure for estimation of prestress losses developed by Professor Ti Huang of Lehigh University. The Lehigh Loss Method should be used for unusual bridges such as spliced I-beam bridges, segmental bridges, bridges with unusual superimposed dead loads (such as under fills), and slender long span bridges where sag could be a problem. For more details, refer to User's Guide for Prestress Loss Estimation Procedure, Fritz Engineering Laboratory Report No. 470.2, Lehigh University. For computations of design stresses, prestress losses are computed for beam age of twenty (20) years when the Lehigh Loss Method is used. The age of the beam is the time since the beam concrete has cured. Whether the losses are entered or are computed, and whether it is an analysis problem or a design problem, the program checks for a minimum percent loss and uses the following minimum losses if the entered or calculated losses are less than the minimum.

- For I-beams, a minimum of 22.8% loss.
- For box beams and plank beams, a minimum of 20.0% loss.

The program then computes β (beta). The remaining fraction of prestressing force after the percent loss has been deducted.

$$\beta = 1.0 - \frac{\alpha}{100}$$

For a design problem, the computed value of β is then compared to the initially assumed value (0.772 for I-beams and 0.8 for box beams and plank beams). If the values are not within 0.005 of each other, the average of the two is substituted in the formula $P = \beta P_i$, and calculations are repeated, beginning with the simultaneous equations in Section 3.5. This process continues until substituted and computed values of β are within 0.005 of each other. When this occurs, the program uses the last assumed value of β and calculates the prestress loss (%) by substituting the last assumed value of β in the following:

$$\alpha = 100 - 100\,\beta$$

The prestress loss, stresses, and ratings printed by the program are based on the above assumed value of α. The prestress loss, stresses, and ratings printed in a design problem may differ when the same problem is run as an analysis problem. This is because the program computes prestress losses in a design problem from the assumed value of β, where as in an analysis problem the program computes prestress loss using the Modified BPR formula or Lehigh Loss method. To verify results, the user may input the value of prestress loss (α) given in the design output.

## 3.8 MOMENT STRENGTH AND CRACKING MOMENT

The program calculates the moment strength based on the specified stress in the bottom layer, $M_{fy}$, for the prestressing steel tension check as described in AASHTO Manual Article 6.6.3.3. The program uses the moment-curvature analysis method based on the stress-strain compatibility of concrete and steel. Refer to Figure 3.8.1 and Figure 3.8.2 for more information on the calculation of $M_{fy}$.

The program next determines the moment strength, $\phi M_n$, and the design factored moment for the pertinent sections. $\phi M_n$ is calculated as per the equations given in DM-4. For design problems, if a design factored moment is less than or equal to its corresponding moment strength, processing will continue. If the design factored moment exceeds the moment strength, the message "MOMENT STRENGTH OF THE SECTION IS INSUFFICIENT, THEREFORE THE DESIGN IS NOT ACCEPTABLE AND SECTION MUST BE CHANGED" will be printed.

$\phi M_n$ and $M_{fy}$ will be reduced if the prestressing strands are not fully developed at midspan. This will occur if $L_D$ minus the beam projection is greater than one-half the span length. The moment strengths are reduced assuming the development of stresses in the strands follows the graph shown in DM-4 Figure 9.27.5(A).

The program also performs the following overload check for a 204-Kip Permit Load:

$$\phi M_n \geq 1.3 \left[ 1.0 \left( M_{DL1} + M_{DL2} \right) + 1.0\, M_{LL+I} \right] \qquad (3.8\text{-}1)$$

$$M_{fy} \geq M_{DL1} + M_{DL2} + M_{LL+I} \qquad (3.8\text{-}2)$$

Equation (3.8-1) is the AASHTO Overload provision and equation (3.8-2) is the PennDOT requirement based on AASHTO Manual Article 6.6.3.3. If either of the above equations is not satisfied, the beam is redesigned and calculations are repeated beginning with the simultaneous equations in Section 3.5.

Cracking moment, live load factor of safety, and the ratio of moment strength to cracking moment are computed with the following formulas:

Cracking moment for a non-composite beam - kip-in.

$$M_{CR} = M_G + M_{DIA} + M_{UDLF} + M_{DL1} + Z_b \left[ \frac{P}{A_b} + \frac{P\,e}{Z_b} - \frac{M_G + M_{DIA} + M_{UDLF} + M_{DL1}}{Z_b} + 7.5 \sqrt{f'_{cb}} \right]$$

Cracking moment for a composite beam - kip-in.

$$M_{CR} = M_G + M_{DIA} + M_{SLB} + M_{DL1} + M_{FWS} + M_{DL1} + Z_{bc}\left[\frac{P}{A_b} + \frac{P\,e}{Z_b} - \frac{M_G + M_{DIA} + M_{DL1}}{Z_b} - \frac{M_{FWS} + M_{DL2}}{Z_{bc}} + 7.5\sqrt{f'_{cb}}\right]$$

Live load factor of safety.

$$FS_{LL} = \frac{M_{CR} - \left[M_G + M_{DIA} + M_{SLB} + M_{DL1} + M_{FWS} + M_{DL2}\right]}{LLDF\;\; M_{LL+I}}$$

Ratio of moment strength to cracking moment.

$$RATIO = \frac{\phi M_n}{M_{CR}}$$

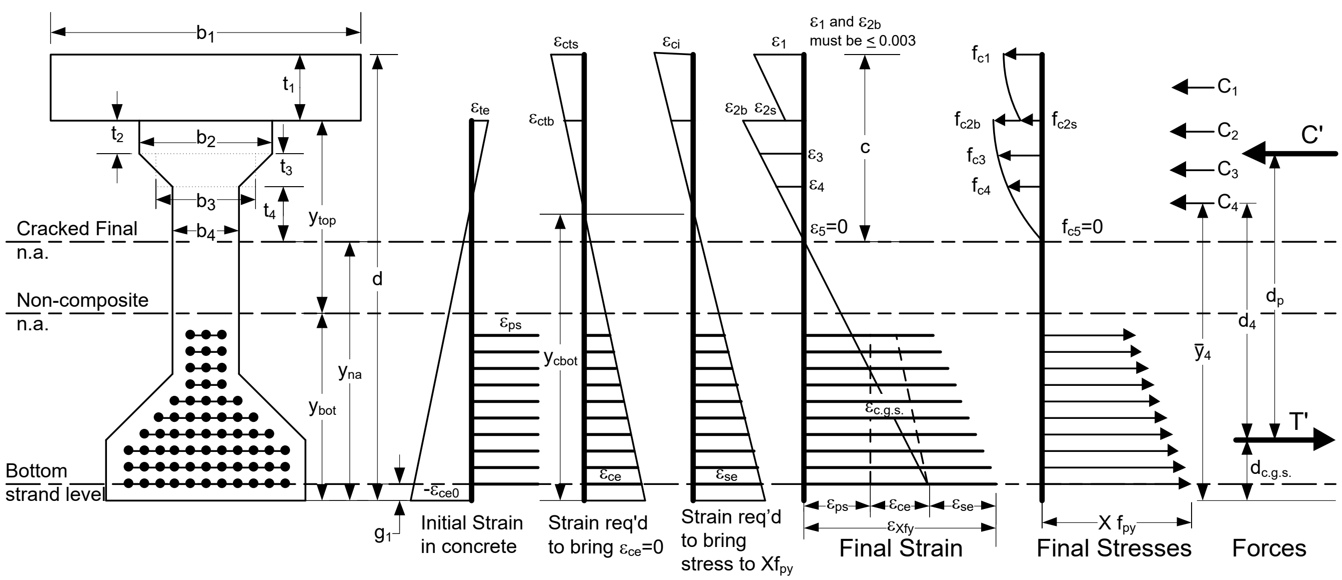


Figure 3.8.1 Calculation of $M_{fy}$

**PROCEDURE**

1. Compute initial strains for the concrete and P/S strands from the effective P/S force.
2. Compute composite strain required to overcome the initial concrete strain.
3. Compute the strain required to produce stress of $Xf_{py}$ in the bottom row of strands. Where $X$ is typically 0.9 for Operating Rating and 0.8 for Inventory Rating.
4. Assume location of N.A.
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 $|(C' - T') / T'| >$ 0.5%, then choose new n.a. and go to step 5.
9. Compute moment arm ($d_p$).
10. Compute moment strength ($M_{Xfpy}$).

**STRAIN EQUATIONS**

Initial strain in concrete due to $P$ and $e$:

$$\varepsilon_{ce0} = \frac{\left(\frac{P}{A_g} + \frac{Pe(y_{bot})}{I_g}\right)}{E_c}$$

$$\varepsilon_{te} = \frac{\left(\frac{-P}{A_g} + \frac{Pe(y_{top})}{I_g}\right)}{E_c}$$

Strain in bottom row of strands due to $P$ and $e$:

$$\varepsilon_{ce} = \frac{\varepsilon_{ce0}(y_{cbot} - g_1)}{y_{cbot}}$$

Strain in slab to overcome $\varepsilon_{ce}$:

$$\varepsilon_{cts} = \frac{\varepsilon_{ce}(d - y_{bot})}{(y_{cbot} - g_1)}$$

$$\varepsilon_{ctb} = \frac{\varepsilon_{ce}(d - y_{bot} - t_1)}{(y_{cbot} - g_1)}$$

Initial Strain in strands:

$$\varepsilon_{ps} = \frac{\left(\frac{P}{A_{ps}}\right)}{E_p}$$

Strain req'd to produce stress $Xf_{py}$ in bottom row of strands:

$$\varepsilon_{se} = \left(\frac{Xf_y}{E_{ps}}\right) - \varepsilon_{ps} - \varepsilon_{ce}$$

$$\varepsilon_{ci} = \frac{\varepsilon_{se}(d - y_{cbot})}{y_{cbot} - g_1}$$

Strain at $f'_c$:

$$\varepsilon_0 = \frac{f'_c}{E_c}\left(\frac{n}{n-1}\right)$$

Where:

$$n = 0.8 + f'_c / 2.5$$

**STRESS EQUATIONS**

Compressive concrete stress at strain $\varepsilon_c$:

$$f_c(y) = f'_c\left[\frac{2\phi y}{\varepsilon_0} - \left(\frac{\phi y}{\varepsilon_0}\right)^2\right]$$

Tensile stress in P/S strands at strain $\varepsilon_{ps}$:

$$f_s(y) = \left[\varepsilon_{ps} + \frac{\varepsilon_{ce}\, y}{y_{na} - g_1} + \phi_{bm}\, y\right]E_{ps}$$

Where $\phi$ is the strain gradient defined as:

$$\phi_{bm} = \frac{\varepsilon_{ci}}{c} \qquad \phi_{slab} = \frac{(\varepsilon_1 - \varepsilon_2)}{t_1}$$

**FORCE EQUATIONS**

Compressive Force in concrete section $i$ :

$$C_i = \frac{(f_{c\,(i)} + f_{c\,(i+1)})}{2} b_i\, t_i$$

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 $C_i$ to bottom of beam:

$$\bar{y}_i = d_i - \frac{(f_{c\,(i)} + 2f_{c\,(i+1)})}{(f_{c\,(i)} + f_{c\,(i+1)})}\left(\frac{t_i}{3}\right)$$

$$d_{c.g.s.} = \frac{\sum T_j\, g_j}{\sum T_j}$$

$$d_p = \frac{\sum C_i\, \bar{y}_i}{\sum C_i} - d_{c.g.s.}$$

**MOMENT CAPACITY**

$$\sum M_{c.g.s.} = 0$$

$$M_{n(Xf_{py})} = 0.5(T' + C')d_p$$

$$M_{Xf_{py}} = \phi M_{n(Xf_{py})}$$

$$\phi = 1.0$$

Figure 3.8.2 $M_{fy}$ Calculation Procedure

## 3.9 STRESSES

Stresses are computed at the following sections: centerline of bearing, the drape point for draped strands, the debonding points for debonded strands, and the point of maximum moment. They are basic beam stresses except where noted. Theoretical stresses are included in the output because they are useful for estimating fatigue life of prestressed bridges.

1. Stresses under initial prestress plus dead load due to girder weight and interior diaphragm(s).

   a. Top fiber of beam.

   $$f_{ti,d} = -\frac{P_i}{A_b} + \frac{P_i\,e}{Z_t} - \frac{M_G + M_{Di}}{Z_t}$$

   b. Bottom fiber of beam.

   $$f_{bi,d} = -\frac{P_i}{A_b} - \frac{P_i\,e}{Z_b} + \frac{M_G + M_{Di}}{Z_b}$$

   c. For draped strands, the eccentricity of the prestressing strands centroid at centerline of bearing, measured from the basic beam neutral axis, is computed unless a value is entered. The least of the following is used. Positive eccentricity is measured downward, negative upward.

   $$e_n = \frac{Z_b}{P_i}\left[f_{ci} - \frac{P_i}{A_b}\right] \quad \text{or} \quad \frac{Z_t}{P_i}\left[f_{tf,d} - \frac{P_i}{A_b}\right]$$

   d. For box beams, stresses in the end block are computed using the above equations with beam properties based on a solid section with or without a paving notch. The paving notch depth, $d_{pn}$, are assumed as follows:

| | | | |
|---|---|---|---|
| Spread box beams: | | | $d_{pn}$ = 3.5" |
| Adjacent box beams: | | | |
| | Composite | (beam depth > 17"): | $d_{pn}$ = 6.5" |
| | | (beam depth ≤ 17"): | $d_{pn}$ = 4.5" |
| | Non-composite | (beam depth > 17"): | $d_{pn}$ = 8.5" |
| | | (beam depth ≤ 17"): | $d_{pn}$ = 0 |

2. Stresses under final prestress plus dead load due to girder weight and interior diaphragm(s).

   a. Top fiber of beam.

$$f_{tf,d} = -\frac{P}{A_b} + \frac{P\,e}{Z_t} - \frac{M_G + M_{Di}}{Z_t}$$

   b. Bottom of beam.

$$f_{bf,d} = -\frac{P}{A_b} - \frac{P\,e}{Z_b} + \frac{M_G + M_{Di}}{Z_b}$$

3. Stresses under final prestress plus permanent (dead) loads. These stresses are only computed when “Y” is input for AASHTO fc. This allows for the additional compressive stress checks in accordance with 1996 AASHTO Article 9.15.2.2. Stresses are computed at the top fiber of the beam and the top fiber of the slab only.

   a. Top fiber of beam.

$$f_{tf,d} = -\frac{P}{A_b} + \frac{P\,e}{Z_t} - \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_t} - \frac{M_{FWS} + M_{DL2}}{Z_{tc}}$$

   b. Top fiber of slab, composite sections only.

$$f_{ts,d} = -\frac{M_{FWS} + M_{DL2}}{Z_{sc}\;n}$$

4. Stresses under live load plus one-half of the sum of the final prestress and the permanent (dead) loads. These stresses are only computed when “Y” is input for AASHTO fc. This allows for the additional compressive stress checks in accordance with 1996 AASHTO Article 9.15.2.2. Stresses are computed at the top fiber of the beam and the top fiber of the slab only.

   a. Top fiber of beam.

$$f_{tf,0.5DL+LL} = 0.5\left[-\frac{P}{A_b} + \frac{P\,e}{Z_t} - \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_t} - \frac{M_{FWS} + M_{DL2}}{Z_{tc}}\right] - \frac{M_{LL+I}}{Z_{tc}}$$

b. Top fiber of slab, composite sections only.

$$f_{ts,0.5DL+LL} = -\frac{M_{LL+I} + 0.5\left[M_{FWS} + M_{DL2}\right]}{Z_{sc}\ \ n}$$

5. Stresses under final prestress plus all design loads.

a. Top fiber of beam.

$$f_{tf,DL+LL} = -\frac{P}{A_b} + \frac{P\,e}{Z_t} - \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_t} - \frac{M_{LL+I} + M_{FWS} + M_{DL2}}{Z_{tc}}$$

b. Bottom fiber of beam.

$$f_{bf,DL+LL} = -\frac{P}{A_b} - \frac{P\,e}{Z_b} + \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_b} + \frac{M_{LL+I} + M_{FWS} + M_{DL2}}{Z_{bc}}$$

c. Top fiber of slab, composite sections only.

$$f_{ts,DL+LL} = -\frac{M_{LL+I} + M_{FWS} + M_{DL2}}{Z_{sc}\ \ n}$$

6. Theoretical tensile stresses at point of maximum moment.

a. Theoretical tensile stress in the bottom fiber at Operating Rating.

$$f_{bf,OC} = -\frac{P}{A_b} - \frac{P\,e}{Z_b} + \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_b} + \frac{M_{LOC} + M_{FWS} + M_{DL2}}{Z_{bc}}$$

$$Factor_{OC} = \frac{f_{bf,OC}}{\sqrt{f'_{cb}}}$$

Where: $M_{OR}$ = The lesser of $\phi M_n$ /DLF and $M_{fy}$.

$Factor_{OC}$ = Theoretical tensile stress at Operating Rating divided by $\sqrt{f'_{cb}}$ .

b. Theoretical compressive stress in top fiber under final prestress plus moment due to 204-Kip Permit Load.

$$f_{tf,PERM} = -\frac{P}{A_b} + \frac{P\,e}{Z_t} - \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_t} - \frac{M_{PERMI} + M_{FWS} + M_{DL2}}{Z_{tc}}$$

c. Theoretical tensile stress in bottom fiber under final prestress plus moment due to 204-Kip Permit Load.

$$f_{bf,PERM} = -\frac{P}{A_b} - \frac{P\,e}{Z_b} + \frac{M_G + M_{DIA} + M_{SLB} + M_{DL1}}{Z_b} + \frac{M_{PERM} + M_{FWS} + M_{DL2}}{Z_{bc}}$$

$$Factor_{PERM} = \frac{f_{bf,PERM}}{\sqrt{f'_{cb}}}$$

Where: $Factor_{PERM}$ = Theoretical tensile stress for the 204-kip Permit Load divided by $\sqrt{f'_{cb}}$.

d. Theoretical compressive stress in top fiber of slab under final prestress plus moment due to 204-Kip Permit Load, composite sections only.

$$f_{ts,PERM} = -\frac{M_{PERMI} + M_{FWS} + M_{DL2}}{Z_{sc}\;n}$$

## 3.10 SHEAR

Shear values and required stirrup spacings are computed at twentieth points of the beam starting at H/2 from the support up to the midspan for individual effects of girder, diaphragm, slab and formwork weights, superimposed dead load, live load plus impact and factored load conditions. Shears are printed at tenth points, quarter point, critical points, and at H/2 from the support. Critical points are points where the calculated stirrup spacing or shear is less than the value at the tenth points. Shear values are computed either as per Article 9.20 of the AASHTO Specifications or the 1979 AASHTO Interim Specifications. Stirrup spacings are computed as per Article 9.20 of the AASHTO Specifications. Two-legged #4 stirrups, $f_{sy}$ of 60 ksi, are assumed unless values are input.

Shear strength provided by the concrete when diagonal cracking results from combined shear and moment is computed first. $V_{LL+I}$ is computed from the load combination causing the maximum moment at the section. If the maximum live load moment at the section is caused by the 204-Kip Permit Load, the factor DLF is used in computations in place of LLF.

$$V_{ci} = 0.6\sqrt{f'_{cb}}\ b'\,d + V_d + \frac{V_i\,M_{cr}}{M_{max}} \qquad \text{and} \qquad V_{ci} \geq 1.7\sqrt{f'_{cb}}\ b'd \quad \text{(Minimum)}$$

Where: $M_{cr} = Z_{bc}\left[6\sqrt{f'_{cb}} + f_{pe} - f_d\right]$

$$f_{pe} = \frac{P}{A_b} + \frac{P\,e}{Z_b}$$

Non-Composite Section:

$$V_d = V_G$$

$$V_i = DLF\left[V_{UDLF} + V_{DL2}\right] + LLF\left[V_{LL+1}\right]$$

$$M_{max} = DLF\left[M_{UDLF} + M_{DL2}\right] + LLF\left[M_{LL+1}\right]$$

$$f_d = \frac{M_G}{Z_b}$$

$$d = D - Y_b + e \quad \text{and} \quad d \geq 0.8\,D$$

Composite Section:

$$V_d = V_G + V_{DIA} + V_{SLB} + V_{DL1}$$

$$V_i = DLF\left[V_{FWS} + V_{DL2}\right] + LLF\left[V_{LL+1}\right]$$

$$M_{max} = DLF\left[M_{FWS} + M_{DL2}\right] + LLF\left[M_{LL+1}\right]$$

$$f_d = \frac{M_G + M_{DIA} + M_{SLB} + M_{DL2}}{Z_b}$$

$$d = D + T3 + T4 - Y_b + e \quad \text{and} \quad d \geq 0.8\,(D + T3 + T4)$$

When a section at a distance of H/2 from the support is closer to the end of the member than the transfer length of the strands, a reduced prestressed force, $P_r$ is used to compute $V_{cw}$.

When H/2 < 50 SDIA: $P_r = P\left[\dfrac{x}{50\ SDIA}\right]$

Where: x = Distance from the end of beam to point of investigation – in.

Shear strength provided by the concrete when diagonal cracking results from excessive principal tensile stress in web.

$$V_{cw} = \left(3.5\sqrt{f'_{cb}} + 0.3\,f_{pc}\right)b'\,d + V_p$$

Where: When $x < x_{drape}\,L$: $V_p = P_r\left[\dfrac{g_e - g_m}{\sqrt{(g_e - g_m)^2 + (x_{drape}\,L)^2}}\right]$

Non-Composite Section:

When $Y_b \leq Y$: $f_{pc} = \dfrac{P_r}{A_b}$

When $Y_b > Y$: $f_{pc} = \dfrac{P_r}{A_b} + \dfrac{P_r\,e\,(Y_b - Y)}{I} - \dfrac{(M_G + M_{DIA} + M_{SLB} + M_{DL1})(Y_b - Y)}{I}$

$d = D - Y_b + e$ and $d \geq 0.8\,D$

Composite Section:

When $Y_{bc} \leq Y$: $f_{pc} = \frac{P_r}{A_b} + \frac{P_r\ e\left(Y_{bc} - Y_b\right)}{I} - \frac{\left(M_G + M_{DIA} + M_{SLB} + M_{DL1}\right)\left(Y_{bc} - Y_b\right)}{I}$

When $Y_{bc} > Y$: $f_{pc} = \frac{P_r}{A_b} + \frac{P_r\ e\left(Y - Y_b\right)}{I} - \frac{\left(M_G + M_{DIA} + M_{SLB} + M_{DL1}\right)\left(Y - Y_b\right)}{I}$

$d = D + T3 + T4 - Y_b + e$ and $d \geq 0.8\left(D + T3 + t4\right)$

The nominal shear strength provided by the concrete, $V_c$, is then taken as the lesser value of $V_{ci}$ and $V_{cw}$. For the 1979 AASHTO Interim method, $V_c$ is computed using the following equation:

$V_c = 0.06\, f_c'\, b'\, j\, d$ and $V_c \leq 180\, b'\, j\, d$

Where: $d = D + T3 + T4 - Y_b + e$ (Composite)

$d = D - Y_b + e$ (Non-Composite)

3.10.1 Shear Design

The required stirrup spacing, s, is computed with the following equations based on Article 9.20 of the 1992 AASHTO Specifications. H20, ML-80 and TK527 loads are not considered for shear design for the "J" live load grouping. Note: $V_{LL+I}$ is computed from the load combination causing the minimum stirrup spacing at the section.

$$s = \frac{A_v\ f_{sy}\ d}{V_s}$$

Where: $\phi = 0.90$

$V_s = \frac{V_u}{\phi} - V_c$, but $V_s \leq 8\sqrt{f'_{cb}}\ b'\ d$

$V_u = DLF\left(V_G + V_{DIA} + V_{SLB} + V_{DL1} + V_{FWS} + V_{DL2}\right) + LLF\left(V_{LL+I}\right)$

$d = D + T3 + T4 - Y_b + e$ and $d \geq 0.8\left(D + T3 + T4\right)$ (Composite)

$d = D - Y_b + e$ and $d \geq 0.8\,D$ (Non-Composite)

The maximum stirrup spacing is the lesser of the following values.

$s_{max} = \left[\frac{A_v}{0.22}\right] 12\,r$ or $s_{max} = 0.75\,D\,r$ or $s_{max} = 24\,r$ or $s_{max} = \frac{A_v\ f_{sy}}{50\,b'}$

Where: When $\left(V_u - \phi\, V_c\right) \;>\; 4\sqrt{f'_{cb}}\; b'\, d$ : $r = 0.5$

When $\left(V_u - \phi\, V_c\right) \;\leq\; 4\sqrt{f'_{cb}}\; b'\, d$ : $r = 1.0$

3.10.2 Shear Analysis and Rating

For an analysis or a rating problem, if the 1979 AASHTO Interim Specifications are chosen, then the shear strength provided by the stirrups, $V_s$ and shear strength, $V_u$, are computed by:

$$V_s = \frac{2\, A_v\, f_{sy}\; j\, d}{s}$$

$$V_u = \phi\left(V_c + V_s + V_p\right)$$

Where: $\phi = 1.0$

$d = D + T3 + T4 - Y_b + e$ (Composite)

$d = D - Y_b + e$ (Non-Composite)

$V_p = P\left[\dfrac{g_e - g_m}{x_{drape}\; L}\right]$ When $x < x_{drape}\, L$

$V_p = 0.0$ When $x \geq x_{drape}\, L$

For an analysis or a rating problem, if the current AASHTO Specifications are chosen, then the $V_s$ and $V_u$ are computed by:

$$V_s = \frac{A_v\, f_{sy}\; d}{s} \quad \text{and} \quad V_s \leq 8\sqrt{f'_{cb}}\; b'\, d$$

$$V_u = \phi\left(V_c + V_s\right)$$

Where: $\phi = 0.9$

$d = D + T3 + T4 - Y_b + e$ and $d \geq 0.8\left(D + T3 + T4\right)$ (Composite)

$d = D - Y_b + e$ and $d \geq 0.8\, D$ (Non-Composite)

3.10.3 Horizontal Shear

Horizontal shear stress and required reinforcement are computed as per AASHTO Article 9.20.4. Two-legged Number 4 stirrups, $f_{sy}$ of 60 ksi, are assumed. The nominal shear strength, $V_{nh}$, and the factored shear force at centerline of bearing, $V_u$, are computed first:

$$V_{nh} = \phi\, 350\, b_v\, d$$

$$V_u = DLF\,[V_{FWS} + V_{DL2}] + LLF\,[V_{LL+1}]$$

Where:
- $\phi$ = 1.0
- $d$ = $D + T3 + T4 - Y_b + e$ (Composite)
- $d$ = $D - Y_b + e$ (Non-Composite)
- $e$ = eccentricity at centerline of bearing.

Required Stirrup spacing, s, is computed next.

When $V_u > V_{nh}$, $s = \dfrac{A_v\, f_{sy}}{50\, b_v}$

When $V_u \le V_{nh}$, $s = 21''$

Horizontal shear stress at centerline of bearing is computed next. The message "HEAVY SCORING FINISH IS REQUIRED" is printed regardless of the horizontal shear stress level.

The horizontal shear stress at centerline of bearing is then checked against the input or default allowable horizontal shear stress ($v_{ha}$).

$$v = \frac{V_u}{b_v\, d}$$

### 3.11 RATING FACTORS

The rating factor is defined as the ratio of the allowable live load to the actual live load. The rating of a bridge is obtained by multiplying the gross weight of the live load with the minimum rating factor. The rating factor for the ML-80 and TK527 loadings are calculated based on the axle loads shown in Figure 2.3.1, which includes a 3% scale tolerance allowed by the vehicle code. The ratings in tons for the ML-80 and TK527 loadings do not include the 3% scale tolerance.

There are three types of ratings calculated by the program: the Inventory Rating, the Operating Rating and the Safe Load Capacity. The Inventory Rating is the load that can be carried by the structure for an infinite period of time. The Operating Rating is the maximum permissible load to which a structure may be subjected. The Safe Load Capacity is the load that can be carried safely by the structure for a long term based on the stress level determined by the engineer. These ratings are calculated based on flexure and shear at various sections on the beam. The rating factors for flexure and shear are calculated based on the Load Factor method from Section 6.6.3.3 of the AASHTO Manual.

The rating factors are calculated at each twentieth point of the beam beginning at H/2 from the centerline of bearing to the midspan. At each analysis point, the moment strength ( $\phi M_{n_x}$ ) and the moment strength at a specified stress in the bottom layer of strands ( $M_{fy_x}$ ) are computed considering the contribution of partially developed prestressing strands. The program assumes that the development of stresses in the strands follows the graph shown in DM-4 Figure 9.27.5(A). The moment strength of the section is computed as per DM-4 9.17. The moment strength of the section based on a specified stress (either input or default of 0.80 of $f_y$ for Inventory Rating or 0.90 of $f_y$ for Operating Rating) in the bottom layer of strands is computed using the moment-curvature analysis method based on the stress-strain compatibility of concrete and steel. For more information on this method, refer to Design of Prestressed Concrete Structures by T.Y. Lin and N.H. Burns (Third Edition, published by John Wiley and Sons) and Figure 3.8.1 on page 3-15. Refer to Figures 9.27.4P(A) and 9.27.5P(A) given in DM-4 for the moment strength of beams with debonded strands. If the moment strength is less than the lesser of 1.2 times the cracking moment ($M_{CR}$) or four thirds the factored moment ($M_u$), the moment strength used in the rating equations is reduced by the ratio of $\phi M_n$ over the lesser of 1.2 $M_{CR}$ or $\frac{4}{3}$ $M_u$.

### 3.11.1 Inventory Rating Based on Flexure

The Inventory Rating factor based on flexure is the minimum rating factor calculated based on either the moment strength of the section ( $\phi M_{n_x}$ ), the moment strength based on a specified stress (either input or default of 0.80 of $f_y$) in the bottom layer of strands ( $M_{fy_{x(IR)}}$ ), or the serviceability rating.

The Inventory Rating factor at a section based on flexure is the lesser of the factors given by the following formulas:

Load Factor Rating:

$$IR = \frac{k\ \phi M_{n_x} - DLF\,[M_{DL}]}{LLF\,[M_{LL+I}]} \qquad \text{or} \qquad IR = \frac{M_{fy_{x(IR)}} - M_{DL}}{M_{LL+I}}$$

Where: $k = 1.0$ when $\phi M_{n_x} \geq MIN\left(1.2\, M_{CR_x}\ ,\ \frac{4}{3} M_{u_x}\right)$

$$k = \frac{\phi M_{n_x}}{MIN\left(1.2\, M_{CR_x}\ ,\ \frac{4}{3} M_{u_x}\right)} \quad \text{when} \quad \phi M_{n_x} < MIN\left(1.2\, M_{CR_x}\ ,\ \frac{4}{3} M_{u_x}\right)$$

Serviceability Rating:

$$IR = \frac{\text{Allowable Stress} - P/S + \text{DL Stress}}{LL + I \ \text{Stress}}$$

At each analysis point, a serviceability rating factor is calculated based on stresses at the top fiber of the slab, the top fiber of the beam and the bottom fiber of the beam. The minimum serviceability rating factor for each analysis point is then compared to the Load Factor rating factor. The lesser of the two factors is stored as the rating factor for that analysis point.

Allowable stresses for serviceability inventory ratings are determined from the input values. Stresses due to prestress, dead load and the live load plus impact are computed using the flexure formula. In calculating stresses for serviceability inventory rating, a debonded strand is assumed to be not effective until it reaches the theoretical transfer length, $L_x + L_t$.

If “Y” is entered for the AASHTO fc input, an additional serviceability rating factor is computed to check concrete compression using an allowable compression of $0.4f'_c$ for the live load plus one-half the sum of the prestress and permanent (dead) load combination. The rating factor for compression stress due to prestress plus all design loads is then computed using an allowable compression of $0.6f'_c$.

If “N” is entered for the AASHTO fc input or the default the used, the only compression stress rating factor computed is for the stress due prestress plus all design loads using the input or default final allowable compression stress, COMP fc.

### 3.11.2 Safe Load Capacity Based on IR

If the engineer chooses to express the allowable stress for Safe Load Capacity (SLC LEVEL) as a percent of IR, the Safe Load Capacity is calculated by the appropriate controlling formula:

If Load Factor Rating controls:

$$SLC = \frac{SL\,[k\ \phi M_{n_x}] - DLF\,[M_{DL}]}{LLF\,[M_{LL+I}]} \quad \text{or} \quad IR = \frac{SL\,[M_{fy_x(IR)}] - M_{DL}}{M_{LL+I}}$$

If Serviceability Rating controls:

$$SLC = \frac{SL\left[\text{Allowable Stress}\right] - P/S + DL\text{ Stress}}{LL + I\text{ Stress}}$$

Where: $SL = 1 + \dfrac{SLC\ LEVEL}{100}$

$k = 1.0$ when $\phi M_{n_x} \geq MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

$k = \dfrac{\phi M_{n_x}}{MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)}$ when $\phi M_{n_x} < MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

3.11.3 Operating Rating Based on Flexure

The Operating Rating factor based on flexure is calculated based on either the moment strength of the section ( $\phi M_{n_x}$ ) or the moment strength based on a specified stress (either input or default of 0.90 of $f_y$) in the bottom layer of strands ( $M_{fy_x(OR)}$ ).

The Operating Rating factor at a section based on flexure is the lesser of the factors given by the following two formulas:

$$OR = \frac{k\,\phi M_{n_x} - DLF\left[M_{DL}\right]}{DLF\left[M_{LL+I}\right]} \quad \text{or} \quad OR = \frac{M_{fy_x(OR)} - M_{DL}}{M_{LL+I}}$$

Where: $k = 1.0$ when $\phi M_{n_x} \geq MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

$k = \dfrac{\phi M_{n_x}}{MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)}$ when $\phi M_{n_x} < MIN\left(1.2\,M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

3.11.4 Safe Load Capacity Based on OR

If the engineer chooses to express the allowable stress for Safe Load Capacity (SLC LEVEL) as a percent of OR the Safe Load Capacity is calculated by one of the following formulas:

If $\phi M_n$ controls:

$$SLC = \frac{SL\left[k\,\phi M_{n_x}\right] - DLF\left[M_{DL}\right]}{DLF\left[M_{LL+I}\right]}$$

If $M_{fy}$ controls:

$$SLC = \frac{SL\left[M_{fy_x(OR)}\right] - M_{DL}}{M_{LL+I}}$$

Where: $SL = \dfrac{SLC \;\; LEVEL}{100}$

$k = 1.0$ when $\phi M_{n_x} \geq MIN\left(1.2\, M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

$k = \dfrac{\phi M_{n_x}}{MIN\left(1.2\, M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)}$ when $\phi M_{n_x} < MIN\left(1.2\, M_{CR_x}\,,\, \tfrac{4}{3} M_{u_x}\right)$

If the SLC LEVEL is entered as A*xx*, where *xx* is a percentage of the Operating rating, the Safe Load Capacity is calculated as a direct percentage of OR.

$$SLC = SL\,(OR)$$

Where: $SL = \;(SLC\; LEVEL)/100$

3.11.5 Shear Ratings

Shear strength is based on either design or input stirrup spacings and is computed based on either current AASHTO Specifications or the 1979 AASHTO Interim specifications. Rating factors for Inventory and Safe Load Capacity expressed as a percentage of IR are computed by the formulas:

$$IR = \frac{\phi(V_c + V_s) - \; DLF\,[V_{DL}]}{LLF\,[V_{LL+I}]}$$

$$SLC = \frac{SL\,[\phi(V_c + V_s)] - \; DLF\,[V_{DL}]}{LLF\,[V_{LL+I}]}$$

Where: $SL = 1 + \dfrac{SLC \;\; LEVEL}{100}$

The factors for Operating Rating and Safe Load Capacity expressed as a percentage of OR:

$$OR = \frac{\phi(V_c + V_s) - \; DLF\,[V_{DL}]}{DLF\,[V_{LL+I}]}$$

$$SLC = \frac{SL\,[\phi(V_c + V_s)] - \; DLF\,[V_{DL}]}{DLF\,[V_{LL+I}]}$$

Where: $SL = \dfrac{SLC \;\; LEVEL}{100}$

If the SLC LEVEL is entered as A*xx*, where *xx* is a percentage of the Operating rating, the Safe Load Capacity is calculated as a direct percentage of OR.

$$SLC = SL\,(OR)$$

Where: $SL = \;(SLC\; LEVEL)/100$

Shear ratings are computed starting from H/2 from the support when the current AASHTO Specifications are used. Shear ratings are computed starting from SPAN/4 when the 1979 AASHTO Interim Specifications are used.

Minimum ratings are printed along with the rating in terms of gross vehicle weight and location. Minimum ratings in terms of gross vehicle weight for flexure and shear for each load type are printed under "CONTROLLING RATINGS."

### 3.12 PARAPET OVERHANG

The maximum parapet overhang $\delta$ (from centerline fascia beam, assuming two-foot curb) that can be allowed before stresses in fascia beam exceed those of interior beam being analyzed or designed is calculated next unless:

1. Beam is non-composite or
2. Composite adjacent box beams are being used or
3. Fascia beam is being analyzed or designed.

**Note:** Initially the allowable overhang is assumed as zero. If the calculated value is within ± 0.50 feet of this assumed value, the procedure is finished and the resulting $\delta$ value is the allowable parapet overhang. If the calculated value is not within ± 0.50 feet, then the average of the assumed value and the calculated value is taken as the new assumed value and $\delta$ is recalculated. (The values M and N are functions of the assumed $\delta$ value – see below.) This process continues until the calculated and assumed values are within 0.50 feet of one another.

$$\delta = \frac{0.0833\ Z_{bc}\ f_b - SPAN^2 \left[\frac{w\,K}{8} + 0.0634 + 0.0094(T)(S)(K) + 0.0019 + S\right] - M}{SPAN^2\ [0.0188(K)(T) + 0.0038] + N}$$

Where:

$$M_U = DLF\,[M_G + M_{DIA} + M_{SLB} + M_{DL1} + M_{FWS} + M_{DL2}] + LLF[M_{LL+I}]$$

$$K = \frac{Z_{bc}}{Z_b}$$

$$IMPCT = 1 + \frac{50}{L + 125} \qquad \text{and} \qquad IMPCT \le 1.3$$

If $(S + \delta) \le 10.0'$ :

$$M = M_U\ IMPCT\left[0.5 - \frac{2}{S}\right] \qquad \text{and} \qquad N = \frac{M_U\ IMPCT}{2\,S}$$

If $10.0' < (S + \delta) \le 14.0'$ :

$$M = M_U \; IMPCT \left[ 1.0 - \frac{7}{S} \right] \qquad \text{and} \qquad N = \frac{M_U \; IMPCT}{S}$$

If $(S + \delta) > 14.0'$ :

$$M = M_U \; IMPCT \left[ 1.5 - \frac{14}{S} \right] \qquad \text{and} \qquad N = \frac{1.5 \; M_U \; IMPCT}{S}$$

## 3.13 CAMBER AND DEFLECTION

1. Camber and deflection values are computed next.

   a. For straight strands without debonding.

$$\Delta_1 = (1 - \Delta f_s) \left[ \frac{P_i \; e \; L^2}{8 \; E_{ci} \; I} \right]$$

   b. For straight strands with debonding.

$$\Delta_1 = \frac{(1 - \Delta f_s)}{2 \; E_{ci} \; I} \left[ P_{i_1} \; e_1 \; x_1^2 + P_{i_2} \; e_2 \left( x_2^2 - x_1^2 \right) + \ldots + P_{i_n} \; e_n \left( x_n^2 - x_{(n-1)}^2 \right) + P_i \; e \left( \frac{L^2}{4} - x_n^2 \right) \right]$$

   c. For draped strands.

$$\Delta_1 = (1 - \Delta f_s) \left[ \frac{P_i \; L^2}{2 \; E_{ci} \; I} \right] \left[ \frac{e_s}{4} - \frac{(e_s - e_n) \; x_{drape}^2}{3} \right]$$

2. Deflection due to girder and interior diaphragms.

$$\Delta_2 = \frac{5 \left( M_G + M_{Di} \right) L^2}{48 \; E_{ci} \; I}$$

3. Deflection due to slab, formwork, and exterior diaphragms.

$$B_1 = \Delta_S = \frac{5 \left( M_{SLB} + M_{De} \right) L^2}{48 \; E_c \; I}$$

4. Deflection due to superimposed dead load(s).

$$B_2 = \Delta_S = \frac{5 \left( M_{FWS} + M_{DL2} \right) L^2}{48 \; E_c \; I_c}$$

5. Net final dead load camber.

$$C = (\Delta_1 - \Delta_2) \, Cr - (B_1 + B_2)$$

6. Maximum live load plus impact deflection. The maximum deflection is computed using influence lines for each live load. The deflections are then multiplied by the impact factor and the deflection distribution factor. These values are reported along with the DM-4 allowable live load plus impact deflections.

## 3.14 PRINCIPAL STRESSES

If an option is specified, the program calculates approximate principal stresses.

Principal stresses are calculated for twentieth points and drape points up to midspan, at selected vertical positions within the beam, i.e. bottom of top chamfers, top of bottom chamfers, etc.

Maximum moments and maximum shears are used in the stress computations. For a given point along the beam, these may not occur under identical load conditions. The maximum moment for a point may be caused by an Alternate Military Loading, while the maximum shear for the same point may be caused by an HS Loading.

The principal stress ($\sigma$) and the corresponding angle of the principal plane ($\tau$) are given by the following equations.

$$\sigma = \left[\frac{\sigma_x + \sigma_y}{2}\right] + \sqrt{\left[\frac{\sigma_x - \sigma_y}{2}\right]^2 + \tau_{xy}^2}$$

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# 4 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 7 (32- and 64-bit versions), Windows 8, Windows 10, and Windows 11 operating systems.

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 downloaded program 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 destination folder, which defaults to "C:\Program Files\PennDOT\PS3 v<version number>\" or "C:\Program Files (x86)\PennDOT\PS3 v<version number>\" for 64-bit operating systems:

1. PS3.exe – Executable program and
2. PS3_DLL.dll - Dynamic Link Library.
3. PS3 Users Manual.pdf – Program User's Manual (PDF Format).
4. PS3RevisionRequestForm.dotx – Revision Request form (MS WORD template).
5. Microsoft C++ library files if not installed in the C:\WINDOWS\WinSxS folders.

The program example problem files (ex*.dat) will be installed in the program example folder, which defaults to "C:\PennDOT\PS3 v<*version number*> Examples\". Users must have write access to this folder in order to run the input files from this folder.

## 4.2 PREPARING INPUT

The program requires an ASCII input file. The input file consists of a series of data lines. Each data line consists of a number of fixed length data fields. A decimal point must be included for any numerical data. Otherwise, the data will be read as an integer. Chapter 5 of the User's Manual includes descriptions of the input and input forms to facilitate data preparation. The input can be created using Engineering Assistant, described below, or any text editor (such as Notepad).

## 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. The entire Engineering Program User's Manual is also accessible 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 software support website at http://penndot.engrprograms.com.

## 4.4 RUNNING THE PROGRAM WITHOUT ENGINEERING ASSISTANT

PS3 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, 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 first 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 gives the option of overwriting the existing file or entering a new output file output file name. If no output file name is entered, a default output file will be used.  The program will then execute.

To cancel the program during execution, press <Ctrl C> or <Ctrl Break>.

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 from within EngAsst or with a text editor, and the *.PDF output file with Adobe Acrobat.

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# 5 INPUT DESCRIPTION

Input forms (See Figures 1, 2, 3 and 4 on pages 5-2, 5-3, 5-4 and 5-5) have been provided to facilitate data preparation for execution of this program. The input form has data lines with appropriate headings. The PROJECT IDENTIFICATION, BRIDGE CROSS SECTION & LOAD DATA, SPAN LENGTHS, PRESTRESS CRITERIA, BEAM DIMENSIONS, and one STRAND DETAILS line must be entered for all problems. The COMMENTS, DEBONDED STRAND DETAILS, STIRRUP DETAILS, and SPECIAL LIVE LOAD DESCRIPTION lines are optional. Up to five STRAND DETAILS lines may be entered. Up to four DEBONDED STRAND DETAILS lines may be entered. The following sections explain each data item. The decimal place for each data item is implied and shown on the form and thus a decimal should not be entered. Refer to Chapter 4 for instructions on how to prepare an input file.

This program will also accept input in the format of the Department's Bridge Analysis and Rating program (BAR6). No conversion of input is required. This feature is provided to allow the use of existing BAR6 input files to run this program. All new input files for rating of prestressed concrete girder bridges must be created using the input forms provided in this manual.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
JULY 2000

Form 1 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION | | | | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR | | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COUNTY | STATE ROUTE | SEGMENT | OFFSET | | | | | | | | | DLF | LLF | | | | | | |
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| = P R S T R | | | | | | | | | | | | | | | | | | | | |

## COMMENTS

| COMMENTS |
|---|
| * |
| * |
| * |

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS | | | UNIT WT DECK CONCRETE | DEAD LOADS | | | | INITIAL PRESTRESSING FORCE | ECCENTRICITY | | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD | | | | | | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SHEAR | MOMENT | DEFLECT | | UDLF | DL1 | FWS | DL2 | | MIDSPAN | END | | | T0 | TS | TD | IC | MFG | IST | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| | | | | | | | | | | | | | | | | | | | | | |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| | | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 5.0.1 Input Form 1 of 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
JULY 2000

Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |

## PRESTRESS CRITERIA

| BEAM CONC f'cb | SLAB CONC f'cs | CONC INIT f'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| | | | | | | | | | | | | | | | | | | | | | | |
| X X X X | X X X | X X X X X | | | | | | | | | | | | | | | | | | | | |
| X X X X | X X X | X X X X X | | | | | | | | | | | | | | | | | | | | |
| X X X X | X X X | X X X X X | | | | | | | | | | | | | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 5.0.2 Input Form 2 of 4

Form 3 of 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
JULY 2000

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

DEBONDED STRAND DETAILS

| DEBONDED LENGTH Lx | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | | 14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. |
| 1 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

STIRRUP DETAILS

| SPEC | STIRRUP AREA | fsy | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 8 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 | 53 | 58 | 63 |
| | | | 0.00 | | | | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 5.0.3 Input Form 3 of 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| | | | | | | | | | |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 5.0.4 Input Form 4 of 4

## 5.1 PROJECT IDENTIFICATION

PROGRAM IDENT

Enter "=PRSTR" to identify the data for this program. The program checks for these characters and terminates execution if the proper combination of characters is not present. The message "IDENT ERROR - EXECUTION TERMINATED" will be printed.

STRUCTURE IDENTIFICATION

Enter a 14-digit Structure Identification number similar to that used in the Bridge Management System (BMS). This number is comprised of four data items for each bridge. The four data items are COUNTY, STATE ROUTE, SEGMENT and OFFSET. Entering this data correctly and saving the input data as permanent members in the Engineering Dialog Input Library will allow this data to be integrated into the Automated Permit Routing/Analysis System (APRAS).

DESCRIPTION

Enter a description of the bridge or problem being analyzed. Any alphanumeric characters up to a maximum of 24 can be entered. Use the first four characters to enter APRAS Span ID.

SLC LEVEL

Enter a code, as explained below, if the Safe Load Capacity (SLC) of the bridge is to be printed in the rating summary. Leave this blank if the SLC value is not desired.

Enter the stress or strength level to which the bridge may be allowed to carry the load to determine its Safe Load Capacity. The level can be expressed as a percent of either the Inventory Capacity (Stress or Strength) or the Operating Capacity (Stress or Strength).

If the SLC level is expressed as a percent Inventory Capacity, enter the letter "I" followed by a two-digit number that indicates the percent of stress or strength above the Inventory Capacity. For example, enter I25 if the stress or strength level can be 25 percent above the Inventory Capacity to determine the Safe Load Capacity of the bridge.

If the SLC level is expressed as a percent of Operating Capacity, enter the letter "O" followed by a two-digit number, which indicates the percent of Operating Capacity that can be used in determining the Safe

Load Capacity of the bridge. For example, enter O85 if the stress or strength level to determine the Safe Load Capacity of the bridge can be 85 percent of the Operating Capacity.

If the SLC level is expressed as a percent of Operating Rating, enter the letter "A" followed by a two-digit number, which indicates the percent of Operating Rating that can be used in determining the Safe Load Capacity of the bridge. For example, enter A85 if the stress or strength level to determine the Safe Load Capacity of the bridge can be 85 percent of the Operating Rating.

LIVE LOAD

If the bridge is to be designed for an HS25 loading and the Increased Military Load, and rated for H, HS, ML80, TK527 and P-82 loadings, enter "J" or leave blank. For this option, DESIGN must be entered as 0, 1 or 2.

If the bridge is to be designed for HS20, Alternate Military Load, ML80 and TK527 loadings, enter "I". For this option, DESIGN must be entered as 0, 1 or 2.

If only the ratings are desired for the H, HS, ML80, TK527, EV2, and EV3 loadings, leave this blank. For this option, DESIGN must be entered as "R".

If the bridge is to be analyzed, rated or designed for a special live loading (defined by axle loads, axle spacings and lane loadings) or a group of special live loadings, enter the number of loadings. A maximum of eight loadings may be entered. The data for the special live loadings, which will be described later, should correspond to the number entered here.

If the bridge is to be analyzed or rated for any one or a group of standard loadings stored in the program, enter one of the following codes:

“A” - Consider an H20 loading only.
“B” - Consider an HS20 loading only.
“C” - Consider an ML80 loading only.
“F” - Consider an HS20 loading and an Alternate Military Load.
“G” - Consider an HS25, Increased Military Load, ML80, TK527 and P-82 loadings.
“H” - Consider an H20, HS20, ML80, TK527 and P-82 loadings.
"L" - Consider FAST Act Emergency Vehicles (EV2 and EV3) and Heavy-Duty Tow Vehicle (SU6TV).
“T” - Consider a TK527 loading only.

For a design problem, the P-82 loading is used only for an Operating Rating check and for stirrup spacing design or shear analysis.

Only one truck load is considered in a lane. If it is necessary to consider more than one unit in the same lane, it must be described as a special live loading.

OUTPUT

Enter “0” for normal output. The normal output does not include detailed rating analysis, only a summary of the ratings.

Enter “1” for normal output with detailed Rating analysis.

Enter ”P” for APRAS output.

IMPACT FACTOR

Enter the factor by which a live load effect must be multiplied to obtain the live load plus impact effect (for example, enter 1.20 for 20% impact or 1.0 for no impact).

Leave blank if the impact factor is to be computed as per the AASHTO Specifications.

GAGE DISTANCE

Enter the lateral distance between the wheels of a truck. If left blank, the program will use 6 feet as specified in the AASHTO Manual. The gage distance is used for computing the lateral distribution of wheel loads used in computing the distribution factor for shear for the girder.

For special live loads, enter only if the gage distance is the same for the entire set of special live loads and is a value other than 6 feet. Otherwise, the program will use the default value or the value entered in the SPECIAL LIVE LOADS data line for each special live load.

PASSING DISTANCE

Enter the minimum lateral distance between adjacent wheels of passing vehicles or twice the minimum distance from the face of the curb to the nearest wheel (curb distance). This is used in calculating the distribution factor for shear (fraction of axle load) for the girder.

For special live loads, enter only if the passing distance is the same for the entire set of special live loads and is a value other than 2 feet. Otherwise, the program will use the default value or the value entered in the SPECIAL LIVE LOADS data line for each special live load.

If this value is not entered, the program will compute it in accordance with AASHTO Manual 5.2.2. For standard loadings, the following values are used:

| Roadway Width | Passing Distance | Curb Distance |
|---|---|---|
| Under 18’ | 4.0’ | 2.0’ |
| 18’ to 20’ | PD | PD/2 |
| Over 20’ | 4.0’ | 2.0’ |

Where: PD = 0.5 (Roadway Width) - Gage Distance

ROADWAY WIDTH

Enter the width of the roadway from curb to curb - feet. This is used to compute passing distance (above).

LOAD FACTORS

DLF

Enter the factor by which dead load moment is multiplied in computing design factored force effects. The default value is 1.30.

LLF

Enter the factor by which live load moment is multiplied in computing the design factored force effects. The default value is 2.17.

I or F

Enter “I” for an interior beam.
Enter “F” for a fascia beam.
The default value is “I”.

PRINCIPAL

Enter “Y” if principal stresses are to be computed and printed.
Enter “N” or leave blank if principal stresses are not desired.

DESIGN

Enter “0” or leave blank for a straight strand design.
Enter “1” for a draped strand design.
Enter “2” for a debonded strand design.

Enter “A” for an analysis problem.
Enter “R” for a rating only problem.

SKEW CORRECTION FACTOR

Enter the skew correction factor to account for increased shear due to skew. This factor is applied to the distribution factor used to compute live load shear. Refer the AASHTO LRFD Section 4.6.2.2.3c. The default value is 1.0.

IR STRESS LEVEL

Enter the level of stress for Inventory Rating in the bottom layer of strands expressed as a fraction of $f_y$ for computing the moment strength of the section $M_{fy(IR)}$. If this is not entered, the program will use a default value of 0.80.

AASHTO fc

Enter “Y” to use the 1996 AASTHO final allowable compressive stress described in Article 9.15.2.2. This option sets the final allowable compressive stress to $0.6f'_c$ for the prestress plus all design loads load combination and sets the final allowable compressive stresses to $0.4f'_c$ for following load combinations: 1.) Prestress plus permanent (dead) loads, and 2.) Live load plus one-half of the sum of the prestress and permanent (dead) loads. If “Y” is entered, the input value for COMP fc in the PRESTRSS CRITERIA line is ignored.

Enter “N” or leave blank to use the final allowable compressive stress entered for COMP fc in the PRESTRSS CRITERIA line. This option (“N”) should be used for all PennDOT designs and ratings in accordance with DM-4.

## 5.2 COMMENTS

Any number of lines may be used to enter user comments. The first column of each line must contain an asterisk (*) to indicate that this is a user comment. These comments may be placed anywhere within the input data. The first three comment lines will be printed on the output for identification.

## 5.3 BRIDGE CROSS SECTION & LOAD DATA

BEAM SPACING

Enter the spacing of beams - inches.

For an interior beam, enter lateral beam spacing, centerline to centerline.

For a fascia beam, enter one half of lateral beam spacing plus parapet overhang from fascia beam centerline to parapet outer face.

DISTRIBUTION FACTORS

SHEAR

Enter the live load distribution factor used in computing reactions at end supports and shear at the end supports. Refer to AASHTO 3.23.1. Enter one-half the wheel load distribution factor. If left blank, a value will be computed by the program assuming an interior beam.

MOMENT

Enter the live load distribution factor. This is equal to one-half of the wheel load distribution factor specified in AASHTO Table 3.23.1 and AASHTO Articles 3.23.4, 3.28.1, and 3.28.2.

Fascia Beams:

I-beams or Spread Box Beams:

Compute simple beam reaction of fascia beam by placing a wheel load two feet away from the face of curb. Compute LLWDF by the formula shown in Figure 1 on page 5-13 and enter half the value here.

Adjacent Box Beams:

Use the formula given in AASHTO 3.23.4.3.

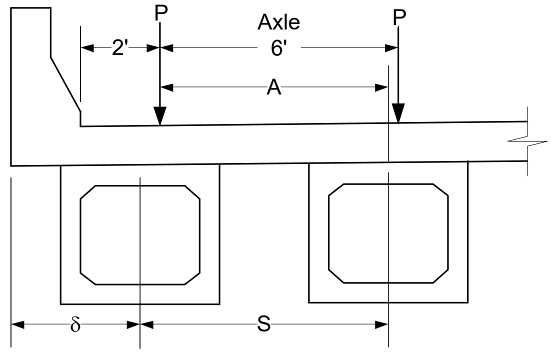
DEFLECT

Enter the live load deflection distribution factor to be used for computing the individual beam deflection due to the live load plus impact. If left blank, the live load deflections will not be printed. The live load deflection distribution factor is equal to the number of design lanes divided by the number of beams. Refer to AASHTO Specifications for details.

$$\text{DEFLECT} = \frac{[\text{No. of Lanes}]\,[\text{Reduction Factor}]}{\text{No. of Beams}}$$

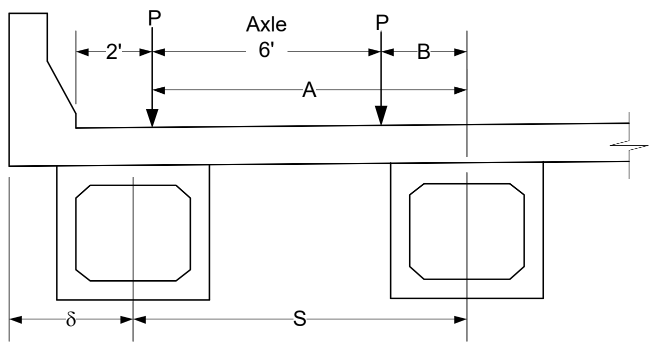
UNIT WT DECK CONCRETE

Enter the unit weight of concrete of the slab - kips/ft$^2$. The default value is 0.150 kips/ft$^2$.



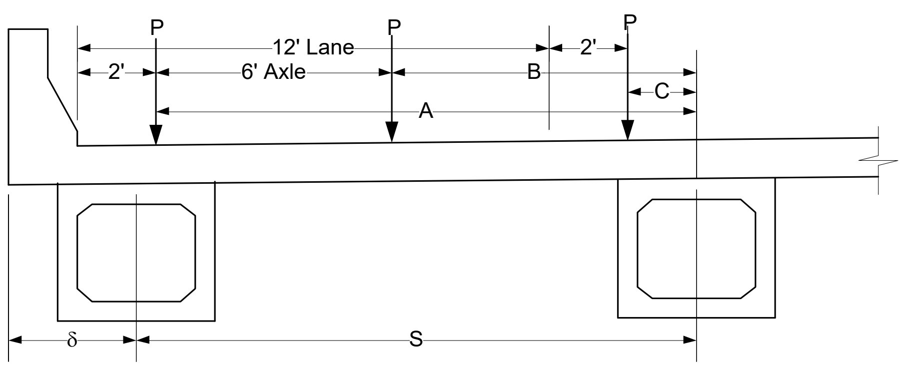

$$LLWDF = \frac{A}{S}$$

Case I: One wheel load between centerlines of outer two beams.




$$LLWDF = \frac{A}{S} + \frac{B}{S}$$

Case II: Both wheel loads between centerlines of outer two beams.




$$LLWDF = \frac{A}{S} + \frac{B}{S} + \frac{C}{S}$$

Case III: Three wheel loads between centerlines of outer two beams.

Note: The above sketches are for a design with a gage distance of 6', a minimum edge distance of 2', a 12' design lane, and a roadway width 24' or greater. For other values of these parameters, the distribution factor should be calculated as a simple beam reaction at the centerline of fascia beam due to wheel loads placed within each lane as per restriction of these parameters. P = Wheel load.

Figure 5.3.1 Live Load Distribution - Exterior Beam

DEAD LOADS

UDLF

Enter the uniform dead load from formwork (pans and accessories) and/or additional concrete weight due to camber acting on the basic beam section - kips/ft$^2$. The value is multiplied by the input BEAM SPACING (converted to feet) to determine the load per foot of beam. If left blank, the program will use default values listed below. Enter zero if this load is not to be considered. Additional information follows for specific beam types.

Interior Beams:

If left blank, the following values will be used. Adjustments may be made when using closed valley forms (consult manufacturer).

| | | | |
|---|---|---|---|
| I-beam | UDLF | = | 0.015 kips/ft$^2$. |
| Spread Box | UDLF | = | 0.015 kips/ft$^2$. |
| Adjacent Box | UDLF | = | 0.006 kips/ft$^2$. |

For a more accurate approximation for an interior beam UDLF load, use the following calculation:

$$UDLF = \frac{WT1 + WT2}{\frac{SPA}{12}} \quad kips/ft^2$$

Where:

$$WT1 = \frac{1}{3}\left[\frac{C}{12}\right]\left[\frac{W2}{12}\right]w_s \quad kips/ft \qquad \text{(Additional concrete due to camber)}$$

$$WT2 = \left[\frac{SPA}{12} - \frac{W2}{12}\right]WTF \quad kips/ft \qquad \text{(Weight of permanent formwork)}$$

| | | | |
|---|---|---|---|
| Where: | C | = | Final camber - inches. |
| | W2 | = | Top flange width - inches. |
| | SPA | = | Beam spacing - inches. |
| | WTF | = | Weight of permanent formwork - kips/ft$^2$. Use 0.015 kips/ft$^2$. For closed valley forms, 0.005 kips/ft$^2$ may be used. |

Exterior Beams:

For an approximation for an exterior beam UDLF load, use the following calculation:

$$\text{UDLF} = \frac{\text{WT1} + \text{WT2} + \text{WT3}}{\delta + \dfrac{\text{SPA}}{24}} \quad \text{kips/ft}^2$$

Where:

$$\text{WT1} = \left[\frac{1 + \text{C} + \text{T4}}{12}\right]\left[\delta - \frac{\text{W2}}{24}\right] w_s \quad \text{kips/ft} \qquad \text{(Additional overhang thickness)}$$

$$\text{WT2} = \frac{1}{3}\left[\frac{\text{C}}{12}\right]\left[\frac{\text{W2}}{12}\right] w_s \quad \text{kips/ft} \qquad \text{(Additional concrete due to camber)}$$

$$\text{WT3} = \left[\frac{\text{SPA}}{24} - \frac{\text{W2}}{24}\right] \text{WTF} \quad \text{kips/ft} \qquad \text{(Weight of permanent formwork)}$$

| | | | |
|---|---|---|---|
| Where: | C | = | Final camber - inches. |
| | T4 | = | Haunch thickness - inches. |
| | $\delta$ | = | Parapet overhang, measured from centerline of fascia beam to outside of parapet - feet. |
| | W2 | = | Top flange width - inches. |
| | SPA | = | Beam spacing - inches. |
| | WTF | = | Weight of permanent formwork - kips/ft$^2$. Use 0.015 kips/ft$^2$. For closed valley forms, 0.005 kips/ft$^2$ may be used. |

Adjacent non-composite box beams only:

Determine the UDLF by using the above procedures. Before entering this value on the input form, add to it the effect of loads due to curb, parapet, railing, etc., and bituminous surface in **kips/ft$^2$**. Alternatively, these loads can be included with the DL1 loads (in kips/ft) described below.

For 3 and 4 foot beams, distribute the load due to curb, parapet, railing, etc., to the fascia and first interior beam.

DL1

Enter the dead load due to the weight of hardware attached to the beam - kips/ft. Do not include the weight of beam, diaphragms, or slab. These weights are computed by the program.

For an adjacent non-composite box or plank beam, the load due to wearing surface, curb, parapet, railing, and sidewalk live load (if any) can either be included with the DL1 loads (in kips/ft) or with the UDLF loads (in kips/$ft^2$).

FWS

Enter the load due to future wearing surface - kips/ft. Distribute the load equally to all beams. Enter the load per foot beam.

Leave blank for an adjacent non-composite box beam.

DL2

Enter the superimposed dead load acting on the beam - kips/ft. Distribute the load equally to all beams. Enter the load per foot beam.

For an exterior spread beam or an interior spread beam, enter the load due to curb, parapet, railing, and sidewalk live load (if any).

For a composite adjacent box beam, enter the load due to curb, parapet, railing, and sidewalk live load (if any). Leave blank for an adjacent non-composite box beam.

INITIAL PRESTRESSING FORCE ($P_i$)

Enter the initial prestressing force (before any losses) applied to the beam - kips. Leave blank for a design problem or if the actual strand pattern is entered in the STRAND DETAILS line. The program will find the required prestressing force and the corresponding eccentricity.

ECCENTRICITY

MIDSPAN

Enter the eccentricity of prestressing force at the center of the span - inches. This is equal to the distance of the center of gravity of strands measured from the neutral axis of the basic beam.

Leave blank for a design problem or if the actual strand pattern is entered in the STRAND DETAILS line.

END

If the strands are draped, enter the eccentricity of prestressing force at the centerline of bearing - inches. Leave blank if value is to be computed by the program.

P/S LOSS %

For the Prestress loss, enter one of the following values. The default is "0004".

Actual - If the beam is to be analyzed or designed for a given loss, enter the percent of prestress loss, e.g. 2500 for 25% loss.

0004 - If low relaxation strands are used and losses are to be computed by the Modified BPR Formula.

0008 - If stress-relieved strands are used and losses are to be computed by the Modified BPR Formula.

0009 - If losses are to be computed by the Lehigh Loss Method. Additional input items (see LEHIGH LOSS METHOD below) are required for this method.

DRAPE POINT

Enter the point at which strands are draped, measured from center of bearing and expressed as a decimal part of the span length. If "1" was entered for DESIGN, the default DRAPE POINT is assumed as 0.3333.

LEHIGH LOSS METHOD

The following six items are entered only when prestress losses are to be computed by the Lehigh Loss Method. Refer to DM-4 regarding the use of this method.

T0

Enter the time when the prestressing force is applied. All time values entered here are number of days since the curing of the beam concrete.

TS

Enter the time when the deck is placed over beams.

TD

Enter the time when superimposed dead load (parapet, railing and future wearing surface, etc.) is applied to the beam.

IC

Enter the code for concrete characteristics. Coefficients of concrete characteristics (elastic strain, creep, and shrinkage) are stored in the program and will be automatically used depending on the code entered.

1 - If upper bound losses are to be considered.
2 - If lower bound losses are to be considered.
3 - If average losses are to be considered.

MFG

Enter the code for manufacturer and size of strands. The strengths and areas of eight types of strands are stored in the program. Enter one of the following codes for strands used. Manufacturer, diameter and area for different strands are shown below. Diameter is in inches and area is in square inches.

| Code | Manufacturer | Diameter | Area |
|---|---|---|---|
| 1 | Bethlehem | 7/16 | 0.115 |
| 2 | CFI | 7/16 | 0.117 |
| 3 | US Steel | 7/16 | 0.116 |
| 4 | Bethlehem | 1/2 | 0.156 |
| 5 | CFI | 1/2 | 0.153 |
| 6 | US Steel | 1/2 | 0.154 |
| 7 | Low Relaxation | 7/16 | 0.117 |
| 8 | Low Relaxation | 1/2 | 0.153 |

IST

Enter the code for type of steel used in strands. The stress-strain characteristics of steel used in different types of strands are stored in the program. Enter one of the following codes for the type of steel used.

| Code | Manufacturer | Diameter |
|---|---|---|
| 1 | Bethlehem | 7/16 |
| 2 | CFI | 7/16 |
| 3 | US Steel | 7/16 |
| 4 | Bethlehem | 1/2 |
| 5 | CFI | 1/2 |
| 6 | US Steel | 1/2 |
| 7 | All M | 7/16 |
| 8 | All M | 1/2 |
| 9 | All | Both |
| 10 | Low Relaxation | 7/16 |
| 11 | Low Relaxation | 1/2 |
| 12 | Low Relaxation | Both |
| 13 | No Relaxation | |

L or S

Enter “L” or leave blank if low relaxation strands are used.

Enter “S” if stress relieved strands are used.

RATE FWS

Enter “Y” if ratings with and without future wearing surface are to be output.

Enter “N” or leave blank if one set of ratings that include future wearing surface is output.

## 5.4 SPAN LENGTHS

Enter the span length (center-to-center bearings) of the prestressed concrete beam. Only one span may be entered at this time. Use the PSLRFD program to design/analyze prestressed concrete beams made continuous for live load and superimposed dead loads.

BEAM PROJECTION

Enter the distance measured from the end of the beam to the centerline of bearing - inches. The default value is 9.0 inches.

## 5.5 DIAPHRAGM DETAILS

Enter these lines to describe the locations of diaphragms. One line to describe interior and one line to describe exterior diaphragms may be entered. **Do not** enter if diaphragms are to be assumed as per BD-651M. If this line is entered and left blank, the program will assume that there are **no** diaphragms. Enter either the number of diaphragms (# DIA) or LOCATION data. If diaphragms are evenly spaced, it is not necessary to enter locations.

IDENT

Enter “I” if the interior diaphragms are being described.

Enter “E” if the exterior diaphragms are being described.

WEIGHT

Enter the weight of each diaphragm to be applied to each girder - kips. If left blank, interior diaphragm weight (IDW) and exterior diaphragm weight (EDW) are computed using the following formulas. The symbols used are the same as input items entered.

For a Box Beam, greater than forty feet:

$$IDW = \frac{\left[(W1 - W3 - W3)(D - T1 - T2) - (B1\,B2) - (B3\,B4)\right] t\ w_b}{1728}$$

For I-beams:

$$EDW = \frac{(SPA - W3)\,(D - T1 - B1 - 9)\; t\; w_s}{1728}$$

For Spread Box Beams:

$$EDW = \frac{(SPA - W1)\,(D - 15)\; t\; w_s}{1728}$$

For Adjacent Box Beam, leave blank. For a Fascia Beam, enter one half of the above value for the corresponding beam type.

THICKNESS

Enter the thickness of the diaphragm - inches. If left blank, a default value of 10 inches will be used.

# DIA

Enter the total number of diaphragms.

DISTANCE

Enter the distance of each diaphragm from centerline of bearing - ft.

## 5.6 PRESTRESS CRITERIA

No signs are input with the following stresses. The program will assign minus signs to compressive stresses and plus signs to tensile stresses. Refer to “Summary of Allowable Design Stresses” from DM-4.

BEAM CONC $f'_{cb}$

Enter the compressive strength of concrete in beam at 28 days - ksi.

SLAB CONC $f'_{cs}$

Enter the compressive strength of concrete in slab at 28 days - ksi.

CONC INIT $f'_{ci}$

Enter the compressive strength of concrete at initial prestressing - ksi. If this is not entered, the program will use a default value equal to 0.85 times $f'_{cb}$.

STEEL INIT $f_{si}$

Enter the initial tensile stress in prestressing steel - ksi. The program uses this value to compute the initial prestressing force. If this is not entered, the program will use a default value equal to 0.70 times $f'_s$, where $f'_s$ is the ultimate strength of prestressing steel (an input value).

STEEL YIELD $F_y$

Enter the specified yield point stress of prestressing steel - ksi. The yield point stress is specified by the manufacturer of strands. It is equal to the minimum load at 1% extension in kips divided by the nominal area of strand in $in^2$. If this is not entered, the program will use a default value of 0.85 times $f'_s$. This value is used to compute $M_{fy}$.

STEEL ULT $f'_s$

Enter the specified ultimate strength of prestressing steel - ksi. A value must be entered for this item. Normally a value of 250 or 270 ksi is used. The program uses this value to set the default values of $f_{si}$ and $F_y$, and to determine the moment strength ($\phi M_n$).

INITIAL ALLOWABLE

COMP $f_{ci}$

Enter the allowable compression in concrete before losses - ksi.

TENS $f_{ti}$

Enter the allowable tension in top fiber of concrete, at centerline of bearing for straight strands or at draped point for draped strands, before losses - ksi.

For debonded design, enter a starting $f_{ti}$ value for the design process. Typical starting $f_{ti}$ values range from $6\sqrt{1000\ f'_{ci}}$ to $8\sqrt{1000\ f'_{ci}}$ .

DRP/DBND $f_{tfd}$

For beams with draped strands, enter the allowable tension in top fiber of concrete at centerline of bearing - ksi.

For beams with debonded strands, enter the allowable tension in the top fiber of concrete at centerline of bearing and at each cut-off point.

FINAL ALLOWABLE

COMP $f_c$

Enter the allowable compression in concrete under design loads after losses - ksi. If this is not entered, the program will use a default value of 0.40 $f'_{cb}$. If “Y” is entered for AASHTO fc in the PROJECT IDENTIFICATION line, the input for COMP $f_c$ is ignored and the allowable compression stress is in accordance with 1996 AASHTO Article 9.15.2.2.

TENS $f_t$

Enter the allowable tension in concrete in the precompressed tensile zone under design loads after losses.

If left blank, the program will use a default value of $3\sqrt{1000\, f'_{ci}}$. A value of zero can be entered.

SLAB $f_{cs}$

Enter the allowable compression in slab concrete - ksi. If this is not entered, the program will use a default value of 0.40 $f'_{cs}$.

ALLOW SHEAR $v_{ha}$

Enter the allowable horizontal shear stress between basic beam and composite slab - ksi. If this is not entered, the program will use a default value of 0.300 ksi in accordance with DM-4 9.20.4.3.

OR STRESS LEVEL

Enter the level of stress for Operating Rating in the bottom layer of strands expressed as a fraction of $f_y$ for computing the moment strength of the section, $M_{fy}$. If this is not entered, the program will use a default value of 0.90.

STEEL E

Enter the modulus of elasticity of prestressing steel - ksi. The default value is 28,000 ksi.

MODULAR RATIOS

DES

Enter the modulus of elasticity of the beam concrete to that of the slab concrete at design loads. If this value is not entered, the following default value is used.

$$n_{des} = \frac{w_b^{1.5}\ 33.0\sqrt{1000\ f'_{cb}}}{w_s^{1.5}\ 33.0\sqrt{1000\ f'_{cs}}}$$

ULT

Enter the modulus of elasticity of the beam concrete to that of the slab concrete at ultimate loads. If this value is not entered, the following default value is used.

$$n_{ult} = \frac{f'_{cb}}{f'_{cs}}$$

CREEP FACTOR

Enter the estimated creep factor for computing camber (see DM-4 9.11.3.2.1P). If this is not entered, the program will use a default value of 1.6.

EST. % LOSS

Enter the estimated percent loss in prestressing force for computing camber. One or two sets of camber computations are provided depending upon the value entered here. The following three cases are considered:

1. If a value greater than zero is entered, the camber is computed based on the value entered. Only one camber value is provided.

2. If zero is entered and the Modified BPR Formula for prestress loss is specified, two camber values are provided: One to determine bridge seat elevations based on 10% prestress loss and another to check a probable sag in the bridge based on 15% prestress loss.

3. If zero or a blank is entered and the Lehigh Loss Method for prestress loss is specified, two camber values are provided: One to determine bridge seat elevations based on the prestress loss at the beam age of 6 months and another to check a probable sag in the bridge based on the prestress loss at the beam age of 20 years.

STRAND DIAMETER

Enter the strand nominal diameter - inches. This value is used to calculate transfer lengths and development lengths of the prestressing strands.

If left blank for a design run, the program in general uses a default value of 0.52” for Grade 270 strands and 0.50” for Grade 250 strands for all type beams. However, if a STRAND AREA is entered on the STRAND DETAILS line, the program will attempt to set the default STRAND DIAMETER to a value corresponding to the input STRAND AREA based on standard strand sizes (refer to the STRAND AREA input description’s standard strand size table).

A value is required for an analysis or rating run. A warning message will be printed for nonstandard strand diameters.

NO OF ROWS

Enter the number of strand rows including those rows with zero strands. Since the program assumes a constant distance between two consecutive rows of strands, some fictitious rows with zero strands must be included here when the strand rows are not equally spaced.

For an analysis or rating problem, if the strand pattern is unknown, but the prestressing force and eccentricity are known, enter zero here. If zero is entered here, values for STRAND AREA, G1, G2 and R1 in the STRAND DETAILS line must be supplied.

NO Lx

Enter the number of debonded lengths. This must be equal to the number of DEBONDED STRAND DETAILS lines entered later.

ST DET

Enter “Y” if the STIRRUP DETAILS line is entered.

Enter “N” or leave blank if the STIRRUP DETAILS line is not entered.

STIRRUP DETAILS line must be entered for a rating problem.

## 5.7 BEAM DIMENSIONS

The variable names for the beam dimensions used on the input form correspond to those in Figures 1, 2 and 3 on pages 5-30, 5-31, and 5-32. For I-beams, box beams with rectangular voids, and plank beams, enter all beam dimensions or enter the beam designation. For a box beam with circular voids, enter all beam dimensions except W3, T1, and T2. B4 is not used for a box beam with a single circular void. All dimensions are in inches.

TYPE

Enter "P" for a Plank beam.
Enter "B" for a Box beam with a rectangular void.
Enter "C" for a Box beam with circular voids.
Enter "I" for an I-beam.
Enter "T" for a Bulb-tee beam.

COMP

Enter “Y” if the beam is composite.
Enter “N” or leave blank if the beam is non-composite.

Note: For a composite beam, the SLAB THICKNESS and HAUNCH dimensions must be entered as described below.

DESIG or D

Enter beam depth D if all beam dimensions are to be entered.

Enter the Standard Beam Designation (e.g. “2654” for a 26/54 AASHTO type I-beam) if beam dimensions are to be completed by the program. The following beam designations listed in BD-652M are stored in the program:

Plank Beams: 36/12, 48/12.

Adjacent Box Beams: 36/17, 36/21, 36/27, 36/30, 36/33, 36/36, 36/39, 36/42, 36/45, 36/48, 36/54, 36/60, 36/66, 48/17, 48/21, 48/27, 48/30, 48/33, 48/36, 48/39, 48/42, 48/45, 48/48, 48/54, 48/60, 48/66.

Spread Box Beams: 36/17, 36/21, 36/27, 36/33, 36/36, 36/39, 36/42, 36/45, 36/48, 36/54, 36/60, 36/66, 48/17, 48/21, 48/27, 48/33, 48/36, 48/39, 48/42, 48/45, 48/48, 48/54, 48/60, 48/66.

PA. I-beams: 18/30, 18/33, 18/36, 20/30, 20/33, 20/36, 20/39, 24/33, 24/36, 24/42, 24/45, 24/48, 24/51, 24/54, 24/60, 24/63, 26/33, 26/36, 26/60, 26/63.

AASHTO Type I-beams: 26/54, 28/63, 28/66, 28/72, 28/78, 28/84, 28/90, 28/96.

PA Bulb-tee beams: Since the bottom flange width of the standard PA bulb-tee sections is constant (33”), the beam depth is used to identify the standard bulb-tee section. The program’s bulb-tee beam designations are shown below with the corresponding BD-652M beam designation in parenthesis.

3125 (33/31.25), 3925 (33/39.25), 4725 (33/47.25), 5525 (33/55.25), 6325 (33/63.25), 7125 (33/71.25), 7925 (33/79.25), 8725 (33/87.25), 9525 (33/95.25),
2925 (33/29.25), 3725 (33/37.25), 4525 (33/45.25), 5325 (33/53.25), 6125 (33/61.25), 6925 (33/69.25), 7725 (33/77.25), 8525 (33/85.25), 9325 (33/93.25),
3150 (33/31.5), 3950 (33/39.5), 4750 (33/47.5), 5550 (33/55.5), 6350 (33/63.5), 7150 (33/71.5), 7950 (33/79.5), 8750 (33/87.5), 9550 (33/95.5),
2950 (33/29.5), 3750 (33/37.5), 4550 (33/45.5), 5350 (33/53.5), 6150 (33/61.5), 6950 (33/69.5), 7750 (33/77.5), 8550 (33/85.5), 9350 (33/93.5).

W1, W2, W3, T1, T2, B1, B2, B3, B4, D1, D2, X1, X2

Refer to Figures 1, 2, 3 and 4 on pages 5-30, 5-31, 5-32 and 5-33 respectively.

Note: **W1** must be left blank if the program is to complete beam dimensions using the Beam Designation entered above. If any other dimensions are input on this line, they will override the dimensions from BD-652M.

Box beams are determined to be adjacent only if BEAM SPACING is less than or equal to W1 plus one-half inch (the required open joint between adjacent box, see BD-654M). Therefore, beam dimensions must be entered for any Adjacent Box Beam designed or analyzed as a fascia beam with a parapet overhang.

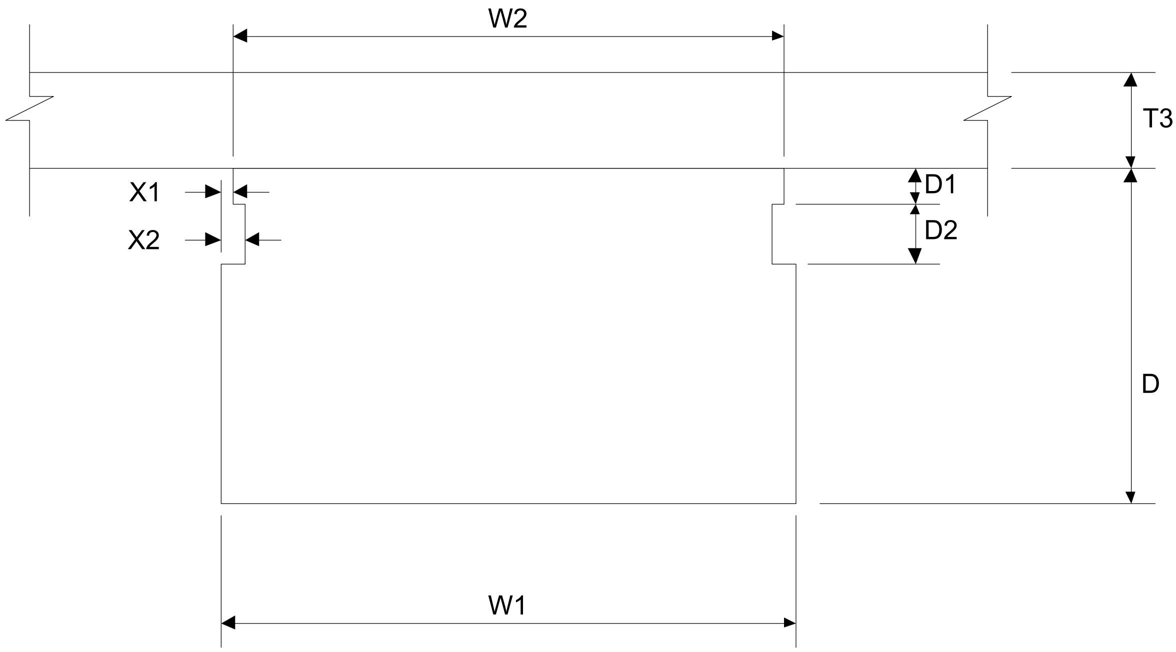
SLAB THICKNESS

For composite beams, enter the effective slab thickness to be considered in the composite section properties that act to resist bending and shear. In the program, a half-inch of wearing surface is added to T3 for the computation of dead load moment and shear.

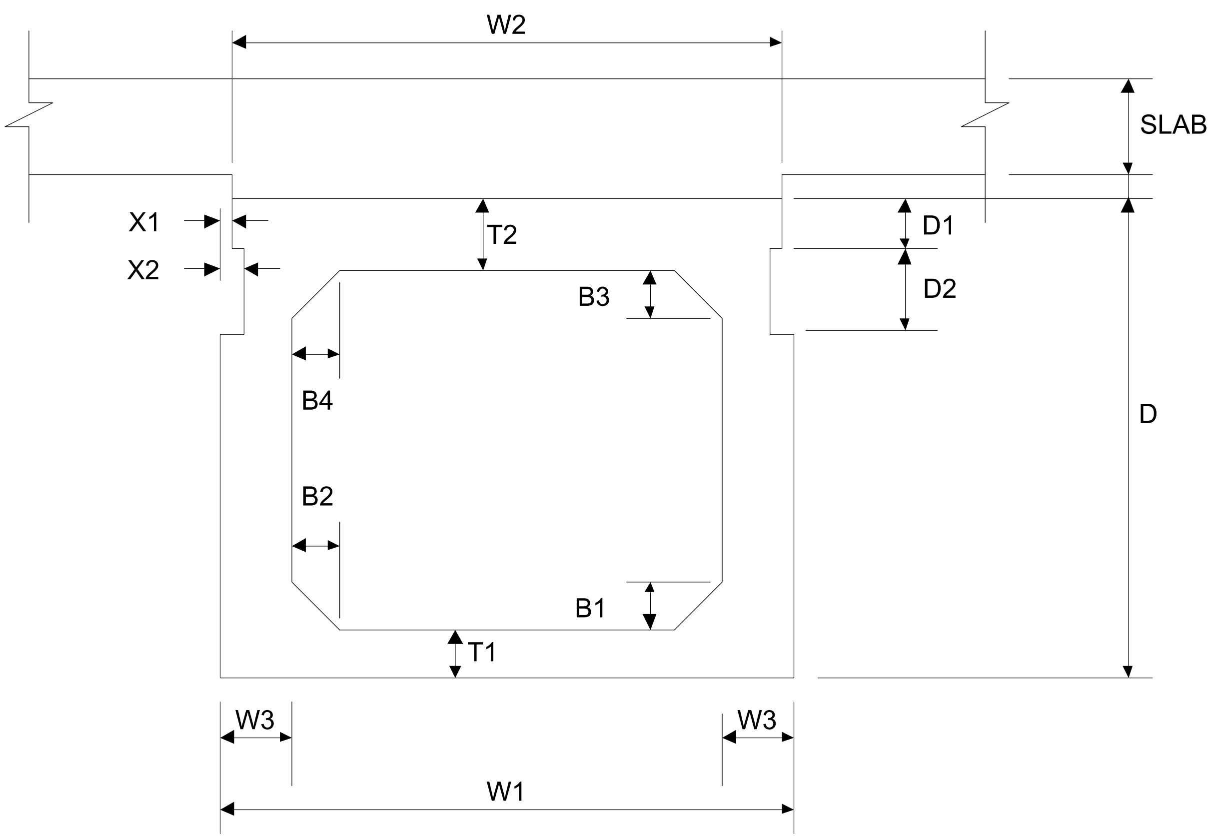
For non-composite beams, leave blank. Include the weight of the slab or bituminous surface course, in uniform dead load from formwork, UDLF.

HAUNCH

Enter the thickness of the haunch, if any.

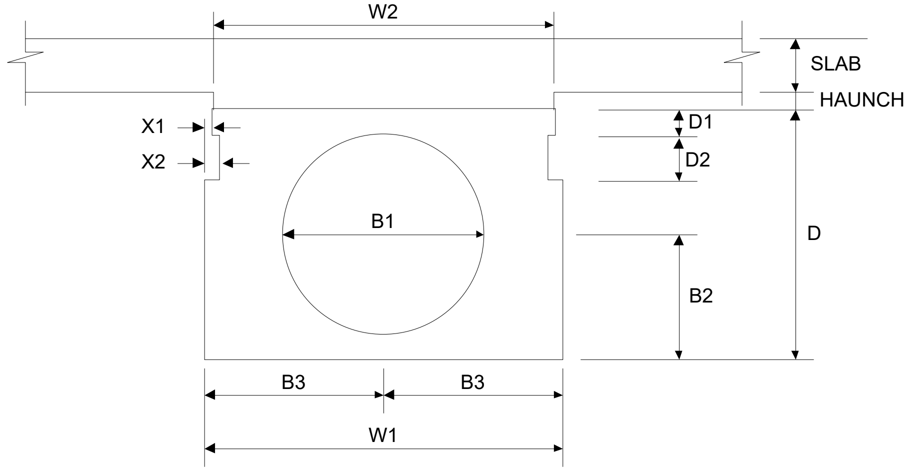



Plank Beam

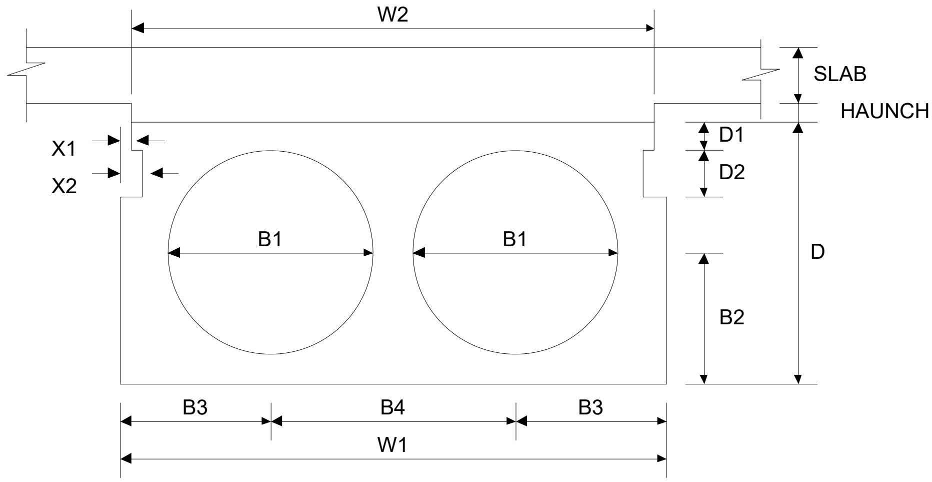



Box Beam – Rectangular Void

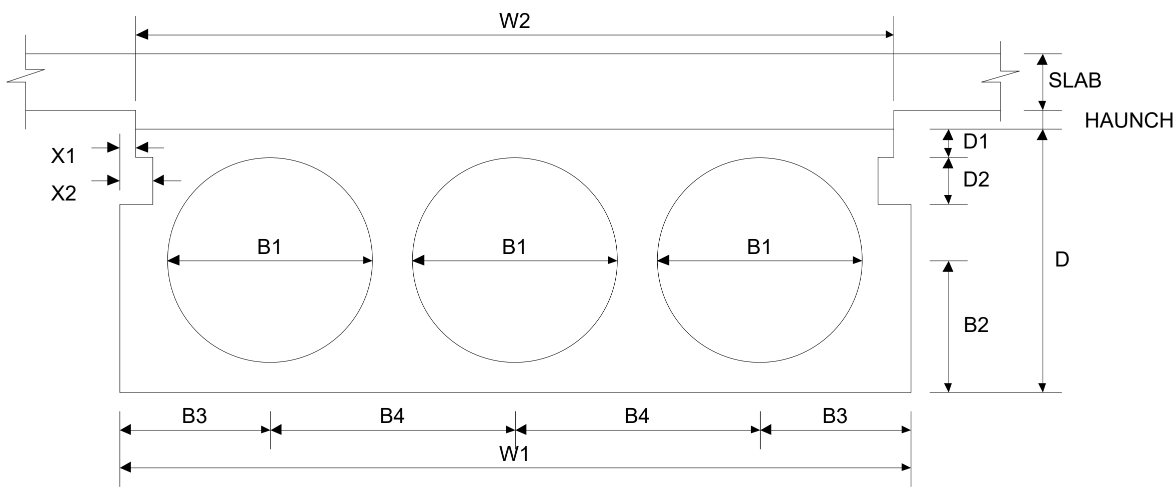
Figure 5.7.1 Beam Dimensions - Box and Plank Beams




Box Beam – One Circular Void

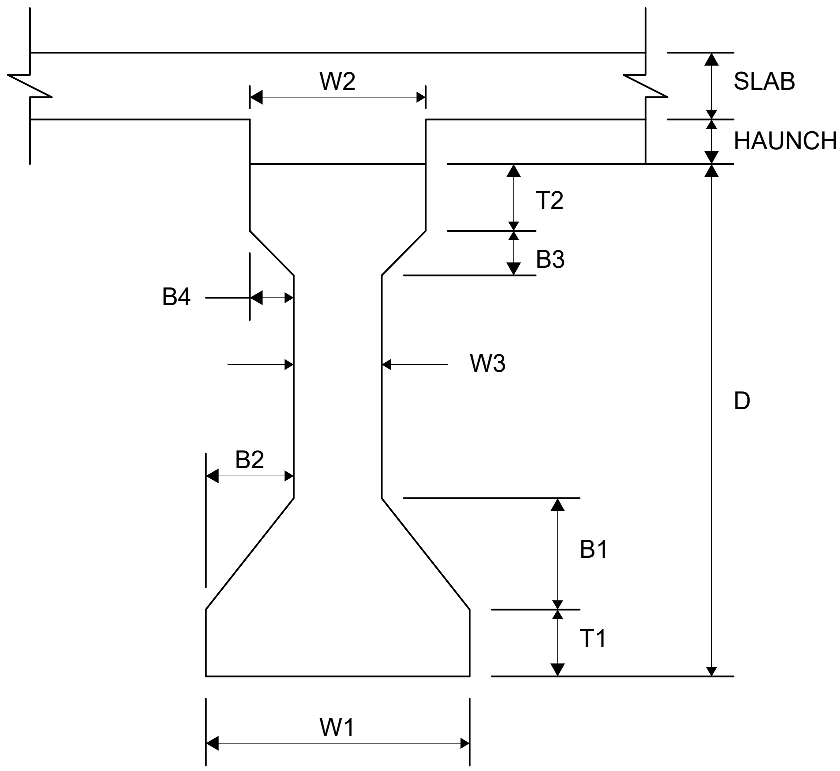



Box Beam - Two Circular Voids

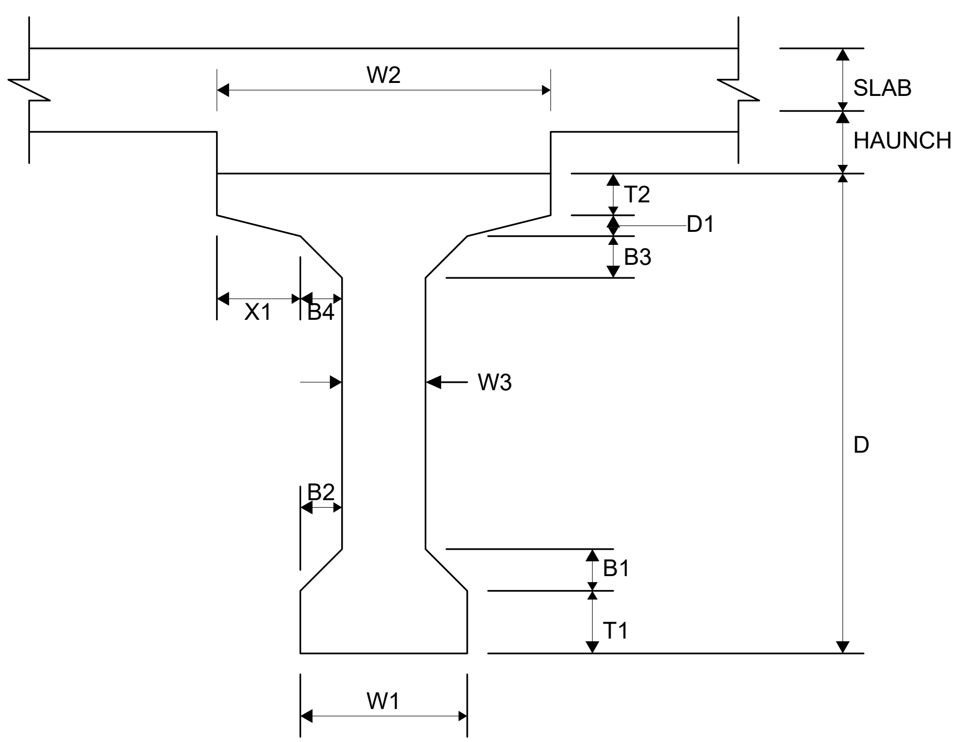



Box Beam – Three Circular Voids

Figure 5.7.2  Beam Dimensions - Box Beam with Circular Voids




Regular I-beam




AASHTO Type 5 I-beam

Figure 5.7.3 Beam Dimensions - I-beams

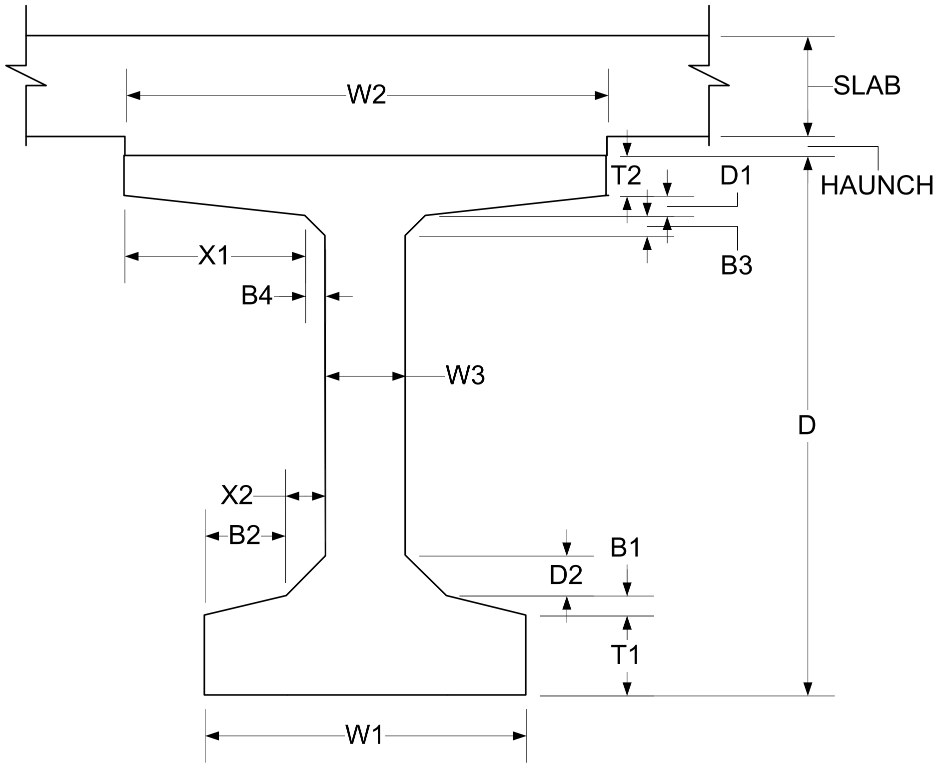



Figure 5.7.4 Beam Dimensions – Bulb-tee beams

## 5.8 STRAND DETAILS

If more than one line is required to enter STRAND DETAILS, do not enter any value in the fields shown by x's on the input form.

### STRAND AREA

Enter the area a single prestressing strand – in$^2$.

If left blank for a design run, the program in general uses a default value 0.167 in$^2$ for Grade 270 strands and 0.144 in$^2$ for Grade 250 strands for all type beams. However, if a STRAND DIAMETER is entered on the PRESTRESS CRITERIA line, the program will attempt to set the default STRAND AREA to a value corresponding to the input STRAND DIAMETER based on standard strand sizes (refer to standard strand size table below).

| Nominal Strand Diameter (in) | Strand Area (in$^2$) |
|---|---|
| **Grade 250** | |
| 1/4 (0.2500) | 0.036 |
| 5/16 (0.3125) | 0.058 |
| 3/8 (0.3750) | 0.080 |
| 7/16 (0.4375) | 0.108 |
| 1/2 (0.5000) | 0.144 |
| Oversized (0.6000) | 0.216 |
| **Grade 270** | |
| 5/16 (0.3125) | 0.061 |
| 3/8 (0.3750) | 0.085 |
| 7/16 (0.4375) | 0.115 |
| 1/2 (0.5000) | 0.153 |
| 1/2 Special (0.5200) | 0.167 |
| Oversized (0.6000) | 0.217 |

Warning messages will be printed for nonstandard strand diameters and when the input STRAND DIAMETER and input STRAND AREA do not correspond to the same standard strand size.

This is required input for an analysis or rating run. If the strand pattern is unknown, enter an assumed area of a single strand and total number of strands (entered as R1 later) corresponding to the known prestressing force.

### G1

Enter the vertical distance from the bottom of beam to the centroid of the bottom row of strands - inches.

Refer to Standard for Bridge Design BD-661M and BD-662M.

If the strand pattern is unknown and both the INITIAL PRESTRESSING FORCE and the MIDSPAN ECCENTRICITY were not entered on the BRIDGE CROSS SECTION line, enter a value for a similar beam from some known standards.

G2

Enter the vertical distance between each row of strands - inches. Refer to BD-661M and BD-662M. The program assumes a constant distance between two adjacent rows.

If the strand pattern is unknown and both the INITIAL PRESTRESSING FORCE and the MIDSPAN ECCENTRICITY were not entered on the BRIDGE CROSS SECTION line, enter the distance of the center of gravity of the strands from the bottom of the beam.

R1 through R100

For a design problem, enter the maximum number of strands to be considered in each row. Rows are numbered starting with R1 at the bottom. A maximum of 100 rows is allowed. Enter as many rows as practical for a given beam. The program uses these for computing maximum practical eccentricity of a prestressing force and determining a strand pattern.

For an analysis problem, enter the actual number of strands in each row. The program assumes that the strand rows are equally spaced (row locations are determined from G1 and G2 input). If the actual strand rows are not equally spaced, enter zero for any strand row that does not exist, but must be accounted for assuming the rows are equally spaced.

If the strand pattern is unknown and both the INITIAL PRESTRESSING FORCE and the MIDSPAN ECCENTRICITY were not entered on the BRIDGE CROSS SECTION line and a zero was entered for NO. OF ROWS in the PRESTRESS CRITERIA line, enter the total number of strands corresponding to known prestressing force under R1.

## 5.9 DEBONDED STRAND DETAILS

For a design problem, do not enter this line. Enter the following items for an analysis problem only. The number of DEBONDED STRAND DETAIL lines entered is equal to the value of NO $L_x$ entered in the PRESTRESS CRITERIA line.

DEBONDED LENGTH, $L_x$

Enter the actual strand debonding length from the centerline of bearing - feet. Debonded lengths must be entered in ascending order, i.e. the distance of the shortest debonded length must be entered first and the distance of the longest debonded length must be entered last. This value must be greater than zero.

If this value is left blank and a corresponding debonding pattern is entered, the program will calculate a debonded length.

1,2,3,4,...13

For each DEBONDED LENGTH $L_x$ entered above, describe the strands that are debonded at this point. Do not include the rows that are debonded at previous points.

ROW NO.

Enter the row number, as defined under STRAND DETAILS, in which the strands are debonded at this point. Do not include the rows that are debonded at previous points.

NO. STR.

Enter the number of strands that are being debonded at this point in the ROW NO entered. Do not include the rows that are debonded at previous points.

## 5.10 STIRRUP DETAILS

Enter this line for an output with shear analysis or to change the default values for a design problem. This line is required for a rating problem. For an analysis problem, values must be entered for LOCATION and SPACING if shear values and shear ratings are to be printed. This line is entered only if ST DET is "Y" on the PRESTRESS CRITERIA line.

Note: This program will design stirrup spacings using the current AASHTO Specifications only. The item "SPEC" described below will affect only shear analysis and shear rating computations.

SPEC

Enter "A" if shear values are to be computed as per Article 9.20 of the AASHTO Specifications. This is the default for BAR6 input.

Enter "9" or leave blank if shear values are to be computed as per the 1979 AASHTO Interim Specifications.

STIRRUP AREA

Enter the area of steel for **one leg** of a stirrup – $in^2$. This value will be multiplied by two to get the total area of web reinforcement. The default value is 0.20 $in^2$ (No. 4 bar stirrups). A warning is issued if the input value exceeds 0.31 $in^2$ (No. 5 bar) or if less than 0.11 $in^2$ (No. 3 bar).

fsy

Enter the yield strength of the stirrups - ksi. The default is 60 ksi.

LOCATION

Enter the location of the point corresponding to the stirrup spacing entered next from centerline of bearing - feet. The location for the first stirrup spacing entered is always zero (centerline of bearing). Leave blank for a shear design problem.

SPACING

Enter the stirrup spacing corresponding to the previous location entered - inches. Leave blank for a shear design problem. For example: for a 100' span with a stirrup spacing of 10" up to the quarter point of the beam and 20" from quarter point to midspan. Enter 0.0 and 10 for the first LOCATION and SPACING, and 25.0 and 20 for the second LOCATION and SPACING, respectively. For a constant stirrup spacing, enter zero for LOCATION and the corresponding stirrup spacing for SPACING.

## 5.11 SPECIAL LIVE LOADING

This form is used to describe the parameters for special live loadings, which the user can use in place of the standard live loadings that are stored in the program. A special live loading consists of two parts: a Lane Loading and a Truck Load. The program analyzes the bridge for both loads separately and stores the governing effects. Enter this data if a number is entered for LIVE LOAD in the PROJECT IDENTIFICATION line. The number of special live loadings described here should correspond to the number entered for LIVE LOAD earlier. A LANE LOADING data line and a TRUCK LOAD data must be used for each special live loading. A maximum of eight special live loadings can be described.

A bridge can be analyzed for special live loadings in two ways. The first method is to include the description of the special live loadings in the same input data file with other data lines described so far. The second method is to create two input data files, one for bridge data described so far and another for the special live loadings data. The second method allows the user to run a set of special live loadings for the same bridge data. This method also allows the users in other states to create a file of customized live loadings and analyze different bridges using this file. Refer to Example Problem 6 for an analysis of a bridge using two data files.

5.11.1 Lane Loading

SP LL NO

Enter an identification number for the special live loading, from 1 to 8.

NUMBER OF AXLES

Enter the number of axles for the Truck Load of the special live loading. There may be a maximum of 24 axles for a Truck Load.

3% INCR

Enter "Y" if all entered axle loads are to be increased by 3%. This option allows permit loads to be checked for a 3% overweight tolerance. If "Y" is entered, the rating factors calculated by the program are based on the input axle loads increased by 3%, while the ratings in tons are based on the input axle loads.

Leave blank if the entered axle loads are not to be increased.

UNIFORM LANE LOAD

Enter the uniform lane load to be used in combination with the concentrated loads (described next) to produce the maximum effect due to special lane loading - kip/ft. Enter this load per linear foot of loaded lane.

If a value is entered, the effect of this lane loading will be compared with the effect of the truck load (described later) and the governing effect will be used as the special live loading effect.

CONC LOAD MOMENT

Enter the concentrated load to be used in combination with the uniform lane load to produce the maximum moment at an analysis point - kips.

CONC LOAD SHEAR

Enter the concentrated load to be used in combination with the uniform lane load to produce the maximum shear at an analysis point - kips.

GAGE DISTANCE

Enter the lateral distance between the wheels of this special live load - feet. If a value is not entered here, the program will use the default value of 6 feet or the value entered in the PROJECT IDENTIFICATION line.

PASSING DISTANCE

Enter the lateral distance between adjacent wheels of passing vehicles or twice the distance from the face of the curb to the nearest wheel (curb distance) - feet. If a value is not entered here, the program will use the default value of 4 feet or the value entered in the PROJECT IDENTIFICATION line.

VARY LAST

If the distance between the last two axles of the TRUCK LOAD of this Special Live Loading is to be varied similar to the HS20 truck described in the AASHTO Specifications, enter "Y". Otherwise, leave blank.

If a “Y” is entered and if a value is entered for the MAX AXLE DIST, described next, the program will calculate the maximum effect due to the truck load described next by varying the distance between the last two axles from the value of DIST entered for the last axle under TRUCK LOAD and the MAX AXLE DIST entered next.

MAX AXLE DIST

If a "Y" is entered for VARY LAST described above, enter the maximum distance between the last two axles of the TRUCK LOAD - feet. Otherwise, leave blank.

5.11.2 Truck Load

AXLE LOAD

Enter the total load on the axle - kips. The number of axle loads entered must correspond to NUMBER OF AXLES entered earlier.

DIST

Enter the distance from the axle under consideration to the next axle - feet. For example, the distance 4 is the distance between axle 4 and axle 5. The total number of distances entered must be one less than the total number of axle loads.

# 6 OUTPUT DESCRIPTION

The program output consists of an echo of the input data followed by the program results printed in tabular format. A description of each output table is provided in the following sections. The final section of this chapter shows the actual format of the output tables.

## 6.1 INPUT DATA

The program first the output heading containing the program name, program number, version number, last updated date, documentation date, the date and time of the run, and the input file name. Next, the first three comment lines are printed for identification. The input data is then printed in horizontal tabular format for each data type. Processed input and default input are printed next in similar tabular format.

## 6.2 BASIC BEAM SECTION PROPERTIES

DEPTH

The depth of the beam - in.

AREA

The area of the beam cross section – $in^2$. For a box beam, an additional ¼"of concrete around the inner void is not included. For an adjacent box beam or a plank beam, the area of the fillets in the shear key is neglected.

WEIGHT

The weight of the beam per foot length - lbs/ft. For a box beam, this includes the weight of additional ¼" of concrete around the inner void.

M OF I

The moment of inertia of the beam – $in^4$.

N.A. TO TOP YT

The vertical distance to the top fiber of the beam from the neutral axis - in.

N.A. TO BOT YB

The vertical distance to the bottom fiber of the beam from the neutral axis - in.

Z TOP

The section modulus of the top fiber of the beam – $in^3$.

Z BOT

The section modulus of the bottom fiber of the beam – $in^3$.

## 6.3 COMPOSITE SECTION PROPERTIES

SLAB WIDTH

The width of the slab portion of the composite section - in. The effective slab width is the lesser of the following values in accordance with 2002 AASHTO Article 9.8.3: one quarter of the span length, center to center beam spacing, or twelve times the slab thickness plus the effective web width. The effective web width for I-beams and bulb-tees is defined as the lesser of (1) six times the maximum thickness of the flange (excluding fillets) on either side of the web plus the web and fillets (6 (T2 + D1) + (W3 + 2 B4)), and (2) the total width of the top flange (W2). The effective web width for box or plank beams is equal to the top flange width (W2).

AREA

The area of composite section converted into an equivalent area of beam concrete – $in^2$.

M OF I

The moment of inertia of the composite section – $in^4$.

N.A. TO TOP SLAB YS

Vertical distance to top of the slab from the neutral axis of the composite section - in.

N.A. TO TOP BEAM YTC

Vertical distance to top fiber of beam from the neutral axis of the composite section - in.

N.A. TO BOT BEAM YBC

Vertical distance to bottom fiber of beam from the neutral axis of the composite section - in.

Z TOP SLAB

The section modulus of the slab – $in^3$.

Z TOP BEAM

The section modulus of the top fiber of the beam – $in^3$.

Z BOT BEAM

The section modulus of the bottom fiber of the beam – $in^3$.

## 6.4 UNIFORM DEAD LOADS ACTING ON GIRDER

The individual uniform dead loads acting on the girder - kips/ft. Some values are input and some values are computed by the program.

GIRDER WEIGHT

The average weight of girder, i.e. the total weight of one girder divided by its length.

SLAB WEIGHT

The dead load due to the weight of slab for a composite section.

HAUNCH WEIGHT

The dead load due to weight of the haunch for a composite section.

FORMWORK WEIGHT

The dead load due to formwork.

INPUT DL1

The dead load acting on the non-composite section. This is equal to the input value as entered in the BRIDGE CROSS SECTION AND LOADING line.

FUTURE WEARING SURFACE

The dead load due to future wearing surface. This is equal to the input value as entered in the BRIDGE CROSS SECTION AND LOADING line.

INPUT DL2

The dead load acting on the composite beam. This is equal to the input value as entered in the BRIDGE CROSS SECTION AND LOADING line.

TOTAL DL1

The total uniform dead load acting on the non-composite section. This is equal to the dead load due to girder, slab, formwork, haunch, and input DL1.

TOTAL DL2

The total dead load acting on the composite beam. This is equal to the dead load due input DL2 and future wearing surface.

## 6.5 MAXIMUM DESIGN MOMENTS AND MOMENT STRENGTHS

Not printed for a rating problem.

GIRDER WEIGHT

The moment at the center of beam span due to the weight of the girder - kip-ft. Includes an additional ¼" concrete around inner perimeter of voids for a box beam.

DIAPH WEIGHT

The maximum moment due to the weight of the interior and exterior diaphragms acting as concentrated loads - kip-ft.

SLAB + FORMWORK

The moment at the center of the span due to the weight of the slab plus the weight of the formwork - kip-ft.

FUTURE WEARING SURFACE

The moment at the center of the span due to the weight of future wearing surface - kip-ft.

TOTAL DL1

The moment at the center of the span due to the total dead load acting on the non-composite section - kip-ft. This includes the weight of the girder, input DL1, and slab plus formwork acting as uniform loads and the weight of the interior and exterior diaphragms acting as concentrated loads.

TOTAL DL2

The moment at the center of beam span due to the superimposed dead loads - kip-ft.

IMPACT FACTOR

Moment and shear coefficient for maximum live load plus impact.

LL + I (LOADING DESIGNATION)

The maximum moment in the span due to the live load plus impact and the designation of live load - kip-ft.

FACTORED

The design factored moment - kip-ft.

MOMENT STRENGTH - AT SPECIFIED STRESS

The moment strength of the section when the stress in the bottom layer of strands reaches a specified stress - kip-ft.

MOMENT STRENGTH - (Phi*Mn)

The moment strength of the section - kip-ft. In addition, a message noting the type of section (rectangular or flanged section and under or over reinforced section) and a message indicating that the design factored moment exceeds the moment strength, when such is the case.

THEORETICAL TENSILE STRESS IN BEAM AT OPERATING RATING

The maximum stress in the bottom fiber of concrete due to the Moment Strength at Operating Rating and a factor equal to the stress divided by the square root of $f'_{cb}$ - ksi.

CRACKING MOMENT (Mcr)

The cracking moment computed as per DM4, Section 9.18.2.1 - kip-ft.

LIVE LOAD F.S.

The live load factor of safety. Refer to formula form Section 3.8.

RATIO (phi*Mn/Mcr)

The ratio of moment strength to cracking moment. A warning message is printed if this value is less than 1.2.

## 6.6 PRESTRESSING FORCE

INITIAL

The initial prestressing force - kips. This is equal to $f_{si}$ times SAREA times the total number of strands. For a beam with bonded strands, given at midspan. For a beam with debonded strands, given at midspan, points of debonding, and centerline of bearing.

LOSS %

The loss of prestressing force as a percent of initial prestressing force. This is either an entered value or a computed value.

EFFECTIVE

The effective prestressing force after losses - kips.

NO OF STRANDS

Number of strands corresponding to the initial prestressing force.

ECCENTRICITY

The distance of the point of application of prestressing force (center of gravity of strands) from the neutral axis of the beam - in. For draped strands, it is reported at centerline of bearing and midspan. For debonded strands, it is reported the same as initial prestressing force.

C.G.S.

The distance of the center of gravity of stands from the bottom of the beam - in.

STRAND PATTERN

The strand pattern corresponding to the design eccentricity (for a design problem only).

P/S LOSS

The method used by the program for computing prestress losses.

TRANSFER LENGTH

The length over which the prestressing force is transferred to the concrete by bond - ft. For debonded problems, transfer length and minimum development length are printed under DEBONDING DATA.

MINIMUM DEVELOPMENT LENGTH

The minimum development length for fully bonded strands - ft. For box beams only, the minimum development length for debonded strands is also printed.

## 6.7 DEBONDING DATA

Printed only for a debonded strand problem.

DEBONDED LENGTH and DEBONDED STRANDS PER ROW

For a design problem only, the computed debonded length and the corresponding number of strands debonded in each row.

AT CRITICAL SECT, EFFECTIVE NUMBER OF STRANDS, etc.

The critical section is at the actual debonded length plus the minimum development length. For each debonding, the effective number of strands for computing the moment strength, the effective number of strands for computing cracking moment, moment strength, cracking moment, and the ratio of moment strength to cracking moment are printed at each critical section. Also, warning messages are printed if the effective number of strands at the critical section is greater than 25% of the total number of strands, if the ratio of moment strength to cracking moment is less than 1.2.

TRANSFER LENGTH

The length over which the prestressing force is transferred to the concrete by bond - ft. A warning message is printed if the actual debonded length plus the transfer length is greater than the maximum permissible debonded length.

MINIMUM DEVELOPMENT LENGTH

The minimum development length - ft.

## 6.8 STRESSES

Not printed for a rating problem.

Stresses are printed at centerline of bearing, drape point, theoretical debonded length (debonded length plus transfer length), and point of maximum moment. Slight overstress may occasionally occur in design. Refer to DM4 to find the permitted amount of overstress and the conditions under which it is allowed. Significant overstress may occasionally occur at the point of drape (bottom fiber under initial prestress) for a design problem using draped strands. This is because the allowable stress at the drape point is not a controlling factor in the design. If the problem cannot be resolved by adjusting the $P_i$ and e values and resubmitting the problem as an analysis, a new section should be chosen to support the given loads.

An allowable tolerance value of 0.025 ksi is applied to concrete in tension, 0.050 ksi in compression. When a computed stress exceeds the corresponding allowable stress, the message "EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE" or "EXCEEDS ALLOWABLE" appears following the calculated values. Occasionally these messages will appear when a stress is exceeded in the decimal portion not shown in the output.

For box beams only, end block stresses at release are printed for a solid section with or without the paving notch and crack control debonding messages are printed if he stresses at centerline of bearing exceeds $3\sqrt{f_{ci}}$ .

GIRDER MOMENT

The moment in the span due to the weight of the beam - kip-ft.

INT DIAPH MOMENT

The moment in the span due to the weight of the interior diaphragms - kip-ft.

STRESSES - INITIAL P/S + GIRDER (COMPUTED)

The stresses at the top fiber of slab, at the top and bottom fiber of beam respectively due to the prestressing force plus the weight of the beam before losses - ksi.

STRESSES IN END BLOCK BEFORE DEBONDING (BASED ON A SOLID SECTION)

Printed for a box beam only. The stresses at the top and bottom fiber of the beam respectively due to the prestressing force plus the weight of the beam using section modulii for a rectangular section - ksi.

LL + I  MOMENT

The moment in the span due to the live load plus impact - kip-ft.

DIST TO CL BRG

The distance of the location in the span, measured from centerline of bearing, where the above live load plus impact moment occurs - ft. This value is printed only at the point of maximum moment.

STRESSES - FINAL P/S + GIRDER (COMPUTED)

The stresses at the top fiber of slab, at the top and bottom fiber of the beam respectively due to the prestressing force plus the weight of the beam - ksi.

STRESSES - FINAL P/S + DL (COMPUTED)

The stresses at the top fiber of slab and at the top fiber of the beam due to the prestressing force and all permanent (dead) loads - ksi. These stresses are only printed when “Y” is entered for AASHTO fc.

STRESSES - 0.5(FINAL P/S+DL) + LL (COMPUTED)

The stresses at the top fiber of slab and at the top fiber of the beam due to the live load plus on-half the sum of the prestressing force and all permanent (dead) loads - ksi. These stresses are only printed when “Y” is entered for AASHTO fc.

STRESSES - FINAL P/S + ALL LOADS (COMPUTED)

The stresses at the top fiber of slab, at the top and bottom fiber of the beam respectively due to the prestressing force plus all design loads - ksi.

STRESSES – ALLOWABLE

The allowable stresses for Inventory Rating at the top fiber of the slab, at the top and bottom fiber of the beam respectively - ksi.

MAXIMUM PARAPET OVERHANG

Maximum distance the parapet is permitted to overhang before stresses in the proposed fascia beam exceeds those shown in the output. The overhang is measured from the centerline of the proposed fascia beam (interpreted within the program as being identical to the interior beam) to the outside of the parapet - ft.

This is printed for interior beams only. It can be used to determine if a special fascia beam design is required.

STRESSES - P-82 LOADING

Theoretical stresses at the top fiber of slab, at the top fiber of beam, and at the bottom fiber of beam respectively due to the prestressing force plus the 204-Kip Permit Load plus dead loads at point of maximum moment - ksi. The stresses for the additional load combinations are printed when "Y" is entered for AASHTO fc. In addition, a factor expressing bottom fiber stress in terms of the compressive strength of concrete, $f'_{cb}$. Not printed if special live loads are entered.

## 6.9 SHEAR DATA – DESIGN

Not printed for a rating problem.

Maximum design shears and required stirrup spacings at H/2, tenth points, quarter point, and critical points (if any) up to midspan, and the number of additional stirrups required in the end block as per AASHTO 9.21.3 for an analysis problem.

Note: Stirrup spacing given for adjacent plank beams shall be utilized with caution since results are affected by selection of input segments. For such beams, stirrups, if required, shall be computed separately and placed according to engineering judgment and practice.

A shear design is printed only for a design problem. If the problem is an analysis and stirrup spacings are not entered on the STIRRUP DETAILS line, the message "NOTE: STIRRUP SPACING IS REQUIRED FOR A SHEAR ANALYSIS TO BE COMPUTED" is printed.

## 6.10 SHEAR DATA – ANALYSIS

Not printed for a rating problem.

Required factored shear forces at H/2, the quarter point, and critical points (if any) up to midspan due to dead load, live load plus impact, total factored shear force due to dead load and live load plus impact, maximum shear strengths provided by the concrete and the stirrups, and the total shear strength.

## 6.11 END SHEAR

The maximum unfactored live load shear (excluding P-82 loading) with and without impact at the support computed as per AASHTO 3.23.1 - kips.

## 6.12 HORIZONTAL SHEAR

Stress occurring between slab and beam (composite sections only) at centerline of bearing computed as per AASHTO Article 9.20.4 - ksi. Also printed is required horizontal shear reinforcement.

## 6.13 RATING DATA

The detailed rating data consists of two output tables, which are only printed when "1" is entered in the OUTPUT field on the PROJECT IDENTIFICATION line. First, the Unfactored Moments and Shears table gives unfactored analysis results (dead load shear and moment, live load shear and moments) for each analysis location. Dead load and live load moments, moment strength, dead load and live load shears, shear strength, and inventory and operating ratings for flexure and shear are printed at twentieth points starting at a distance of H/2 from the support. If the 1979 AASHTO Interim Specifications were specified for shear ratings, ratings are printed at twentieth points starting at the quarter point. An optional printout of ratings without the future wearing surface included in the dead load is also available.

The rating factors for the ML-80 and TK527 loadings are based on the axle loads shown in Figure 2.3.1, which have been increased by the 3% scale tolerance allowed by the vehicle code. Rating factors for special live loads are based on the input axle loads increased by 3% only if "Y" is entered for 3% INCR as described in Section 5.11.1. The ratings in tons for the ML-80 and TK527 loadings do not include the 3% scale tolerance. The ratings in tons for special live loads also do not include the 3% tolerance. For all other standard loads, the rating factors and the ratings in tons are based on the axles loads shown in Figure 2.3.1.

The following values are printed for the governing ratings for each live load:

LIVE LOAD TYPE

The live load designation.

GROSS WEIGHT

Live load vehicle gross weight – tons.

X

Analysis point location expressed as a percentage of the span length.

LOCATION FROM CL BRG

The distance measured from the centerline of bearing to the analysis point location - ft.

DL1 MOMENT

The maximum moment at the analysis point location indicated due to DL1 - kip-ft.

DL2 MOMENT

The maximum moment at the analysis point location indicated due to DL2 - kip-ft.

LL + I MOMENT

The maximum moment at the analysis point location indicated due to the live load plus impact - kip-ft. If an "L" is printed next to this value, it indicates that the equivalent lane loading governs.

DL1 SHEAR

The maximum shear at the analysis point location indicated due to DL1 - kip-ft.

DL2 SHEAR

The maximum shear at the analysis point location indicated due to DL2 - kip-ft.

LL + I SHEAR

The maximum shear at the analysis point location indicated due to the live load plus impact - kip-ft. If an "L" is printed next to this value for an H or HS loading, it indicates that the equivalent lane loading governs.

MOMENT STRENGTH (phi*Mn)

The moment strength of the section at the analysis point location indicated - kip-ft.

CRACKING MOMENT (Mcr)

The cracking moment of the section at the analysis point location indicated computed according to DM-4 Section 9.18.2.1 - kip-ft.

INVENTORY RATING MOMENT STRENGTH AT SPECIFIED STRESS (IR Mfy)

The moment strength when the in the bottom layer of strands reaches the Inventory Rating stress level for the section at the analysis point location indicated - kip-ft.

OPERATING RATING MOMENT STRENGTH AT SPECIFIED STRESS (OR Mfy)

The moment strength when the Operating Rating stress in the bottom layer of strands reaches the Operating Rating stress level for the section at the analysis point location indicated - kip-ft.

MOMENT RATING IR

The controlling inventory moment rating factor at the analysis point location indicated. A one-letter code appears after the rating factor to identify the controlling rating case.

MOMENT RATING OR

The controlling operating moment rating factor at the analysis point location indicated. A one-letter code appears after the rating factor to identify the controlling rating case.

SHEAR STRENGTH

The Shear Strength of the section at the analysis point location indicted – kips.

SHEAR RATING IR

The controlling inventory shear rating factor at the analysis point location indicated. A one-letter code appears after the rating factor to identify the controlling rating case.

SHEAR RATING OR

The controlling operating shear rating factor at the analysis point location indicated. A one-letter code appears after the rating factor to identify the controlling rating case.

LOCATION FROM CL BRG

The distance measured from centerline of bearing to the location of the controlling inventory rating - ft. Stresses are then printed for this location.

STRESSES - P/S

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to the prestressing force - ksi.

STRESSES - DL1

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to DL1 - ksi.

STRESSES - DL2

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to DL2 - ksi.

STRESSES - P/S + DL

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to the prestressing force, DL1 and DL2 combined - ksi.

STRESSES - LL + I

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to the live load plus impact - ksi.

STRESSES – TOTAL

The stresses at the top fiber of slab, at the top fiber of beam and at the bottom fiber of beam due to the prestressing force, DL1, DL2 and live load plus impact combined - ksi.

STRESSES - IR ALLOW

The allowable stresses for Inventory Rating at the top fiber of slab, at the top fiber of beam and the bottom fiber of beam for the P/S + DL + LL load combination (either input COMP fc or in accordance with 1996 AASHTO Article 9.15.2.2 when “Y” entered for AASHTO fc) - ksi.

STRESSES - P/S + DL (for AASHTO fc = “Y” only)

The stresses at the top fiber of slab and at the top fiber of beam due to the prestressing force, DL1 and DL2 combined - ksi.

STRESSES - 0.5(P/S + DL) (for AASHTO fc = “Y” only)

The stresses at the top fiber of slab and at the top fiber of beam due to one-half the sum of the prestressing force and the permanent (dead) load - ksi.

STRESSES - LL + I (for AASHTO fc = “Y” only)

The stresses at the top fiber of slab and at the top fiber of beam due to the live load plus impact - ksi.

STRESSES - TOTAL (for AASHTO fc = “Y” only)

The stresses at the top fiber of slab and at the top fiber of beam due to live load (including impact) plus one-half the sum of the prestressing force and the permanent (dead) loads - ksi.

STRESSES - IR ALLOW (for AASHTO fc = “Y” only)

The allowable compression stress for Inventory Rating at the top fiber of slab and at the top fiber of beam for the P/S + DL and the 0.5(P/S+DL) + LL load combinations in accordance with 1996 AASHTO Article 9.15.2.2 - ksi.

FLEXURAL RATINGS (BASED ON MOMENT)

The governing Inventory rating, Operating rating, and Safe Load Capacity rating (if requested), expressed in factors and tons, based on flexure, and their locations in feet.

SHEAR RATINGS

The governing Inventory rating, Operating rating, and Safe Load Capacity rating (if requested), expressed in factors and tons, based on shear, and their locations in feet.

## 6.14 RATING SUMMARY

Controlling moment and shear rating factors, ratings (in tons) and location (in feet from centerline of bearing) for each live load at Inventory, Operating and Safe Load Capacity levels. This table is printed as the normal rating output when “0” or a blank is entered in the OUTPUT field on the PROJECT IDENTIFICATION line.

## 6.15 CONTROLLING RATINGS

The minimum shear or flexural rating value in tons for the given live load(s).

## 6.16 CAMBER AND DEFLECTION

Camber due to prestressing, various deflections caused by specified dead loads, final dead load camber, and maximum live load plus impact deflection.

## 6.17 PRINCIPAL STRESSES

If Principal stresses are requested, the following values are printed.

1. Maximum principal stresses and their angles of orientation at certain positions within the beam due to design and maximum factored load conditions. These stresses are given at each 20th point along the beam, up to midspan.

2. Stresses at points to the left and right of the drape point for drape stranded girders.

3. Corresponding moments and shears at these points due to girder, diaphragm, slab, and formwork weights; superimposed dead loads; and live load plus impact.

## 6.18 FORMATTED OUTPUT TABLES

The following pages contain the format (i.e., the title, output parameters, units, field widths and decimal locations) for each of the output tables described 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 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 command, the program will print different combinations of these output tables.

```
                    PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

PROGRAM P4353030                                                ii/ii/iiii iii:ii
VERSION i.i               LAST UPDATED ii/ii/iiii        DOCUMENTATION ii/iiii

INPUT: aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

STRUCTURE ID - aaaaaaaaaaaaaa - aaaaaaaaaaaaaaaaaaaaaaaa
 SLC   LIVE   OUT-  IMPACT     GAGE     PASSING   ROADWAY  LOAD FACTORS
LEVEL  LOAD   PUT   FACTOR   DISTANCE  DISTANCE   WIDTH     DLF   LLF    I OR F
 aii    a     a  xxxx.xxx     xx.x      xx.x     xx.xx   xx.xx xx.xx      a

                         SKEW      IR
 PRINCIPAL            CORRECTION  STRESS  AASHTO
 STRESSES     DESIGN    FACTOR    LEVEL     FC
     a          a     xx.xxx     x.xxx     a

                          BRIDGE CROSS SECTION AND LOADING

                                 UNIT WEIGHT                           INITIAL
 BEAM     DISTRIBUTION FACTORS    OF DECK         DEAD LOADS             P/S
SPACING  SHEAR MOMENT DEFLECTION  CONCRETE   UDLF   DL1   FWS   DL2    FORCE
xxxx.x  xx.xxx xx.xxx xx.xxx    xxxx.xxxx  xx.xxxx x.xxx x.xxx x.xxx xxxx.xxx

                                                            RATINGS
ECCENTRICITY    P/S              LEHIGH LOSS METHOD     STRAND  w/ & w/o
MIDSPAN  END   LOSS %   XDRAPE  T0  TS  TD IC MFG IST   L or S    FWS
xx.xxx xx.xxx  xxx.xx   x.xxxx  ii iii iii  i  i  ii      a        a


                               SPAN LENGTHS (SIMPLE)
                                                                            BEAM
SPAN #     1       2       3       4       5       6       7       8       PROJ
LENGTH xxxx.xx                                                            xxx.xxx

                           EXTERIOR DIAPHRAGM DETAILS
                           INTERIOR DIAPHRAGM DETAILS
                     INTERIOR AND EXTERIOR DIAPHRAGM DETAILS

ID  WEIGHT  THICK  #DIA  DIST   DIST   DIST   DIST   DIST   DIST   DIST   DIST
 a  xx.xxx xxx.xx  iii xxx.xx xxx.xx xxx.xx xxx.xx xxx.xx xxx.xx xxx.xx xxx.xx


                               PRESTRESS CRITERIA

  BEAM    SLAB    CONC    STEEL   STEEL   STEEL      INITIAL ALLOWABLE
  CONC    CONC    INIT    INIT    YIELD    ULT     COMP   TENS  DRP/DBND
  F'CB    F'CS    F'CI     FSI     Fy      F'S      FCI    FTI    FTFD
 x.xxx   x.xxx   x.xxx  xxxx.x  xxxx.x  xxxx.x    x.xxx  x.xxx   x.xxx

  FINAL ALLOWABLE   ALLOW    OR            MODULAR           EST.
 COMP  TENS  SLAB   SHEAR  STRESS  STEEL     RATIOS    CREEP    %     STRAND
  FC    FT   FCS     VHA   LEVEL     E      DES  ULT   FACTOR  LOSS  DIAMETER
x.xxx x.xxx x.xxx   x.xxx  x.xxx iiiiiii  x.xxx x.xxx   xx.x   xx.x   x.xxxx

  NUMBER OF    NUMBER OF    STIRRUP
    ROWS          Lx        DETAILS
    iiii          ii           a
```

If beam dimensions are entered:

```
                        PRESTRESSED CONCRETE BEAM DIMENSIONS

 TYPE    COMP       D        W1       W2       W3       T1       T2
    a       a    xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx

                                                                SLAB
   B1     B2     B3     B4     D1      D2      X1      X2      THICK  HAUNCH
xxx.xx xxx.xx xxx.xx xxx.xx  xxx.xx  xxx.xx xxx.xxx xxx.xxx  xxx.xx  xxx.xx
```

If beam designation entered:

```
                        PRESTRESSED CONCRETE BEAM DIMENSIONS

TYPE   COMP   DESIGNATION   D        W1       W2       W3       T1       T2
 a      a       aa/aa    xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx  xxx.xxx

                                                                SLAB
   B1     B2     B3     B4     D1      D2      X1      X2      THICK  HAUNCH
xxx.xx xxx.xx xxx.xx xxx.xx  xxx.xx  xxx.xx xxx.xxx xxx.xxx  xxx.xx  xxx.xx


                                   STRAND DETAILS

 AREA    G1     G2      R1   R2   R3   R4   R5   R6   R7   R8   R9   R10
xx.xxx xx.xx xx.xxx     ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R11 - R20       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R21 - R30       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R31 - R40       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R41 - R50       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R51 - R60       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R61 - R70       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R71 - R80       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R81 - R90       ii   ii   ii   ii   ii   ii   ii   ii   ii   ii
        R91 - R100      ii   ii   ii   ii   ii   ii   ii   ii   ii   ii


                              DEBONDED STRAND DETAILS

DEBONDED    1        2        3        4        5        6        7        8
 LENGTH  ROW NO   ROW NO   ROW NO   ROW NO   ROW NO   ROW NO   ROW NO   ROW NO
   LX    NO STR   NO STR   NO STR   NO STR   NO STR   NO STR   NO STR   NO STR
xxx.xxx  ii ii    ii ii    ii ii    ii ii    ii ii    ii ii    ii ii    ii ii
 9 - 14  ii ii    ii ii    ii ii    ii ii    ii ii    ii ii


                                 STIRRUP DETAILS
SPEC. FOR  STIRRUP
ANAL/RATE   AREA   FSY  LOCATION SPACING   LOCATION SPACING   LOCATION SPACING
    a      xx.xxx  iii  xxx.xx   xx.xxx    xxx.xx   xx.xxx    xxx.xx   xx.xxx
                        xxx.xx   xx.xxx    xxx.xx   xx.xxx    xxx.xx   xx.xxx
```

```
SPECIAL LIVE LOADING i

                                 LANE LOADING

      NUMBER        UNIFORM  CONC    CONC                                   MAX
       OF     3%     LANE   LOAD    LOAD     GAGE    PASSING   VARY   AXLE
      AXLES  INCR    LOAD  MOMENT   SHEAR  DISTANCE  DISTANCE  LAST   DIST
       ii      a   xx.xxx xxx.xxx xxx.xxx   xxx.x     xxx.x      a  xxxx.x

                                  TRUCK LOAD

      AXLE                AXLE                AXLE                AXLE
       NO.  LOAD   DIST   NO.  LOAD   DIST   NO.  LOAD   DIST   NO.  LOAD   DIST
       ii  xx.xx  xx.xx  ii  xx.xx  xx.xx  ii  xx.xx  xx.xx  ii  xx.xx  xx.xx


                                DEFAULT VALUES

    aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa
    aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa
    aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa  aaaaaaa
```

For rating runs:

```
 ******************************************************************************
 *                          RATING OF AN aaaaaaaa BEAM                        *
 ******************************************************************************


                          BASIC BEAM SECTION PROPERTIES

   DEPTH    AREA    WEIGHT   M OF I    N.A. TO     N.A. TO    Z TOP    Z BOT
    IN      IN.2    LBS/FT    IN.4    TOP YT IN.  BOT YB IN   IN.3     IN.3
  xxx.xx  xxxx.x  xxxx.xx xxxxxxx.x   xxx.xx      xxx.xx   xxxxxx.x xxxxxx.x


                           COMPOSITE SECTION PROPERTIES

  SLAB   AREA    M OF I  N.A. TO   N.A. TO   N.A. TO   Z TOP    Z TOP    Z BOT
  WIDTH  IN.2     IN.4   SLAB TOP  BEAM TOP  BEAM BOT  SLAB     BEAM     BEAM
 xxx.xx xxxx.x xxxxxxx.x xxx.xx    xxx.xx    xxx.xx  xxxxxx.x xxxxxx.x xxxxxx.x


                 UNIFORM DEAD LOADS ACTING ON GIRDER  (KIPS/FT)

                                                 FUTURE
 GIRDER    SLAB    HAUNCH  FORMWORK   INPUT   WEARING   INPUT    TOTAL    TOTAL
 WEIGHT   WEIGHT   WEIGHT   WEIGHT     DL1    SURFACE    DL2      DL1      DL2
 x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx  xx.xxxx  xx.xxxx
                       DEAD LOAD AND LIVE LOAD REACTIONS

     DL1       DL2      IMPACT   LL+I aaaaa LL+I aaaaa LL+I aaaaa LL+I aaaaa
   REACTION  REACTION   FACTOR   REACTION   REACTION   REACTION   REACTION
   xxxx.x    xxxx.x    xx.xxx   xxxx.x a   xxxx.x a   xxxx.x a   xxxx.x a

                                  LL+I aaaaa LL+I aaaaa LL+I aaaaa LL+I aaaaa
                                  REACTION   REACTION   REACTION   REACTION
                                  xxxx.x a   xxxx.x a   xxxx.x a   xxxx.x a
```

For design or analysis runs:

```
******************************************************************************
*                        aaaaaaaa OF AN aaaaaaaa BEAM                        *
******************************************************************************


                         BASIC BEAM SECTION PROPERTIES

  DEPTH   AREA    WEIGHT   M OF I    N.A. TO     N.A. TO    Z TOP    Z BOT
   IN     IN.2    LBS/FT    IN.4    TOP YT IN.  BOT YB IN   IN.3     IN.3
 xxx.xx  xxxx.x xxxxx.xx xxxxxxx.x  xxxx.xx     xxxx.xx   xxxxxx.x xxxxxx.x

                          COMPOSITE SECTION PROPERTIES

 SLAB   AREA    M OF I  N.A. TO   N.A. TO   N.A. TO   Z TOP    Z TOP    Z BOT
 WIDTH  IN.2     IN.4   SLAB TOP  BEAM TOP  BEAM BOT  SLAB     BEAM     BEAM
xxx.xx xxxx.x xxxxxxx.x xxx.xx    xxx.xx    xxx.xx  xxxxxx.x xxxxxx.x xxxxxx.x


                 UNIFORM DEAD LOADS ACTING ON GIRDER  (KIPS/FT)

                                                 FUTURE
GIRDER    SLAB    HAUNCH  FORMWORK   INPUT   WEARING   INPUT    TOTAL    TOTAL
WEIGHT   WEIGHT   WEIGHT   WEIGHT     DL1    SURFACE    DL2      DL1      DL2
x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx   x.xxxx  xx.xxxx


******************************************************************************
*           MAXIMUM DESIGN MOMENTS AND MOMENT STRENGTHS  (KIP-FT)           *
******************************************************************************


                            FUTURE                                      FACTORED
 GIRDER  DIAPH   SLAB +   WEARING   TOTAL    TOTAL    IMPACT  LL + I  1.30(DL)
 WEIGHT  WEIGHT  FORMWRK  SURFACE    DL1      DL2     FACTOR  (aaaaa) 2.17(LL+I)
xxxxx.x xxxxx.x xxxxx.x  xxxxx.x  xxxxx.x xxxxx.x   xx.xxx xxxxx.x   xxxxx.x



                                 MOMENT
                                STRENGTH aaa
    AT 0.900 FY                 xxxxx.x
    Phi*Mn                      xxxxx.x  aaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

    THEORETICAL TENSILE STRESS IN
    BEAM AT OPERATING RATING (KSI)
     (TENSION +   COMPRESSION -)       CRACKING    LIVE LOAD    RATIO
          BOT FIBER  FACTOR *        MOMENT (Mcr)     F.S.   (phi*Mn/Mcr)
           xx.xxx    xxx.xxx          xxxxxx.x     xxx.xxx    xxx.xxx aa

  *  FACTOR EQUALS THEORETICAL TENSILE STRESS DIVIDED BY SQUARE ROOT OF F'CB

 **  WARNING - MOMENT STRENGTH IS LESS THAN xx.x TIMES CRACKING MOMENT

***  MOMENT STRENGTHS HAVE BEEN REDUCED TO ACCOUNT FOR THE INSUFFICIENT
     DEVELOPMENT OF PRESTRESSING STRANDS DUE TO THE SPAN LENGTH.
```

For straight strand runs:

```
******************************************************************************
*                   PRESTRESSING FORCE (STRAIGHT STRANDS)                    *
******************************************************************************


    INITIAL    LOSS %    EFFECTIVE  NO. OF STRANDS  ECCENTRICITY  C.G.S.
   xxxx.xxx    xxx.xx    xxxx.xxx        iii          xxx.xxx    xxx.xxx


   Strand pattern printed for design runs only:

   - STRAND PATTERN USED BASED ON THE DESIGN ECCENTRICITY OF xxx.xxx INCHES:

      R1  R2  R3  R4  R5  R6  R7  R8  R9  R10  . . .
      ii  ii  ii  ii  ii  ii  ii  ii  ii  ii

     P/S LOSS BY aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

     TRANSFER LENGTH Lt   xx.xxx FT.
     MINIMUM DEVELOPMENT LENGTH FOR FULLY BONDED STRANDS  xx.xxx FT.
```

For draped strand runs:

```
******************************************************************************
*       PRESTRESSING FORCE (DRAPED STRANDS AT xxx.xxx FT. FROM CL BRG)       *
******************************************************************************

               INITIAL     LOSS %     EFFECTIVE     NO. OF STRANDS
              xxxx.xxx     xxx.xx     xxxx.xxx           iii

                    AT MID SPAN:  ECCENTRICITY   C.G.S (GM)
                                    xxx.xxx      xxx.xxx

                    AT CL BRG.:   ECCENTRICITY   C.G.S (GE)
                                    xxx.xxx      xxx.xxx


   Strand pattern printed for design runs only:

   - STRAND PATTERN USED BASED ON THE DESIGN ECCENTRICITY OF xxx.xxx INCHES:

      R1  R2  R3  R4  R5  R6  R7  R8  R9  R10  . . .
      ii  ii  ii  ii  ii  ii  ii  ii  ii  ii


     P/S LOSS BY aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

     TRANSFER LENGTH Lt   xx.xxx FT.
     MINIMUM DEVELOPMENT LENGTH FOR FULLY BONDED STRANDS  xx.xxx FT.
```

For debonded strand design or analysis runs:

```
*****************************************************************************
*                   PRESTRESSING FORCE (DEBONDED STRANDS)                    *
*****************************************************************************


    AT CL BRG.:
    -----------
     INITIAL    LOSS %  EFFECTIVE  EFF NO OF STRANDS  ECCENTRICITY  C.G.S.
    xxxx.xxx     xx.xx  xxxx.xxx         iii            xxx.xxx    xxx.xxx


    AT DEBONDED LENGTH xx.xxx FT. FROM CL BRG.:
    ------------------------------------------
     INITIAL    LOSS %  EFFECTIVE  EFF NO OF STRANDS  ECCENTRICITY  C.G.S.
    xxxx.xxx     xx.xx  xxxx.xxx         iii            xxx.xxx    xxx.xxx


    AT MID SPAN:
    ------------
     INITIAL    LOSS %  EFFECTIVE  EFF NO OF STRANDS  ECCENTRICITY  C.G.S.
    xxxx.xxx     xx.xx  xxxx.xxx         iii            xxx.xxx    xxx.xxx

  Strand pattern printed for design run only:

  - STRAND PATTERN USED BASED ON THE DESIGN ECCENTRICITY OF xxx.xxx INCHES:

     R1  R2  R3  R4  R5  R6  R7  R8  R9  R10  . . .
     ii  ii  ii  ii  ii  ii  ii  ii  ii  ii

    P/S LOSS BY aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```

For debonded strand analysis runs:

```
*****************************************************************************
*                              DEBONDING DATA                                *
*****************************************************************************


    AT CRITICAL   # OF STRANDS
    SECTION (FT   FOR STRENGTH   MOMENT   CRACKING       RATIO
    FROM CL BRG) phi*Mn   Mcr    STRENGTH   MOMENT     (phi*Mn/Mcr)
    xxx.xxx       iii a   iii   xxxxxx.x  xxxxxx.x      xx.xxx  aa
    MIDSPAN       iii a   iii   xxxxxx.x  xxxxxx.x      xx.xxx  aa

    * WARNING  NUMBER OF DEBONDED STRANDS EXCEEDS 25% OF TOTAL STRANDS

   ** phi*Mn IS LESS THAN xx.x TIMES THE CRACKING MOMENT

  TRANSFER LENGTH Lt   xx.xxx FT.
  MINIMUM DEVELOPMENT LENGTH FOR DEBONDED STRANDS      xx.xxx FT.
  MINIMUM DEVELOPMENT LENGTH FOR FULLY BONDED STRANDS  xx.xxx FT.
```

For debonded strand design runs:

```
******************************************************************************
*                              DEBONDING PATTERN                             *
******************************************************************************


    DEBONDED                  DEBONDED STRANDS/ROW
     LENGTH   R1  R2  R3  R4  R5 . . .
    xxx.xxx   ii  ii  ii  ii  ii

    AT CRITICAL   # OF STRANDS
    SECTION (FT   FOR STRENGTH   MOMENT   CRACKING       RATIO
    FROM CL BRG) phi*Mn  Mcr    STRENGTH   MOMENT     (phi*Mn/Mcr)
    xxx.xxx       iii    iii    xxxxxx.x  xxxxxx.x      xx.xxx
    MIDSPAN       iii    iii    xxxxxx.x  xxxxxx.x      xx.xxx

  TRANSFER LENGTH Lt   xx.xxx FT.
  MINIMUM DEVELOPMENT LENGTH FOR DEBONDED STRANDS      xx.xxx FT.
  MINIMUM DEVELOPMENT LENGTH FOR FULLY BONDED STRANDS  xx.xxx FT.


******************************************************************************
*           STRESSES AT RELEASE IN KSI  (TENSION +  COMPRESSION -)           *
******************************************************************************


                         AT CL BRG (aaaaaaaa STRANDS)
                         ----------------------------

     GIRDER   INT DIAPH                TOP FIBER   TOP FIBER   BOT FIBER
     MOMENT    MOMENT                     SLAB        BEAM        BEAM
     xxxx.x    xxxx.x
        INITIAL P/S + GIRDER  (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
        ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

     ** EXCEEDS ALLOWBLE
    *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE
```

For box beams only:

```
    STRESSES IN END BLOCK BEFORE DEBONDING WITHIN THE PAVING NOTCH
        (BASED ON SOLID SECTION)
          TOP FIBER BEAM:  xx.xxx a     BOTTOM FIBER BEAM:  xx.xxx a

        * STRESSES EXCEED 3 * sqrt(f'ci), CRACK CONTROL DEBONDING
           IS REQUIRED AS PER SECTION 1107.01, PUB. 408


    STRESSES IN END BLOCK BEFORE DEBONDING BEYOND THE PAVING NOTCH
        (BASED ON SOLID SECTION)
          TOP FIBER BEAM:  xx.xxx a     BOTTOM FIBER BEAM:  xx.xxx a

        * STRESSES EXCEED 3 * sqrt(f'ci), CRACK CONTROL DEBONDING
           IS REQUIRED AS PER SECTION 1107.01, PUB. 408
```

For draped strand runs only:

```
                AT DRAPE POINT xx.xxx FT. FROM CL BRG
                -------------------------------------

   GIRDER   INT DIAPH                TOP FIBER   TOP FIBER   BOT FIBER
   MOMENT    MOMENT                     SLAB        BEAM        BEAM
   xxxx.x    xxxx.x
      INITIAL P/S + GIRDER  (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE
```

For debonded strand runs only:

```
               AT DEBONDED LENGTH xx.xxx FT. FROM CL BRG
               -----------------------------------------

   GIRDER   INT DIAPH                TOP FIBER   TOP FIBER   BOT FIBER
   MOMENT    MOMENT                     SLAB        BEAM        BEAM
   xxxx.x    xxxx.x
      INITIAL P/S + GIRDER  (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE


                      AT POINT OF MAXIMUM MOMENT
                      --------------------------

   GIRDER   INT DIAPH   DIST TO       TOP FIBER   TOP FIBER   BOT FIBER
   MOMENT    MOMENT     CL BRG.          SLAB        BEAM        BEAM
   xxxx.x    xxxx.x     xxx.xxx
      INITIAL P/S + GIRDER  (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE


******************************************************************************
*                     DESIGN LIVE LOAD  -  aaaaaaaaaa                        *
******************************************************************************

                     AT CL BRG (aaaaaaaa STRANDS)
                     ----------------------------

   LL + I               STRESSES IN KSI  (TENSION +  COMPRESSION -)
   MOMENT                            TOP FIBER   TOP FIBER   BOT FIBER
   xxxx.x                               SLAB        BEAM        BEAM
      FINAL P/S + GIRDER    (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx
```

For AASHTO fc = “Y” only:

```
      FINAL P/S + DL        (COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx
```

For AASHTO fc = “Y” only:

```
      0.5(FINAL P/S+DL) + LL(COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx

      FINAL P/S + ALL LOADS (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE
```

For draped strand runs only:

```
                  AT DRAPE POINT xx.xxx FT. FROM CL BRG
                  -------------------------------------

   LL + I              STRESSES IN KSI  (TENSION +  COMPRESSION -)
   MOMENT                            TOP FIBER   TOP FIBER   BOT FIBER
   xxxx.x                               SLAB        BEAM        BEAM
      FINAL P/S + GIRDER    (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

For AASHTO fc = "Y" only:
      FINAL P/S + DL        (COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx

For AASHTO fc = "Y" only:
      0.5(FINAL P/S+DL) + LL(COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx

      FINAL P/S + ALL LOADS (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE
```

For debonded strand runs only:

```
           AT THEORETICAL DEBONDED LENGTH xx.xxx FT. FROM CL BRG
           -----------------------------------------------------

   LL + I               STRESSES IN KSI  (TENSION +  COMPRESSION -)
   MOMENT                             TOP FIBER   TOP FIBER   BOT FIBER
   xxxx.x                                SLAB        BEAM        BEAM
      FINAL P/S + GIRDER    (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

For AASHTO fc = "Y" only:
      FINAL P/S + DL        (COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx
```

For AASHTO fc = "Y" only:

```
      0.5(FINAL P/S+DL) + LL(COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx

      FINAL P/S + ALL LOADS (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE



                        AT POINT OF MAXIMUM MOMENT
                        --------------------------

   LL + I   DIST TO     STRESSES IN KSI  (TENSION +  COMPRESSION -)
   MOMENT   CL BRG.                   TOP FIBER   TOP FIBER   BOT FIBER
   xxxx.x   xxx.xxx                      SLAB        BEAM        BEAM
      FINAL P/S + GIRDER    (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx
```

For AASHTO fc = "Y" only:

```
      FINAL P/S + DL        (COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx
```

For AASHTO fc = "Y" only:

```
      0.5(FINAL P/S+DL) + LL(COMPUTED)  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx

      FINAL P/S + ALL LOADS (COMPUTED)  xx.xxx aaa  xx.xxx aaa  xx.xxx aaa
      ALLOWABLE                         xx.xxx      xx.xxx      xx.xxx

   ** EXCEEDS ALLOWBLE
  *** EXCEEDS ALLOWABLE BUT WITHIN TOLERANCE


  SPECIAL FASCIA DESIGN REQ'D IF PARAPET OVERHANG IS GREATER THAN xx.xx FT.
```

```
****************************************************************************
*                               P-82 LOADING                               *
****************************************************************************


                            AT POINT OF MAXIMUM MOMENT
                            --------------------------

     LL + I   DIST TO   COMPUTED STRESSES IN KSI  (TENSION +  COMPRESSION -)
     MOMENT   CL BRG.            TOP FIBER   TOP FIBER   BOT FIBER
     xxxx.x   xxx.xxx               SLAB        BEAM        BEAM    FACTOR *
        INITIAL P/S + GIRDER       xx.xxx      xx.xxx      xx.xxx
        FINAL P/S + GIRDER         xx.xxx      xx.xxx      xx.xxx
```

For AASHTO fc = “Y” only:

```
        FINAL P/S + DL             xx.xxx      xx.xxx
        0.5(FINAL P/S+DL) + LL     xx.xxx      xx.xxx

        FINAL P/S + ALL LOADS      xx.xxx      xx.xxx      xx.xxx    xx.xx
```

For shear analysis:

```
****************************************************************************
*                     SHEAR DATA  (aaaaaaaaaaaaaaaaaa)                     *
****************************************************************************


           REQ'D FACTORED SHEAR (KIPS)            SHEAR STRNEGTH (KIPS)
                                                   VC        VS   0.9(VC+VS)
      X      D.L.      LL+I   TYPE   TOTAL     CONCRETE   STIRRUPS   TOTAL
     H/2   xxxx.xx  xxxx.xx  aaaaa xxxx.xx     xxxx.xx   xxxx.xx   xxxx.xx
     x.xx  xxxx.xx  xxxx.xx  aaaaa xxxx.xx     xxxx.xx   xxxx.xx   xxxx.xx

     UNFACTORED LL SHEAR AT SUPPORT FOR BEARING DESIGN IS xxx.xx KIPS (aaaaa)
     UNFACTORED LL+I SHEAR AT SUPPORT FOR BEARING DESIGN IS xxx.xx KIPS (aaaaa)
     HORIZONTAL SHEAR STRESS (KSI) AT CL BRG x.xxx COMPUTED  x.xxx ALLOWABLE

     MINIMUM HORIZONTAL SHEAR REINFORCEMENT IS NUMBER 4 BARS AT 21 INCHES
     HEAVY SCORING FINISH IS REQUIRED
```

For shear design:

```
****************************************************************************
*                        SHEAR DATA  (1992 AASHTO)                         *
****************************************************************************


              DESIGN SHEARS (KIPS) AND STIRRUP SPACING (INCHES)

  X    GIRDER  DIAPH SLAB+FORM   DL1     DL2    LL+I   TYPE  FACTORED  ST.SPA.
 H/2   xxx.xx xxx.xx  xxx.xx  xxx.xx  xxx.xx  xxx.xx  aaaaa xxxx.xx    xx.xx
 x.xx  xxx.xx xxx.xx  xxx.xx  xxx.xx  xxx.xx  xxx.xx  aaaaa xxxx.xx    xx.xx

     UNFACTORED LL SHEAR AT SUPPORT FOR BEARING DESIGN IS xxx.xx KIPS (aaaaa)
     UNFACTORED LL+I SHEAR AT SUPPORT FOR BEARING DESIGN IS xxx.xx KIPS (aaaaa)
     MAXIMUM SPACING IS THE SMALLER VALUE OF EITHER 3/4 BEAM DEPTH OR 21 IN.
     BASED ON 2 LEGGED STIRRUPS, AREA = x.xx in^2, FSY = 60 KSI

     HORIZONTAL SHEAR STRESS (KSI) AT CL BRG x.xxx COMPUTED  x.xxx ALLOWABLE

     MINIMUM HORIZONTAL SHEAR REINFORCEMENT IS NUMBER 4 BARS AT 21 INCHES
     HEAVY SCORING FINISH IS REQUIRED
```

Detailed Rating analysis for both moment and shear:

```
****************************************************************************
*                              RATING DATA                                 *
*                RATING DATA (with future wearing surface)                 *
*              RATING DATA (without future wearing surface)                *
****************************************************************************

LIVE LOAD TYPE:  aaaaa           GROSS WEIGHT:  xxx.xx TONS

                  UNFACTORED MOMENTS AND SHEARS

      LOCATION       DL1       DL2       LL+I        DL1       DL2      LL+I
 X   FROM CL BRG   MOMENT   MOMENT    MOMENT      SHEAR     SHEAR    SHEAR
H/2   xxx.xxx     xxxxx.x  xxxxx.x  xxxxx.xa   xxxxx.x  xxxxx.x  xxxxx.x
x.xx  xxx.xxx     xxxxx.x  xxxxx.x  xxxxx.xa   xxxxx.x  xxxxx.x  xxxxx.x

          LL+I MOMENT CODE:
               L = LANE LOADING GOVERNS


                             STRENGTHS AND RATINGS

              MOMENT STRENGTHS           MOMENT                     SHEAR
     --------------------------------    RATINGS                   RATINGS
              CRACKING   IR      OR    ---------------  SHEAR   ------------
 X    phi*Mn    Mcr     Mfy     Mfy       IR      OR   STRENGTH   IR     OR
H/2  xxxxx.xa xxxxx.x xxxxx.x xxxxx.x xx.xxxa xx.xxxa
x.xx xxxxx.xa xxxxx.x xxxxx.x xxxxx.x xx.xxxa xx.xxxa
x.xx xxxxx.xa xxxxx.x xxxxx.x xxxxx.x xx.xxxa xx.xxxa xxxxx.x xx.xxx xx.xxx

CODES:  MOMENT STRENGTH CODE:
              # = MOMENT STRENGTH REDUCED BY phi*Mn/1.2Mcr RATIO
```

```
     INVENTORY RATING CODES:
           IF SERVICEABILITY GOVERNS INVENTORY RATING:
                B = BOTTOM STRESS GOVERNS
                T = TOP STRESS GOVERNS
                S = SLAB STRESS GOVERNS

           U = phi*Mn GOVERNS
           F = Mfy GOVERNS

     OPERATING RATING CODES:
           U = phi*Mn GOVERNS
           F = Mfy GOVERNS
                           GOVERNING RATINGS


 STRESSES AT xx.xxx FROM CL BRG  (TENSION + COMPRESSION -)
                     TOP FIBER  TOP FIBER  BOT FIBER
                        SLAB       BEAM       BEAM
                 P/S   xx.xxx     xx.xxx     xx.xxx
                 DL1   xx.xxx     xx.xxx     xx.xxx
                 DL2   xx.xxx     xx.xxx     xx.xxx
                        -----      -----      -----
            P/S + DL   xx.xxx     xx.xxx     xx.xxx
              LL + I   xx.xxx     xx.xxx     xx.xxx
                        -----      -----      -----
        TOTAL          xx.xxx     xx.xxx     xx.xxx
        IR ALLOW       xx.xxx     xx.xxx     xx.xxx
```

For AASHTO fc = “Y” only:

```
        P/S + DL       xx.xxx     xx.xxx
        IR ALLOW       xx.xxx     xx.xxx

        0.5(P/S + DL)  xx.xxx     xx.xxx
              LL + I   xx.xxx     xx.xxx
                        -----      -----
        TOTAL          xx.xxx     xx.xxx
        IR ALLOW       xx.xxx     xx.xxx


  FLEXURAL RATINGS (BASED ON MOMENT)            SHEAR RATINGS (aaaaaa)

        FACTOR   TONS   LOCATION                      FACTOR   TONS   LOCATION
                       FROM CL BRG                                   FROM CL BRG
   IR  xx.xxx  xxxx.xx  xxx.xxx              IR  xx.xxx  xxxx.xx  xxx.xxx
   OR  xx.xxx  xxxx.xx  xxx.xxx              OR  xx.xxx  xxxx.xx  xxx.xxx
   SLC xx.xxx  xxxx.xx  xxx.xxx              SLC xx.xxx  xxxx.xx  xxx.xxx
   Axx xx.xxx  xxxx.xx  xxx.xxx              Axx xx.xxx  xxxx.xx  xxx.xxx


NOTE: FOR A COMPOSITE BEAM, THE STRESSES PRINTED FOR P/S AND DL1 ARE BASED ON
      SECTION MODULI OF THE BASIC BEAM.  THE STRESSES PRINTED FOR DL2 AND
      LL+I ARE BASED ON SECTION MODULI OF THE COMPOSITE BEAM.

      SERVICABILTY IR RATINGS ARE BASED ON STRESSES DUE TO P/S+DL AND LL+I.
```

Detailed Rating analysis for moment only:

```
*****************************************************************************
*                               RATING DATA                                 *
*                 RATING DATA (with future wearing surface)                 *
*               RATING DATA (without future wearing surface)                *
*****************************************************************************


LIVE LOAD TYPE:  aaaaa           GROSS WEIGHT:  xxx.xx TONS

                  UNFACTORED MOMENTS AND SHEARS

      LOCATION      DL1       DL2       LL+I        DL1       DL2      LL+I
 X   FROM CL BRG   MOMENT   MOMENT   MOMENT       SHEAR     SHEAR     SHEAR
H/2   xxx.xxx     xxxxx.x  xxxxx.x  xxxxx.x    xxxxx.x  xxxxx.x  xxxxx.x
x.xx  xxx.xxx     xxxxx.x  xxxxx.x  xxxxx.x    xxxxx.x  xxxxx.x  xxxxx.x



                             STRENGTHS AND RATINGS

              MOMENT STRENGTHS            MOMENT
     --------------------------------     RATINGS
              CRACKING   IR      OR    ---------------
 X    phi*Mn    Mcr     Mfy     Mfy      IR      OR
H/2  xxxxx.xa xxxxx.x xxxxx.x xxxxx.x xx.xxxa xx.xxxa
x.xx xxxxx.xa xxxxx.x xxxxx.x xxxxx.x xx.xxxa xx.xxxa

CODES:  INVENTORY RATING CODES:
              IF SERVICEABILITY GOVERNS INVENTORY RATING:
                   B = BOTTOM STRESS GOVERNS
                   T = TOP STRESS GOVERNS
                   S = SLAB STRESS GOVERNS

              * = LOAD FACTOR INVENTORY RATING GOVERNS
              F = Mfy GOVERNS

        OPERATING RATING CODES:
              U = phi*Mn GOVERNS
              F = Mfy GOVERNS


                            GOVERNING RATINGS


    STRESSES AT xx.xxx FROM CL BRG  (TENSION + COMPRESSION -)
                      TOP FIBER  TOP FIBER  BOT FIBER
                         SLAB       BEAM       BEAM
                  P/S   xx.xxx     xx.xxx     xx.xxx
                  DL1   xx.xxx     xx.xxx     xx.xxx
                  DL2   xx.xxx     xx.xxx     xx.xxx
                         -----      -----      -----
             P/S + DL   xx.xxx     xx.xxx     xx.xxx
               LL + I   xx.xxx     xx.xxx     xx.xxx
                         -----      -----      -----
           TOTAL        xx.xxx     xx.xxx     xx.xxx
           IR ALLOW     xx.xxx     xx.xxx     xx.xxx
```

For AASHTO fc = "Y" only:

```
         P/S + DL         xx.xxx     xx.xxx
         IR ALLOW         xx.xxx     xx.xxx

         0.5(P/S + DL)    xx.xxx     xx.xxx
                LL + I    xx.xxx     xx.xxx
                           -----      -----
         TOTAL            xx.xxx     xx.xxx
         IR ALLOW         xx.xxx     xx.xxx

         0.5(P/S + DL)    xx.xxx     xx.xxx
                LL + I    xx.xxx     xx.xxx
                           -----      -----
         TOTAL            xx.xxx     xx.xxx
         IR ALLOW         xx.xxx     xx.xxx

   FLEXURAL RATINGS (BASED ON MOMENT)

         FACTOR   TONS   LOCATION
                        FROM CL BRG
    IR  xx.xxx   xxx.xx  xxx.xxx
    OR  xx.xxx   xxx.xx  xxx.xxx
    SLC xx.xxx   xxx.xx  xxx.xxx
    Axx xx.xxx   xxx.xx  xxx.xxx


NOTE: FOR A COMPOSITE BEAM, THE STRESSES PRINTED FOR P/S AND DL1 ARE BASED ON
      SECTION MODULI OF THE BASIC BEAM.  THE STRESSES PRINTED FOR DL2 AND
      LL+I ARE BASED ON SECTION MODULI OF THE COMPOSITE BEAM.

      SERVICABILTY IR RATINGS ARE BASED ON STRESSES DUE TO P/S+DL AND LL+I.


******************************************************************************
*                               RATING SUMMARY                               *
******************************************************************************


   FLEXURAL RATINGS (BASED ON MOMENT)           SHEAR RATINGS (aaaaaa)

LOAD       FACTOR   TONS   LOCATION              FACTOR   TONS   LOCATION
                          FROM CL BRG                           FROM CL BRG
aaaaa IR  xx.xxx   xxx.xx  xxx.xxx          IR  xx.xxx   xxx.xx  xxx.xxx
      OR  xx.xxx   xxx.xx  xxx.xxx          OR  xx.xxx   xxx.xx  xxx.xxx
      SLC xx.xxx   xxx.xx  xxx.xxx          SLC xx.xxx   xxx.xx  xxx.xxx
      Axx xx.xxx   xxx.xx  xxx.xxx          Axx xx.xxx   xxx.xx  xxx.xxx
```

```
******************************************************************************
*                             CONTROLLING RATINGS                            *
******************************************************************************



     VEHICLE TYPE              IR          OR
     VEHICLE TYPE              IR          OR          aaa

     aaaaa LOADING (TONS)   xxx.xx a    xxx.xx a
     aaaaa LOADING (TONS)   xxx.xx a    xxx.xx a    xxx.xx a

     F = FLEXURAL RATING        S = SHEAR RATING

        CONTROLLING RATINGS ABOVE COMPUTED WITHOUT FUTURE WEARING SURFACE.



******************************************************************************
*                            CAMBER AND DEFLECTIONS                          *
******************************************************************************


     CAMBER TO DETERMINE BRIDGE SEAT ELEVATIONS -


           ASSUMING A PRESTRESS LOSS xx.xxx PERCENT
           AND A CREEP FACTOR OF x.x

           CAMBER DUE TO PRESTRESS                             xx.xxxx  IN.
           DEFLECTION DUE TO GIRDER + INT DIAPH               (xx.xxxx) IN.
                                                               ========
                                             INITIAL CAMBER    xx.xxxx  IN.

           CAMBER A = CREEP FACTOR X INITIAL CAMBER            xx.xxxx  IN.
           DEFLECTION DUE TO SLAB + FORMWORK + EXT DIAPH + DL1 (xx.xxxx) IN.
           DEFLECTION DUE TO SUPERIMPOSED DEAD LOADS          (xx.xxxx) IN.
                                                               ========
           * ESTIMATED FINAL CAMBER (UPWARD +, SAG -)          xx.xxxx  IN.



     CAMBER TO CHECK A PROBABLE SAG IN BRIDGE -


           ASSUMING A PRESTRESS LOSS xx.xxx PERCENT
           AND A CREEP FACTOR OF x.x

           CAMBER DUE TO PRESTRESS                             xx.xxxx  IN.
           DEFLECTION DUE TO GIRDER + INT DIAPH               (xx.xxxx) IN.
                                                               ========
                                             INITIAL CAMBER    xx.xxxx  IN.

           CAMBER A = CREEP FACTOR X INITIAL CAMBER            xx.xxxx  IN.
           DEFLECTION DUE TO SLAB + FORMWORK + EXT DIAPH + DL1 (xx.xxxx) IN.
           DEFLECTION DUE TO SUPERIMPOSED DEAD LOADS          (xx.xxxx) IN.
                                                               ========
           * ESTIMATED FINAL CAMBER (UPWARD +, SAG -)          xx.xxxx  IN.
```

```
    MAXIMUM LL+I DEFLECTION:

          DUE TO aaaa LOADING                 xx.xxxx IN.


    ALLOWABLE LL+I DEFLECTION:

          FOR BRIDGES W/O SIDEWALKS           xx.xxxx IN. (L/800)
          FOR BRIDGES WITH SIDEWALKS          xx.xxxx IN. (L/1000)


    NOTE: DEFLECTION DISTRIBUTION FACTOR NOT ENTERED, LL+I DEFLECTION
          NOT COMPUTED.


******************************************************************************
*                              PRINCIPAL STRESSES                            *
*        (ANGLES ARE MEASURED FROM BEAM AXIS, COUNTERCLOCKWISE IF -)         *
******************************************************************************


 SPAN xxx.x FEET          BEAM SPACING xxx INCHES


 PRINCIPAL STRESS AT x.xx SPAN FROM LEFT CL BRG.

                   GIRDER  DIAPHRAGM   SLAB    DL1    SUP.D.L.   LL+I
   MOMENT(KIP-FT) xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx (aaaaa)
   SHEAR (KIPS)   xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx  xxxx.xx (aaaaa)


                                 DESIGN LOAD
    DISTANCE          STRESS KSI            ANGLE DEGREES
    FROM BOT         DL       TOT            DL           TOT

  xxx.xxx IN.    xx.xxx    xx.xxx      xxx.xxxx     xxx.xxxx


                                FACTORED LOAD
    DISTANCE          STRESS KSI            ANGLE DEGREES
    FROM BOT         DL       TOT            DL           TOT

  xxx.xxx IN.    xx.xxx    xx.xxx      xxx.xxxx     xxx.xxxx
```

# 7 EXAMPLE PROBLEMS

This chapter contains six (6) example problems to aid users in preparing data for their problems. A general description and a description of the required input along with completed input forms are given for each example. Refer to Chapter 5 Input Descriptions when preparing data for your specific problem. The following six example problems are included in this chapter.

1. Example Problem 1 - Rating problem of a bridge consisting of prestressed concrete I-beams. Flexural and shear ratings are included in the output.

2. Example Problem 2 - Analysis of an interior box beam with debonded strands. Stirrup details are provided. Shear analysis is done using the 1979 AASHTO Interim specifications.

3. Example Problem 3 - Analysis of an I-beam with draped strands and an unknown strand pattern using a special live load.

4. Example Problem 4 - Design of an I-beam with debonded strands.

5. Example Problem 5 - Design of a box beam with draped strands.

6. Example Problem 6 - Example 2 using a separate Special Live Load data file.

The actual input data files and resulting output for the example problems are not listed in this manual, but input files (Ex1.dat, Ex2.dat, etc.) are included electronically with the executable program in the installation directory (default "C:\PennDOT\Ps3 v<*version number*> Examples"). The example problems can be run so that the output can be viewed.

## Chapter 7 Example Problems

### 7.1 EXAMPLE PROBLEM 1

PROBLEM DESCRIPTION

Example Problem 1 is the rating of a prestressed concrete I-beam bridge. The bridge has a simply supported span length of 80 feet and consists of six prestressed concrete I-beams that are spaced at 8 feet center-to-center. The bridge carries four traffic lanes. Figure 7.1.1 on page 7-4 shows the typical cross section of the bridge and beam dimensions.

INPUT

The following input lines are entered. Refer to the completed input forms as shown in Figure 7.1.2 starting on page 7-5.

1. Project Identification

   SLC LEVEL is entered as "I25" so that Safe Load Capacity is expressed as a percentage of the Inventory Capacity. DESIGN is entered as "R" for a rating problem. Default values will be used for all other items.

2. Bridge Cross Section and Loading

   a. SPACING is entered as 96.0 inches.

   b. DISTRIBUTION FACTORS for MOMENT and DEFLECTION are computed as follows.

$$\text{D.F.} = 1.0 + \frac{4}{8} + \frac{2}{8} = 1.750 \text{ wheels} = \frac{1.750}{2} \text{ axles} = 0.875 \quad (\text{Shear})$$

$$\text{D.F.} = \frac{8}{5.5} \text{ wheels} = \frac{1.4545}{2} \text{ axles} = 0.727 \quad (\text{Moment})$$

   c. UDLF, the uniform dead load from formwork, is entered as zero so that a default value is not used.

   d. Dead Load FWS is the dead load due to the future wearing surface per beam.

$$\text{FWS} = (8)\,(0.030) = 0.240 \text{ kips/ft}$$

   e. Dead Load DL2 is the superimposed dead load due to the parapet loads distributed equally to the six beams.

$$\text{DL2} = \frac{2\,(0.506)}{6} = 0.169 \text{ kips/ft}$$

   f. Low relaxation strands are utilized and the losses are to be computed using the Modified Bureau of Public Roads (BPR) formula. Therefore, P/S LOSS % is entered as 0004.

3. Span Lengths

   The span length of 80.00 feet measured center-to-center of bearing is taken from plans.

4. Diaphragm Details

   No diaphragms are considered. Therefore, the interior and exterior diaphragm details lines are entered with zeros filled in for WEIGHT and # DIA.

5. Prestress Criteria

   The compressive strengths of beam and slab concrete are entered under BEAM CONC. $f'_{cb}$ and SLAB CONC. $f'_{cs}$ respectively. The ultimate strength of prestressing steel is entered under STEEL ULT f′s. For all other stresses, the default values will be used. One half inch diameter low relaxation strands are utilized. The total NO. OF ROWS of strands is 15. Shear ratings are desired and therefore, STIRRUP DETAILS must be provided. This is indicated by entering a "Y" for ST DET.

6. Prestressed Concrete Beam Dimensions

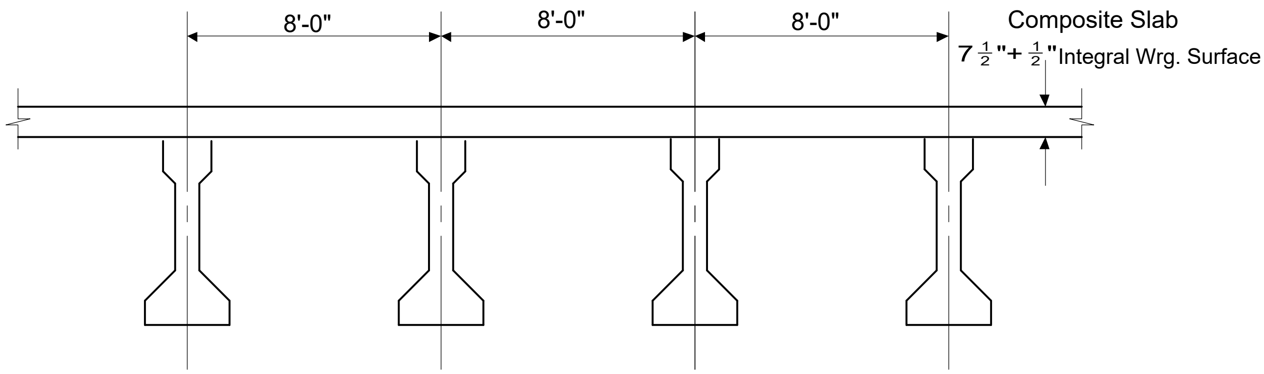
   This is a composite I-beam (TYPE = I and COMP = Y). Beam DESIG is entered as "2454" for a standard 24/54 AASHTO type I-beam. SLAB THICKNESS is 7.5 inches and does not include ½ inch of integral wearing surface.

7. Strand Details

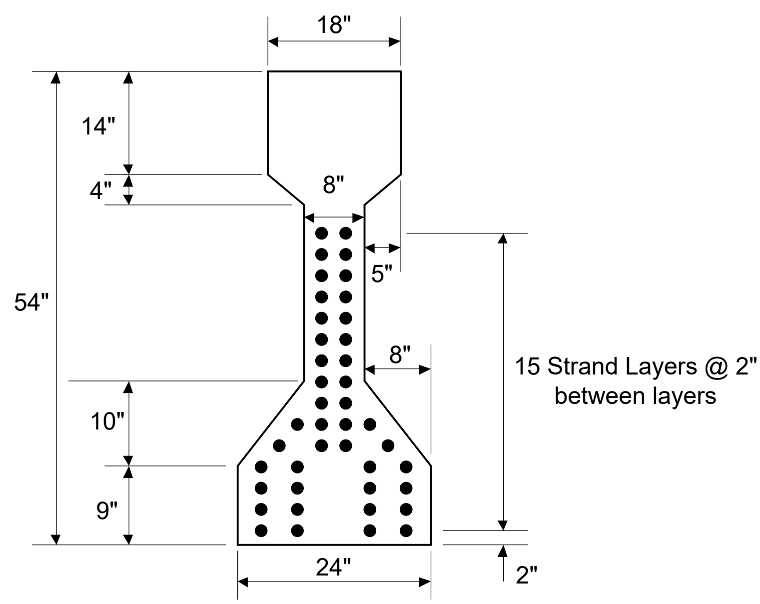
   The 15 rows of ½ diameter strands (STRAND AREA = 0.153 $in^2$) are spaced 2 inches apart (G2) from the bottom row is 2 inches from the bottom of the beam. There are 4 strands in each of the bottom 6 layers (R1-R6) and 2 strands in each of the top 9 layers (R7-R15). Refer to details in Figure 1 on page 7-4.

8. Stirrup Details

   Since shear ratings are desired, Stirrup Details must be provided in order to determine the areas of shear reinforcement. Shear values are to be computed using the current AASHTO Specifications; therefore, "A" is entered for SPEC. Shear reinforcement is provided by Grade 60 Number four two-legged vertical stirrups. Stirrups are spaced at 18 inches in the end thirds of the beam and are space at 20 inches in the middle third of the beam. Stirrup spacings must be entered up to midspan.




**Bridge Cross Section**




**Beam Cross Section and Prestressing Strand Locations**

Figure 7.1.1 Example Problem 1 – Details

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JULY 2000

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## PROGRAM P4353030
## PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

### PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | 41 | 0240 | 0024 | 0000 | EXAMPLE PROBLEM 1 | I25 | | | | | | | | | | | R | | | |

### COMMENTS

*THIS IS AN EXAMPLE OF A RATING PROBLEM

*

*

### CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 96.0 | .875 | .727 | | | 0.0000 | | .240 | .169 | | | | 00.04 | | | | | | | | | |

### SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| S | 80.00 | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.1.2 Example Problem 1 – Input

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |
| I | 0.000 | 0.00 | 0 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 |
| E | 0.000 | 0.00 | 0 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 |

## PRESTRESS CRITERIA

| BEAM CONC f 'cb | SLAB CONC f 'cs | CONC INIT f 'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f 's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |
| 6.500 | 4.500 | | | | 270.0 | | | | | | | | | | | | | | 0.5000 | 15 | 0 | Y |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |
| I | Y | 2454 | | | | | | | | | | | | | | 7.50 | |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| .153 | 2.00 | 2.000 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |

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Figure 7.1.2 Example Problem 1 – Input (cont.)

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JULY 2000

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DEBONDED STRAND DETAILS

| DEBONDED LENGTH Lx | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | | 14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. |
| 1 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

## STIRRUP DETAILS

| SPEC | STIRRUP AREA | fsy | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 8 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 | 53 | 58 | 63 |
| A | 0.200 | 60 | 0.00 | 18.000 | 26.67 | 20.000 | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.1.2 Example Problem 1 – Input (cont.)

## 7.2 EXAMPLE PROBLEM 2

PROBLEM DESCRIPTION

Example Problem 2 is an analysis of an interior box beam. The beam is to be investigated for a given prestressing force. Figure 7.2.1 on page 7-10 shows the typical cross section of the bridge and beam dimensions.

INPUT

The following input lines are entered. Refer to the completed input forms as shown in Figure 7.2.2 starting on page 7-11 .

1. Project Identification

   LIVE LOAD is entered as "B" so that the live load used for analysis and rating is HS20. The dead load and live load factors are entered as 1.3 and 2.17, respectively. Principal stresses are not desired, therefore, PRINCIPAL is entered as "N". DESIGN is entered as "A" for an analysis problem. Default values will be used for all other items.

2. Bridge Cross Section and Loading

   SPACING is entered as 132.0 inches. Distribution factors for moment and deflection are entered. Losses are to be computed using the Modified Bureau of Public Roads (BPR) Formula; therefore, P/S LOSS % is coded as 0004. 270k low relaxation strands are used, therefore, L or S is coded as “L”. Two sets of ratings (with and without future wearing surface) are desired, therefore, RATE FWS is coded as “Y”.

3. Span Lengths

   The span length of 87.00 feet measured center-to-center of bearing is taken from plans.

4. Diaphragm Details

   Interior diaphragm data is not entered so that the program will use default values.

   One exterior diaphragm (IDENT = "E") is entered (#DIA = 1). The weight is left blank so that the program will compute a value.

5. Prestress Criteria

The compressive strengths of beam and slab concrete are entered under BEAM CONC. $f'_{cb}$ and SLAB CONC. $f'_{cs}$ respectively. The initial and final allowable stresses for tension and compression are entered. The ultimate strength of prestressing steel is entered under STEEL ULT. $f'_s$. For all other stresses, the default values will be used. Allowable horizontal shear stress ($v_{ha}$) is 0.300 ksi. The creep factor entered is 2.0. One half inch diameter low relaxation strands are utilized. The total NO. OF ROWS of strands is 18. The number of DEBONDED DETAILS lines entered is 3. Shear ratings are desired and therefore, STIRRUP DETAILS must be provided. This is indicated by entering a "Y" for ST DET.

6. Prestressed Concrete Beam Dimensions

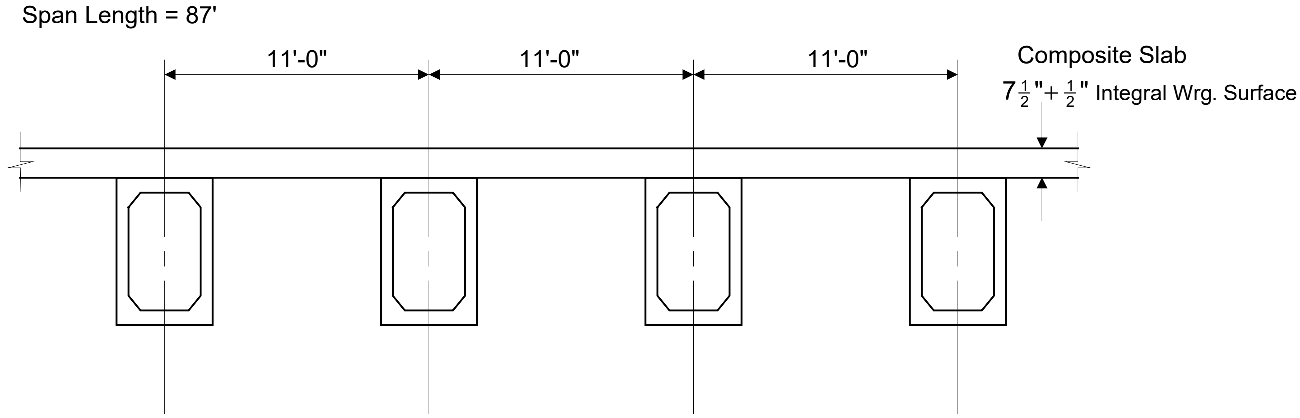
This is a composite box beam (TYPE = B and COMP = Y). Beam dimensions are entered corresponding to symbols for a box beam described in Chapter 5. SLAB THICKNESS is 7.5 inches and does not include ½ inch of integral wearing surface. HAUNCH thickness is 0.5 inches.

7. Strand Details

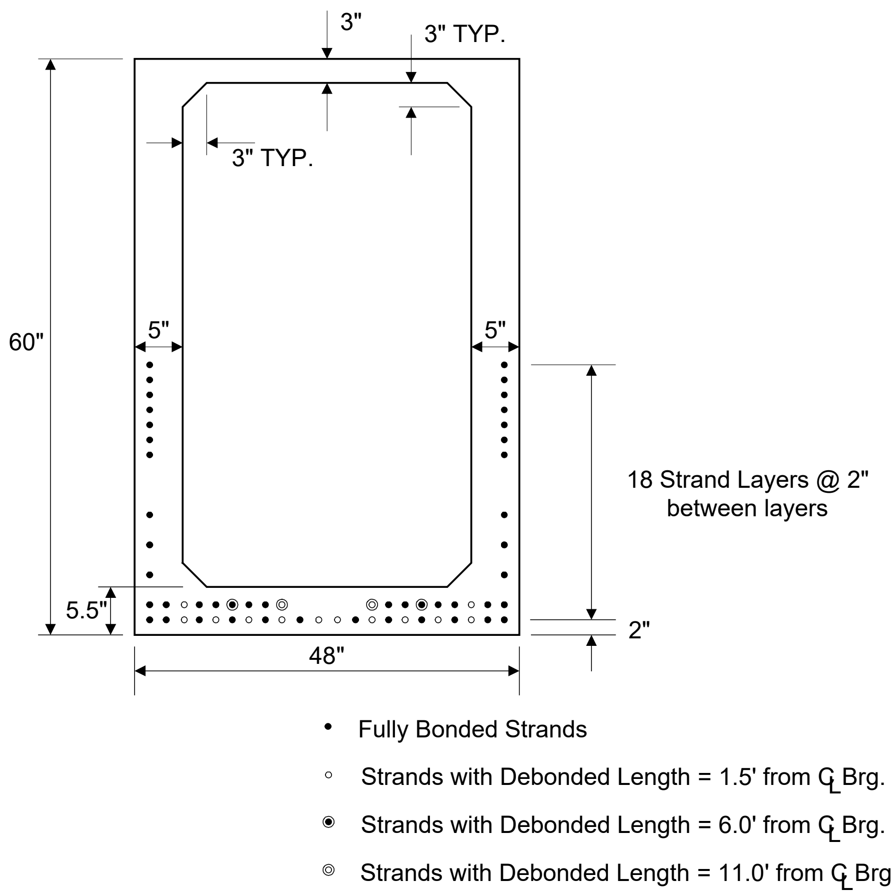
The 18 rows of ½ inch diameter strands (STRAND AREA = 0.153 $in^2$) are spaced 2 inches apart (G2) and the bottom row is 2 inches from the bottom of the beam (G1). The strand pattern is detailed in Figure 1 on page 7-10.

8. Stirrup Details

Since the shear ratings are desired, Stirrup Details must be provided in order to determine the areas of shear reinforcement. Shear values and ratings are to be computed as per the 1979 AASHTO Interim specifications; therefore, SPEC is entered as "9". Shear reinforcement is provided by Grade 60 No. 4 two legged vertical stirrups. Stirrups are spaced at 5.25 inches from the centerline of bearing to 6 feet from centerline of bearing, at 6 inches from 6 feet to 14 feet from centerline of bearing and at 8 inches from 14 feet to the midspan. Stirrup spacings must be entered up to midspan.




Bridge Cross Section




Beam Cross Section and Prestressing Strand Layout

Figure 7.2.1 Example Problem 2 – Details

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Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | | | B | | | | | | 1.30 | 2.17 | | N | A | | | |

## COMMENTS

| COMMENTS |
|---|
| * EXAMPLE PROBLEM 2 - DEBONDED ANALYSIS |
| * |
| * |

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 132.0 | | .755 | .667 | | | | .240 | .377 | | | | 00.04 | | | | | | | | L | Y |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| | 87.00 | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.2.2 Example Problem 2 – Input

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |
| E | . | . | 1 | . | . | . | . | . | . | . | . |
| | . | . | | . | . | . | . | . | . | . | . |

## PRESTRESS CRITERIA

| BEAM CONC f'cb | SLAB CONC f'cs | CONC INIT f'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |
| 6.500 | 4.500 | 5.500 | 189.0 | . | 270.0 | 3.300 | .445 | .222 | 2.600 | .242 | . | .300 | | | . | . | 2.0 | | .5000 | 18 | 3 | Y |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |
| B | Y | 6.000 | 48.00 | 48.000 | 5.000 | 5.500 | 3.000 | 3.00 | 3.00 | 3.00 | 3.00 | . | . | . | . | 7.50 | 0.50 |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| .153 | 2.00 | 2.000 | 22 | 18 | | 2 | | 2 | | 2 | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |

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PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | | | B | | | | | | 1.30 | 2.17 | | N | A | | | |

## COMMENTS

*EXAMPLE PROBLEM 2 - DEBONDED ANALYSIS
*
*

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 132.0 | | .755 | .667 | | | | .240 | .377 | | | | 00.04 | | | | | | | | L | Y |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| | 87.00 | | | | | | | | |

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Figure 7.2.2 Example Problem 2 – Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 3 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

DEBONDED STRAND DETAILS

| DEBONDED LENGTH Lx | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | | 14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. |
| 1 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 |
| 15.00 | 1 | 10 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.00 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.00 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

STIRRUP DETAILS

| SPEC | STIRRUP AREA | fsy | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 8 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 | 53 | 58 | 63 |
| 9 | . | | 0.00 | 5.250 | 6.00 | 6.000 | 14.00 | 8.000 | . | . | . | . | . | . |

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PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | | | B | | | | | | 1.30 | 2.17 | | N | A | | | |

## COMMENTS

| COMMENTS |
|---|
| *EXAMPLE PROBLEM 2 - DEBONDED ANALYSIS |
| * |
| * |

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 132.0 | | .755 | .667 | | | | .240 | .377 | | | | 00.04 | | | | | | | | L | Y |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| | 87.00 | | | | | | | | |

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Figure 7.2.2 Example Problem 2 – Input (cont.)

## 7.3 EXAMPLE PROBLEM 3

PROBLEM DESCRIPTION

Example Problem 3 is an example of an analysis of an interior I-beam with draped strands using a special live load. The bridge has a simply supported span length of 92 feet. The beam is to be investigated for a given prestressing force and eccentricity. The strand pattern is unknown. Figure 7.3.1 on page 7-18 shows the typical cross section of the bridge and beam dimensions.

INPUT

The following input lines are entered. Refer to the completed input forms as shown in Figure 7.3.2 starting on page 7-19.

1. Project Identification

   The bridge is to be analyzed for a single special loading, therefore, a "1" is coded for LIVE LOAD. PRINCIPAL is entered as "Y" for a printout of the principal stresses. DESIGN is entered as "A" for an analysis problem. Default values will be used for all other items.

2. Bridge Cross Section and Loading

   a. Beam SPACING is entered as 84.0 inches. The DISTRIBUTION FACTOR for MOMENT is entered as 0.636 and for DEFLECTION is entered as 0.400.

   b. UDLF is entered as 0.0150 kips/ft$^2$. Dead Load due to the future wearing surface FWS is entered as 0.150 kips/ft. Dead Load DL2 is the superimposed dead load due to the parapet loads and is entered as 0.202 kips/ft.

   c. The initial prestressing force, $P_i$, is computed below. The eccentricity at the midspan is 26.3 inches. The eccentricity at the centerline of bearing is 16.573 inches.

   $$P_i = (f_{si})\text{ (No. of Strands) (Strand Area)} = (189)(44)(0.154) = 1280.664 \text{ kips}$$

   d. The drape point is located 38.7 feet from the centerline of bearing; therefore, DRAPE POINT is coded as 4210.

   $$\text{DRAPE POINT} = \frac{38.7}{92.0} = 0.4210$$

   e. Losses are to be computed using the Lehigh Loss method; therefore, P/S LOSS % is coded as 0009.

3. Span Lengths

The span length of 92.0 feet measured center-to-center of bearing is taken from plans.

4. Diaphragm Details

Interior diaphragms are not considered for this problem. Two exterior diaphragms are considered; therefore, IDENT is entered as "E" and # DIA is 2. Exterior diaphragm weight is computed with the following formula:

$$EDW = \frac{(SPA - W3)(D - T1 - B1 - 9)\, t\, w_s}{1728} = \frac{(84 - 8)(63 - 10 - 8 - 9)(10)\, 0.150}{1728} = 2.375 \text{ kips}$$

5. Prestress Criteria

The compressive strengths of beam and slab concrete are entered under BEAM CONC. $f'_{cb}$ and SLAB CONC. $f'_{cs}$ respectively. The ultimate strength of prestressing steel is entered under STEEL ULT. $f'_s$. For all other stresses, the default values will be used. One half inch diameter low relaxation strands are utilized. The total NO. OF ROWS of strands is zero for an unknown strand pattern.

6. Prestressed Concrete Beam Dimensions

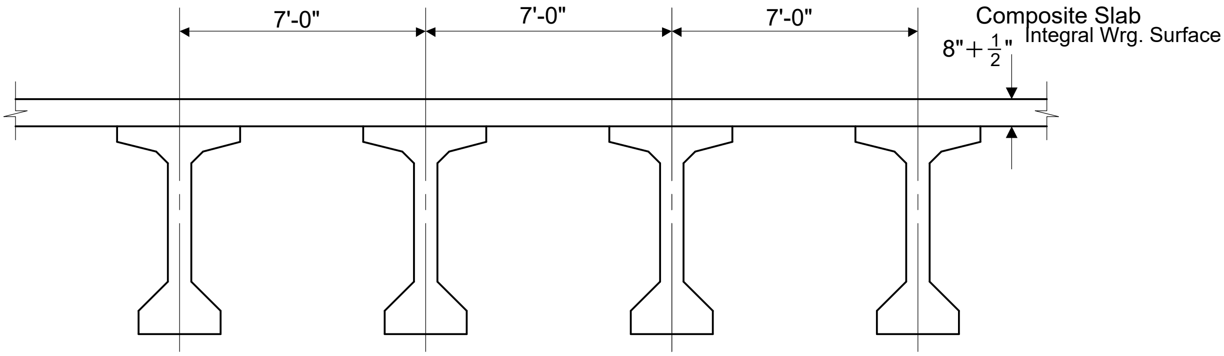
This is a composite I-beam (TYPE = I and COMP = Y). Beam DESIG is entered as "2863" for a standard 28/63 AASHTO type I-beam. Beam dimensions are entered in accordance with the symbols used for the regular I-beam. SLAB THICKNESS is 8.0 inches and does not include ½ inch of integral wearing surface.

7. Strand Details

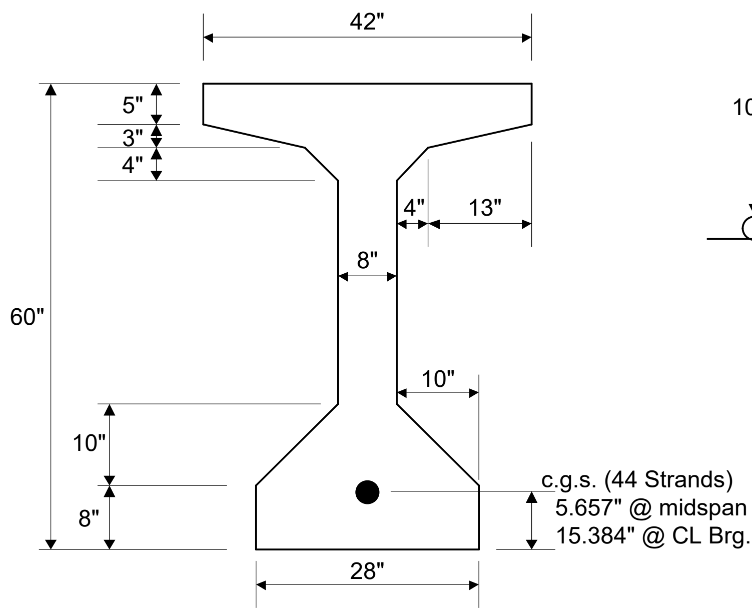
Strand area is assumed to be 0.154 in$^2$. The vertical distance from the bottom of the beam to the centroid of the bottom of row of strands (G1) is assumed to be 2.0 inches. The strand pattern is unknown, therefore, G2 is equal to the center of gravity of the strands at midspan and is entered as 5.657 inches. R1 is the number of strands corresponding to the initial prestressing force entered and is assumed to be 44 strands.

8. Special Live Load

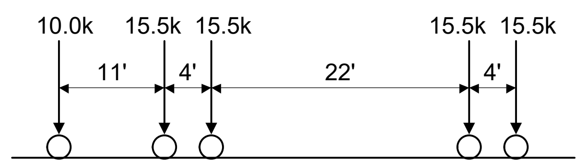
One special live load has been described. Refer to details in Figure 1 on page 7-18.



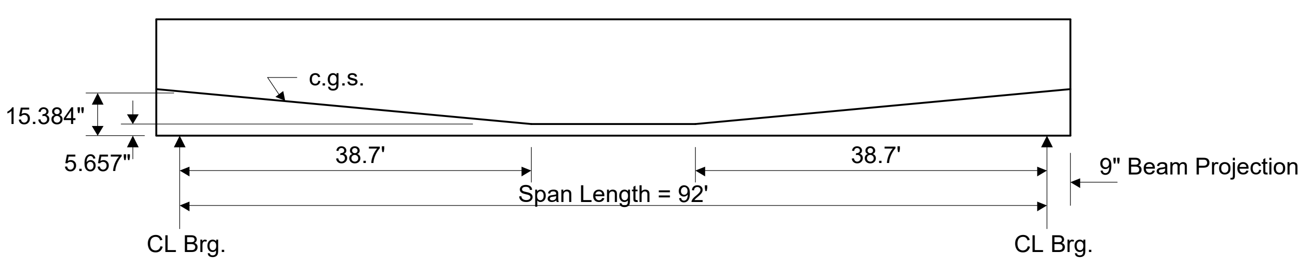

**Bridge Cross Section**




**Beam Cross Section and Prestressing Strand Data**




**Special Live Load**




**Drape Point Location**

Figure 7.3.1 Example Problem 3 – Details

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | EXAMPLE PROBLEM 3 | | 1 | | | | | | | | | Y | A | | | |

## COMMENTS

* DRAPED STRAND ANALYSIS WITH LIVE LOAD

*

*

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 84.0 | | .636 | .400 | | 0.0150 | | .150 | .202 | 1280.664 | 26.300 | 16.573 | 00.09 | .4210 | 2 | 30 | 90 | 3 | 6 | 6 | | |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| S | 92.00 | | | | | | | | |

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Figure 7.3.2 Example Problem 3 – Input

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

Form 2 of 4

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |
| E | 2.375 | | | | | | | | | | |
| | | | | | | | | | | | |

## PRESTRESS CRITERIA

| BEAM CONC f 'cb | SLAB CONC f 'cs | CONC INIT f 'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f 's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |
| 6.500 | 4.500 | 5.500 | 189.0 | | 270.0 | 3.300 | .222 | | 2.600 | .242 | 1.800 | .300 | | | | | 2.0 | | 0.5000 | 0 | 0 | N |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |
| I | Y | 28.63 | | | | | | | | | | | | | | 8.00 | |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| .153 | 2.00 | 5.657 | 44 | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |

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Figure 7.3.2 Example Problem 3 – Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 3 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DEBONDED STRAND DETAILS

| DEBONDED LENGTH Lx | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | | 14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. | ROW No. | No. STR. |
| 1 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

## STIRRUP DETAILS

| SPEC | STIRRUP AREA | fsy | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING | LOCATION | SPACING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 8 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 | 53 | 58 | 63 |
| | | | 0.0 | | | | | | | | | | | |

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Figure 7.3.2 Example Problem 3 – Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

Form 4 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| 1 | 5 | | . | . | . | . | . | | . |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| 10.00 | 11.0 | 15.50 | 4.0 | 15.50 | 22.0 | 15.50 | 4.0 | 15.50 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY ………………………………….  DATE …../…../…..  SHEET …..OF…..

Figure 7.3.2 Example Problem 3 – Input (cont.)

## 7.4 EXAMPLE PROBLEM 4

PROBLEM DESCRIPTION

Example Problem 4 is an example of a design problem using debonded strands. The bridge has a simply supported span length of 115 feet. Figure 7.4.1 on page 7-26 shows the typical cross section of the bridge and beam dimensions.

INPUT

The following input lines are entered. Refer to the completed input forms as shown in Figure 7.4.2 starting on page 7-27.

1. Project Identification

   LIVE LOAD is entered as "I" so that the live loads used for design and rating are HS20, Alternate Military Loading, and ML80 loading. DESIGN is entered as "2" for a debonded strand design problem. Default values will be used for all other items.

2. Bridge Cross Section and Loading

   SPACING is entered as 95.0 inches. The DISTRIBUTION FACTOR for MOMENT is entered as 0.720 and for DEFLECTION is entered as 0.386. UDLF is entered as 0.0139 kips/ft$^2$. Dead Load DL2, the superimposed dead load due to the parapet loads distributed equally to the beams is entered as 0.331 kips/ft. Default values will be used for all other items.

3. Span Lengths

   The span length of 115.0 feet measured center-to-center of bearing is taken from plans.

4. Prestress Criteria

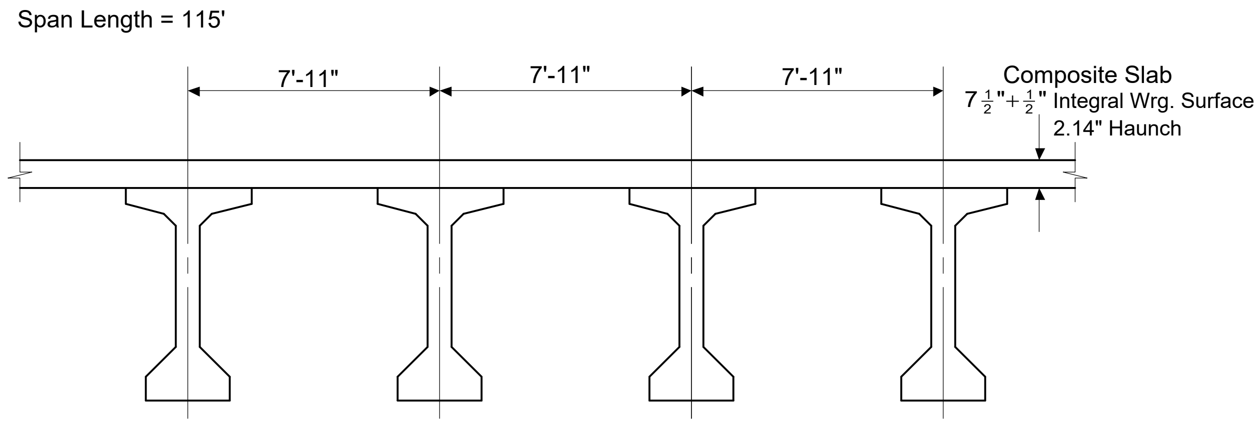
   The compressive strengths of beam and slab concrete are entered under BEAM CONC. $f'_{cb}$ and SLAB CONC. $f'_{cs}$ respectively. The ultimate strength of prestressing steel is entered under STEEL ULT. $f'_s$. Initial and final allowable stresses are entered. Allowable horizontal shear stress ($v_{ha}$) is 0.300 ksi. The creep factor entered is 2.0. One half inch diameter low relaxation strands are utilized. The total NO. OF ROWS of strands entered is 20.

5. Prestressed Concrete Beam Dimensions

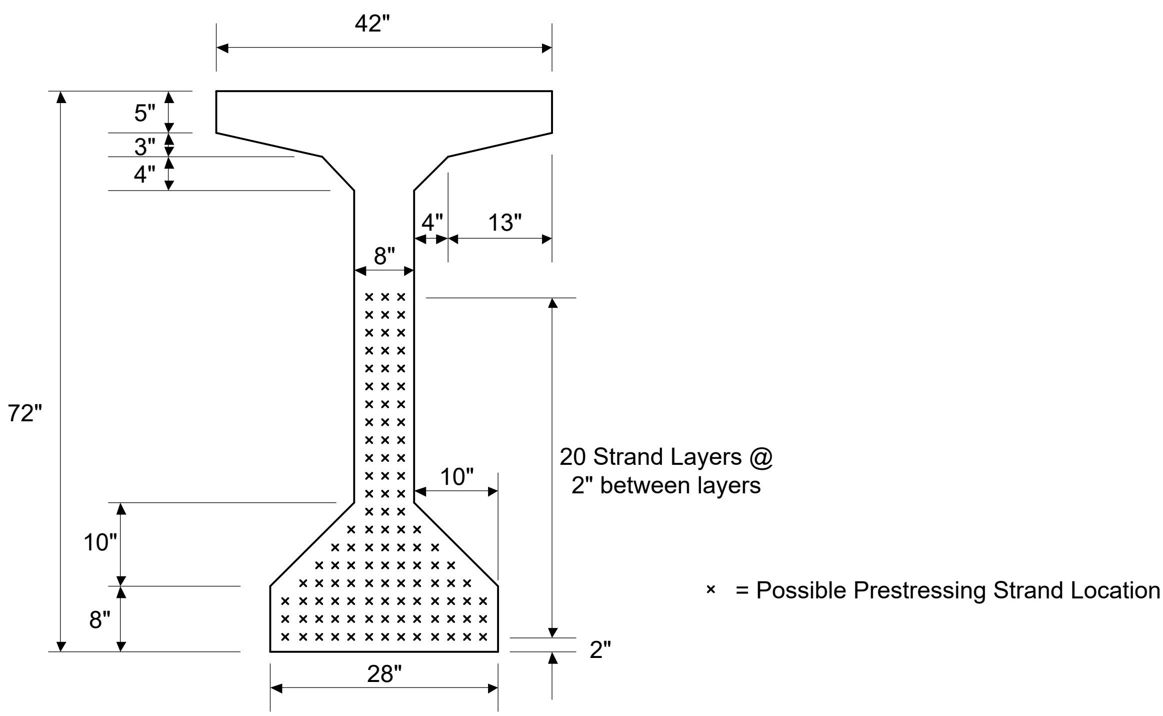
   This is a composite I-beam (TYPE = I and COMP = Y). Beam DESIG is entered as "2872" for a standard 28/72 AASHTO type I-beam. Beam dimensions are entered in accordance with the symbols used for the AASHTO type I-beam. SLAB THICKNESS is 7.5 inches and does not include ½ inch of integral wearing surface. HAUNCH thickness is 2.14 inches.

6. Strand Details

   The rows of ½ inch diameter strands (STRAND AREA = 0.167 $in^2$) are spaced 2 inches apart (G2) and the bottom row is 2 inches from the bottom of the beam (G1). There are twenty rows of strands entered.




**Bridge Cross Section**




**Beam Cross Section and Prestressing Strand Locations**

Figure 7.4.1 Example Problem 4 – Details

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | EXAMPLE PROBLEM 4 | | I | | | | | | | | | | 2 | | | |

## COMMENTS

| COMMENTS |
|---|
| * DEBONDED STRAND DESIGN PROBLEM |
| * |
| * |

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 95.0 | | .720 | .386 | .1500 | 0.0139 | | | .331 | | | | | | | | | | | | | |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| S | 315.00 | | | | | | | | |

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.4.2 Example Problem 4 – Input

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

Form 2 of 4

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

## PRESTRESS CRITERIA

| BEAM CONC f 'cb | SLAB CONC f 'cs | CONC INIT f 'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f 's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |
| 7.600 | 4.500 | 6.200 | . | . | 270.0 | 4.120 | .551 | .252 | 3.040 | .262 | . | 300. | | | . | . | 1.8 | 15 | 0.5200 | 20 | | |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |
| I | Y | 28.72 | . | . | . | . | . | . | . | . | . | . | . | . | . | 7.50 | 2.14 |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| 0.167 | 2.00 | 2.000 | 13 | 13 | 13 | 11 | 9 | 7 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |

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Figure 7.4.2 Example Problem 4 – Input (cont.)

## 7.5 EXAMPLE PROBLEM 5

PROBLEM DESCRIPTION

Example Problem 5 is an example of a design problem using a draped strand design. The bridge has a simply supported span length of 75 feet.

Figure 7.5.1 on page 7-31 shows the typical cross section of the bridge and beam dimensions.

INPUT

The following input lines are entered. Refer to the completed input forms as shown in Figure 7.5.2 starting on page 7-32.

Project Identification

LIVE LOAD is entered as "J" so that the live loads used for design are HS25, Increased Military Loading, and P-82 loading. Live loads for rating are HS25, IML, P-82, and ML80 loading. DESIGN is entered as "1" for a draped strand design problem. Default values will be used for all other items.

1. Bridge Cross Section and Loading

SPACING is entered as 132.0 inches. The DISTRIBUTION FACTOR for MOMENT is entered as 0.775 and for DEFLECTION is entered as 0.667. Dead Load DL2, the superimposed dead load due to the parapet loads distributed equally to the beams, is entered as 0.617 kips/ft. Default values will be used for all other items.

2. Span Lengths

The span length of 75.0 feet measured center-to-center of bearing is taken from plans.

3. Diaphragm Details

One interior diaphragm is entered (IDENT = "I" and # DIA = 1) at the midspan (DISTANCE = 37.50 feet). Exterior diaphragms are not considered for this problem.

4. Prestress Criteria

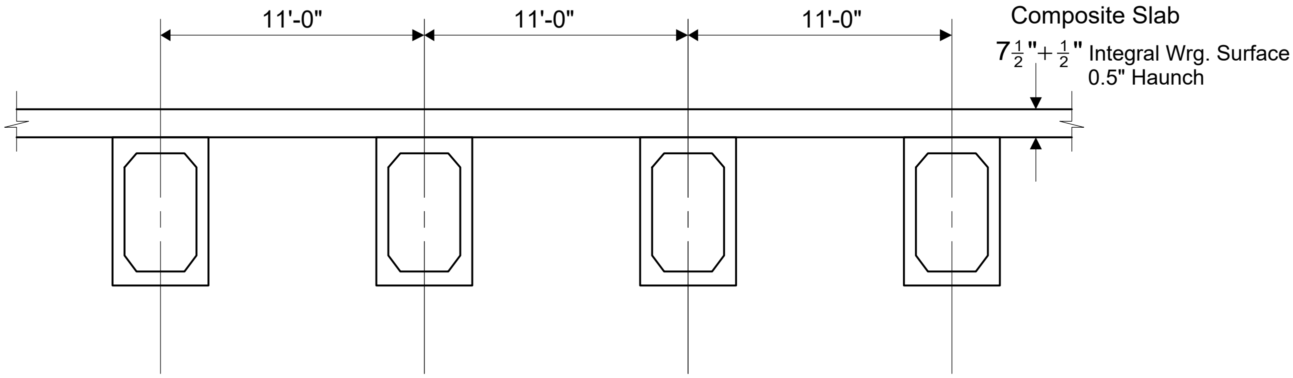
The compressive strengths of beam and slab concrete are entered under BEAM CONC. $f'_{cb}$ and SLAB CONC. $f'_{cs}$ respectively. The ultimate strength of prestressing steel is entered under STEEL ULT. $f'_s$. For all other stresses, the default values will be used. Allowable horizontal shear stress ($v_{ha}$) is 0.225 ksi. The creep factor entered is 2.0. One half inch diameter low relaxation strands are utilized. The total NO. OF ROWS of strands is 24.

5. Prestressed Concrete Beam Dimensions

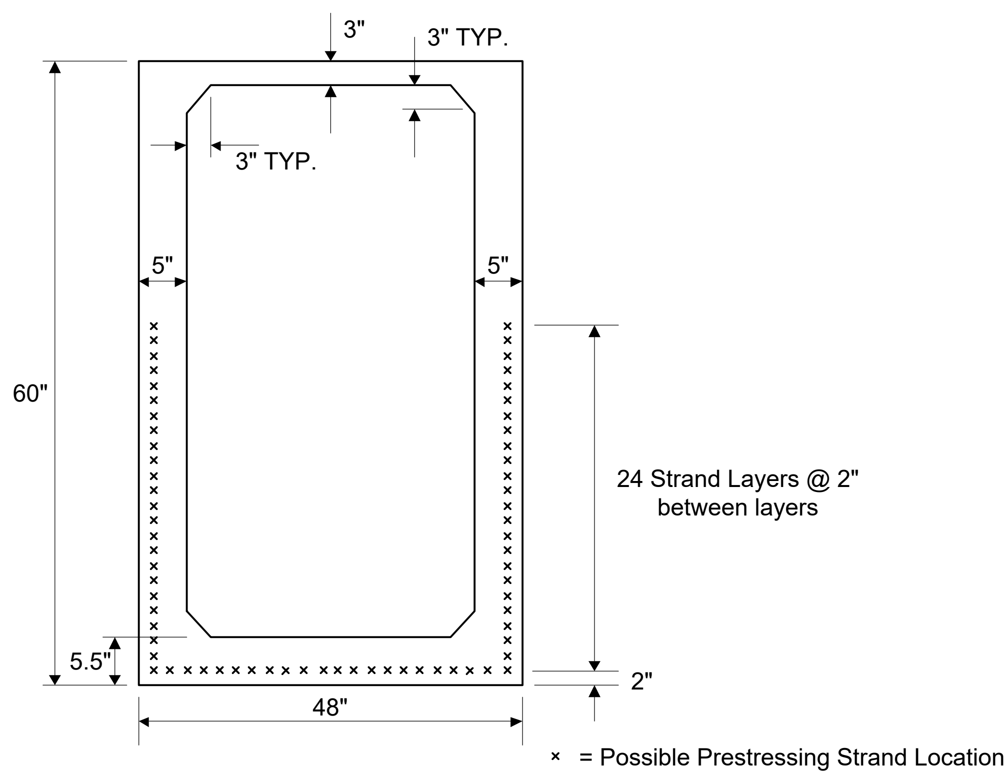
This is a composite spread box beam (TYPE = B and COMP = Y). Beam DESIG is entered as "4866" for a standard 48/66 type box beam. Beam dimensions are entered in accordance with the symbols used for the regular box beam. SLAB THICKNESS is 7.5 inches and does not include ½ inch of integral wearing surface. HAUNCH thickness is 0.5 inches.

6. Strand Details

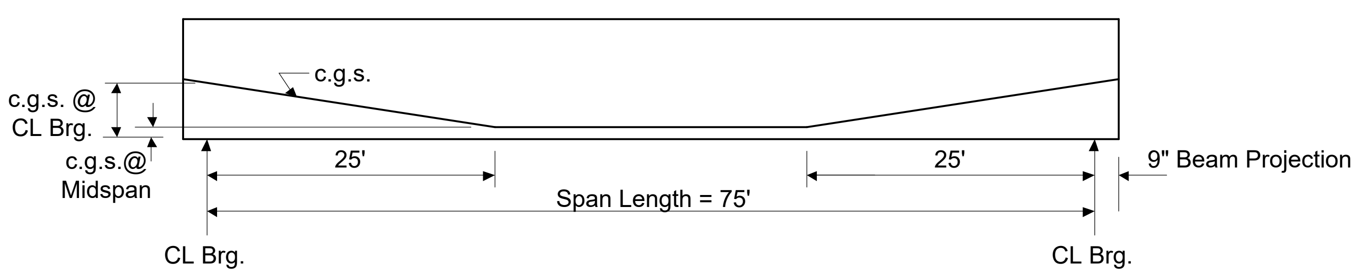
The 24 rows of ½ inch diameter strands (STRAND AREA = 0.167 $in^2$) are spaced 2 inches apart (G2) and the bottom row is 2 inches from the bottom of the beam (G1). There are 24 rows of strands entered.




**Bridge Cross Section**




**Beam Cross Section and Prestressing Strand Location**




**Drape Point Location**

Figure 7.5.1 Example Problem 5 – Details

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

# PROGRAM P4353030
# PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## PROJECT IDENTIFICATION

| PROGRAM IDENT | STRUCTURE IDENTIFICATION: COUNTY | STATE ROUTE | SEGMENT | OFFSET | DESCRIPTION | SLC LEVEL | LIVE LOAD | OUTPUT | IMPACT FACTOR | GAGE DISTANCE | PASSING DISTANCE | ROADWAY WIDTH | LOAD FACTOR: DLF | LLF | I or F | PRINCIPAL | DESIGN | SKEW CORRECTION FACTOR | IR STRESS LEVEL | AASHTO fc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 9 | 13 | 17 | 21 | 45 | 48 | 49 | 50 | 54 | 57 | 60 | 64 | 67 | 70 | 71 | 72 | 73 | 77 | 80 |
| =PRSTR | | | | | EXAMPLE PROBLEM 5 | | J | | | | | | | | | | 1 | | | |

## COMMENTS

| COMMENTS |
|---|
| *DESIGN OF A BOX BEAM WITH DRAPED STRANDS |
| * |
| * |

## CROSS SECTION & LOAD DATA

| BEAM SPACING | DISTRIBUTION FACTORS: SHEAR | MOMENT | DEFLECT | UNIT WT DECK CONCRETE | DEAD LOADS: UDLF | DL1 | FWS | DL2 | INITIAL PRESTRESSING FORCE | ECCENTRICITY: MIDSPAN | END | P/S LOSS % | DRAPE POINT | LEHIGH LOSS METHOD: T0 | TS | TD | IC | MFG | IST | L or S | RATE FWS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 26 | 31 | 36 | 41 | 48 | 53 | 58 | 62 | 66 | 68 | 71 | 74 | 75 | 76 | 78 | 79 |
| 1.320 | | 0.775 | 0.667 | | | | | 0.0617 | | | | | | | | | | | | | |

## SPAN LENGTHS

| CONT | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | BEAM PROJECTION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 7 | 12 | 17 | 22 | 27 | 32 | 37 | 42 |
| S | 075.00 | | | | | | | | |

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Figure 7.5.2 Example Problem 5 – Input

PENNSYLVANIA DEPARTMENT OF TRANPORTATION
JULY 2000

Form 2 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

## DIAPHRAGM DETAILS

| IDENT | WEIGHT | THICKNESS | # DIA | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE | DISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6 | 10 | 13 | 18 | 23 | 28 | 33 | 38 | 43 | 48 |
| I | | | 001 | 037.50 | | | | | | | |
| | | | | | | | | | | | |

## PRESTRESS CRITERIA

| BEAM CONC f'cb | SLAB CONC f'cs | CONC INIT f'ci | STEEL INIT fsi | STEEL YIELD Fy | STEEL ULT f's | INITIAL ALLOWABLE | | | FINAL ALLOWABLE | | | ALLOW SHEAR Vha | OR STRESS LEVEL | STEEL E | MODULAR RATIO | | CREEP FACTOR | EST % LOSS | STRAND DIAMETER | No. OF ROWS | No. Lx | ST DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | COMP fci | TENS fti | DRP/DBND ftfd | COMP fc | TENS ft | SLAB fcs | | | | DES | ULT | | | | | | |
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | | 49 | 52 | 55 | 60 | 64 | 68 | 70 | 72 | 77 | 79 | 80 |
| 6.500 | 4.500 | 5.500 | | | 270.0 | | | | | | | .225 | | | | | 2.0 | | 0.5200 | 24 | | N |

## BEAM DIMENSIONS

| TYPE | COMP | DESIG or D | W1 | W2 | W3 | T1 | T2 | B1 | B2 | B3 | B4 | D1 | D2 | X1 | X2 | SLAB THICK | HAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 7 | 11 | 16 | 21 | 28 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 60 | 64 | 68 |
| B | Y | 48.66 | | | | | | | | | | | | | | 07.50 | 00.50 |

## STRAND DETAILS

| STRAND AREA | G1 | G2 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 | R19 | R20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 |
| 0.167 | 2.00 | 02.000 | 22 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 |
| XXXX | XXX | XXXXX | 02 | 02 | 02 | 02 | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |
| XXXX | XXX | XXXXX | | | | | | | | | | | | | | | | | | | | |

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Figure 7.5.2 Example Problem 5 – Input (cont.)

## 7.6 EXAMPLE PROBLEM 6 - USING SPECIAL LIVE LOADING DATA FILE

### PROBLEM DESCRIPTION

Example Problem 6 is an example of how to analyze a bridge for special live loadings using two data files, one for the bridge data and another for the special live loadings data. The bridge data file is the same that was created for Example Problem 2. The special live loadings data file is created using the Input Form 4 Special Live Loads. For this example problem, it is assumed that the user wants to analyze the bridge described in Example Problem 2 for a set of four special live loadings. The first live loading is the same as the H20 loading described in AASHTO. The second live loading is similar to the HS20 loading except some loading parameters have been modified. The third and fourth live loadings are typical legal loads used in the user's state. These loadings are shown in Figure 7.6.1 on page 7-36.

### INPUT

The bridge data file is created using the completed input data sheets shown in Figure 7.6.2 starting on page 7-37. Enter the file name as PS3EX2.DAT.

The special live loading data file is created using the completed input data sheets shown in Figure 5.0.4. Input Form 4 is filled out for four special live loadings. Enter the file name for the special live loading data file as LOADGR1.DAT. Both data files can be created using any text editor or the Input Data Processor program called PS3IP.EXE. Refer Chapter 4 for more information on how to use the Input Data Processor program.

### RUNNING PS3

Once both data files are created, either type PS3 at the DOS prompt or double click on the PS3.exe file using Windows Explorer.

The program prompts should be completed as follows:

```
    PRESTRESSED CONCRETE GIRDER DESIGN AND RATING
                   Version 3.5
                Copyright (c) 1993-2000
             Commonwealth of Pennsylvania
             Department of Transportation

  Enter Input File Name: PS3EX2.DAT

  Special Live Loads from a Separate File? (Yes or <No>): Yes

  Enter Special Live Load File Name: LOADGR1.DAT
  Review Output on Terminal? (Yes or <No>): Yes
```

```
Enter Output File Name (if output is to be saved):
```

Alternately, the program can be executed using the following command at the DOS prompt.

```
PS3 PS3EX2.DAT PS3EX2.OUT LOADGR1.DAT
```

Where PS3 is the executable file, PS3EX2.DAT is the bridge data input file, PS3EX2.OUT is the output file and LOADGR1.DAT is the special live loading data file. In the above command, each of the files can be specified by giving the full directory path.

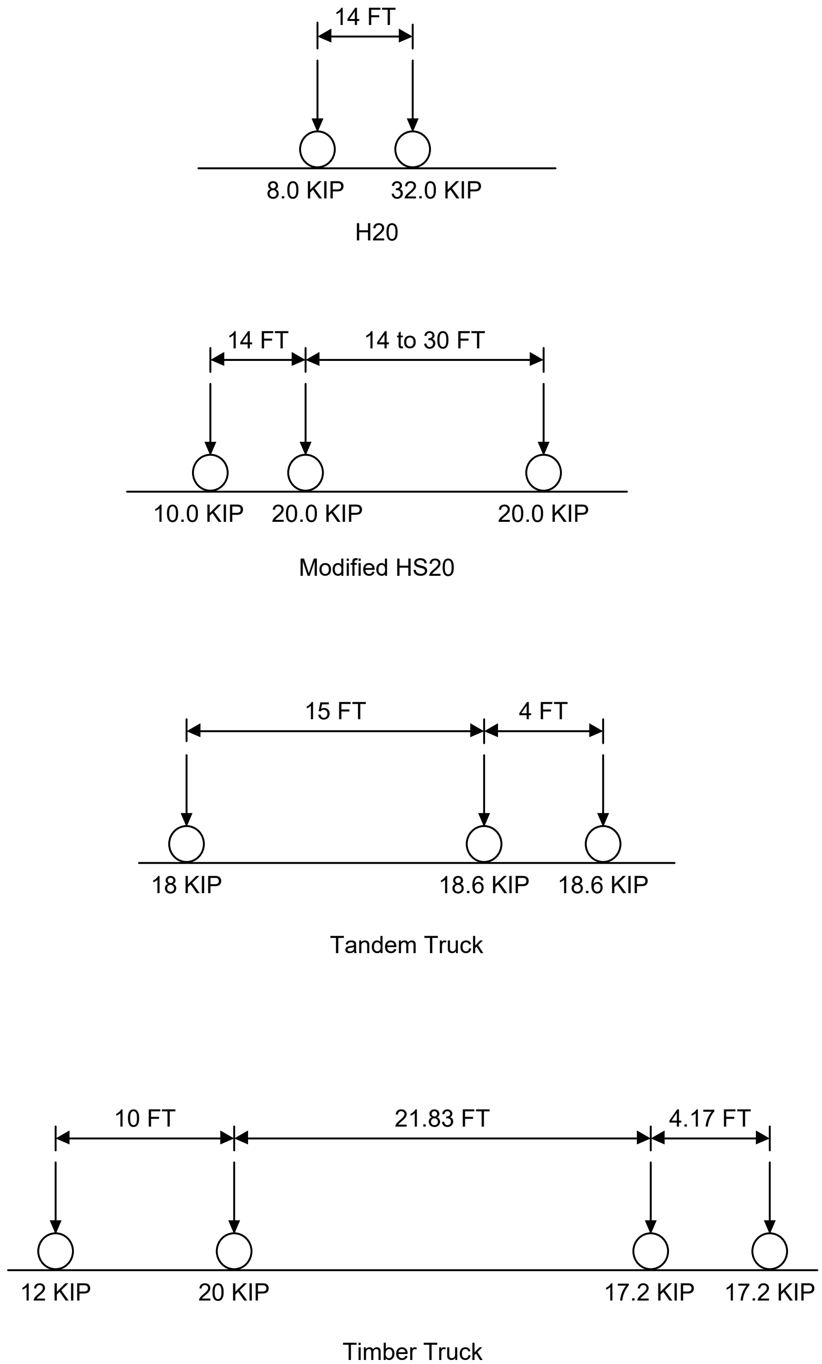


Figure 7.6.1  Example Problem 6 - Special Live Loads

Form 4 of 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| 1 | 05 | | 0.640 | 18.000 | 26.000 | 6.0 | 4.0 | | |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| 08.00 | 14.0 | 32.00 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY .......................................   DATE ...../...../.....   SHEET .....OF.....

Figure 7.6.2 Example Problem 6 – Input

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| 2 | 3 | | 0.640 | 18.000 | 26.000 | 6.0 | 4.0 | Y | 30.0 |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| 10.00 | 14.0 | 20.00 | 14.0 | 20.00 | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.6.2 Example Problem 6 – Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

Form 4 of 4

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| 3 | 3 | | . | . | . | . | . | | . |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| 18.00 | 15.0 | 18.60 | 4.0 | 18.60 | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY ........................................ DATE ...../...../..... SHEET .....OF.....

Figure 7.6.2 Example Problem 6 – Input (cont.)

Form 4 of 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
SSEPTEMBER 2010

PROGRAM P4353030
PRESTRESSED CONCRETE GIRDER DESIGN AND RATING

SPECIAL LIVE LOADING

LANE LOADING

| SP LL No. | NUMBER OFAXLES | 3% INCR | UNIFORM LANE LOAD | CONC LOAD MOMENT | CONC LOAD SHEAR | GAGE DISTANCE | PASSING DISTANCE | VARY LAST | MAX AXLE DIST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 4 | 5 | 9 | 14 | 19 | 22 | 25 | 26 |
| 4 | 4 | | . | . | . | . | . | | . |

TRUCK LOAD

| AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST | AXLE LOAD | DIST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 8 | 12 | 15 | 19 | 22 | 26 | 29 | 33 | 36 | 40 | 43 | 47 | 50 | 54 |
| 12.00 | 10.0 | 20.00 | 21.8 | 17.20 | 4.2 | 17.20 | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Note: Both the Lane Load and the Truck Load must be described as a set for each of the special live loads.

PREPARED BY ....................................... DATE ...../...../..... SHEET .....OF.....

Figure 7.6.2 Example Problem 6 – Input (cont.)

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# 8 TECHNICAL QUESTIONS AND REVISION REQUESTS

This chapter contains reply forms to make it easier for users to convey their questions, problems or comments to the proper unit within the Department. General procedures for using these forms are given. Users should keep the forms in the manual as master copies, which can be reproduced as needed.

## 8.1 TECHNICAL QUESTIONS

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 this form or the information provided on this 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 completed form should be sent to the Bridge Quality Assurance Division (see form for complete address).

## 8.2 REVISION REQUESTS

This form is to be used to report suspected program malfunctions that may require revisions to the program. It can also be used to request revisions that may be required due to changes in specifications and to request program enhancements. Unexpected or incorrect output, rejection of input data, endless program cycling, and program abortion are examples of occurrences that may need to be reported on this form. Users are requested to review their input data and the program User's Manual before submitting this form for processing.

This 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 the Engineering Unit via mail, fax, or e-mail.

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# PS3
# TECHNICAL QUESTION FORM

This form is to be used to ask questions on technical issues related to this engineering program. Questions on the interpretations of the design specifications as implemented in this program, why certain assumptions are made by the program and other questions not related to the operation of this program may be submitted using this form or by calling the telephone number listed in this form. Users are requested to read the User's Manual, LFD Specifications and DM-4 before submitting this form or calling to ask questions.

CONTACT PERSON: ______________________________ DATE: ____________________
ORGANIZATION: ______________________________ PHONE: ____________________
E-MAIL ADDRESS: ______________________________ FAX: ____________________
PROGRAM VERSION: _________

Clearly state your question(s) and attach documentation you feel would be helpful in answering your question(s). If you require more space, use additional 8½ x 11 sheets of plain paper.

FORWARD COMPLETED FORM TO: Pennsylvania Dept. of Transportation
Bridge Office
Commonwealth Keystone Building, 7th Floor
400 North Street
Harrisburg, PA 17120-0094
PHONE: (717) 787-2881
FAX: (717) 787-2882

FOR DEPARTMENT USE ONLY
RECEIVED BY: ________________ ASSIGNED TO: ____________________ DATE: ______________

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# PS3
# REVISION REQUEST FORM

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: ______________________________ FAX: ____________________
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, Licensees should provide the input data file on a diskette. If you require more space, use additional 8½ x 11 sheets of plain paper.

FORWARD COMPLETED FORM TO: Pennsylvania Office of Administration
Bureau of Solutions Management,
Highway Applications Division
Engineering Software Section
P. O. Box 8213
Harrisburg, PA 17105-8213
PHONE: (717) 783-8822
FAX: (717) 705-5529
E-MAIL: PenndotBisEngineer@pa.gov

FOR DEPARTMENT USE ONLY
RECEIVED BY: ________________ ASSIGNED TO: ____________________ DATE: ______________

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