USER'S MANUAL FOR

BRIDGE ANALYSIS AND RATING
(BAR7)

pennsylvania
DEPARTMENT OF TRANSPORTATION

Version 7.15.0.0

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USER'S MANUAL FOR

COMPUTER PROGRAM BAR7

BRIDGE ANALYSIS AND RATING

Version 7.15.0.0

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February 2018

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BRIDGE ANALYSIS AND RATING

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SUMMARY OF AUGUST 1991 REVISIONS - VERSION 7.0

The Department's Bridge Analysis and Rating program has been revised as follows:

1. The program now performs rating analysis of all members using both the Allowable Stress Method and the Load Factor Method in accordance with the AASHTO Manual for Maintenance Inspection of Bridges. The previous version used only the Allowable Stress Method.

2. Many other enhancements such as analysis of transition (cover plate cut-off) sections, variable and/or composite floorbeam sections, cover plate cut-offs within a parabolic haunch, composite section in a negative moment region, hybrid sections, unsymmetrical sections, encased I-beams and an option for various levels of output have been made.

3. The capability of rating a prestressed concrete bridge (type "PSB") has been removed and will be made available in the Department's Prestressed Concrete Girder Design and Rating Program.

4. The stress or strength level for Safe Load Capacity can be specified as percent of inventory or operating stress or strength.

5. The input form for Steel Member Properties has been revised to include hybrid and unsymmetrical sections. A new input form has been added to enter lateral brace points and stiffener spacings that are required for the Load Factor Method.

6. A factor for growth in the average daily truck traffic (ADTT) can be taken into account for fatigue life analysis.

7. The revised program is now referred to as BAR7. A new User's Manual for BAR7 is published.

SUMMARY OF DECEMBER 1991 REVISIONS - VERSION 7.1

BAR7 Version 7.1 contains the following revisions.

1. The program now uses design fatigue stress range due to one lane (HS20 truck) to calculate the remaining life of the bridge in accordance with 4/91 revisions to DM4.

2. The user can specify a constant ADTT for the past and a constant ADTT for the future for fatigue life analysis.

3. For a concrete T-beam bridge, both the bent-up bars and stirrups can be entered as shear reinforcement.

4. A new output option has been added to show both the moment and shear ratings of a concrete bridge.

5. The maximum shear carried by shear reinforcement is limited per AASHTO specifications.

6. SPAN NO (column 1) on Input Form 8, Girder Fatigue Detail is added.

7. The User's Manual has been revised to reflect the above changes and other editorial revisions. The revised pages are marked as Revised 12/91.

SUMMARY OF MARCH 1992 REVISIONS - VERSION 7.2

BAR7 Version 7.2 contains the following revisions.

1. A correction has been made in the parabolic interpolation calculations. This applies to haunched sections near supports.

2. A correction has been made to use the input value for impact factor for bridge types "CSL" and "CTB". The program was overriding the input value with the default value.

3. A correction has been made to print the appropriate service strength for load factor serviceability.

SUMMARY OF NOVEMBER 1992 REVISIONS - VERSION 7.3

BAR7 Version 7.3 contains the following revisions.

1. Changes have been made in the calculation of allowable stresses for truss tension members. A new input item, FU, has been added to the Truss Member Properties.

2. A correction has been made in the calculation of moment-shear interaction. Simultaneous live load shears have been introduced for maximum live load moments. The program now checks four live load moment-shear combinations for moment-shear interaction rating.

3. An error correction has been made in the effective slab width calculation for composite floorbeams.

4. A correction has been made to initialize ALPHA in the Concrete Member Properties to the default of 45 degrees as specified in the Input Data Requirements.

5. An error correction has been made to allow 15 stringer locations to be entered.

6. All negative ratings will now be printed as -99.9.

7. A correction has been made in the logic used to analyze truss panel types 14 and 15. Revisions have been made to the analysis of trusses with counters. Diagonals in panel types 13, 14 and 15 are assumed as tension only members. These diagonals no longer can take any compression. The warning message has been revised.

8. The maximum number of spans for a girder or stringer has been increased to 15 on the mainframe and the 386 based PC versions. The standard PC version is still limited to a maximum of six spans for a girder or stringer.

9. Two new input items, STRINGER DL1 and FLOORBEAM DL1, have been added to include weights of slab haunch and permanent formwork in the analyses of stringer and floorbeam.

10. An error correction has been made to fix erratic floorbeam ratings for truss fatigue problems.

11. Additional input edit checks have been added.

12. An error correction has been made to fix a problem where wheel loads were allowed to be too close to the curb when analyzing floorbeams with one design lane.

13. A correction has been made to fix a problem where the maximum axle load may not have been selected for certain special live loads when analyzing floorbeams.

14. A correction has been made to fix a problem where fatigue analysis was not using the HS truck loading if four or more special live loads were entered.

15. Changes have been made to the messages and output for sections that do not meet flange or web buckling criteria.

16. A correction has been made to the moment rating calculation for steel members in transition between compact and braced non-compact. Also, a correction has been made to the moment capacity of a non-compact section.

17. A correction has been made to compute the allowable compression reduction factor for the allowable stress method whenever the compression flange is not continuously supported. Previously the reduction factor was only computed when load factor analysis indicated an unbraced section.

18. A correction has been made to use the F_y of the compression flange instead of the F_y of the web when checking the load factor D/t_w ratios for hybrid steel girders.

19. A correction has been made to use the correct section properties for floorbeams having multiple segments.

20. A correction has been made to use the correct section properties for fatigue details that are in a haunched girder section.

21. A correction has been made to the calculation of girder or floorbeam weight when the depth of section varies.

22. A correction has been made to allow T-beams to have bent up bars with no stirrups.

23. The program now checks the compact section requirements of a composite steel section with a positive moment as shown on the revised Load Factor Rating Flow Chart.

24. The User's Manual has been revised to reflect the above changes and other editorial revisions. A new User's Manual has been published.

SUMMARY OF JULY 1993 REVISIONS - VERSION 7.4

BAR7 Version 7.4 contains the following revisions.

1. Changes have been made in the calculation of maximum reactions and shears at intermediate supports of continuous spans. The lateral distribution of wheel loads is now in accordance with the Bureau of Design Strike-Off-Letter 431-93-05. Refer to this S.O.L. for details.

2. A change has been made to the buckling checks for built-up sections. The unsupported width of the compression flange is taken as the distance from the outer edge of flange to the centerline of rivet or bolt, which is assumed to be 1.5 inches from the end of the angle. The unsupported depth of the web in compression (D_{cp} or D_c) is taken as the distance from the neutral axis to the centerline of rivet or bolt, which is assumed to be 1.5 inches from the end of the angle.

3. A new input item DIRECT has been added to the Project Identification on the first input form. This provides the User with an option to analyze a live load moving in only one direction.

4. Another code has been added for the LIVE LOAD item on the Project Identification. Enter "D" to consider a P-82 loading only.

5. An error correction has been made to fix an abnormal job termination that occurred when simple span beams were entered with no brace points.

6. An error correction has been made to the calculation of shear at cut-off points within the last tenth of each span.

7. A modification has been made to allow the Steel Member Properties SECT TYPE to change at RANGE points.

8. An error correction has been made to fix a situation where in some instances AASHTO Articles 10.48.1.1(b) and 10.50.1.1.2 were not checked before allowing a section to be a transition section.

9. An error correction has been made to the check for AASHTO Article 10.50.1.1.2. The program had been checking $D_{cp} < (d + t_s)/7.5$. A new value D_p has been added to the list of notations.

10. An error correction has been made to fix erroneous section properties and ratings for composite cantilever floorbeams.

11. An error correction has been made to the calculation of STRINGER DL1 acting on the girder.

12. An error correction has been made to fix a problem where in some instances the program was using the wrong stiffener information for analysis points at intermediate supports.

13. An error correction has been made to the calculation of the stringer effective slab width when girders are included as stringer locations.

14. A modification has been made to make sure the program always checks both unbraced lengths (left and right) when analyzing a section at a brace point.

15. An error correction has been made to fix a problem where in some instances the program was giving a negative moment-shear interaction rating for the allowable stress method.

16. An error correction has been made to fix a problem where in some instances the program was using the wrong depth for the fatigue section properties at a cutoff where there was no depth entered (depth varies due to straight or parabolic haunch).

SUMMARY OF DECEMBER 1994 REVISIONS - VERSION 7.5

BAR7 Version 7.5 contains the following revisions.

1. A modification has been made to the calculation of girder ratings. Input item SPEC is checked to determine if 1988 DM-4 equations are to be used for bending capacity of an unbraced section. The default will be the AASHTO equations. The program was previously using both equations and taking the smaller (more conservative) value.

2. In checking the lateral bracing requirement of a compact section (AASHTO Eqn. 10-95), b'/t ratio of a braced non-compact section (AASHTO Eqn. 10-98), bending coefficient C_b in calculating the bending strength of an unbraced section (AASHTO Eqns. 10-102, 10-102e and 10-102g), and the moment-shear interaction (AASHTO Eqn. 10-117), the factored moments and shears are now calculated using a beta factor for live load equal to 1.67. The program was previously using a value of 1.0.

3. The program has been modified to print negative reactions (uplift).

4. A 14-digit BMS ID plus a 4-digit Span ID can be entered on the first Problem Identification line.

5. 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.

6. For a concrete or composite steel structure, the input item F'C must be entered. Previously the program assumed a default value of 2.375 ksi.

7. A modification has been made to accommodate negative values less than -9.99 for input item CL OF GIRDER OR TRUSS TO CURB.

8. Error corrections have been made to section properties calculations. The top and bottom plate moments of inertia have been added to the total moment of inertia of the steel section. A correction has been made to the moment of inertia equations for angles in built-up sections in composite, positive and negative moment regions. The calculation of the bridge type "EIB" composite M of I has been changed to include entire non-composite beam M of I regardless of the type of beam (W, P or B). Previously it assumed type W.

9. An error correction has been made to the parabolic interpolation of simultaneous moments for live load shears in the last segment of a span.

10. An error correction has been made to the calculation of the effective slab width for a composite girder when the bridge type is "GFF".

11. An error correction has been made to the calculation of the floorbeam weight when the first section of a cantilever floorbeam varies in depth.

12. The moment-shear interaction rating calculations have been revised. For compact or transition sections, the governing non-compact moment strength is used to calculate the load factor moment-shear interaction rating. Moment-shear interaction is not calculated for an unstiffened section.

13. The Detailed Rating output has been enhanced.

14. A correction has been made to Example Problem 4 in the User's Manual. The weight of railing and parapet should be included as DL2 and the weight of SIP forms should be part of DL1.

15. The User's Manual has been corrected and revised. The complete manual has been reprinted.

SUMMARY OF FEBRUARY 1996 REVISIONS - VERSION 7.6

BAR7 Version 7.6 contains the following revisions.

1. A correction has been made to the fatigue life calculations. A different iteration process is now used that provides convergence for problems with a larger difference between recent year and future year.

2. A modification has been made to correct a situation where a symmetrical problem generated unsymmetrical results.

3. A new input item has been added for the unit weight of deck concrete. This will allow the user to enter lightweight concrete. Previously the program always used 150 pounds per cubic foot.

4. The program will now check to make sure that girder member properties are entered before floorbeam and stringer section properties. Properties entered in the wrong order will be flagged as an input error.

5. The program will now check to make sure that the first range of the girder member properties is not zero.

6. The program will now elaborate on messages for format errors by specifying the data line type expected by the program.

7. The program will now allow the user to enter a negative haunch value for the bridge type "EIB" which will be converted to a positive to indicate that the top of the beam is below the bottom of the slab.

8. A new live load option has been added. Enter Live Load code "E" to consider H20, HS20, Type 3, Type 3S2 and Type 3-3 loadings.

9. A correction has been made to the floorbeam analysis. The program was applying the reduction due to the no. of lanes for moment to both moment and shear. The program will now use the no. of lanes for shear to reduce shear.

10. A correction has been made to the check for a compact section when the bridge type is "EIB". For unshored construction the program was not properly checking the criteria for $D_p > (d+t_s)/7.5$.

11. A modification has been made to accommodate negative values less than -9.99 for the input of STRINGER LOCATIONS.

12. The program will now check for uplift at bearings on continuous bridges. If the total reaction at any support is less than 10% of the dead load reaction, the program will print a warning message.

13. The User's Manual has been corrected and revised. The revised pages to the manual have been distributed.

SUMMARY OF JUNE 1996 REVISIONS - VERSION 7.7

BAR7 Version 7.7 contains the following revisions.

1. A modification has been made to the special live loading input 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.

2. Increased the number of special live loadings from five to eight.

3. Added the capability to read the special live loading data from a separate input file for the PC version.

4. A correction has been made to print an uplift warning when applicable, even when the output option is for summary only.

5. When calculating unbraced lengths, the dead load points of contraflexure are considered only when the input item SPEC indicates the 1989 AASHTO Specifications or Article D10.48.4.1 of 1988 DM-4.

6. The logic for shear ratings has been changed so that the d_0/D ratio is no longer checked against $(260/(D/tw))^2$ when computing K and Vu. The Load Factor Rating Flow Chart has been revised.

7. A correction has been made to the summary output (OUTPUT=1) where the floorbeam ratings were incorrect when lane loading governed.

8. A correction has been made to fix a problem where stringer locations input data was being shifted when trailing zeros were omitted.

9. A correction has been made to the calculation of impact factor for a truss having an input value of H3 greater than zero.

10. The User's Manual has been corrected and revised. The complete manual has been reprinted.

SUMMARY OF DECEMBER 1997 REVISIONS - VERSION 7.8

BAR7 Version 7.8 contains the following revisions.

1. A correction has been made to print the appropriate section properties at an analysis point that is also the beginning of a variable depth range.

2. An input check has been added to flag a zero range on girder properties as an error.

3. A correction has been made to the equation for shear carried by the steel of a reinforced concrete member. The allowable stress needed to be divided by 1000.0 to convert psi to ksi when calculating V_{sir} and V_{sor} for bent up bars.

4. A correction has been made to the equation for calculating the depth of neutral axis for a cracked section and also the quadratic equation used to calculate the moment of inertia of an encased I-beam.

5. A correction has been made to use the inputted value for unit weight of deck concrete instead of 150 for the calculation of the weight of slab on each stringer.

6. Ductility requirements for a compact composite beam in positive moment region are now checked as per article 10.50.1.1.2 of 1996 AASHTO. Composite steel sections with F_y greater than 50 ksi cannot be compact.

7. If all sections of a steel girder, stringer or floorbeam do not qualify as compact sections, the maximum bending strength of each section is taken as the moment capacity at first yielding as specified in AASHTO Article 10.50(f).

8. If the girder or floorbeam does not have a constant web depth, then the sections do not qualify as compact sections.

9. The provisions of AASHTO Article 10.48.3 are no longer considered. Sections qualified as transition sections in previous versions will be reported as braced non-compact sections.

10. A correction has been made to fix a problem that occurred when fifteen stringer locations were entered with one of the locations equal to zero. The program was calculating the wrong value for the number of stringers.

11. A new output option ("B") to print a full input echo and summary has been added.

12. A check has been added so that there can be only one line of stringer member properties.

13. A check has been added so that the last range of steel member properties in each span must be equal to the span length.

14. The stringer weight printed for dead load acting on the girder was for one stringer. The program has been changed to print the weight of all stringers acting on the girder.

15. A new input item has been added to the Truss Member Properties for GROSS AREA TENSION. This is the gross cross sectional area that is to be used in conjunction with F_y to calculate the allowable tension in the member.

16. Distribution factors may now be input for a skewed concrete slab bridge (bridge type "CSL").

17. For a non-compact section, if the moment strength is governed by slab concrete, the program now uses 0.85 f'c as the stress in extreme fiber of concrete instead of f'c in calculating M_U for the Load Factor Method.

18. A correction has been made to the calculation of the allowable compression in a partially supported or unsupported compression flange using the Allowable Stress Method. Previously it was applying the bending capacity reduction factor, R_b that is calculated for the Load Factor Method.

19. The User's Manual has been corrected and revised. The complete manual has been reprinted.

SUMMARY OF FEBRUARY 1999 REVISIONS - VERSION 7.9

BAR7 Version 7.9 contains the following revisions.

1. A correction has been made to the application of the reduction factor for the number of lanes when calculating moment and shear values in a floorbeam.

2. For a continuous girder or stringer, a correction has been made to the calculation of impact factors for negative and positive moments and reactions at interior supports. For a floorbeam, a correction has been made to the calculation of impact factors for negative moment and shear.

3. The use of length L in the Impact Formula given in AASHTO 3.8.2.1 is now defined in the method of solution.

4. A correction has been made to the check for flange buckling, 1996 AASHTO Equation (10-122), for composite members in positive moment. This check is no longer considered as part of the compactness criteria, but may result in a warning message for flange buckling.

5. A correction has been made to the allowable stress rating factor based on concrete stress in a composite section. The stress due to DL2 is now computed using the modular ratio of 3n. Previously it was incorrectly using the modular ratio of n.

6. A correction has been made to the check for whether or not to print composite section properties.

7. A correction has been made in reporting the critical rating, whether it is based on a compact section or a non-compact section for a bridge consisting of a series of simple spans (CONT code is entered as "S" for a multi-span girder or stringer). Previously the program reported the critical rating based on a non-compact section even if the entire span where the critical section was located was compact, but other span/s did not qualify as compact sections. Now each span is evaluated independent of other spans and the most critical rating is reported based on the section qualifications (compact or non-compact) of that span.

8. A rating factor code being blank has been added to indicate that the compact moment strength governs.

9. The Rating Summary now prints the minimum positive moment rating, the minimum negative moment rating and their locations for each loading.

10. Multiple stringers may now be analyzed in one run.

11. A new input item (S OVER FACTOR) has been added.

12. A new bridge type FSS has been added to represent floorbeams and stringers with no truss or main girder.

13. A new bridge type GGF has been added to allow multiple girders on floorbeams. This type uses stringer locations input to apply girder dead loads to floorbeams, and girder span lengths for floorbeam spacings.

14. Lane load is now checked for stringers. Previously it was assumed that lane loading would not control for stringers.

15. The standard PC version (640K memory) of this program will no longer be supported. The only PC version now available requires a 386 based PC or higher with at least 2 megabytes of memory.

16. The program has been revised to print the dates in either the MM/YYYY or the MM/DD/YYYY format.

17. The User's Manual has been corrected and revised. The revised pages to the manual have been distributed.

SUMMARY OF APRIL 2003 REVISIONS - VERSION 7.10

BAR7 Version 7.10 contains the following revisions.

1. Increase the number of truss panels allowed from 60 to 99.

2. Increase the size of some of the output fields to avoid printing ******.

3. Correct an error where 2.375 were being printed as the default input value of UNIT WEIGHT DECK CONC.

4. Add a new bridge type "CPL" to analyze precast slab type bridges.

5. Add an input error edit check to flag an error if the moment distribution factor is not entered when the CONT code for stringer span lengths is "C".

6. Correct an error in the calculation of the plastic moment capacity for a built-up section. When the plastic neutral axis falls in the vertical part of the bottom angles, the portion of the web above the neutral axis had the wrong sign. Hence, the Mu was being calculated incorrectly.

7. Print the value of DP/D' in the detailed output (OUTPUT code is "A").

8. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because Fy is > 50 ksi for a positive moment composite section.

9. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because it does not have a constant web depth.

10. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because B'/T is greater than the maximum allowable B'/T.

11. Correct an error in the calculation of distance to consider allowable steel stresses in bent up bars for a concrete structure. The depth that was entered in inches needed to be converted to feet.

12. Correct an error so that the appropriate sign (+ or -) is applied to the Overload Moment Strength on the output.

13. Add an input error edit check to flag an error if no angle data is entered when the steel member type is "B".

14. Correct an error so that a decimal point can be explicitly entered for the axle distance of a special live load.

15. Increase the space between the output fields C BOT and S TOP when printing section properties.

16. Modify the uplift warning message to indicate the live load that produced the uplift.

17. Since the effective slab width may be based on the span length, print the effective slab width and thickness for each span of composite member properties.

18. Correct an error so that Flexural Stresses - Slab are printed for composite stringers.

19. Add a new input item for Integral Wearing Surface at the end of the Concrete Member Properties data. The default value is 0.5 inches.

20. Correct an error in the detailed output (OUTPUT code is "A"). When printing the Area, M of I and C Bot properties for LL+I, check for + or - LL moment and print properties accordingly.

21. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because DP/D' is greater than 5 for a positive moment composite section.

22. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because 2DCP/TW is greater than the allowable maximum.

23. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because 2DCP/TW + 9.35(B'/T) is greater than the allowable maximum.

24. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because LB/RY is greater than the allowable maximum.

25. Print a message in the detailed output (OUTPUT code is "A") if the section has a possible web-buckling problem because the web thickness check fails (D/TW is greater than the allowable maximum).

26. Print a message in the detailed output (OUTPUT code is "A") if the section is unbraced non-compact because the unbraced length is greater than the allowable spacing of lateral bracing in the compression flange.

27. Print a message in the detailed output (OUTPUT code is "A") if the section has a possible flange-buckling problem because it does not meet the compression flange projection requirement.

28. Check for web buckling based on whether the section is unstiffened, transversely stiffened or longitudinally stiffened.

29. Do not allow a longitudinally stiffened section to be compact as per the 2000 Interims of AASHTO Standard Specifications.

30. Do not allow a built-up section to be compact because of holes in the tension flange as per the 2000 Interims of AASHTO Standard Specifications.

31. Print a message in the detailed output (OUTPUT code is "A") if the section is not compact because of either of the above two items.

32. Correct an error for Bridge Type "EIB", shored versus unshored construction. For shored construction, use DL2 properties for DL1 stresses and rating calculations, but do not use DL2 depth to compute shear rating.

33. When calculating the ratings for each of the four cases:
    (a) Maximum positive moment & simultaneous shear
    (b) Maximum negative moment & simultaneous shear
    (c) Maximum positive shear & simultaneous moment
    (d) Maximum negative shear & simultaneous moment

    Do not consider the ratings from cases (a) and (b) when determining the controlling shear ratings and do not consider the ratings from cases (c) and (d) when determining the controlling moment ratings.

34. Add an input error edit check to flag an error if the Deck Width is less than the Roadway Width.

35. Add an input error edit check to flag an error if the sum of truss panel widths for each span does not equal the span length.

36. Allow a combination of panel type 7 followed by panel type 8 if the appropriate vertical member is not present and the truss is internally determinate. Add checks for VERTICAL POST = ‘N’ based on whether the truss is a deck truss or a thru truss and print an error if the truss is internally indeterminate.

37. Correct an error so that dead loads are not redistributed to the wrong panel joints when panel type 7 follows panel type 8 or panel 8 follows panel 7 and there is a vertical missing between panels.

38. Add a check and print an error message when an invalid (negative) square root argument occurs because the combined stress formula has inappropriate input values for calculating the allowable compression in an eccentrically loaded truss member.

39. Add a check to allow multiple negative stringer locations when computing main girder effective slab width.

40. Recompile the program using the latest version of Compaq Visual Fortran.

41. Do not check for uplift on stringers of a GFS type bridge.

42. Revise the User's Manual to reflect that output values for the design fatigue stress range (FSRD) and the effective fatigue stress range (FSRE) do not contain the PA Traffic Factor (PTF).

43. The allowable compression in an eccentrically loaded truss member using the combined stress formula is based on factor of safety equal to 2.12 for IR and 1.70 for OR. Previously it was based on 0.55 F_y for IR and 0.75 F_y for OR.

44. Correct shear strength calculation for end panels of transversely stiffened girders. Do not include post-buckling resistance due to tension-field action (Use AASHTO equation 10-119 instead of AASHTO equation 10-114).

45. Correct shear strength calculation for interior panels of transversely stiffened hybrid girders. Do not include post-buckling resistance due to tension-field action (Use AASHTO equation 10-149 instead of AASHTO equation 10-113).

46. Use the Safe Load Capacity (SLC) ratings if they exist for an APRAS/ABAS job.

47. Add a new live load posting vehicle TK527.

48. Add an input error edit check to flag an error if the accumulative sum of truss panel widths does not fall within 1/2" of the accumulative span lengths for each span.

49. Add an input error edit check to flag an error if the truss "HINGE AT" joint designation on the Bridge Cross Section and Loading data is not at a support.

50. Provide an error message if a negative stringer location is entered when the OVERHANG is zero.

51. Compute the allowable tension in truss members that have moment of inertia equal to zero and only skip the calculation of allowable compression.

52. Add an input error message to flag when brace points or stiffeners are entered for a stringer.

53. Correct calculations to use appropriate stringer section properties based on stinger span. This is because the effective slab width may now be different between spans.

54. Add a check for an unexpected end-of-file and print out an informative error message.

55. Change ML80 & TK527 loadings as per PUB 238, page IP 03-2. lso, use this same methodology for special live loads that have 3% INCR. The axle weights for the ML80 and TK527 loadings shown in Figure 2.4.1 Standard Live Loadings include the 3% scale tolerance allowed by the vehicle code. When calculating the gross vehicle weight of these vehicles for determining the ratings in tons, the 3% tolerance is removed.

56. Correct the calculation of moment of inertia for a composite section when the neutral axis is above the bottom of the slab. The area of concrete below the neutral axis should be neglected.

57. For bridge type GGF, correct the calculation of the effective slab width for the critical girder by using the same method used to calculate the effective slab width for a critical stringer.

58. Correct a problem where erratic results (very large ratings or *****) were being printed for certain special loads.

59. Correct a problem where Type FSS with floorbeam overhang causes BAR7 to crash or go into a loop.

60. Allow more than 5 spans for a continuous truss. Limit is 15 spans, same as for girders.

61. Add new bridge Type TTT to analyze a truss only with no floorbeams or stringers.

62. Rearrange the output of the input default values into the order in which they are entered.

63. Use 1983 AASHTO 3.23.4.3 to calculate the moment distribution factor for Type CPL instead of 1996 AASHTO 3.23.4.3.

64. Add a Note to the output stating that the program does not check stiffener spacings against the AASHTO/DM4 minimum stiffener spacing criteria.

65. Use the clear depth instead of the total depth to calculate the area of the web when computing shear stresses.

66. Add an input check and print an error when stringer/girder locations are unsymmetrical about the center of floorbeam span.

67. Correct the calculation for the weight of floorbeams that have overhangs. The length of the overhang was incorrectly included in the length of the first positive range.

68. Allow comment lines to be included in a separate special live load input file.

69. The User's Manual has been revised for the above revisions. In addition, the manual’s format was changed and the manual is available in Adobe Acrobat PDF format.

The following is a list of reported errors, user requests and clarifications from BAR7 Version 7.9 that have not been addressed in Version 7.10.

1. Incorporate CBA and BSP libraries to be used as engines in BAR7.

2. Add new input items to make use of BSP library to allow for non-standard beam sections (deteriorated or patched).

3. Add new input items to make use of CBA library to allow for user supplied or non-uniform dead loads. This will provide capability to analyze counterweights to prevent uplift as well as point loads.

4. Provide analysis for a special live load in one lane and a specified "other" vehicle(s) in remaining lane(s), where "other" vehicle(s) are defined through the LIVE LOAD field on the Project Identification.

5. Add two new codes to the LIVE LOAD field on the Project Identification as follows: I - consider HS20 and ML80 loadings and J - consider HS25, IML and ML80 loadings.

6. Add new input items for single lane distribution factor and multi-lane distribution factors, moment and shear.

7. Add a third option to LANES input for user to define a median barrier.

8. Allow different gage distances for multiple special live loads and recalculate distribution factors for each load.

9. Check provisions of AASHTO Equation (10-119) when rating unsymmetrical stiffened girders.

10. Correct calculation of estimated fatigue life HS20 TRK STRESS for positive and negative live load plus impact moments. The program should use the distribution factor for one lane instead of the multi-lane moment distribution factor entered by the user.

11. Provide the capability to handle the situation where the deck is overhanging the girder with no cantilever or bracket on the floorbeam.

12. Allow a cantilever floorbeam to be non-continuous, i.e., partial or no moment passed thru at the support.

13. Incorporate new equation for C_b (AASHTO 10.48.4.1) for discreetly supported compression flange of a floorbeam, stringer or girder.

SUMMARY OF OCTOBER 2003 REVISIONS - VERSION 7.10a

BAR7 Version 7.10a contains the following revisions.

1. Correct an input error that was inadvertently being printed for some truss bridges. When checking for the “HINGE AT” location not falling on a support, in some instances, the program was printing the error even though the hinge was on a support.

2. Correct an error in the compactness check for a positive moment composite section. The program was causing compact sections to be treated as non-compact because the b’/t ratio was greater than the maximum b’/t for a non-composite section.

3. When analyzing a section that falls at a brace point, clarify the unbraced section maximum strength for output option “A” by printing brace points x1 and x2.

SUMMARY OF MARCH 2004 REVISIONS - VERSION 7.11

BAR7 Version 7.11 contains the following revisions.

1. Incorporate the Department's Continuous Beam Analysis (CBA) program as a library and use it as an analysis engine for BAR7. This yields slightly different but more accurate results of BAR7 because:
   - CBA uses centroid instead of midpoint of M/EI trapezoidal loading.
   - CBA uses 20th points instead of 10th points for an analysis of a girder.
   - CBA uses a couple of new load positions for the vehicle placement over the influence line.

2. Incorporate the Department's Beam Section Properties (BSP) program as a library so that sections properties calculated and used in BAR7 are consistent with other programs.

3. Incorporate the following corrections that were included in BAR7 v7.10a:
   - Correction to the input edit check for the HINGE AT location that is not on a support.
   - Correction for error with the rating of positive moment composite sections such that b'/t limit is not used.
   - Eliminate the NaN error for some truss member forces.

4. Use Compaq Visual Fortran to break the source code into separate files for each routine and code all COMMON blocks into INCLUSE statements (this does not affect the BAR7 results).

Note: The reported errors, user requests and clarifications except for item1 listed on page xxx have not yet been addressed in Version 7.11. They will be addressed in future versions of BAR7.

SUMMARY OF DECEMBER 2004 REVISIONS - VERSION 7.11.0.6

BAR7 Version 7.11.0.6 contains the following revisions.

1. Add a warning message to clarify the situation where the user enters a shear distribution factor and designates that there is only one stringer and it is an interior stringer. The program will use the inputted value instead of the value calculated based on the interior stringer's spacing. (BAR7REV116)

2. Correct a problem where a Type GFS structure with no slab and very small stringers plus multiple stringer spans and multiple live loads caused an abnormal termination. (BAR7REV117)

3. Clarified the descriptions of the DL1 and DL2 input items in the User's Manual pertaining to their use in the application of sidewalk live load. (BAR7REV118)

4. Add two new codes for the LIVE LOAD input item on the PROJECT IDENTIFICATION data. Use code "I" to consider HS20 and ML80 loadings. Use code "J" to consider HS25, IML and ML80 loadings. (BAR7REV055)

5. Correct the User's Manual on page 1-2. Define AASHTO Specifications as AASHTO Standard Specifications for Highway Bridges, Fifteenth Edition, 1996. (BAR7REV120)

6. Correct a problem where a Type GFF structure with more than fourteen floorbeams caused an abnormal termination. (BAR7REV121)

7. Increase the size limit for the length of file names so that extra long file names (more than 100 characters) may be used. (BAR7REV122)

8. Correct an error in the calculation of the load factor rating based on concrete strength in a composite section. The program now computes the stress due to DL2 using the modular ratio of 3n. Previously it was incorrectly using the modular ratio of n. (BAR7REV123)

9. Apply one-lane distribution factor instead of multi-lane distribution factor to the HS20 TRK STRESS +(LL+I) and -(LL+I) values printed in the FATIGUE LIFE ESTIMATION output. (BAR7REV060)

10. On the Girder Fatigue Detail input, add fatigue detail categories BP and EP, equivalent to B' and E', to work around an issue with Engineering Dataset Manager. (BAR7REV124)

11. Correct a problem where the program printed asterisks in some of the Fatigue Analysis output fields when running with Output Option 6. (BAR7REV126)

12. When calculating the live load factors for a floorbeam, neglect the wheel loads that do not fall within the limits of the length of the floorbeam. (BAR7REV127)

13. Add a new input item (END PANEL) to the Project Identification to act as a switch to disallow the shear in the end panel from governing the rating at that section. BAR7 version 7.9 and earlier erroneously allowed the shear capacity to include post buckling strength in the end panel of girders. This was also true for the interior and end panels of hybrid girders. BAR7 version 7.10 corrected this problem, however, the load rating for some girder structures are now controlled by low shear ratings in the end panel. (BAR7REV128)

14. Add an input error message when a brace point spacing is entered greater than the span length. (BAR7REV129)

SUMMARY OF JULY 2005 REVISIONS - VERSION 7.11.0.8

BAR7 Version 7.11.0.8 contains the following revisions.

1. A problem has been corrected where a truss analyzed for a uniform lane load entered via the Special Live Load input gives the same incorrect result for LL forces regardless of the value entered for the Uniform Lane Load. (BAR7REV131)

2. The revision to BAR7 v7.10 (BAR7REV047) required the use of AASHTO 10.48.8.3 Equation (10-149) when calculating the allowable shear force for hybrid girders. This was causing unusually low ratings for some existing structures. A new input item (HYB) has been added to act as a switch. The purpose of this new input switch will be to select the shear rating equation to use for hybrid sections, AASHTO 10.48.8.3 equation (10-149) or equation (10-113). (BAR7REV132)

3. The revision to BAR7 v7.11.0.6 (BAR7REV128) did not change the calculation of the allowable shear force in an end panel. It simply provided a switch to disallow end panel shear governing. This sometimes resulted in a rating of 999.99 reported at that section. Instead of using the new END PANEL input switch to override the end panel shear rating, the switch is now used to determine whether to use AASHTO Equation (10-118) or (10-113). (BAR7REV133)

4. For a continuous composite girder, the program attempts to compute a negative moment rating based on the amount of reinforcement in the slab. When zero area of steel is entered for the longitudinal slab reinforcement, the program abnormally terminated with a divide by zero. A check has been added to print an input error when no longitudinal slab reinforcement is entered for a continuous composite girder. (BAR7REV134)

5. Figure 2.4.1 Standard Live Loadings has been revised to reflect the more accurate value of 13.68 kips for the first axle of the ML80 live load. (BAR7REV135)

SUMMARY OF DECEMBER 2005 REVISIONS - VERSION 7.11.0.9

BAR7 Version 7.11.0.9 contains the following revisions.

1. The limit for the maximum number of axles for user defined Special Live Loads has been increased from 24 to 80. (BAR7REV136)

2. A problem has been corrected for a truss analysis job that abnormally terminated when the panel type configuration produced zero force in one of the top chords. An input error message is now generated when an invalid panel type configuration is encountered. (BAR7REV137)

3. A problem was corrected where a job would abnormally terminate when run through the Engineering Manager or Engineering Assistant graphical user interface (GUI). The program will now run and produce the appropriate messages in the output listing that is accessible in the GUI. (BAR7REV138)

4. At a girder section where lane loading governs for an H20 Truck, it was detected that the Critical Rating was greater than the POS MOM Rating on the Load Rating summary page. This problem is related to revision number 33 in the Summary of April 2003 Revisions - Version 7.10 on page xxvii. The program has been modified so that when determining the minimum positive and negative moment ratings, the cases for maximum positive shear & simultaneous moment and maximum negative shear & simultaneous moment are not considered. (BAR7REV139)

SUMMARY OF MAY 2007 REVISIONS - VERSION 7.12.0.0

Since the release of BAR7 Version 7.11.0.9, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.12.0.0 contains the following revisions.

Input Revisions

1. A cross check error was fixed in the program when the maximum number (i.e. 5) of different Floorbeam brace point spacings or stiffener spacings was entered. (BAR7REV141)

2. A problem has been corrected where the input variables for the FY in the top and bottom flanges of a stringer were not being used properly. (BAR7REV146)

3. An input check was added and an error message is printed if more than 3 floorbeams are entered. (BAR7REV152)

Output Revisions

4. When running a job with additional section properties analysis points added, the output is reporting this point twice in the tables of section properties. Added a check for duplicate analysis points and skipped printing those points. (BAR7REV154)

5. Modified the program to print code 1 for negative moment impact factor at a point with negative moment. (BAR7REV155)

6. Corrected the discrepancy in the printing of the message “NOTE: THIS MEMBER DOES NOT HAVE ALL SECTIONS QUALIFIED AS COMPACT SECTIONS. THEREFORE, EVEN …” between simple spans or a continuous span. (BAR7REV158)

7. Corrected the value being reported for the MR at that section when reviewing the detailed output for a specific section of a continuous girder. (BAR7REV156)

BRIDGE ANALYSIS AND RATING

Section Property Revisions

8. A problem has been corrected where the program was reporting invalid section properties at all but the first location when analyzing stringers at multiple locations. (BAR7REV145)

9. Corrected the bottom flange angle vertical and horizontal leg dimensions in the sketch for the built-up section in the EngAsst. Previously, this sketch for built-up section was not consistent with the sketch on Page 5-55 in the User's Manual. (BAR7REV144)

10. The program has been enhanced to compute section properties on both sides of the cutoff for the purpose of analyzing and rating each section. Previously, BAR7 picked the section properties that had the less moment capacity and used those properties for the rating calculations. Please note that for the purpose of stiffness and determining the reactions, moments, shears, deflections, and rotations, the BAR7 process does not change and it will pass the appropriate moment of inertia to CBA. (BAR7REV150)

11. A problem has been corrected because the depth of section was not calculated correctly when a variable depth plate girder section (Type P) transitions into a wide flange beam (Type W). Modified the code to accommodate all combinations of steel member types and variable depths. (BAR7REV159)

Live Load Revision

12. A problem has been corrected where the program was reporting invalid section properties at all but the first location when analyzing stringers at multiple locations. (BAR7REV145)

13. The Live Load code of "9" should not be a valid code according to the documentation. In case there may be some old input files with live load code equal to "9", the "9" will be interpreted as number of special live loads equal to one. (BAR7REV149)

Flexural Capacity Revision

14. The program has been enhanced to calculate correctly the moment capacity of a reinforced concrete T-beam when the area of compression reinforcement is equal to (or close to equal to) the area of tension reinforcement in the beam. (BAR7REV151)

15. Modified the program to use M1/M2 ratio based on the span 2 unbraced length when analyzing the point at the end of the span 2 and to use M1/M2 ratio based on the span 3 unbraced length when analyzing the point at the beginning of the span 3. (BAR7REV153)

16. Corrected the signs of the MU values at some of the brace points. (BAR7REV157)

Program Revision

17. The program has been converted to Intel Visual Fortran compiler v9.1. (BAR7REV140)

SUMMARY OF MAY 2008 REVISIONS - VERSION 7.12.0.1

BAR7 Version 7.12.0.1 contains the following revisions:

General Program Revisions

1. Corrected a problem where all the sections properties at the beginning of the first span were equal to zero. This was causing slight differences in the results for continuous span structures.

2. Resolved conflicting variable name and subroutine name issue between BAR7 and CBA code. (BAR7REV162)

3. Allowed for a CBA enhancement that accepts user defined distribution factors. (BAR7REV163)

Input Revisions

4. When a negative cover plate thickness is entered for a wide flange section to describe a deteriorated flange, the program now assumes the deterioration applies the entire flange width when the corresponding cover plate width is **not** entered (left blank). Previously, the program would only consider the deterioration when a value was entered for the corresponding cover plate width. (BAR7REV164)

5. Live load codes 7 and 8 were added to the dropdown list for the “Live Load” field of the “Project” tab in Engineering Assistant (EngAsst). (BAR7REV166)

Output Revisions

6. The unbraced length (L_b) and width of the projecting flange element (b′) values are now printed in the detailed output when the 1989 AASHTO Specification is used to compute the maximum strength of an unbraced section. (BAR7REV161)

Load Revisions

7. Added a separate live load (beta) factor of 1.0 for the P-82 permit vehicle. (BAR7REV160)

User Manual Revisions

8. Corrected the shear capacity equation for Operating Ratings for slab bridges and T-beam bridges in Section 3.6.3 of the User’s Manual. (BAR7REV165).

SUMMARY OF APRIL 2010 REVISIONS - VERSION 7.13.0.0

Since the release of BAR7 Version 7.12.0.1, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.13.0.0 contains the following revisions.

General Program Revisions

1. Revise the Truss Geometry Images 2 and 3 in the Engineering Assistant (EngAsst) and Figure 5.11.1 (Truss Geometry) in the User Manual to clarify the meaning of H3 parameter. Add Figure 5.11.6 Truss Geometry (Example 4) to better explain the input of Truss Geometry. (BAR7REV169)

2. Correct a typo of Live Load item in the Help Screen of project tab in EngAsst. (BAR7REV176)

3. Revise the Chapter 7 Example 5 pp 7-42 & 7-53. In example 5, the Lane, Moment Distribution Factor, and Ranges of Steel Member Property card are incorrect. Also, change text to improve readability. (BAR7REV180)

Input Revisions

4. Correct the end-of-file error for bridge type of “TTT” when the input data file does not have a blank input line at the end of input file. (BAR7REV168)

5. Add the edit check for special live loads: you must have the truck load and the number of axles of this truck shall be between 2 and 80. (BAR7REV171)

6. Increase the number of ranges in the Steel Member Properties card to 100. (BAR7REV172)

7. Correct a typo in format (XXXDD) of the WF BEAM OR WEB PLATE DEPTH of Steel Member Properties card in Figure 5.1.6 (Input Form 6) of the User Manual. (BAR7REV178)

8. Add GUSSET PLATE PROPERTIES card and GUSSET PLATE MEMBERS card to allow the user input the gusset plate information. (BAR7REV167)

9. Correct an incorrect error check for the Distribution Factors with a “TTT” bridge type. Distribution factors don’t need to be entered for the bridge type of “TTT”. (BAR7REV181)

10. Add the edit check for ADTT Year to avoid the "Divide by Zero" error which crashed the program. (BAR7REV182)

BRIDGE ANALYSIS AND RATING

Section Property

11. Implement unreleased version of Beam Section Property (BSP) v1.5.0.2. The current release version of BSP is v1.3. (BAR7REV173)

12. For Steel Member Properties card, increase the lines of steel members to 300 (150 if SYMMETRY is entered "Y"). (BAR7REV179)

13. Output the program calculated truss member lengths so that users can verify that the truss model is correct. (BAR7REV170)

Allowable Stress

14. The allowable bending stress equation as listed in Tables 6.6.2.1-1 and 6.6.2.1-2 of the 1994, 2nd Edition (2000 Interim) AASHTO Manual for the Condition Evaluation of Bridges shall be used when checking the combined stress equation in AASHTO 10.36. Several new Items were added into Truss Member Properties card in Figure 5.1.5 (Input Form 5). This option is available when CORS in the Bridge Cross Section and Loading card is coded with "X". (BAR7REV174)

Load Revisions

15. Add the skew correction factor for shear to account for increased shear due to skew as refer to the AASHTO LRFD Section 4.6.2.2.3c for bridge types of "CTB" and "GGG". The skew correction item was added into Bridge Cross Section and Loading card in Figure 5.1.1 (Input Form 1) of the User Manual. (BAR7REV175)

Gusset Plate

16. The program has been revised adding the ability of gusset plate analysis and rating utilizing Load Factor Rating (LFR) method. (BAR7REV167)

Program Revision

17. The program has been converted to Intel Visual Fortran compiler 10.1.013 using Microsoft Visual Studio 2005. (BAR7REV177)

SUMMARY OF AUGUST 2013 REVISIONS - VERSION 7.13.0.1

Since the release of BAR7 Version 7.13.0.0, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.13.0.1 contains the following revisions.

General Program Revisions

1. Add two values to the SLC Level field at the PROJECT IDENTIFICATION card. If the SLC level is expresses as a percent of Operating Rating Factor, enter the letter “A” followed by a two-digit number which indicate the percent of Operating Rating Factor that can be used in determining the Safe Load Capacity of the bridge. (BAR7REV197)

Program Revision

2. This program has been converted to Intel(R) Visual Fortran Compiler XE on IA-32, version 12.1.3 Package ID: w_fcompxe_2011.9.300 with Microsoft Visual Studio 2010. (BAR7REV198)

SUMMARY OF OCTOBER 2014 REVISIONS - VERSION 7.14.0.0

Since the release of BAR7 Version 7.13.0.1, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.14.0.0 contains the following revisions.

Programming Revisions

1. The method of calling the engineering program DLL from the Engineering Assistant has been changed for compatibility with EngAsst v2.5.0.0 which uses Microsoft's .NET Framework, version 4.5. Because of this, BAR7 will no longer work with EngAsst v2.4.0.6 or v2.4.0.9 unless the EngAsst "Edit / Run EXE - Command Window" option is selected. BAR7 will no longer work with EngAsst v2.4.0.0 and earlier.
2. The program has been compiled with Intel Visual Fortran compiler XE 12.1.3.300 [IA-32] using Microsoft Visual Studio 2010 version 10.0.40219.1. (BAR7REV201)

Input Revisions

3. Various new input items were added.
   PONY TRUSS field at the PROJECT IDENTIFICATION card
   PDF field at the PROJECT IDENTIFICATION card
   PATCH Field at the BRIDGE CROSS SECTION AND LOADING card
   Various fields at the ADDITIONAL TRUSS MEMBER PROPERTIES card
   Various fields at the CONCENTRATED PATCH LOADS card
   Various fields at the DISTRIBUTED PATCH LOADS card
4. Added an edit check to prevent users from entering 0 for span no in STEEL MEMBER PROPERTIES CARD. (BAR7REV189)
5. Added edit checks to prevent BAR7 from crashing unexpectedly if "L" is entered for LANES and the bridge type is "FSS", "GFF", "GFS", "GGF", "TFF", "TFS", or "TTT". For one loaded traffic lane if the traffic lane width (WIDTH) is greater than zero, then the percentage of the live load to be applied to the traffic lane, %LL, shall not be zero. Otherwise, the program crashes due to division by zero. For multiple loaded traffic lanes, the WIDTH and %LL of at least one loaded lane shall not be zero. It is possible that some lanes can have %LL = 0%. (BAR7REV190)

Load Rating Revisions

6. For the Load Factor method, the program now assumes the contribution of the bent up bars to the shear capacity (entered as shear area, Av, for R.C. slabs (Bridge Type = CSL)) applies only up to a distance based on d distance and ALPHA. (BAR7REV183)
7. Load Factor ratings are now provided for truss members with or without eccentricity. (BAR7REV191)

Load Revisions

8. Provided options to place uniform and/or concentrated loading on a bridge. The effects of these patch loads are considered as dead loads and are added into dead load effects for load rating analyses. (BAR7REV192)
9. Corrected an error that caused the program to abort when 6 Special Live Loads were entered. The number of special live loads was increased to 8. (BAR7REV185)
10. For the LIVE LOAD field of PROJECT IDENTIFICATION card, a new loading code, K, was added to automatically evaluate the HS, ML-80, TK527, PA58, and AASHTO Type 3 loadings. (BAR7REV199)

Output Revisions

11. For concrete bridges, the output format of the live load analysis results was revised. (BAR7REV184)
12. Corrected the member length calculation for the end post of Panel 0. The member length was reported in feet instead of inches. (BARREV187)
13. The PDF output file creation is now optional. (BAR7REV196)

Specification Revisions

14. Incorporated a top chord stability check for top chords and vertical chords at up to three floorbeam locations for pony trusses. (BAR7REV194)

SUMMARY OF JANUARY 2015 REVISIONS - VERSION 7.14.0.1

Since the release of BAR7 Version 7.14.0.0, several problem reports have been received. This release of BAR7 Version 7.14.0.1 contains the following revisions.

<u>Programming Revisions</u>

1. The member IDs and member forces reported for each plate location in the "Gusset Plates: DL & LL Forces and Angles" tables for truss panels with midpoints may be incorrectly matched. However, the correct member forces are used for the rating calculations. The output table has been corrected. (BAR7REV202)

2. For patch load analysis of girders, an incorrect array index for the end shears may result in an array bound error. The array index was corrected. (BAR7REV203)

3. Flange projection violations (888.88 F) in the detailed “Strength and Load Factor Ratings” tables were mistakenly not reported while a warning was displayed following the rating summary table at the end of the output file. The projection violations are now reported in the “Strength and Load Factor Ratings” tables. (BAR7REV204)

SUMMARY OF JUNE 2017 REVISIONS - VERSION 7.14.0.3

Since the release of BAR7 Version 7.14.0.1, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.14.0.3 contains the following revisions.

Load Revisions

1. Added a new live load code, L, at the PROJECTION IDENTIFICATION data card to automatically evaluate the load ratings of EV2, EV3, and SU6TV loadings per the FHWA load rating for FAST Act's emergency vehicles memo dated November 3, 2016 (BAR7REV215).

   EV2: single rear axle emergency vehicle

   Two axles: 24k – 15' – 33.5k

   EV3: tandem rear axle emergency vehicle

   Three axles: 24k – 15' – 31k – 4' – 31k

   SU6TV: heavy-duty tow and recovery vehicle

   11 axles: 5.75k – 10' - 8k – 4' - 8k – 4' – 25.63k – 4' – 25.63k – 4' - 8k – 14' – 8k – 4' - 8k – 4' - 17k – 4' - 17k – 4' - 8k

2. Added AASHTO Type 3-S2 and AASHTO Type 3-3 to the existing LIVE LOAD code, K, at the PROJECTION IDENTIFICATION data card (BAR7REV220)

SUMMARY OF FEBRUARY 2018 REVISIONS - VERSION 7.15.0.0

Since the release of BAR7 Version 7.14.0.3, several error reports and user requested enhancements have been received. This release of BAR7 Version 7.15.0.0 contains the following revisions.

General Program Revisions

1. **For bridge types of "FSS" & "GGF", the UNSYM PIER field at the column of 79 of the BRIDGE CROSS SECTION AND LOADING card was added to allow the user whether to implement one floorbeam analysis under unsymmetrical pier support configuration per BAR7 Run (BAR7REV193).**
2. **Increase the maximum number of FBs to be analyzed to 5 (from 3) and increase the maximum number of FB ranges to 9 (from 5) for symmetrical FB and to 18 (from 5) for unsymmetrical FB (BAR7REV209).**
3. **Increase user-input traffic lane locations from 6 to 7 in Traffic Lane Location data card and added an error message of "total lane width (xxxx.xx) in the Traffic Lane Locations card input shall be less than the roadway width (xxxx.xx) (BAR7REV211).**
4. **Added the warning message in subroutine XL_Brace.for 1. when PR10 is true (OUTPUT = A) and there is a governing positive moment and the top flange if not braced; 2. when PR10 is true and there is a governing negative moment and the bottom flange is not braced (BAR7REV213).**
5. **Corrected the mistake of the deck contribution areas for end exterior floorbeam when calculating the dead load reactions from the single-span stringer above acting to the floorbeams (BAR7REV218).**
6. **Added new rating factor codes to indicate whether the flange or web buckling controls in the final ratings in the Rating Summary (BAR7REV219).**
7. **This program has been converted to Microsoft Visual Studio Professional 2017 version 15.4.4 and Intel(R) Visual Fortran Compiler (2017 update 5) version 17.0.5.267 (IA-32) (BAR7REV221)**

Input Revisions

8. **Various new input items were added**
   COMPACT field at the PROJECTION IDENTIFICATION card
   UNSYM PIER field at the BRIDGE CROSS SECTION AND LOADING card
   UPC card = UNSYMMETRICAL PIER SUPPORT CONFIGURATION card
   LANE 7 at the TRAFFIC LANE LOCATIONS card
   SECTION SHAPE field at the STEEL MEMBER PROPERTIES card

Load Factor

9. For load factor method, add an input item, COMPACT, at the column 79 of the PROJECT IDENTIFICATION card to allow the user whether to implement the all-or-none compact requirements in the calculation of rating summary for stringers, floorbeams, and girders (BAR7REV206).

Load Revisions

10. For bridge type of “GGF” which has multiple beams (or stringers) supported by the floorbeams below, user shall use DL1 for stringer analysis using the girder subroutine and DL1ST was not used. DL1ST shall be used in the floorbeam analysis (the computation of DL1 concentrated dead load reactions acting on the floorbeams from stringers above) using the floorbeam subroutine. Therefore, for floorbeam analysis, if DL1ST was not entered by the user, DL1ST will be restored by the value of DL1 entered by the user (BAR7REV207).
11. Provide options to place uniform and/or concentrated patch loading on floorbeams of a bridge (BRA7REV208).
12. For steel members composited with the reinforced or non-reinforced concrete deck, the CONC DECK in the PROJECT IDENTIFICATION card shall be entered with a “Y” and the CONCRETE MEMBER PROPERTIES card shall be entered. If not, a warning message will be issued instead of issuing the error message to stop the BAR7 program because the previous existing incorrect code in APRAS. The integral wearing surface (default is 0.5”) entered by the user shall be deducted from the SLAB THICK in the BRIDGE CROSS SECTION AND LOADING card for the calculation of the section properties (BAR7REV210).

Box-shape Floorbeam

13. For bridge type of “FSS” or “GGF”, rating of non-composite, non-compact box-shape cross girders workaround using BAR7 program with I-shape beams with minor modifications on input. (BAR7REV216)

Output

14. For Output Option = 6 (fatigue estimation only) and PDF = Y, the result shall produce the pdf output (BAR7REV205).
15. Instead of printing the special live output based on the sequence of input in the data file, program shall print the special live output based on their Special Live Load IDs (BAR7REV212).

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1 GENERAL DESCRIPTION

1.1 PROGRAM IDENTIFICATION

PROGRAM TITLE: Bridge Analysis and Rating

PROGRAM NAME: BAR7

VERSION: 7.15.0.0

SUBSYSTEM: Superstructure

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Pennsylvania Department of Transportation

ABSTRACT:

BAR7 is the enhanced version of the Bridge Analysis and Rating computer program developed by the Pennsylvania Department of Transportation to aid bridge engineers in analyzing a highway bridge to determine its load carrying capacity and to estimate its fatigue life. The results of the structural analysis performed by BAR7 can be utilized for load rating, rehabilitation or design of a bridge. BAR7 can analyze a simple span reinforced concrete T-beam bridge or a slab bridge and a simple or continuous span steel bridge comprising of a deck, stringers, floorbeams and girders or trusses. BAR7 can also analyze girders with in-span hinges and cantilever trusses. Computed values include reactions, moments, shears, strengths, truss member forces, stresses, deflections, rating factors, influence line ordinates for various effects at different sections and an estimated fatigue life of a steel girder or a truss. All members of the bridge are analyzed and then rated for a set of standard live loadings or special live loadings using both the Allowable Stress and Load Factor Methods in a single run. The structural and rating analyses are performed in accordance with the AASHTO Manual for Maintenance Inspection of Bridges and the AASHTO Specifications for Highway Bridges. The fatigue life analysis is performed in accordance with the Pennsylvania Department of Transportation Design Manual Part 4. The gusset plate analysis and rating for a truss bridge is performed in accordance with the LFR (Load Factor Rating) procedures described in the FHWA Publication "Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges". The pony truss stability check is performed in accordance with the LFR (Load Factor Rating) procedures described in the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges.

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, 1996. 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

AASHTO Guide Spec for Pedestrian Bridges

AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, December 2009

AASHTO Guide Spec for Truss

AASHTO Guide Specifications for Strength Design of Truss bridges (Load Factor Design) 1985

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

FHWA - Federal Highway Administration

PennDOT - Pennsylvania Department of Transportation.

2 PROGRAM DESCRIPTION

2.1 GENERAL

Rating a bridge for its capacity to carry the live load safely and to provide a useful service requires a careful evaluation of many complex factors. This evaluation must include a complete detailed analysis of the structure using some established standard. The objective of this program is to aid the bridge engineer in performing the analysis required to determine the live load capacity rating and the fatigue life of a bridge using the standards provided by the AASHTO Manual for Maintenance Inspection of Bridges, the 1996 AASHTO Specifications for Highway Bridges, and the Pennsylvania Department of Transportation Design Manual Part 4.

For this manual, the AASHTO Manual for Maintenance Inspection of Bridges will be referred to as AASHTO Manual, the 1996 AASHTO Specifications for Highway Bridges will be referred to as AASHTO Specifications, and the Pennsylvania Department of Transportation Design Manual Part 4 will be referred to as DM4. For further information about bridge rating, refer to these publications.

The rating of a bridge is determined using a group of specified loads and a predetermined stress level to which the structure may be subjected to, considering the specified traffic condition. The two stress levels used for this purpose are called the Inventory stress and the Operating stress. The Inventory stress is the lower stress level to which the structure may be subjected to for an indefinite period. The Operating stress is the upper stress level and it is the absolute maximum stress allowed on the structure.

The traffic conditions used for this analysis are the number of design traffic lanes the bridge can carry in accordance with the AASHTO Manual and the number of traffic lanes that are in service or to be loaded. The ratings are computed in accordance with the requirements of the AASHTO Manual and the criteria established by the Pennsylvania Department of Transportation.

The ratings are computed based on flexural stresses for a beam type member (such as a girder, stringer, floorbeam, concrete slab, or concrete T-beam) and based on axial stresses or combined axial and bending stresses for a truss member. Both the Allowable Stress Method and the Load Factor Method are used to compute the ratings

The program can analyze a bridge as it exists or as defined (rehabilitated) by the engineer. Thus, the analysis results can be used for bridge rating or for bridge rehabilitation projects.

2.2 RATINGS DEFINED

The program computes five types of ratings of a bridge. These ratings are based on different combinations of allowable stresses and traffic conditions. The first two ratings are as per requirements of the AASHTO Manual. The next three ratings are given as an option. The five types of ratings are defined below.

2.2.1 Inventory Rating (Design)

This 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 (DESIGN) in the Rating Summary.

2.2.2 Operating Rating (Design)

This is the load that may produce the absolute maximum permissible stress and it is the maximum load allowed on a structure. This rating is based on the Operating stress or strength and the number of design traffic lanes positioned and loaded as specified in the AASHTO Manual. This is printed as OR (DESIGN) in the Rating Summary.

2.2.3 Safe Load Capacity

This 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 that is determined by the engineer and the traffic lanes that are in service. This is referred to as SLC and is printed in the Rating Summary.

2.2.4 Inventory Rating (Loaded)

This is the rating based on the Inventory stress level and the number and positions of traffic lanes to be loaded as defined by the engineer. This is printed as IR (LOADED) in the Rating Summary.

2.2.5 Operating Rating (Loaded)

This is the rating based on the Operating stress level and the number and positions of traffic lanes to be loaded as defined by the engineer. This is printed as OR (LOADED) in the Rating Summary.

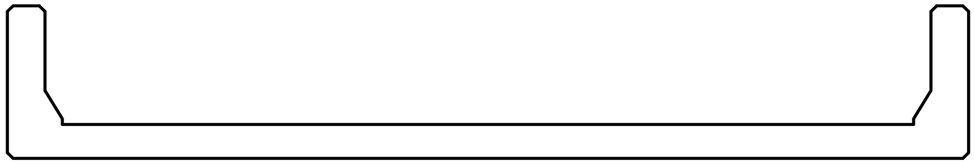
2.3 BRIDGE TYPES

The ratings defined above can be obtained for the following types of bridges. For this program, each bridge type is designated by a three-character code (given in parenthesis below). This manual will refer to each bridge type by this code. The types of bridges that can be analyzed and rated using this program are:

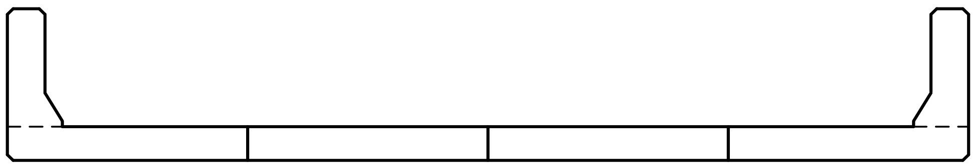
1. Single span Precast Concrete Slab Bridge (CPL). See Figure 2.3.1 on page 2-5.
2. Single span Concrete Slab Bridge (CSL). See Figure 2.3.1 on page 2-5.
3. Single span Concrete T-beam Bridge (CTB). See Figure 2.3.1 on page 2-5.
4. Encased I Beam (EIB). In this type of bridge, the steel I section beam is completely or partially encased in the concrete deck. The beams encased in concrete are either shored or unshored during construction. The program assumes an encased I-beam as a composite section neglecting concrete below the neutral axis of the composite section. The encased I-beam can be considered composite only if there is sufficient reinforcement wrapped around the beam to provide composite action between the beam and slab concrete. See Figure 2.3.3 on page 2-7.
5. Floorbeam-Stringer Type Bridge (FSS). In this type of bridge, the deck is supported by the floorbeams and the stringers, and the floorbeam is supported by two columns. The limitations on the floorbeam and stringer are the same as for the bridge type "GFS" or "TFS", and the floorbeam may not be supported by more than two columns. Box-shaped steel cross girder/floorbeam are considered as non-composite, non-compact only. See Figure 2.3.5 on page 2-9.
6. Girder-Floorbeam Type Bridge (GFF). In this type of bridge, the deck is supported by the floorbeams and there are no stringers. The limitations on the girder and floorbeam are the same as for the bridge type "GFS". See Figure 2.3.2 on page 2-6.
7. Girder-Floorbeam-Stringer Type Bridge (GFS). In this type of bridge, the main girder and stringer may have a maximum of fifteen simple or continuous spans. Except for box-shaped steel cross girder/floorbeam, the main girder and floorbeam may be composite or non-composite with variable or uniform cross section. The stringer must have a uniform cross section. See Figure 2.3.2 on page 2-6.
8. Multigirder-Floorbeam Type Bridge (GGF). In this type of bridge, the deck is supported by beams or girders that span over floorbeams. The floorbeam is supported by two columns. The limitations on the girder are the same as for the bridge type "GGG", and the floorbeam may not be supported by more than two columns. Box-shaped steel cross girder/floorbeam are considered as non-composite, non-compact only. See Figure 2.3.5 on page 2-9.
9. Multigirder Steel Bridge (GGG) with a maximum of fifteen simple or continuous spans and either composite or non-composite cross-section. See Figure 2.3.1 on page 2-5.
10. Truss-Floorbeam Type Bridge (TFF). In this type of bridge, the deck is supported by the floorbeams and there are no stringers. The limitations on the truss are the same as for the bridge type "TFS". The limitations on the floorbeam are the same as for the bridge type "GFS". See Figure 2.3.4 on page 2-8.
11. Truss-Floorbeam-Stringer Type Bridge (TFS). A single span truss or a continuous truss with two to fifteen spans may be analyzed. The total number of panels in a truss is limited to ninety-nine (99). The truss must

be statically determinate internally. Only single span trusses may have counters (diagonal members that can carry only tension force). Truss members can carry the axial stress and the combined axial and bending stress due to the eccentricity of end connections. The limitations on the stringer and floorbeam are the same as for the bridge type "GFS". See Figure 2.3.4 on page 2-8.

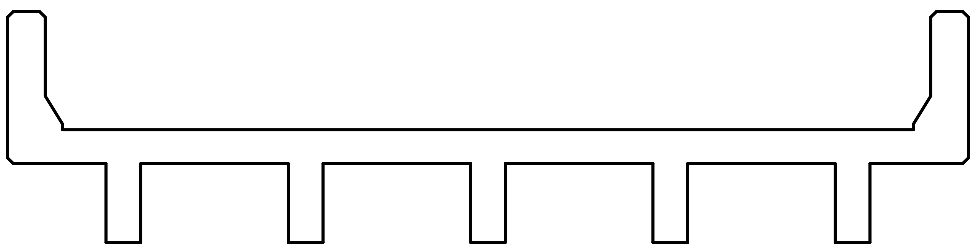
12. Truss-Floorbeam-Stringer Type Bridge (TTT). This is the same as TFS without floorbeam and stringer analyses.



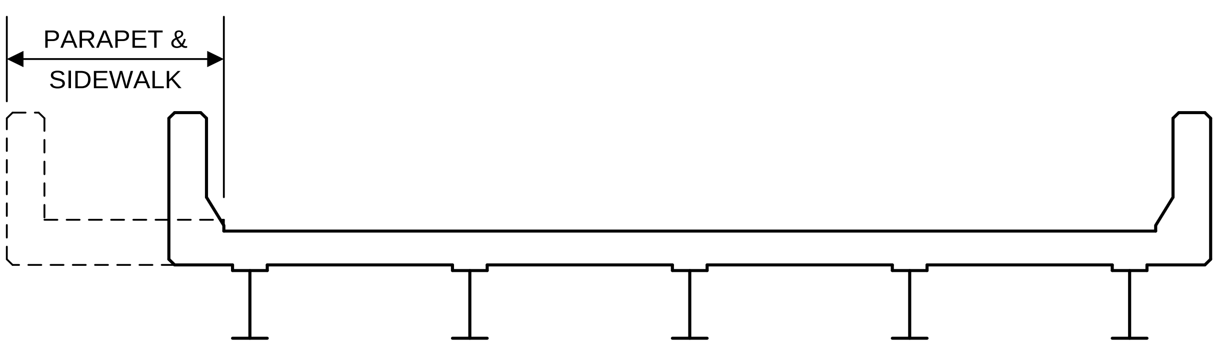
CONCRETE SLAB BRIDGE - TYPE "CSL"



PRECAST CONCRETE SLAB BRIDGE - TYPE "CPL"

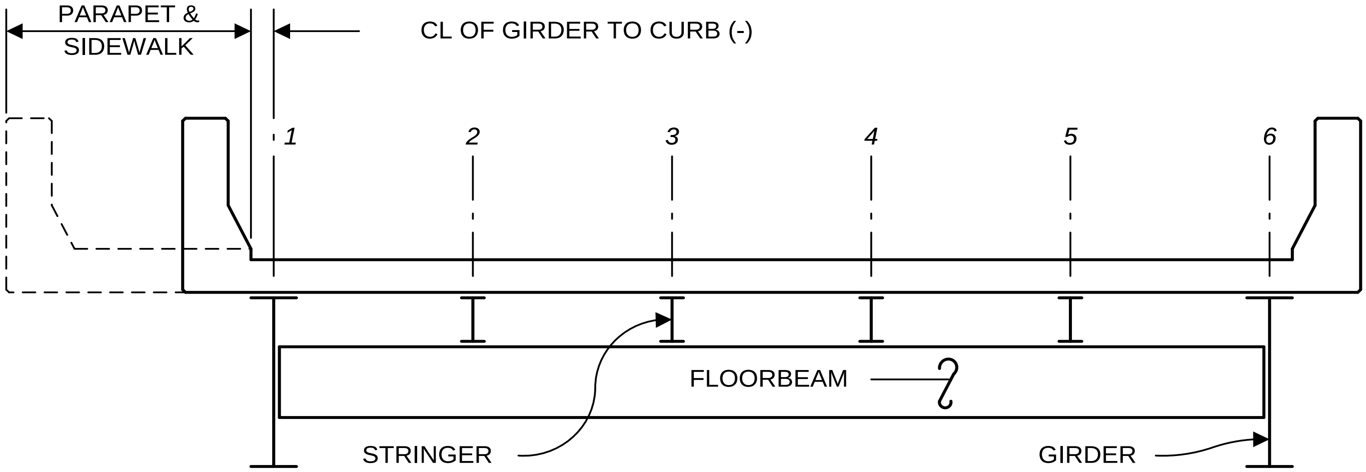


CONCRETE T-BEAM BRIDGE - TYPE "CTB"

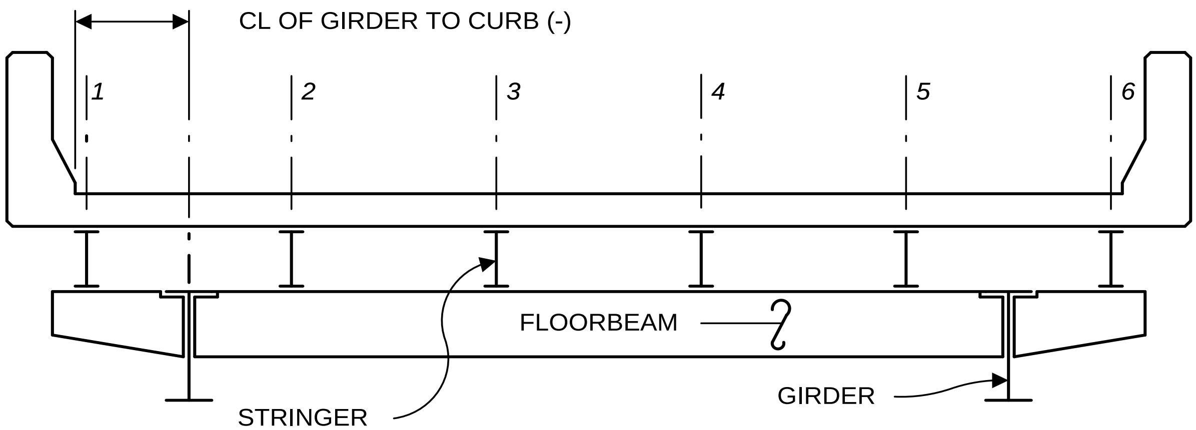


MULTIGIRDER STEEL BRIDGE - TYPE "GGG"

Figure 2.3.1 Bridge Types "CSL", "CPL", "CTB", and "GGG"



GIRDER FLOORBEAM STRINGER STEEL BRIDGE - TYPE "GFS"



GIRDER FLOORBEAM STRINGER STEEL BRIDGE - TYPE "GFS"

GIRDER FLOORBEAM STEEL BRIDGE - TYPE "GFF"

Figure 2.3.2 Bridge Types "GFS" and "GFF"

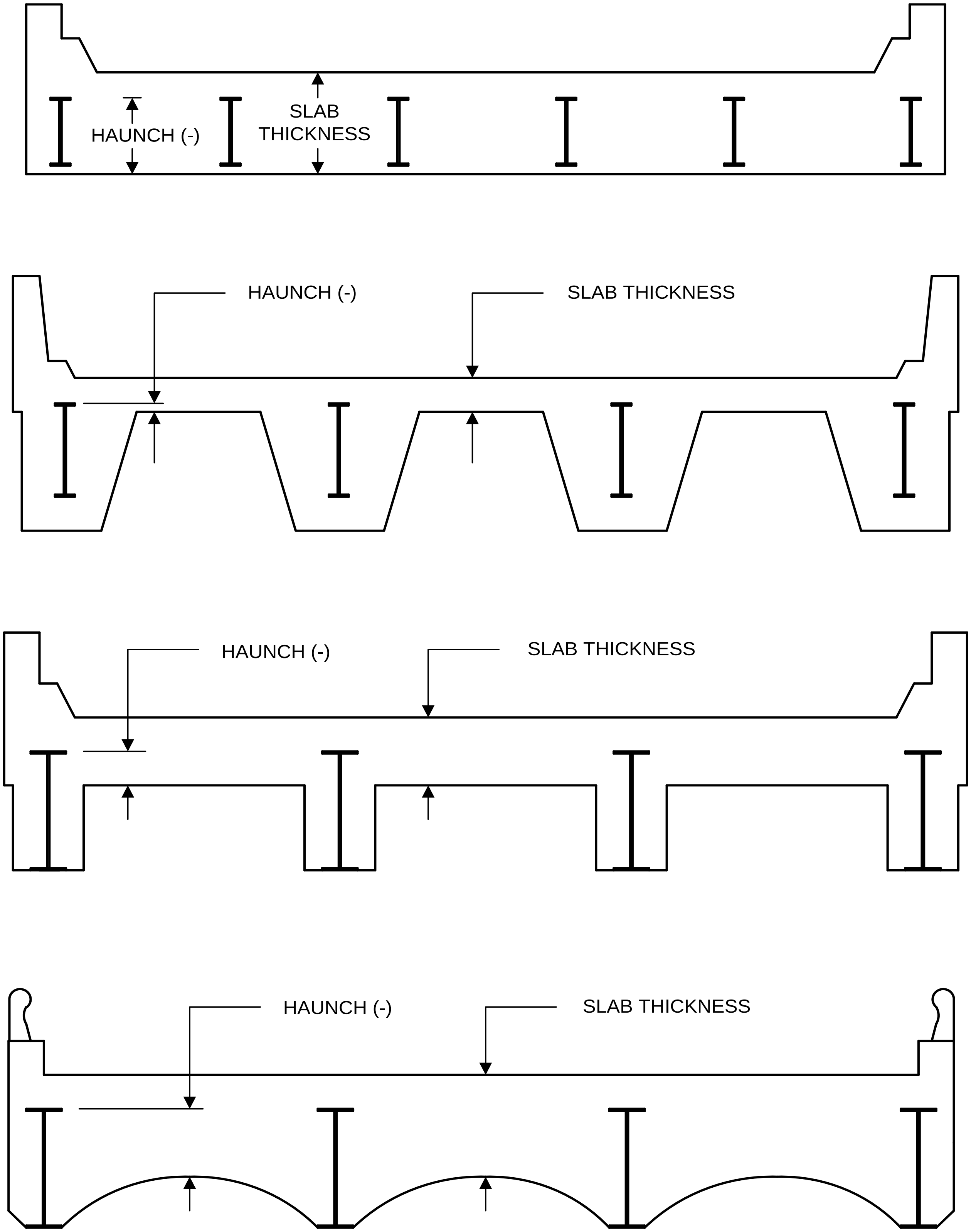
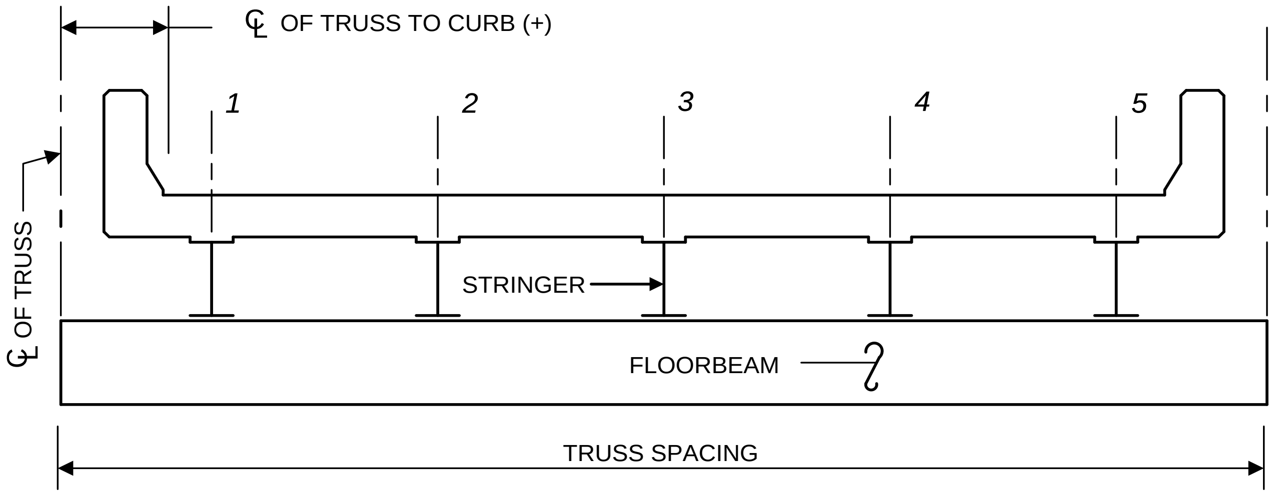
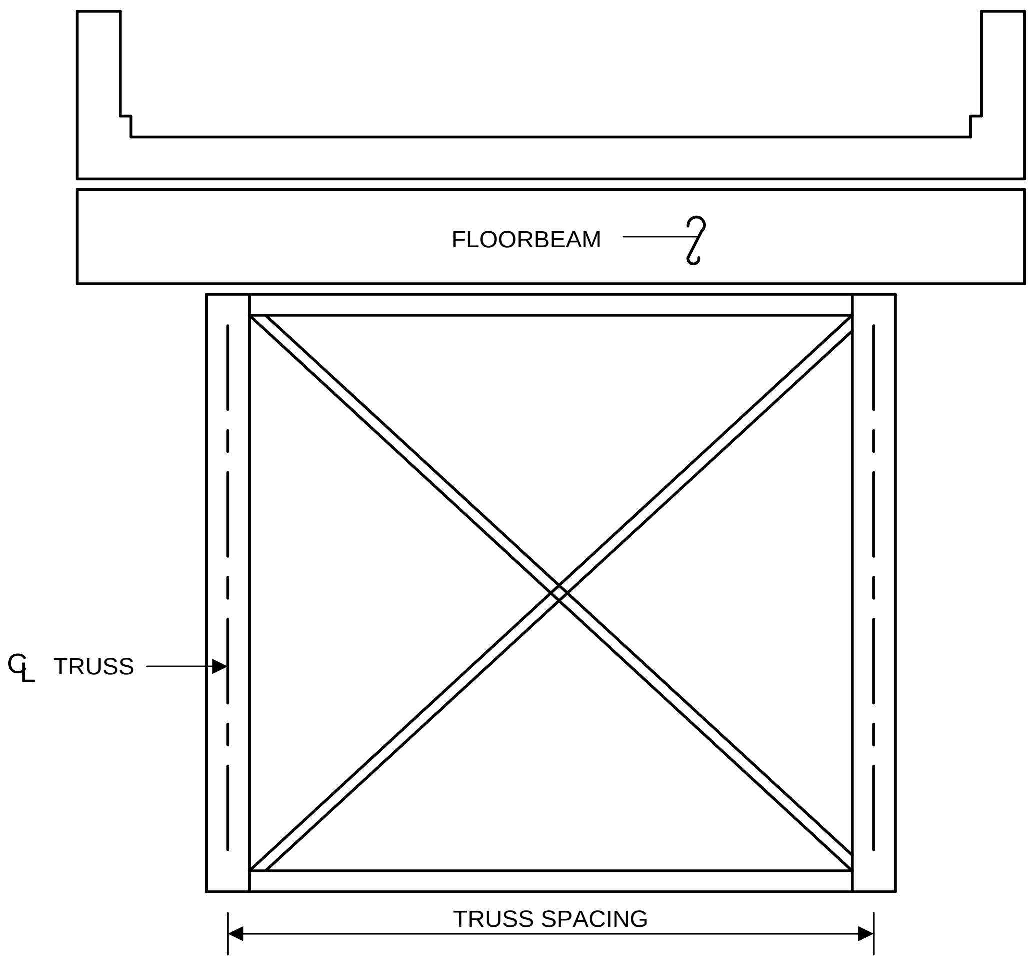


Figure 2.3.3 Bridge Type "EIB"

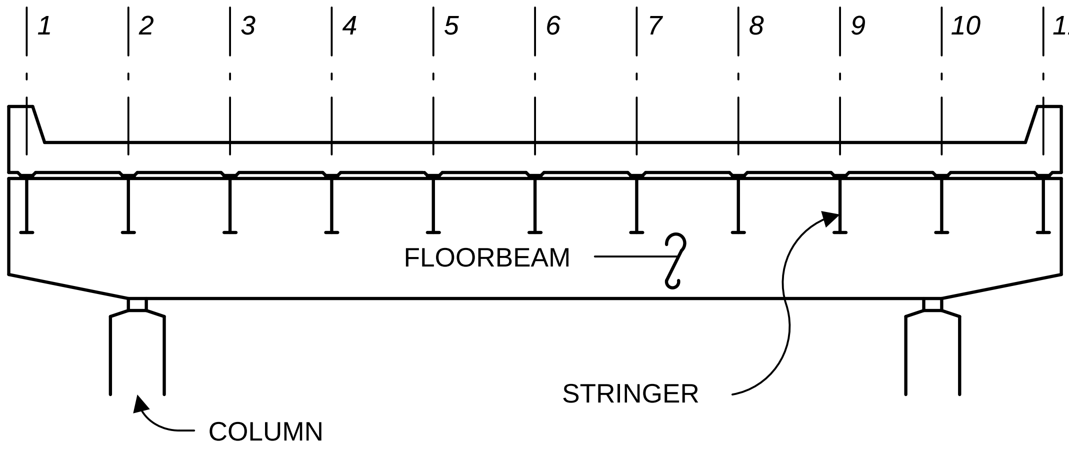


TRUSS FLOORBEAM STRINGER STEEL BRIDGE - TYPE "TFS"

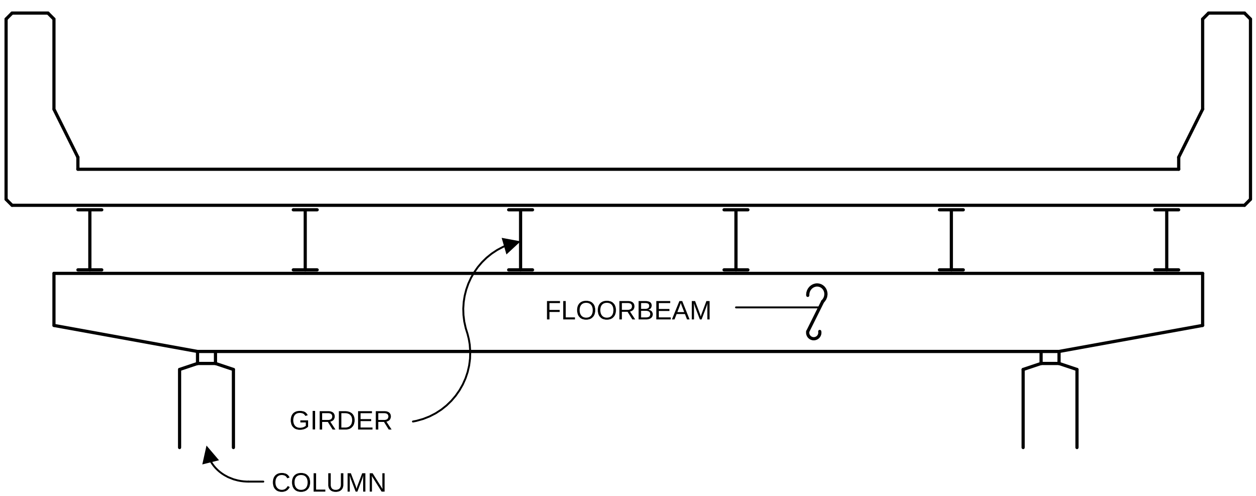


TRUSS FLOORBEAM STEEL BRIDGE - TYPE "TFF"

Figure 2.3.4 Bridge Types "TFS" and "TFF"



FLOORBEAM STRINGER STEEL BRIDGE - TYPE "FSS"



MULTIGIRDER FLOORBEAM STEEL BRIDGE - TYPE "GGF"

Figure 2.3.5 Bridge Types "FSS" and "GGF"

2.4 LIVE LOADINGS

Fifteen standard live loadings (LIVE LOAD = A to T) are built into the program. These are designated as H20, HS20, HS25, AML (Alternate Military Load), IML (Increased Military Load), ML80, TK527, P-82 (204 Kips Permit Vehicle), Type 3 Unit, Type 3S2 Unit, Type 3-3 Unit, PA58, EV2 (FAST Act Emergency Vehicle), EV3 (FAST Act Emergency vehicle), and SU6TV (FAST Act Heavy-Duty Tow and Recovery Vehicle). See Figure 2.4.1 on page 2-11. The loadings H20 and HS20 are described in the AASHTO Specifications. An ML80 is the maximum legal load in Pennsylvania. The TK527 is a new posting vehicle effective January 1, 2002. **The axle weights of ML80 and TK527 include 3% additional for scale tolerance.** The Type 3 **Unit**, Type 3S2 **Unit**, and Type 3-3 **Unit** are AASHTO typical legal loads **which controls weight limits for short-span, medium-span, and long-span bridges, respectively**. The PA58 is for risk-based posting. EV2, EV3, and SU6TV are described in FAST Act effective December 4, 2015. 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 a bridge for different groups of these loadings. These options are explained in the Chapter 5 Input Data Requirements of this manual.

In place of standard loadings described above, the bridge can also be analyzed for a maximum of eight special loadings that can be described by entering various parameters of the loadings. This may be useful in analyzing a permit load or a set of loadings customized by the user when it may be necessary to consider more than one unit of standard loading in a lane. A special live load may have 2 to 80 axles for a truck loading and an associated lane loading.

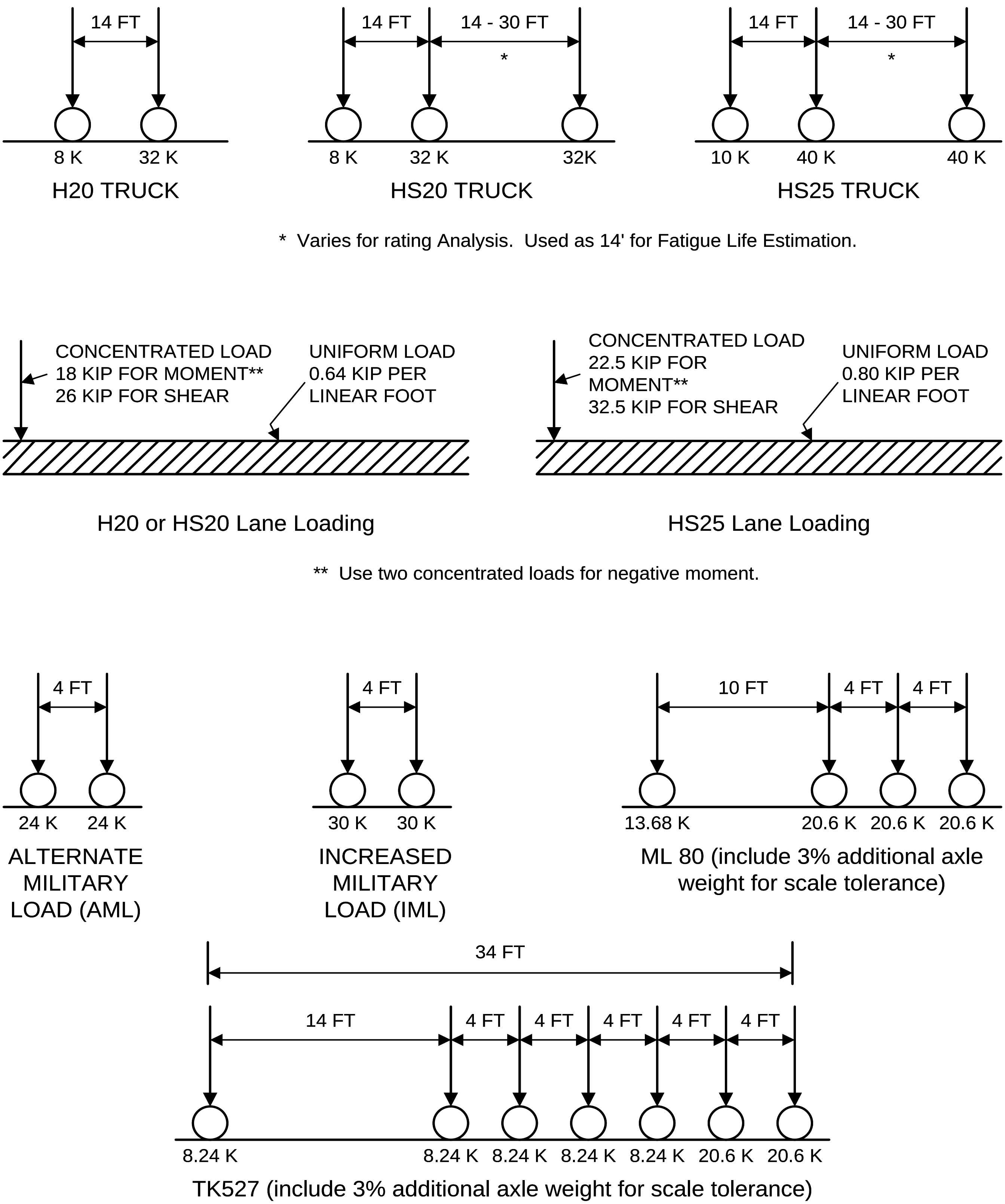
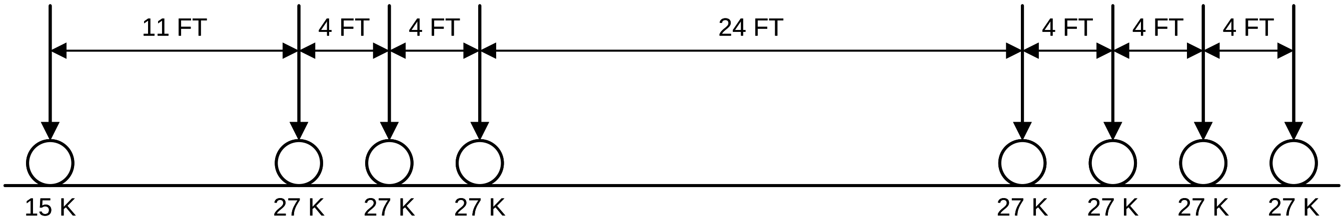
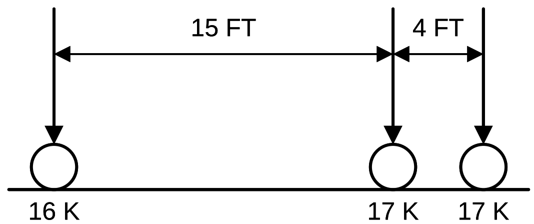


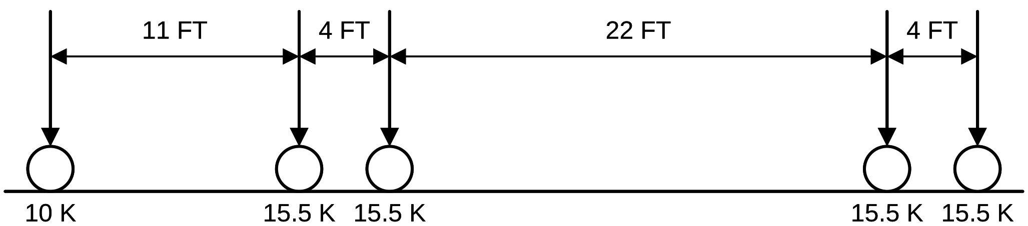
Figure 2.4.1 Standard Live Loadings



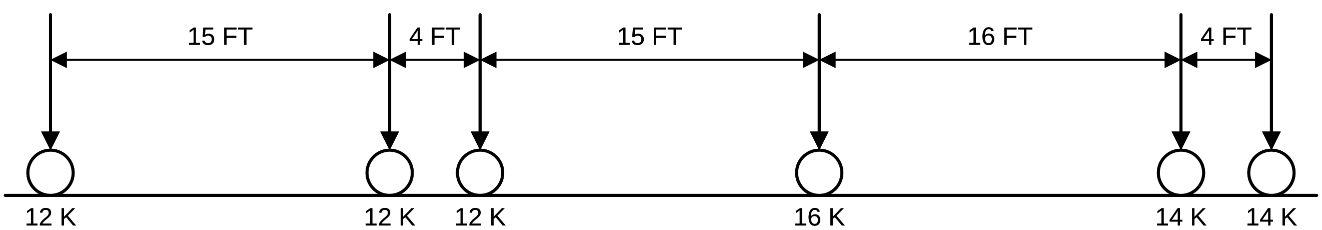
P-82
204 KIPS PERMIT VEHICLE



Type 3 Unit (25T)



Type 3S2 Unit (36T)



Type 3-3 Unit (18+22=40T)

Figure 2.4.1 Standard Live Loadings (cont'd)

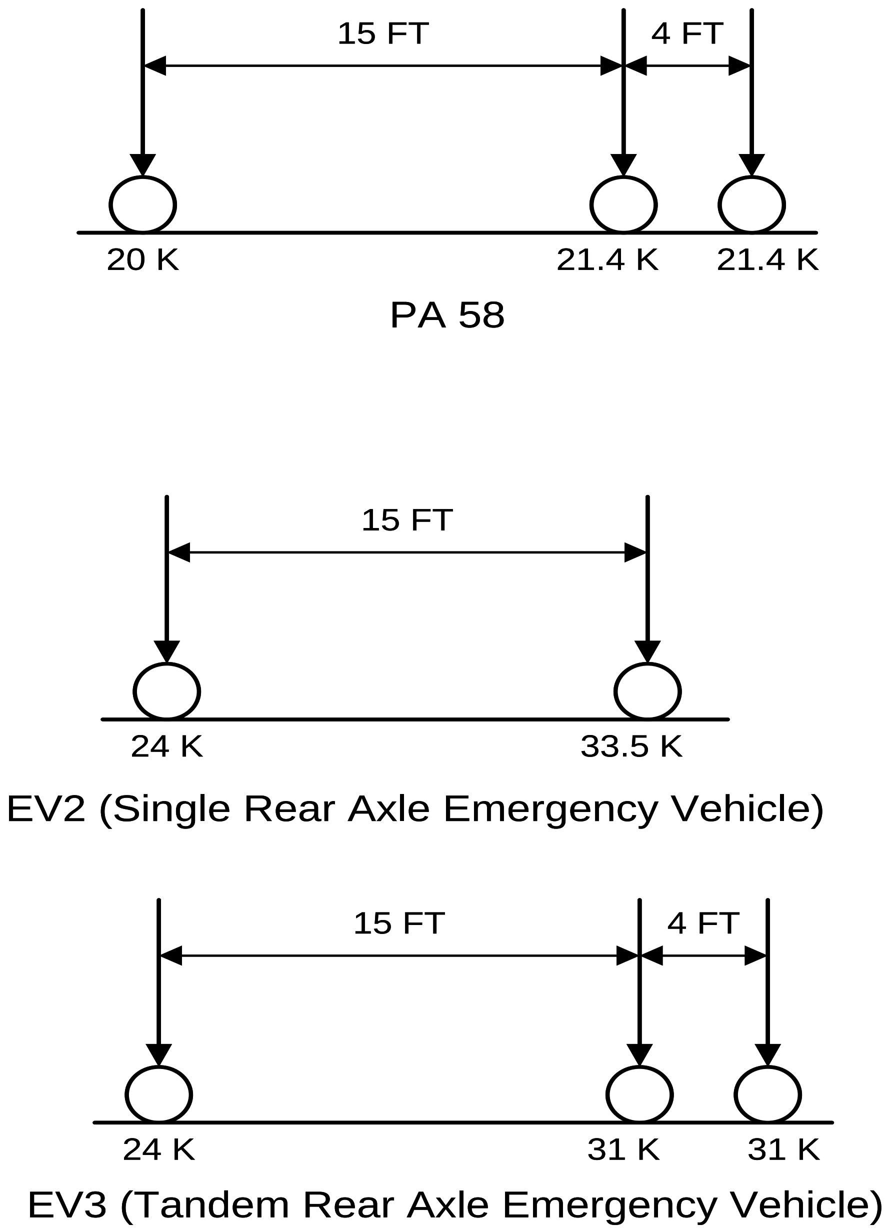


Figure 2.4.1 Standard Live Loadings (cont'd)

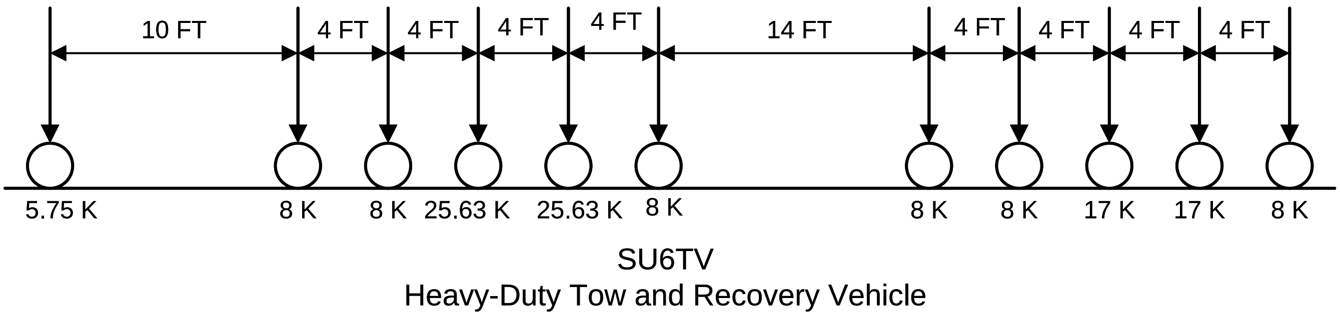


Figure 2.4.1 Standard Live Loadings (cont'd)

3 METHOD OF SOLUTION

The primary purpose of this program is to calculate the load ratings of a bridge in accordance with the AASHTO Manual. The load ratings are calculated by performing the structural analysis of all primary members of a bridge. This structural analysis is referred to as the rating analysis. The rating analysis is performed by carrying out the following calculations.

1. Calculate Section Properties.
2. Calculate Dead Load Effects.
3. Calculate Maximum Live Load Plus Impact Effects.
4. Calculate Member Stresses and Strengths.
5. Rate Section by criteria set forth in AASHTO Manual.

The program performs above calculations using the classical methods of structural analysis. The program employs the principles of statics for simple span girders and trusses, and the flexibility matrix method for a continuous girder or truss. The live load analysis is performed using the influence line method. The ratings are computed based on the Allowable Stress Method and the Load Factor Method.

Chapter 3 Method of Solution

3.1 NOTATIONS

The following are the meanings of notations used in various expressions in this section.

A	=	Area of cross section under consideration.
A_b	=	Area of I-beam.
A_c	=	Area of cross section of R.C. Slab, Precast Slab, or R.C. T-Beam.
A_f	=	Area of flange.
A_f	=	Area of one fastener, bolt or rivet.
A_g	=	Total gross area of steel for all elements.
A_i	=	Area of steel for element i.
A_n	=	Area of net section.
A_s	=	Area of tension reinforcement.
A_{sf}	=	Area of reinforcement to develop compressive strength of overhanging flanges of I- and T-sections.
A_s'	=	Area of compression reinforcement.
A_{vb}	=	Area of shear reinforcement (bent up bars).
A_{vs}	=	Area of shear reinforcement (both legs of stirrup).
ADTT	=	Average daily truck traffic.
b	=	Web thickness of R.C. T-beam.
b	=	Beam flange width.
b_w	=	Web thickness of concrete member.
b'	=	Width of projecting flange element.
B	=	Effective width of slab.
c	=	Distance from the extreme bottom fiber of steel to the neutral axis of the steel section of encased I-beam.
C	=	Web buckling coefficient.
C_b	=	Moment correction factor
C_{bot}	=	Distance from the extreme bottom fiber of steel to the neutral axis.
C_{conc}	=	Distance from the extreme fiber of concrete to the neutral axis.
C_m	=	Bending compression interaction coefficient.
C_{reinf}	=	Distance from the centroid of reinforcement to the neutral axis.
C_{top}	=	Distance from the extreme top fiber of steel to the neutral axis.
d	=	Distance from extreme compression fiber to centroid of tension reinforcement.
d	=	Depth of steel beam or girder.
d	=	Depth of encased I-beam.
d	=	Nominal diameter of the fastener.
d'	=	Distance from extreme compression fiber to centroid of compression reinforcement.
d'	=	Distance from bottom of encased I-beam to bottom of slab.
d_i	=	Distance from center of gravity of element i to the bottom.
d_0	=	Spacing of intermediate stiffener.

D	=	Clear, unsupported distance.
D_c	=	Clear distance between the elastic neutral axis and the compression flange.
D_{cp}	=	Clear distance between the plastic neutral axis and the compression flange.
D_p	=	Distance from top of slab to plastic neutral axis.
D'	=	Distance from the top of the slab to the neutral axis at which a composite section in positive bending theoretically reaches its plastic moment capacity.
DF_1	=	Distribution factor for one lane.
E_s	=	Effective slab width of R.C. T–beam.
E	=	Modulus of elasticity.
f_a	=	Allowable stress in bending.
f_c'	=	Specified compressive strength of concrete.
f_{cir}	=	Allowable stress in concrete for inventory rating.
f_{cor}	=	Allowable stress in concrete for operating rating.
f_{DL1}	=	Stress due to non-composite dead load.
f_{DL2}	=	Stress due to composite dead load.
f_{LL+I}	=	Stress due to live load plus impact.
f_{max}	=	Maximum flange stress.
f_{sir}	=	Allowable stress in steel for inventory rating.
f_{sor}	=	Allowable stress in steel for operating rating.
f_{sr}	=	Stress in reinforcement steel.
f_v	=	Shear stress.
F	=	Maximum compressive stress due to moment-shear interaction.
F_{bx}	=	Allowable compressive stress in partially supported or unsupported compression flange.
F_{bt}	=	Allowable compressive stress in a "T" section composed of the compression flange and 1/3 of the compression part of the web.
F_{CIR}	=	Allowable force in truss member for inventory rating.
F_{COR}	=	Allowable force in truss member for operating rating.
F_{DL}	=	Truss member force due to dead load.
F_{LL+I}	=	Truss member force due to live load plus impact.
F_{sr}	=	Allowable fatigue stress range.
F_u	=	Specified minimum tensile stress.
F_V	=	Allowable shear stress.
F_{vir}	=	Allowable shear stress for inventory rating.
F_{vor}	=	Allowable shear stress for operating rating.
F_y	=	Specified minimum yield point of the steel.
GF	=	ADTT growth factor for the future.
GF_1	=	ADTT growth factor for the past.
h	=	Depth of concrete T-beam.

I_b = Moment of inertia of basic steel section for encased I-beam.

I_c = Moment of inertia of cracked section for encased I-beam.

I_i = Moment of inertia of element i.

I_U = Moment of inertia of uncracked section for encased I-beam.

I_{xx} = Moment of inertia of section about the X-X axis.

I_{yy} = Moment of inertia of section about the Y-Y axis.

I_{yc} = Moment of inertia of compression flange about the vertical axis in the plane of the web.

IM = Vehicular dynamic load allowance

IR = Inventory rating factor.

J = $[(bt^3)_c + (bt^3)_t + Dt_w^3]/3$, where b and t represent the flange width and thickness of the compression and tension flange, D is the web depth, and t_w is the web thickness.

k = Buckling coefficient.

L = Length of unsupported flange between lateral connections, knee braces, and or other points of support.

L_b = Unbraced length.

m = Number of years between year built and year of ADTT count for fatigue analysis.

M = Maximum bending moment.

M_c = Moment capacity of the section.

M_{CIR} = Moment capacity of the section for inventory rating.

M_{COR} = Moment capacity of the section for operating rating.

M_{DL} = Moment due to dead load.

M_{DL1} = Moment due to non-composite dead load.

M_{DL2} = Moment due to composite dead load.

M_{LL+I} = Moment due to live load plus impact.

M_O = Moment strength based on overload provisions.

M_P = Full plastic moment of section.

M_U = Maximum bending strength.

M_{UD} = Maximum bending strength for deck.

M_{UT} = Maximum bending strength for tension.

M_Y = Moment capacity at first yield of the composite positive moment section, F_y times S_{LL+I}.

M_1 = Smaller moment at the end of the unbraced length.

M_2 = Larger moment at the end of the unbraced length.

n = Ratio of modulus of elasticity of steel to that of concrete.

n_1 = Year of first ADTT count for fatigue life analysis.

n_2 = Year of second ADTT count for fatigue life analysis.

OR = Operating Rating factor.

r ’ = Radius of gyration of the compression flange about the Y-Y axis of web.

r_t = Radius of gyration of a T-section comprising flange and one-third of the web in compression.

r_y = Radius of gyration of the entire section about the Y-Y axis.

R = Remaining fatigue life in years.

R = Reduction factor for hybrid section.

R = Reduction factor for allowable compression in unbraced section.

RF = Rating factor.

RF_M = Rating factor for moment.

RF_{MC} = Rating factor for moment, compression flange yielding.

RF_{MD} = Rating factor for moment, concrete in deck yielding.

RF_{MT} = Rating factor for moment, tension flange yielding.

RF_{MV} = Rating factor for moment-shear interaction.

RF_O = Rating factor based on overflow provisions.

RF_V = Rating factor for shear.

s = Stirrup spacing.

S = Section modulus.

S_B = Section modulus for bottom fiber of steel section.

S_C = Section modulus for top fiber of concrete.

S_{DL1} = Section modulus for non-composite dead load.

S_{DL2} = Section modulus for composite dead load.

S_{LL+I} = Section modulus for live load plus impact.

S_R = Section modulus for steel reinforcement in composite section.

S_S = Section modulus for tension steel in concrete slab or T-beam.

S_{SC} = Section modulus for compression steel in concrete slab.

S_T = Section modulus for top fiber of steel section.

SL = Safe load capacity.

SLC = Safe load capacity rating factor.

S_{xC} = Section modulus with respect to the compression flange.

t = Flange thickness.

t = Effective slab thickness.

t = Thickness of the connected material.

t_s = Slab thickness.

t_w = Web thickness.

v = Shear stress at a section.

v_c = Allowable shear stress in concrete.

v_{cir} = Permissible shear stress carried by concrete for inventory rating.

v_{cor} = Permissible shear stress carried by concrete for operating rating.

v_s = Allowable shear stress in steel.

V = Shearing force.

V_C = Shear capacity of a section.

V_{CIR} = Shear capacity of a section for inventory rating.

V_{COR} = Shear capacity of a section for operating rating.

V_{DL} = Shear due to dead load.

V_{DL1} = Shear due to non-composite dead load.

V_{DL2} = Shear due to composite dead load.

V_{LL+I} = Shear due to live load plus impact.

V_P = Shear yielding strength of the web.

V_{sir} = Nominal shear strength provided by shear reinforcement for inventory rating.

V_{sor} = Nominal shear strength provided by shear reinforcement for operating rating.

V_U = Shear capacity of a section.

w = Effective width of composite section for encased I-beam divided by modular ratio n.

x = Depth of neutral axis for reinforced concrete section.

x = Location of neutral axis of a steel section measured from the bottom of the section.

x_i = Location of neutral axis of element i.

y_{tc} = Depth of uncracked section of encased I-beam.

Z = Plastic section modulus.

α = Angle of bent up bars to be used as shear reinforcement.

α = Factor for effective fatigue stress range.

γ = Summation factor for effective fatigue stress range.

Δ = Remaining fatigue cycles.

λ = Projected fatigue cycles.

3.2 SECTION PROPERTIES

Section properties are required to solve for reactions in a continuous member and to calculate deflections, stresses and strengths for all members. Various section properties (cross sectional area, moment of inertia, section moduli, etc.) are computed from the dimensions entered through input forms provided for various members of a bridge. The program will compute the section properties on both sides of the cutoff for analyzing and rating each section. Direct formulas and iterative processes are used for calculations of these properties as explained in this section.

3.2.1 R. C. Slab and Precast Concrete Slab

Refer to Figure 3.2.1 on page 3-9.

The cross-sectional area to be used in calculating the weight of the member is calculated by:

$$A_c = \frac{(B)(t_s)}{144.}$$ where B = 12.0” for R. C. Slab

The depth of neutral axis, x, is computed by solving the following equation:

$$\tfrac{1}{2} B x^2 + [(2n-1)A_s' + nA_s]x - (2n-1)A_s'd' - nA_s d = 0$$

The moment of inertia of transformed section (steel areas converted into equivalent concrete area) is computed by:

$$I_c = \tfrac{1}{3} Bx^3 + (2n-1)A_s'(x-d')^2 + nA_s(d-x)^2$$

The section modulus for top fiber of concrete is computed by:

$$S_c = \frac{I_c}{x}$$

The section modulus for tension steel is computed by:

$$S_s = \frac{I_c}{n(d-x)}$$

The section modulus for compression steel (if present) is computed by:

$$S_{sc} = \frac{I_c}{2n(x-d')}$$

3.2.2 R. C. T-Beam

Refer to Figure 3.2.1 on page 3-9.

Effective slab width, E_s, is computed as the minimum of the following three values:

1. Center-to-center spacing of beams in inches.
2. 12 (t) + b where b = web thickness.
3. One-fourth the span length in inches.

The cross-sectional area to be used in calculating the weight of the member is calculated by:

$$A_c = (h - t_s)(b) + (spacing)(t_s)$$

The initial depth of neutral axis, x_i is computed neglecting the area of web above the neutral axis:

$$x_i = \frac{\frac{1}{2}(E_s)t^2 + (2n-1)A_s'd' + nA_s d}{E_s t + (2n-1)A_s' + nA_s}$$

If x_i is less than or equal to t, the actual depth of neutral axis, x, is computed by solving the following equation:

$$\frac{1}{2}E_s x^2 + [(2n-1)A_s' + nA_s]x - (2n-1)A_s'd' - nA_s d = 0$$

If x_i is greater than t, the actual depth of neutral axis, x, is computed by solving the following equation:

$$\frac{1}{2}(b)x^2 + [E_s t - (b)t + (2n-1)A_s' + nA_s]x - \frac{1}{2}(E_s)t^2 - (2n-1)A_s'd' - nA_s d = 0$$

The moment of inertia of the section is computed by:

$$I_c = \frac{1}{12}E_s t^3 + E_s t(x - \frac{t}{2})^2 + \frac{1}{3}(b)(x-t)^3 + (2n-1)A_s'x - d')^2 + nA_s(d-x)^2$$

Various section moduli are then computed using the equations given in Section 3.2.1, R. C. Slab and Precast Concrete Slab.

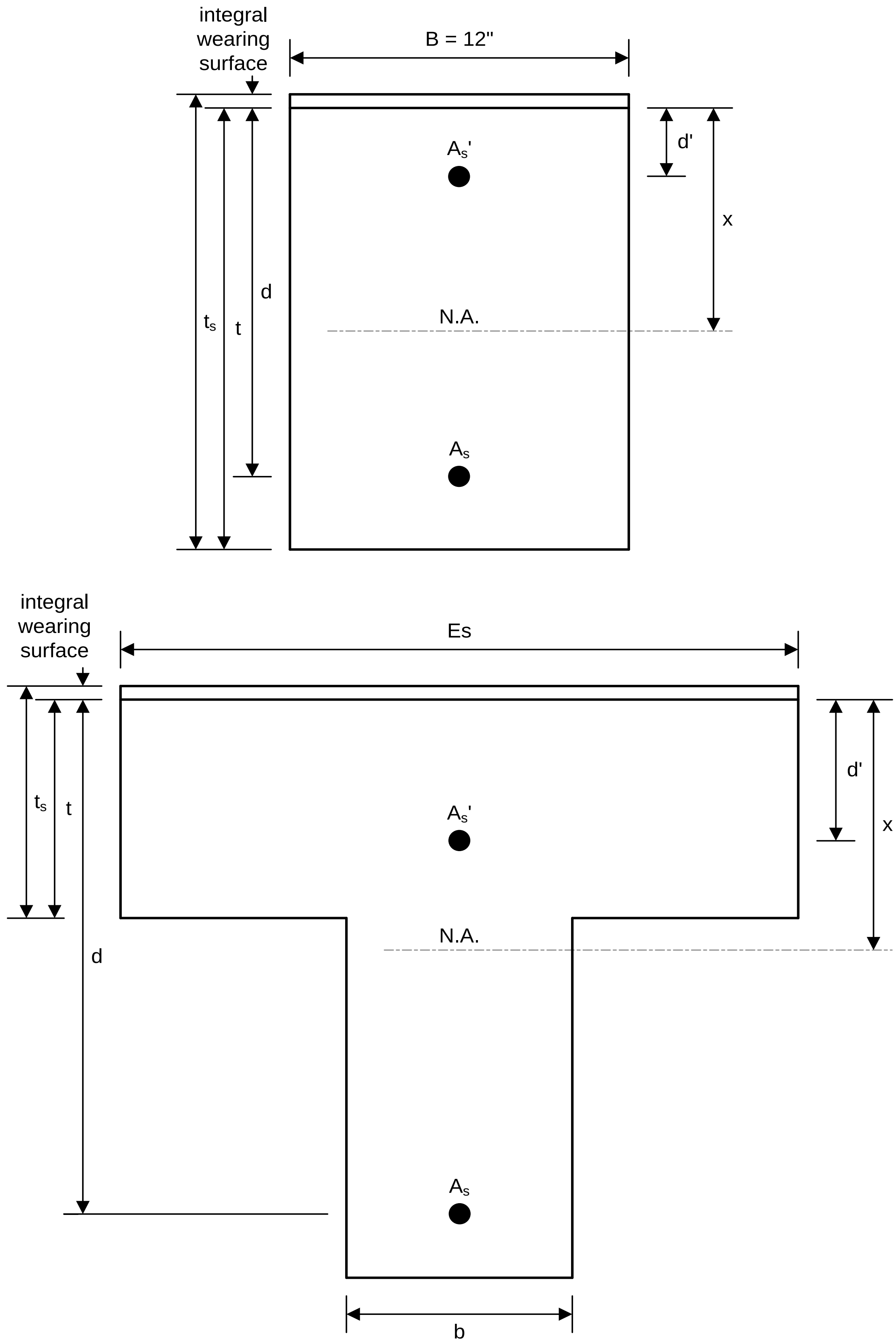


Figure 3.2.1 Concrete Section Properties

3.2.3 Girder, Floorbeam or Stringer

Non-composite section properties for DL1 and/or DL2, composite section properties (n) for DL2, composite section properties (3n) for live load, and composite section properties at negative bending moment region will be computed by the PennDOT Beam Section Properties (BSP) program.

The effective slab width for a composite section is taken as the minimum of the following three values:

1. Center-to-center spacing of member in inches.
2. Twelve times the effective slab thickness (total slab thickness -½" integral wearing surface).
3. One-fourth the span length in inches.

The effective slab width is then divided by a modular ratio (3n for section properties for DL2. and n for section properties for LL + I). The effective slab thickness is computed by subtracting one-half inch from the total slab thickness entered.

If the section is non-composite, the effective slab width is not computed and only the section properties for a steel section are computed as explained next.

All equations used in calculating the section properties are not given here since they vary with the type and details of a section. However, the basic steps involved and some generic equations are given here. Examples of detailed calculations for various situations can be found in any standard textbook on structural steel design.

The location of neutral axis measured from the bottom of the section is given by:

$$\bar{x} = \frac{\sum A_i d_i}{A_g}$$

Where A_i is the area and d_i is the distance of the center of gravity of the element i from the bottom.

The moment of inertia of the section about the neutral axis is given by:

$$I_{xx} = \sum (I_i + A_i x_i^2)$$

Where I_i is the moment of inertia of element i about its own center of gravity and x_i is the distance of the element's center of gravity from the neutral axis of the section.

In calculating $\bar{x}$ and I_{xx} for a composite section subjected to a negative moment, the concrete area in tension is neglected. Also, for a composite section subjected to positive moment, the width of the effective slab is divided by n or 3n to convert the concrete area into equivalent steel area.

The section moduli for various locations of the section are then computed by:

$$S_T = \frac{I_{xx}}{C_{top}} \quad \text{(Section modulus at the top of steel section)}$$

$$S_B = \frac{I_{xx}}{C_{bot}}$$ (Section modulus at the bottom of steel section)

$$S_C = \frac{I_{xx}}{C_{conc}}$$ (Section modulus at the top of slab – positive moment section)

$$S_R = \frac{I_{xx}}{C_{reinf}}$$ (Section modulus at the center of gravity of reinf. – negative moment section)

In addition to above section properties, the program also computes the following section properties that are required for Load Factor Method. These properties are not printed out, but are used for intermediate calculations to determine whether the section is compact, braced non-compact or unbraced non-compact. These properties are the moment of inertia of the section about Y-Y axis, Iyy, the radius of gyration of the entire section about Y-Y axis, r_y the radius of gyration of a T–section comprising one-third of the web and whole flange on compression side of section beyond elastic neutral axis, r_t and the radius of gyration of the compression flange about the Y-Y axis of web, r'.

I_{yy} is computed in the same manner as I_{xx} except the Y-Y axis of the section is considered.

The radius of gyration is computed by:

$$r_y = \sqrt{\frac{I_{yy}}{A}}$$

Where A is the area of cross section under consideration. Refer to Figure 3.2.2 on page 3-12.

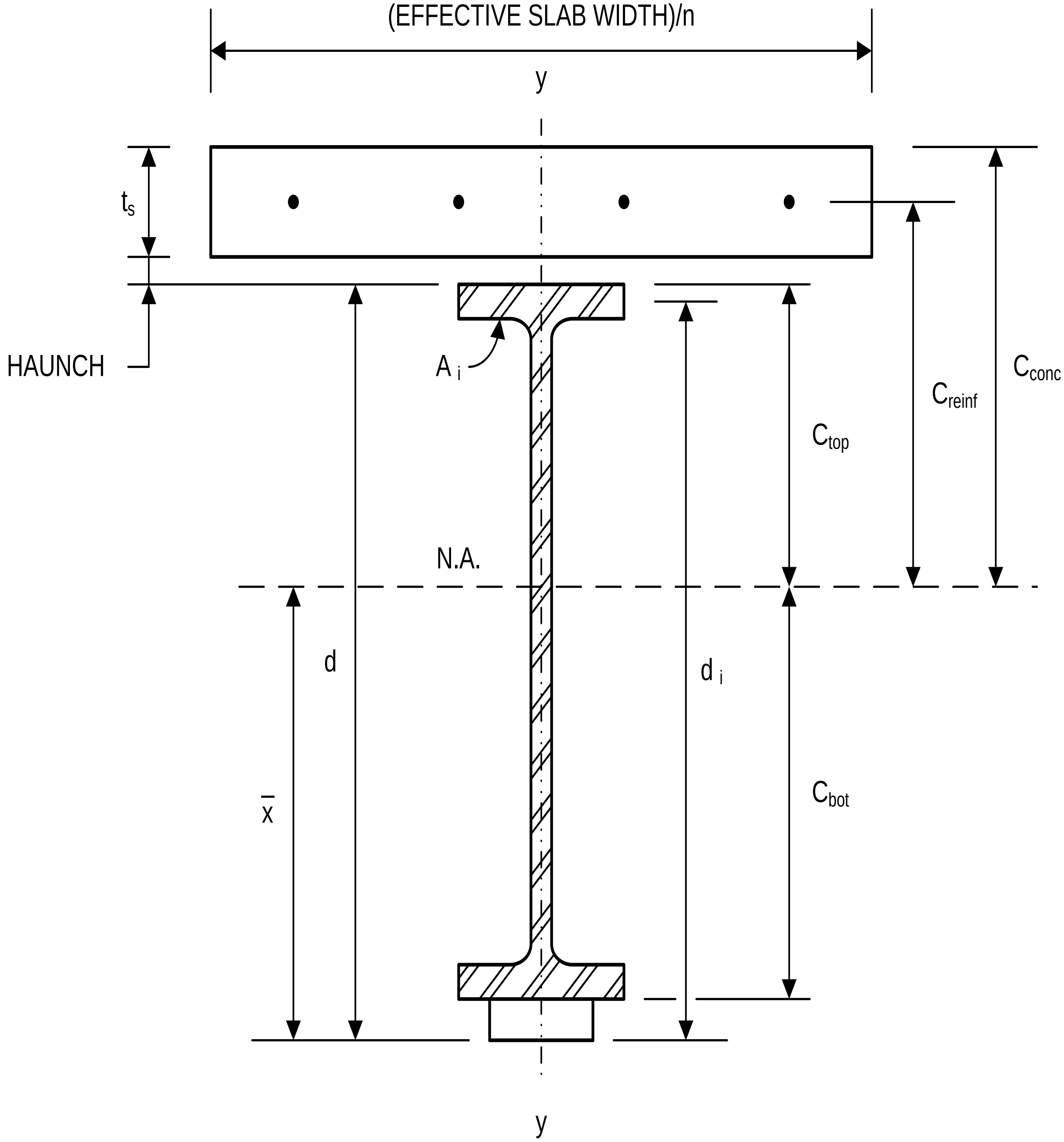


Figure 3.2.2 Steel Section Properties

3.2.4 Encased I-Beam

The program treats an encased I-beam as a composite steel section **with 3n** for DL2 and **a composite steel section with n for** LL + I neglecting the concrete area in tension for flexure (cracked section). The program treats an encased I-beam as composite for DL1 for shored construction and non-composite for DL1 for unshored construction. The following equations are used to compute the section properties of an encased I-beam. Refer to Figure 3.2.3 on page 3-13.

The depth of neutral axis for a cracked section is computed by solving the following equation for y_{tc}.

$$\frac{wy_{tc}^{2}}{2} + A_b y_{tc} - A_b(t_s + d' - c) = 0$$

The moment of inertia of a cracked section is computed by:

$$I_c = I_b + A_b(t_s + d' - c - y_{tc})^2 + \frac{wy_{tc}^{3}}{3}$$

If an encased I-beam is non-composite due to its poor condition or other details, it should be analyzed as a "GGG" bridge type.

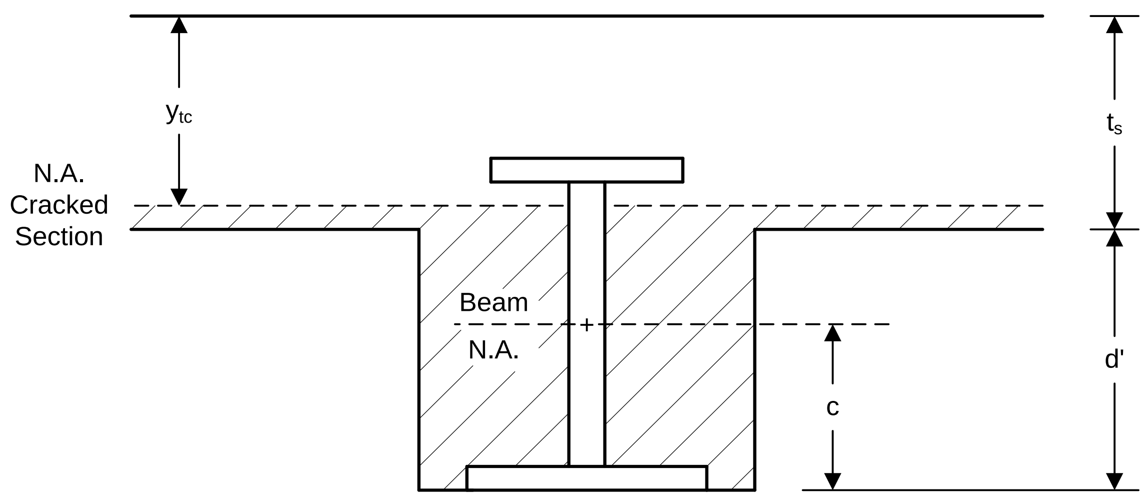


Figure 3.2.3 Encased I-Beam Section

3.2.5 Truss Member

Member properties for a truss member are input by the user. The program uses these properties to calculate the allowable forces for each truss member. Truss members can be rated by the Load Factor Method, but users will need to input additional section properties. These section properties shall be computed carefully and may or may not be computed using the department's Beam Section Properties (BSP) program.

3.3 CONTINUOUS STRUCTURE ANALYSIS

A continuous structure can be analyzed by various conventional methods of structural analysis such as slope-deflection, moment distribution, stiffness matrix or flexibility matrix method. The latter methods are suitable for computer applications because they are based on matrix algebra. BAR7 uses the modified flexibility method that was developed by the author. This section explains how the program utilizes this method to analyze a continuous girder, a continuous truss and a cantilever truss.

3.3.1 Continuous Girder

A continuous girder is a statically indeterminate structure. It is statically indeterminate because there are more unknown reactions than can be determined by the application of the condition equations for static equilibrium. The first step in analyzing a girder is to determine the support reactions. If reactions are known, then the moment and shear at any section can be easily calculated by statics. In the flexibility method, the reactions are solved by formulating as many simultaneous equations as there are supports. Two equations can easily be formed by summation of all vertical forces to zero and summation of all moments about a given point equal to zero (equilibrium equations). Other equations are formed by knowing the fact that deflections at all intermediate supports are zero (these are known as compatibility equations). If the girder has in-span hinges, it is also known that the moments at these hinges are zero (because a hinge cannot resist a moment). The modified flexibility method utilizes this additional information in formulating simultaneous equations and solving them.

The equilibrium equations mentioned above are easy to set. However, the compatibility equations require calculations of deflections in a simple span girder. A typical compatibility equation would state that the deflection at an intermediate support point of a continuous beam when the support is removed must be equal to the upward deflection caused by the unknown reaction at that support. If the deflection of a simply supported beam, derived from a continuous beam by removing intermediate supports, can be found, then the compatibility equation can be set.

The method described above is basically used to formulate these simultaneous equations and then these equations are solved using matrix algebra.

3.3.2 Continuous Truss

The method utilized for analysis of a continuous truss is like the method used for a continuous girder without hinges. The reactions are solved by formulating as many simultaneous equations as there are supports. Two equilibrium equations are formed by setting the summation of all vertical loads to zero and the summation of moments of all loads about the left most support equal to zero. The compatibility equations are formed by setting the deflections at intermediate supports for a determinate truss equal to and opposite in sign of deflections due to a vertical force applied at each support equal to unknown reaction. These equations are then solved by matrix algebra. The deflections at intermediate supports for a determinate truss are calculated using the method of virtual work.

3.3.3 Cantilever Truss

A cantilever truss is a continuous truss with in-span hinges. The program assumes that a cantilever truss is a statically determinate truss, i.e. the truss has as many hinges as there are redundant reactions (Number of supports = 2 + number of hinges). The reactions are solved by formulating as many simultaneous equations as there are supports. The equations are formed by:

1. Setting the sum of all vertical loads equal to zero.
2. Setting the sum of moments for all vertical loads and reactions about the left most support equal to zero.
3. Setting the moment of all loads and reactions about each hinge equal to zero.

These equations are then solved by matrix algebra. Once the reactions are known, member forces are determined by method of joints and sections.

3.4 DEAD LOAD ANALYSIS

The program employs the following technique for dead load analysis of various bridge components.

3.4.1 Girder

Two types of dead loads act on a girder. The first load, hereinafter referred to as 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, girder, slab, haunch, permanent formwork, stringers, floorbeams, diaphragms, bracings, stiffeners and other hardware attached to the main member such as the girder or truss. The second load, hereinafter referred to as DL2, is the dead load that acts on the composite section **with 3n** of the member. DL2 includes the load due to the weight of parapet, sidewalk, median, railing, steel grid flooring, timber flooring, other structures permanently attached to the deck, and the sidewalk live load. The engineer enters some of these loads and some are computed by the program. This will be explained in detail later in this manual.

Each span of the girder is divided into ten (10) equal segments and a section (or analysis point) is considered at each end of the segment (total of 11 sections in each span). For a simple span, the maximum moments due to DL1 and DL2 are computed by applying the principles of statics. For a continuous span, first the reactions at the supports are computed using the modified flexibility method developed by the author. For this method, refer to Section 3.3.1 CONTINUOUS GIRDER. For computations of reactions due to DL1, the moments of inertia of non-composite sections are used. For computations of reactions of EIB's shored construction due to DL1, the moments of inertia of composite sections with modular ratio equal to 3n are used. For computations of reactions due to DL2, the moments of inertia of composite sections with modular ratio equal to 3N are used. The moments and shears at tenth points are then computed applying the principles of statics.

3.4.2 Stringer

The method used for dead load analysis of a stringer is the same as that used for girder analysis. The dead loads acting on the stringer are computed assuming all stringers equally carry the total dead load acting on the deck. The weight of the slab acting on the stringer varies depending on the stringer spacing. **The critical stringer in the specified span will carry the largest weight of slab due to the largest sum of the left and right stringer spacing.**

3.4.3 Concrete Slab or T-Beam

For a concrete slab or T -beam, the dead load consists of weight of beam, deck, diaphragms, parapets, median, railings and other structures permanently attached to the deck or beam. The maximum dead load moment in the span is computed in the same manner described for simple span girders. For an analysis of a concrete slab bridge, one-foot wide slab is considered.

3.4.4 Encased I-Beam

For an encased I-beam, the dead load consists of weight of beam, deck, interior and exterior diaphragms, formwork, parapets, median, railings and other structures permanently attached to the deck or beam. The maximum dead load moment in the span is computed in the same manner described for simple span girders.

3.4.5 Truss

The engineer enters the dead loads acting on a truss as joint loads. The member forces in a simple span truss are computed by the method of joints and sections. The member forces in a continuous span truss are computed using the flexibility matrix method. For details on analysis of continuous truss by flexibility matrix method, refer to Analysis of Framed Structures by Gere and Weaver.

3.4.6 Floorbeam

The dead loads acting on the floorbeam are due to the weight of deck, stringers, floorbeam, **STRINGER DL1, FLOORBEAM DL1,** and other loads described as DL2 in girder analysis.

For bridges without stringers ("GFF" and "TFF"), the total uniformly distributed DL1 dead loads (UDL1) along the floorbeams are floorbeam weights, deck weight*(corresponding floorbeam spacing), and FLOORBEAM DL1. The total uniformly distributed DL2 dead loads (UDL2) along the floorbeams are DL2*(corresponding floorbeam spacing).

For bridges with stringers ("FSS", "GFS", "GGF" and "TFS"), the total uniformly distributed DL1 dead loads along the floorbeams are floorbeam weights and FLOORBEAM DL1. The total uniformly distributed DL2 dead loads along the floorbeams are 0. The reactions due to DL1 and DL2 computed in the stringer analysis phase are assumed to act as concentrated loads on the floorbeam. If simple stringers are on top of floorbeams, the total concentrated DL1 and DL2 dead loads from the stringers are computed by simple beam method. If continuous stringers are on top of floorbeams, the total concentrated DL1 and DL2 dead loads from the stringers are computed by the influence line method along the stringer spans.

To analyze half a floorbeam, the moment **and shear** due to dead loads is computed at the center of the floorbeam span **by simple beam method**. If the floorbeam extends outside the main girder**,** truss**, or support** and if it is continuous, the moment at the center of the floorbeam is computed treating the outside portion of the floorbeam as a cantilever.

In the case of patch loads acting on the floorbeam or unsymmetrical pier configuration, the entire floorbeam will be analyzed and the moment and shear at each analysis point are computed by CBA

program by simple beam method. The floorbeam can be analyzed as a simple span without cantilever, a continuous 2-span floorbeam with left or right cantilever, or a continuous 3-span floorbeam with left and right cantilevers.

3.4.7 Patch Load

The effects of two dead load types (DL1 and DL2) of concentrated or distributed patch loads are added to the dead load for the computation of the overall dead load effects.

The patch loads for the primary members will be applied for the following bridge types:

1. The concrete member (**C**) of “CPL”, “CSL”, or “CTB”
2. The girder (**G**) of “EIB”, “GFF”, “GFS”, or “GGG”
3. The truss member (**T**) of “TFF”, “TFS”, or “TTT”
4. **The floorbeam member (F) of “FSS”, “GFF”, “GFS”, “GGF”, “TFF”, or “TFS”**

The distributed patch loads can be uniformly (rectangular shape) or linearly distributed (triangular or trapezoidal shape).

The patch load acting on the concrete member**, floorbeam,** or girder will be analyzed by CBA (Continuous Beam Analysis) to obtain the corresponding reactions, moments, and shears at all analysis points. These values will be added into the corresponding dead load effect at all analysis points.

The patch loads acting on the truss are input by users and will be broken into panels. Each panel will have its share of patch loads to be analyzed by assuming the left and right truss joints of the panel acting like a simply supported beam to obtain the corresponding reactions at the left and right truss joints. Add all these reactions from all panel analyses into user input truss joint dead loads.

Please note that the patch load for each member type will not impact to other member type. For example, a bridge type of “GFS”, the patch load applied to a floorbeam will not transfer the patch load to the girders.

3.5 LIVE LOAD ANALYSIS

The program uses the following techniques for live load analysis of various bridge components.

3.5.1 Beam, Stringer or Girder

A longitudinal beam type member (steel girder or stringer. reinforced concrete slab or T-beam or encased I-beam) is analyzed for a live load using the influence line method. For this purpose, the member is divided into ten (10) equal segments of each span. A unit vertical load is applied at each tenth point one at a time and various effects (support reaction, shear, moment and deflection) are calculated at each of the tenth points across the member. In calculating these effects, principles of statics are used for simple spans and the modified flexibility method is used for continuous 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.

3.5.2 Floorbeam

The maximum live load effect (moment or shear) at a given section in the floorbeam is calculated by assuming the deck acting as a continuous (or simple) beam spanning over the floorbeam and the floorbeam acting as a simple (or cantilever) beam spanning between (or over) the main girders or trusses. The program also assumes that the loads are transferred to the floorbeam through the deck as if the stringers do not exist.

To calculate the longitudinal effect (in the direction of traffic), the program **starts** calculating the reactions at the floorbeam due to longitudinal movement of the **truck or lane live** load, then treating these reactions as concentrated loads acting on the floorbeam. **For bridges types without stringers ('GFF' and 'TFF') (i.e. the deck is supported directly by floorbeams) and the distribution factor for moment is entered (i.e. DFS_M > 0), t**he longitudinal effect on the floorbeam is calculated in accordance with **1996** AASHTO Specifications 3.23.3 **Bending Moments in Floor Beams**. **The reaction on the floorbeam is calculated by multiplying the non-zero distribution factor for moment entered in the input with the maximum axle weight of the live load as per 1996 AASHTO Specifications Table 3.23.3.1. However, 1. for bridges types without stringers and the distribution factor for moment is not entered (i.e. DFS_M = 0), or 2. for bridge types with stringers ('FSS', 'GFS', 'GGF', & 'TFS') , the reaction on the floorbeam is calculated by the influence line method along the stringer spans as explained in Section 3.5.4 INFLUENCE LINE.**

To calculate the transverse effect, the program starts with one lane and places it closest to the left curb **(i.e. from the left curb to the right curb)**. Then it places the two concentrated loads (0.5 kip each, always at a gage distance apart) within that lane with the left load at one-half the passing distance away from the left edge of the lane. For this position of the load, the program calculates and stores the reaction at the left girder/truss centerline and moments and shears at critical points (left girder/truss centerline and one-tenth points up to mid span of floorbeam). The loads are then moved 0.1 foot to the right, and the moments and shears at critical points are calculated again. The governing moments and shears are stored. The loads are again moved to the right by 0.1 foot and the above procedure is repeated until the right load is at one-half the passing distance from the right edge of the lane. Next, the lane is moved 0.1 foot to the right and the above calculations are repeated until the right edge of the lane is closest to the right curb.

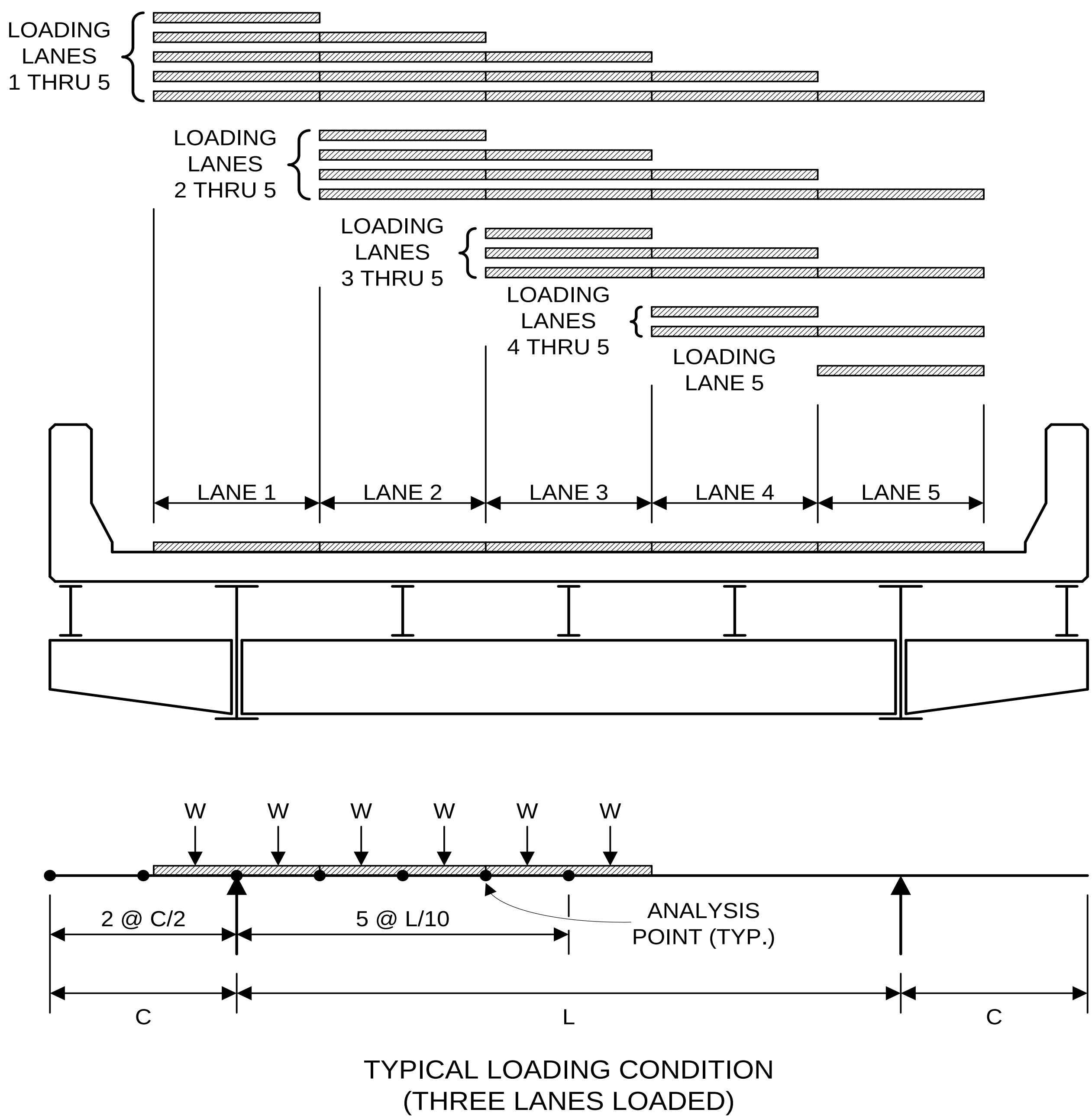


Figure 3.5.1 Floorbeam Live Load Analysis

A lane is then added and the above procedure is repeated starting from placing the leftmost lane closest to the left curb. When two or more lanes are considered, the load is moved within each lane within the limitations of the passing distance. Also, the reduction for live load intensity is considered when two or more lanes are loaded. When all lanes are considered and moved from left to right as explained above, the maximum moments and shears are obtained at critical points. These moments and shears based on 0.5 kip concentrated loads are referred to as the moment and shear factors. The moments and shears at transition points are then calculated by interpolation of 10th point moments and shears. Refer to Figure 3.5.1 on page 3-20. The actual effect at a given section is found by multiplying the moment or shear factor with the actual live load reaction calculated as explained above. The following equations show how the moment and shear factors and the live load moment and shear at a section are calculated for a case shown in Figure 3.5.2 on page 3-22. Please note that these equations are for this case only. Also, note that the lateral placement of loads for maximum moment and shear factors will be different.

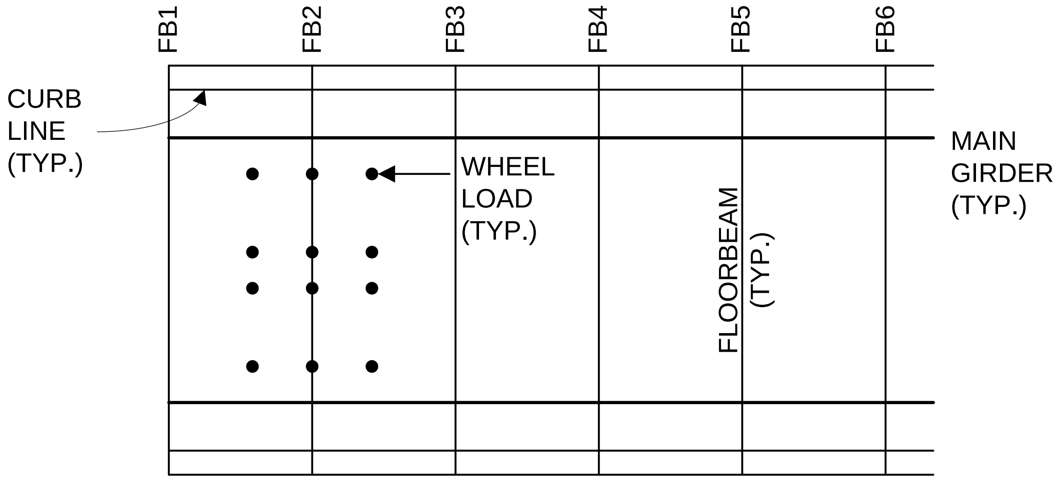
$$R = (P_1)(O_1) + (P_2)(O_2) + (P_3)(O_3)$$

$$R_L = \frac{C\,R}{2} \qquad \text{where} \qquad C = [(L - X_1) + (L - X_2) + (L - X_3) + (L - X_4)] \div L$$

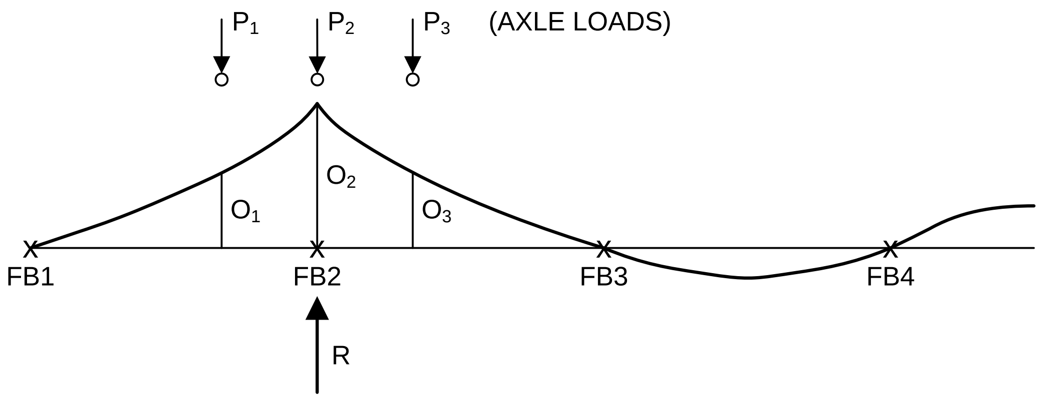
$$M_X = (MF)(R) \qquad \text{where} \qquad MF = Moment\ Factor = \frac{(C)(X) - (X - X_1) - (X - X_2)}{2}$$

$$V_X = (SF)(R) \qquad \text{where} \qquad SF = Shear\ Factor = \frac{(C - 1)}{2}$$

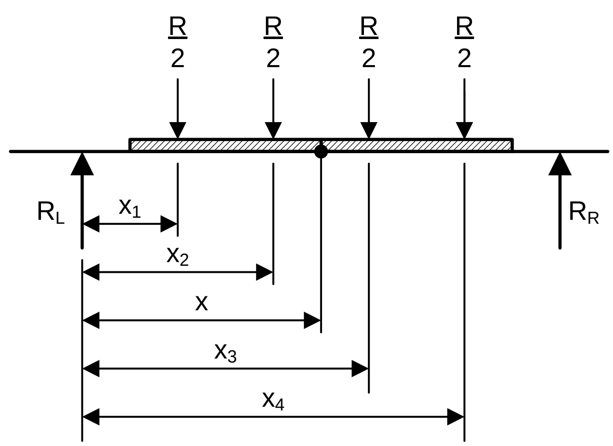
Please note that the program doesn't calculate the transverse effect by placing the truck one by one from the right curb to the left curb. For floorbeams with significant unsymmetrical pier configuration, it may require to run BAR7 again with modified input data measured from the centerline of the right girder, truss, or support.



PLAN VIEW OF WHEEL LOAD POSITIONS



INFLUENCE LINE FOR REACTION AT FLOORBEAM 2



LOADING TWO LANES FOR MAXIMUM MOMENT

Figure 3.5.2 Floorbeam Live Load Analysis

3.5.3 Truss

For live load analysis, trusses are divided into two categories. These are: A. Simple or continuous span trusses without counters, and B. Simple span trusses with counters.

A **simple or continuous span** truss without counters is analyzed by the influence line method. For this, a unit vertical load is applied one at a time at each upper or lower joint, depending upon whether it is a deck truss or through truss, and the member forces are found using the method described above for the dead load analysis. When all joints are loaded, the influence lines for member forces are generated. Each influence line is then analyzed for the maximum live load effect by the method described later in this section.

For a simple span truss with counters, the actual live load is moved across the truss considering one joint at a time and trying all possible load positions to produce the maximum **and minimum** effect. The analysis begins with the assumption that the dead load forces are already present when the live load is applied. This is important to assure the proper action of the diagonal (counter) for a given position of the live load. For each joint, the following positions of the live load are tried. First, the axle number one is placed at the joint under consideration and all other axles are placed to the left in their respective positions. For the axles that fall between the joints, equivalent joint loads are computed assuming the panel to act as a simple span. For this position of the load, the combined dead load plus live load forces are computed. The maximum **and minimum** force is stored for each member. Next, the axle number two is placed over the joint and the procedure described above is repeated. This process is continued until the last axle is over the joint. Then the axles are placed such that the center of gravity of the **all live** load**s** coincides with the joint and the member forces are computed again. Next, the axle loads are reversed and the whole procedure is repeated. This gives the effects of the live load moving across the bridge in the other direction. When this process is completed, the maximum **and minimum member** force**s are** obtained for each member. The **member** force**s in tension due to live load are obtained by algebraically subtracting the corresponding member forces in tension due to dead load from the maximum member forces in tension due to the combination of live load and dead load. The member forces in compression due to live load are obtained by algebraically subtracting the corresponding member forces in compression due to dead load from the minimum member forces in compression.**

3.5.4 Influence Line

As described earlier, the influence lines are generated for moments in the girder and member forces in the truss. Each influence line is then analyzed as described here to find the maximum live load effect. For this, the influence line is divided into several 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, the effects of equivalent lane loading must also be investigated. To find the effects of lane loading (uniform load plus a floating concentrated load), the sum of all positive and the sum of all negative areas of the influence line are computed. Also, the absolute maximum positive ordinate and the absolute maximum negative ordinate are found. To find the positive lane loading effect, the sum of positive areas is multiplied by the uniform load and added to the product of the maximum positive ordinate and the applicable (moment or shear) concentrated load in the same manner. The governing effects are stored. Refer to Figure 3.5.3 on page 3-25 and Figure 3.5.4 on page 3-26.

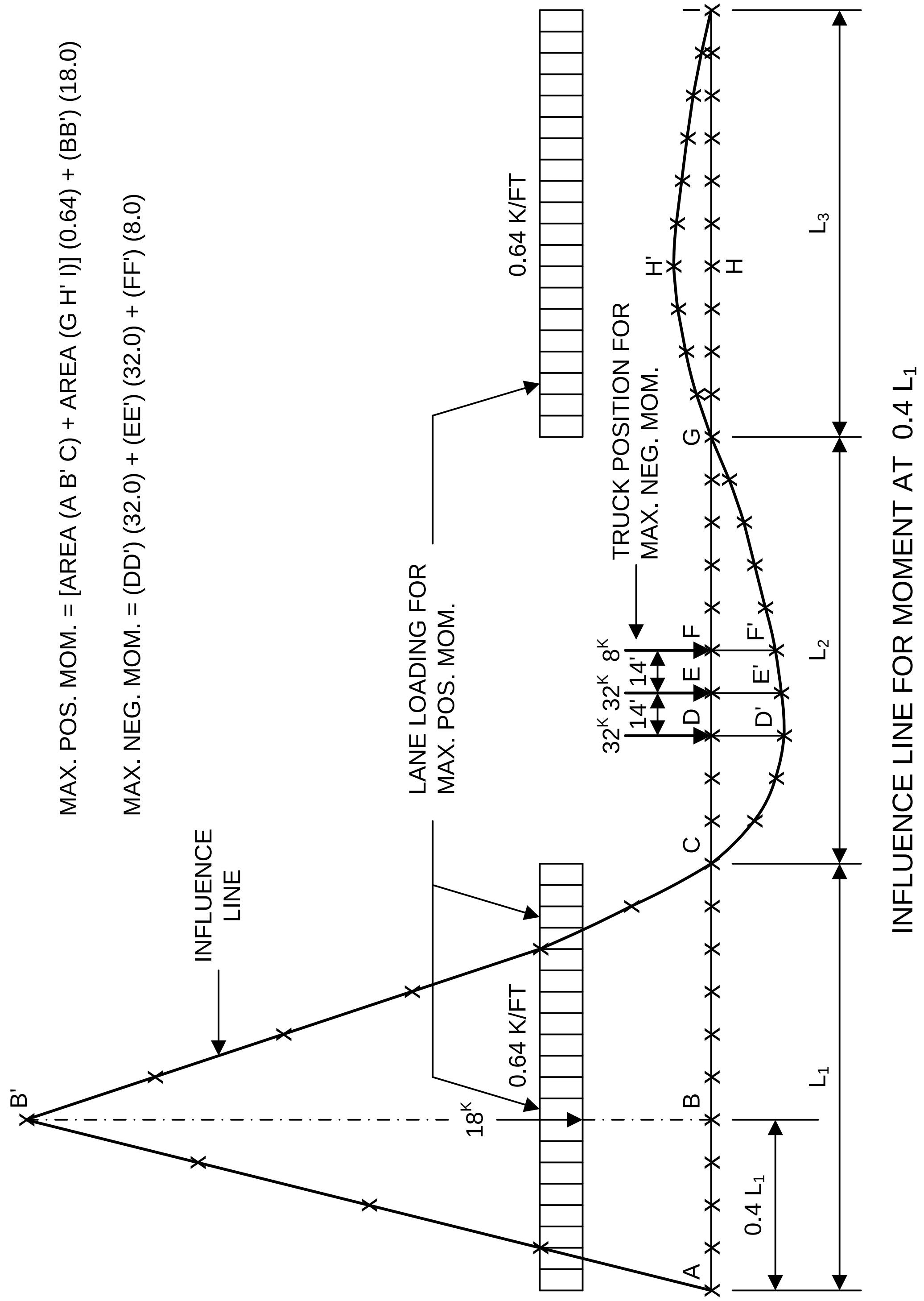


Figure 3.5.3 Moment Influence Line

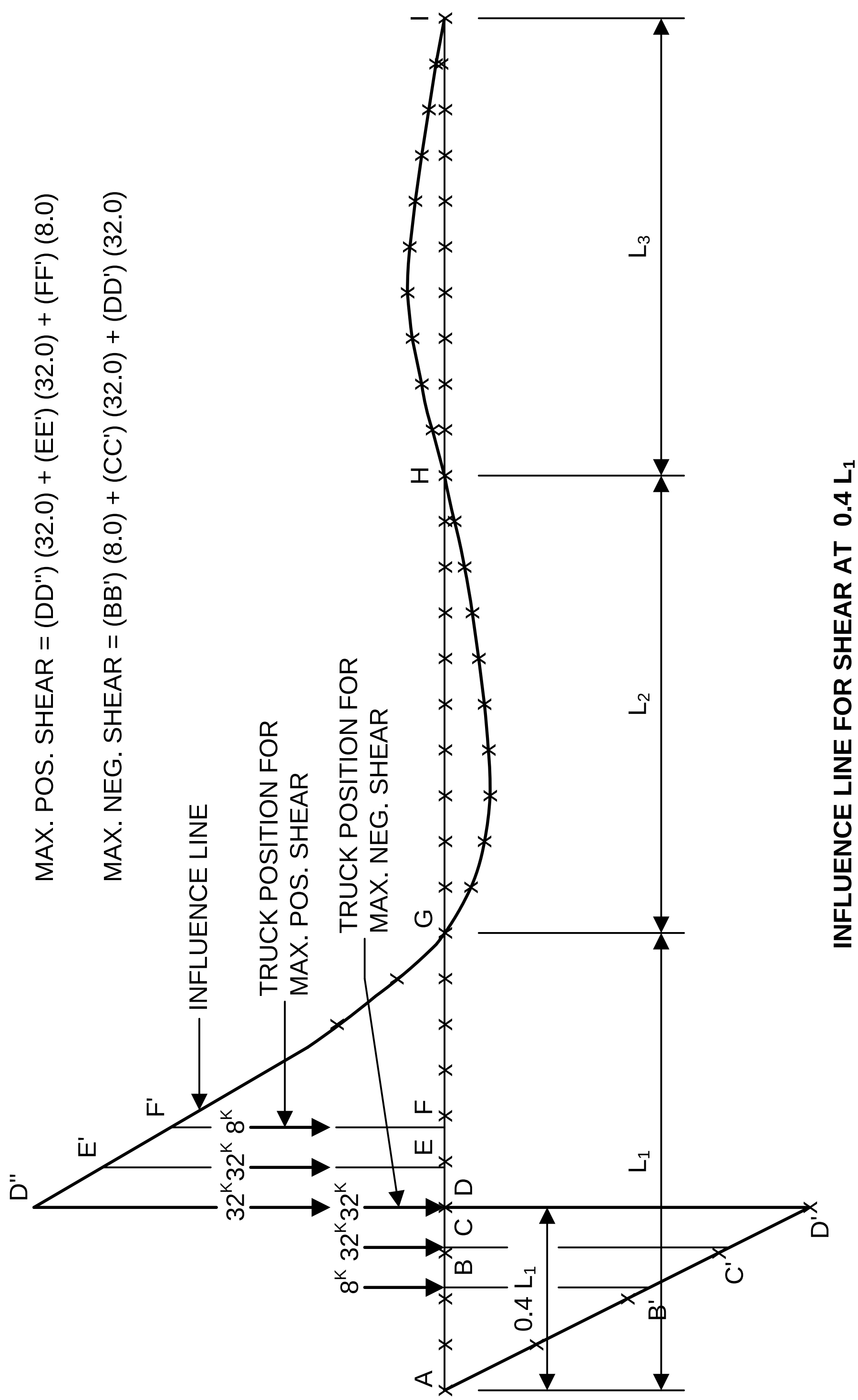


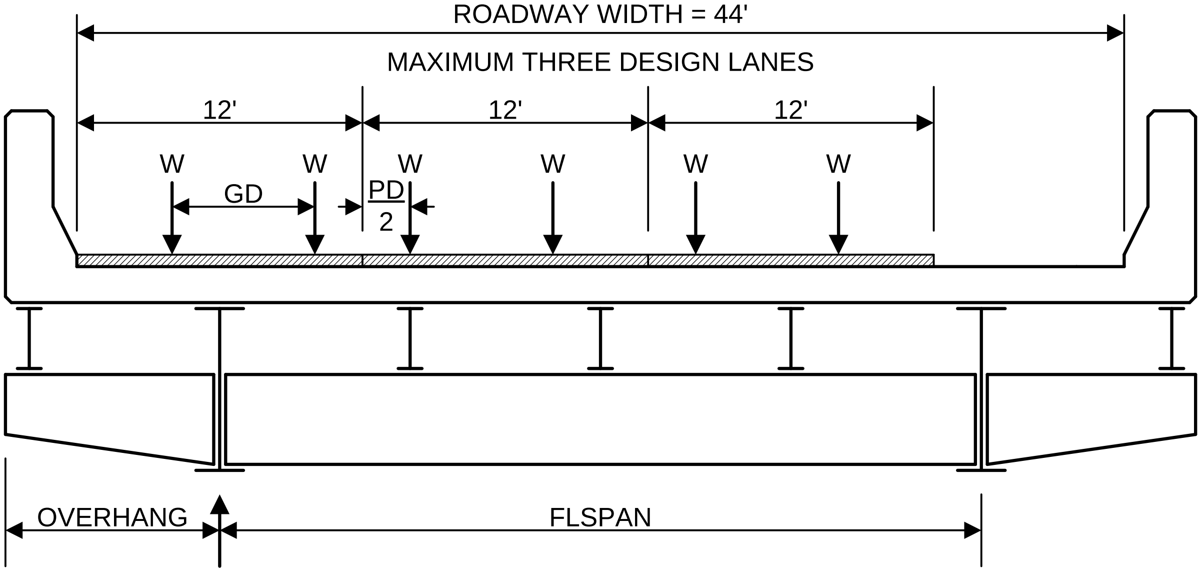
Figure 3.5.4 Shear Influence Line

3.5.5 Live Load Distribution

The live load distribution factor is defined as a fraction (or multiple) of the axle load that is carried by the member of a bridge. The live load distribution factors for moment, shear and deflections for a girder of the multigirder bridge, a stringer of bridge types "GFS" and "TFS", an R. C. T-beam and an encased I-beam are determined and entered by the user. The live load distribution factor for the main girder or truss is computed by the program in accordance with the AASHTO Manual and the AASHTO Specifications as explained below.

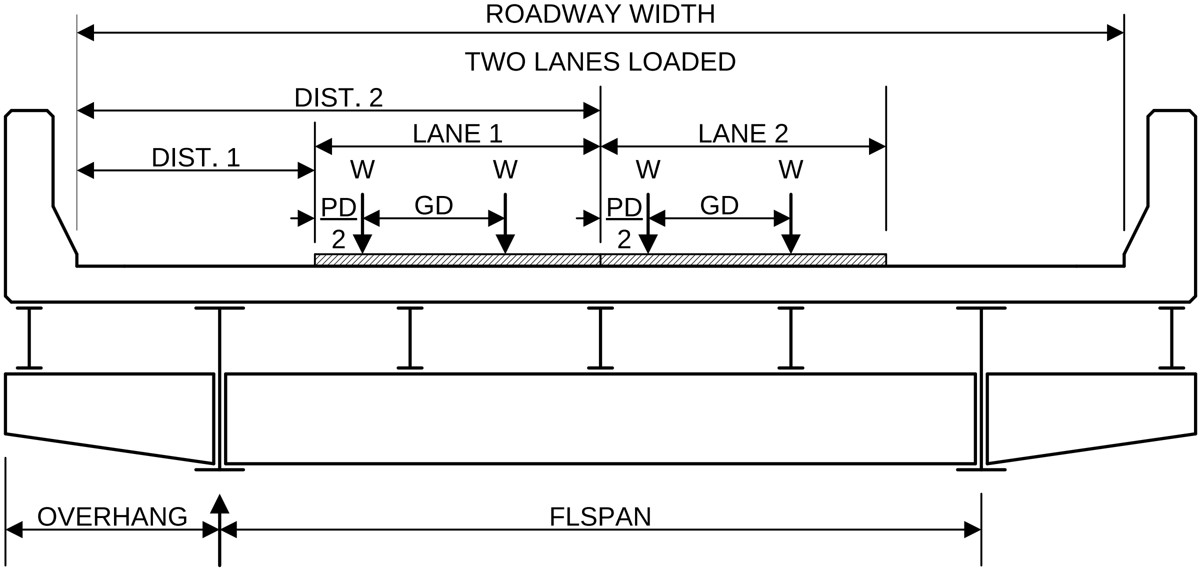
The distribution factor calculated for the main girder or truss is a function of the width, number and location of traffic lanes, the distance between two wheels (gage distance), the minimum distance between two passing vehicles (passing distance) and the center-to-center spacing of main girders or trusses. The distribution factor is computed either based on the design traffic lanes (determined by the program in accordance with AASHTO Specifications) or the loaded traffic lanes (as defined by the user). The live load effect (moment, shear or axial force) used in calculating the Inventory and Operating rating based on design lanes or loaded lanes is obtained by applying the appropriate distribution factor.

The distribution factor is computed as follows. The wheels are placed within each lane in accordance with the AASHTO Manual such that the maximum reaction occurs at the left girder or truss centerline. The reaction expressed as a fraction (or multiple) of the total number of lanes is the distribution factor. A reduction in live load intensity is applied when more than one lanes are loaded. This reduction is applied in accordance with the AASHTO Specifications when design lanes are considered and according to percentage of live load for each lane (input value) when loaded lanes are considered. Figure 3.5.5 on page 3-28 shows the placement of lanes and the calculation of distribution factor based on design lanes and loaded lanes.



RL = GIRDER DISTR FACTOR (DESIGN)

= REACTION OF WHEEL LOADS PLACED WITHIN DESIGN LANES CLOSEST TO LEFT GIRDER/TRUSS



RL = GIRDER DISTR FACTOR (LOADED)

= REACTION OF WHEEL LOADS PLACED WITHIN LOADED LANES CLOSEST TO LEFT GIRDER/TRUSS

Figure 3.5.5 Live Load Distribution Factors

3.5.6 Impact

The impact factors (I) **are added to all live loads to account for the speed, vibration, and momentum from the vehicle traffic and** are computed using the following formula given in the AASHTO Specifications.

$$I = \frac{50}{L + 125}$$ **, I shall be less than or equal to 0.3**

For computing the impact fraction I, the program uses the loaded length "L" **in feet** as described below.

For a continuous girder or stringer, the loaded length "L" is taken as follows:

1. For a positive reaction at an end support, the end span length is used.
2. For a negative reaction at an end support, the length of the adjacent loaded span is used.
3. For a positive reaction at an interior support, the average length of two adjacent spans is used.
4. For a negative reaction at an interior support, the average length of two nearest loaded spans is used.
5. For a positive moment at an interior support, the average length of two nearest loaded spans is used.
6. For a negative moment at an interior support, the average of two adjacent span lengths is used.
7. For a positive moment at any point within a span, the length of the span is used.
8. For a negative moment at any point within a span, the length of the loaded span is used. The span with the largest area under the influence line is determined to be the loaded span.
9. For a shear, the length of the loaded portion of the span from the point under consideration to the far reaction is used.

For a floorbeam, the loaded length “L” is taken as follows:

1. For a positive moment in the floorbeam, the center-to-center distance between the main girders or trusses is used.
2. For a negative moment at any point in a cantilevered floorbeam, a length of zero is used to apply the impact fraction of 0.3.
3. For a shear in the cantilever, a length of zero is used to apply the impact fraction of 0.3.
4. For a shear at any point between the main girders or trusses, the length of the loaded portion of the floorbeam from the point under consideration to the far girder or truss is used.

For each member of the truss the loaded length "L" is taken as follows:

1. For the maximum compression in the top chord and the maximum tension in the bottom chord of a continuous span truss, the length of the span is used where the member belongs.
2. For the maximum tension in the top chord and the maximum compression in the bottom chord of a continuous span truss, the average length of two adjacent spans is used.
3. For the maximum tension in the bottom chord and the maximum compression in the top chord of a simple span truss, the length of the span is used.
4. For the diagonals and vertical members, the length of the positive area of the influence line is used for the maximum tension and the length of the negative area of the influence line is used for the

maximum compression. However, the area of the influence line considered is limited to the span where the member belongs.

3.5.7 Redistribution of Moments

For a continuous girder with the compact section, the dead load and live load plus impact moments are redistributed if the user has specified the option for redistribution. The negative moments are reduced and the positive moments are increased as per AASHTO Specifications Article 10.48.1.3. The program uses the following equations to calculate the adjusted moments. Refer to Figure 3.5.6 on page 3-31.

$$\Delta_1 = 0.1M_1 \quad \text{if } M_1 < 0$$

$$= O \quad \text{if } M_1 = 0 \text{ or } M_1 \text{ and } M_2 > 0$$

$$= O \quad \text{if } M_1 > 0 \text{ and } M_2 < 0$$

$$\Delta_2 = 0.1M_2 \quad \text{if } M_2 < 0$$

$$= O \quad \text{if } M_2 = 0 \text{ or } M_1 \text{ and } M_2 > 0$$

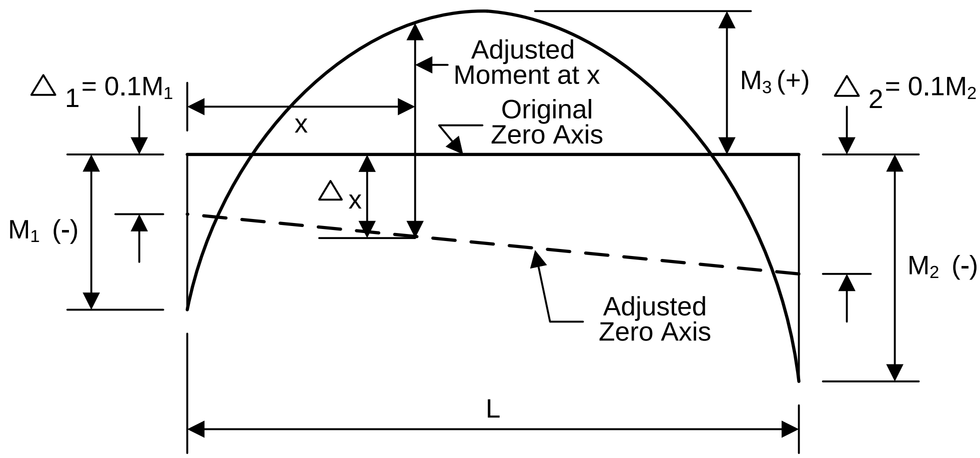
$$= O \quad \text{if } M_2 > 0 \text{ and } M_1 < 0$$

$$\Delta_x = \Delta_1 + \frac{\Delta_2 - \Delta_1}{L} X$$

$$Adjusted\ Moment = Unadjusted\ Moment + \Delta_x$$

where

M_1 and M_2	= Moments at adjacent supports
M_3	= Peak moment in the span
L	= Length of span where the section is located
Δ_1 and Δ_2	= Adjustment of zero axis at adjacent supports
X	= Distance of section from the support of the span



$$\Delta_x = \Delta_1 + \frac{\Delta_2 - \Delta_1}{L} X$$

Figure 3.5.6 Redistribution of Moments

3.6 SECTION CAPACITY

The Allowable Stress Method utilizes the section capacity to calculate the rating. Section capacities are based on allowable stresses as specified in the AASHTO Manual.

3.6.1 Allowable Stresses

The program uses the following allowable stresses to calculate the moment capacity of a flexural member in accordance with the AASHTO Manual Articles 6.6.2.1, 6.6.2.3 and 6.6.2.4 with the exception of partially supported or unsupported compression flange. The allowable stresses are calculated from the F_y and f_c' values as specified by the user.

	Inventory	Operating	
Steel (Flexure tension and fully supported compression)	0.55 F_y	0.55 F_y	
Steel (Flexure partially supported compression)	F_b	1.36 F_b	
Steel (Shear)	0.33 F_y	0.45 F_y	
Concrete (Compression due to bending)	f_{cir}	f_{cor}	
f_c' Unknown (Left Blank)	950 psi	1300 psi	
f_c' Known (Entered)	0.40 f_c'	0.55 f_c'	
Reinfor**cing Steel**:	f_{sir}	f_{sor}	Fy
Grade Unknown	18,000 psi	25,000 psi	33,000 psi
Structural Grade	18,000 psi	25,000 psi	36,000 psi
Grade 40	20,000 psi	28,000 psi	40,000 psi
Grade 50	20,000 psi	32,500 psi	50,000 psi
Grade 60	24,000 psi	36,000 psi	60,000 psi

3.6.2 Flexural Steel Member

1. The allowable stress in a compression flange supported laterally its full length by embedment in concrete is calculated per AASHTO Specifications Table 10.32.1 A (equal to 0.55 F_y for Inventory Rating and 0.75 F_y for Operating Rating).
2. The allowable compression in partially supported or unsupported compression flange, defined as F_b under ALLOWABLE STRESSES, is calculated according to the year of specifications to be used (input) as follows:

$$F_b = \frac{M_U}{1.82\,S}$$

where M_U is calculated per Equation (10-102), and

S is section modulus of compression flange (for 1989 Specs)

$F_b = F_b$ given in Table 10.32.1A (1990 Interim) or

$F_b = \frac{F_b}{1.82}$ given in D10.48.4.1 (DM4), whichever is smaller (for 1990 Specs)

When the 1989 Specifications are used, the program does not use the equation given for F_b in Table 10.32.1A (1989) because of a slight inconsistency in defining the term b used in Table 10.32.1A and the term b' used in Equation (10-102). The program takes a conservative approach by using the Load Factor equation and applying a factor of safety of 1.82 to get an Allowable Stress equation.

3. The moment capacity of the steel section for Inventory Rating, M_{CIR}, is calculated by:

$M_{CIR} = f_{sir} S$ where, f_{sir} = 0.55 F_y or F_b

4. The moment capacity of the steel section for Operating Rating, M_{COR}, is calculated by:

$M_{COR} = f_{sor} S$ where, f_{sir} = 0.75 F_y or 1.36 F_b

5. The shear capacity of the steel section for Inventory Rating, V_{CIR}, is calculated by:

$V_{CIR} = t_w D F_{vir}$ where, $F_{vir} = F_V$

as calculated by AASHTO Specifications 10.34.4.1 for unstiffened web

or as calculated by AASHTO Specifications 10.34.4.2 for stiffened web

6. The shear capacity of the steel section for Operating Rating, V_{COR}, is calculated by:

$V_{COR} = t_w d F_{vor}$ where, F_{vor} = 1.36 F_{vir}

3.6.3 Flexural Concrete Member

1. The moment capacity of the concrete section for Inventory Rating, M_{CIR}, is calculated by:

$M_{CIR} =$ least of $f_{cir} S_C$ and $f_{sir} S_S$

2. The moment capacity of the concrete section for Operating Rating, M_{COR}, is calculated by:

$M_{COR} =$ least of $f_{cor} S_C$ and $f_{sor} S_S$

3. The shear capacity of the concrete section for Inventory Rating, V_{CIR}, is calculated by:

$v_{cir} = 0.95\sqrt{f_c'}$ for 1974 and later specifications

$= 0.03 f_c'$ for 1973 and earlier specifications, but not greater than 90 psi

$V_{sir} = A_{vb} \sin\alpha f_{sir}$ but not greater than $1.5\sqrt{f_c'}\, b_w d$ for slab bridge where b_w = 12.0

$= \frac{A_{vs} d f_{sir}}{s} + A_{vb} \sin\alpha f_{sir}$ but not greater than $4.0\sqrt{f_c'}\, b_w d$ for T-beam bridge

$$V_{CIR} = v_{cir} b_w d + V_{sir}$$

4. The shear capacity of the concrete section for Operating Rating, V_{COR}, is calculated by:

$$v_{cor} = 1.27 v_{cir}$$

$$V_{sor} = A_{vb} \sin\alpha\, f_{sor}$$ but not greater than $(1.27)1.5\sqrt{f_c'}\, b_w d$ for slab bridge*

$$= \frac{A_{vs} d f_{sor}}{s} + A_{vb} \sin\alpha\, f_{sor}$$ but not greater than $(1.27)4.0\sqrt{f_c'}\, b_w d$ for T-beam bridge*

$$V_{COR} = v_{cor} b_w d + V_{sor}$$

*Note: To maintain the same factor of safety for service load and load factor methods, the Bureau of Design has decided to use the value 1.27.

3.6.4 Truss Members

The allowable force in a truss member is computed in accordance with the provisions of Article 6.6.2.1 of the AASHTO Manual. For a tension member and for a compression member without an end eccentricity, the allowable stresses are computed using the formulas given in Tables 6.6.2.1-1 and 6.6.2.1-2 of the AASHTO Manual.

For a compression member with an end eccentricity, the allowable force is computed by either the provisions of Article 10.36 of the AASHTO Specifications (Combined Stresses Formula) or the procedure contained in Appendix A11 of the AASHTO Manual (Secant Formula).

If the Combined Stresses Formula is used, the equations given in AASHTO Specifications Article 10.36 are set equal to 1.0 and F_{bx} is calculated using the equation given in Tables 6.6.2.1-1 and 6.6.2.1-2 of the 1994 AASHTO Manual.

The 1996 AASHTO Equation (10-42) results in the following quadratic equation in terms of allowable axial force P.

$$-\frac{F_{bx}}{A_g^2 F_{ex}'} P^2 + \left[\frac{F_a F_{bx}}{A_g F_{ex}'} + \frac{F_{bx}}{A_g} + \frac{C_m F_a e_x c}{I_x}\right] P - F_a F_{bx} = 0$$

where $$F_a = \frac{F_y}{(FS)}\left[1 - \frac{\left(\frac{kL}{r}\right)^2 F_y}{4\pi^2 E}\right]$$ for $\frac{kL}{r} \le c_c$

$$F_a = \frac{\pi^2 E}{(FS)\left(\frac{kL}{r}\right)^2}$$ for $\frac{kL}{r} > c_c$

$$c_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

$$F_{bx} = \frac{91x10^6 C_b}{(FS2)S_{xc}}\left(\frac{I_{yc}}{\ell}\right)\sqrt{0.772\frac{J}{I_{yc}} + 9.87\left(\frac{d}{\ell}\right)^2}$$

$\leq 0.55F_y$ at the inventory level   1994 AASHTO Manual

$\leq 0.75F_y$ at the operating level   1994 AASHTO Manual

$$F_{ex}' = \frac{\pi^2 E}{(FS)\left(\frac{k\ell}{r}\right)^2}$$

A_g = Gross area of member

I_x = Moment of Inertia of member about the x-axis

I_{yc} = Moment of Inertia of compression flange about the vertical axis in the plan of the web.

L = Unsupported length of member

ℓ = Length of unsupported flange between lateral connections, knee braces, or other points of support.

r = $\sqrt{\frac{I_x}{A_g}}$, governing radius of gyration

r' = $\frac{b}{\sqrt{12}}$

b = Flange width

c = Distance from the neutral axis to extreme compression fiber

Cb = 1.0 for compression truss members.

Cm = 1.0 for pinned-pinned connections.

d = Depth of girder

e_x = Eccentricity of member about x-axis

FS = 2.12 at the inventory level

= 1.70 at the operating level

$FS2$ = 1.82 at the inventory level

= 1.34 at the operating level

J	=	$[(bt^3)_c + (bt^3)_t + Dt_w^3]/3$, where b and t represent the flange width and thickness of the compression and tension flange, D is the web depth, and t_w is the web Thickness.
k	=	0.875 for pinned ends
	=	0.75 for riveted ends
S_{xc}	=	Section modulus with respect to the compression flange.

P is taken as the smaller of the roots given by the above quadratic equation and the following 1996 AASHTO Equation (10-43).

$$P = \frac{1}{\dfrac{1}{0.472 A_g F_y} + \dfrac{e_x c}{I_x F_{bx}}}$$

If the procedure contained in Appendix A11 of the AASHTO Manual is used, the program assumes that the eccentricity at both ends of the member is the same, and thus the other formulas of that article are considered not applicable.

3.7 MAXIMUM STRENGTH

The ratings calculated by the Load Factor Method are based on the following load-strength relationship.

$$Maximum\ Strength = 1.3\left[DL1 + DL2 + (RF)(LL + I)\right]$$

where DL1, DL2, and LL+I are effects due to non-composite dead load, composite dead load and live load plus impact and RF is the rating factor.

The program uses the logic given in the flow chart shown in Figure 3.7.2 on page 3-41 to calculate RF. Please note that the beta factor for live load plus impact used for moments and shears to calculate the rating factor in the above relationship and in the flowchart is 1.0 and RF is the Operating Rating Factor.

The Maximum Strengths of a section are flexural strength, shear strength, strengths based on overload provisions and moment-shear interaction. The program calculates the following strengths.

3.7.1 Flexural Strength of Steel Member

The Flexural Strength, M_U, is calculated for various types of sections depending upon whether the section is compact, braced non-compact or unbraced non-compact as defined in the AASHTO Specifications. The program uses the logic given in the flow chart shown in Figure 3.7.2 on page 3-41 to determine the type of section. The beta factor for live load plus impact used for moments and shears in checking compactness, ductility and moment-shear interaction equations shown in the flow charts is taken as 1.67. Refer to the AASHTO Specifications for symbols and equations used in the flow chart. The program calculates the flexural strengths based on the yielding of tension flange, compression flange and top of concrete slab or tension reinforcement and uses appropriate strength to determine the critical rating factor.

The flexural strength of box-shaped steel cross girder/floorbeam is calculated assuming it is non-composite and non-compact. The flexural resistance prescribed in AASHTO LRFD Article 6.12.2.2.2 has been considered for these members.

3.7.1.1 Compact Section

The Flexural Strength, M_U, of a compact section is taken as the full plastic moment of the section, M_p, and is calculated in the following manner. First the location of the plastic neutral axis is assumed at the mid height of the steel section. Assuming all fibers stressed to the yield stress, forces in various elements of the section are calculated by multiplying the area and yield stress of the element. The sum of forces in elements in compression is compared with the sum of forces in elements in tension. If these forces are not equal, a new position of the neutral axis is assumed and the above steps are repeated until both forces become equal. The maximum strength of the section is found by taking the first moment of all forces about the neutral axis, taking all forces and moment arms as positive quantities. Refer to Figure 3.7.1 on page 3-40.

Program assumes bridges with variable depth web, built up section, or longitudinal stiffener as non-compact section.

Non-composite sections meeting compact section requirements (1996 AASHTO Specifications Article 10.48.1.1 (a) (b) (c)) shall be computed as compact sections. Composite sections meeting compact section requirements (1996 AASHTO Specifications Article 10.48.1.1 (b) (c)) and F_y less than 50,000 psi shall be computed as compact sections.

For checking the ductility requirements of a compact composite section in positive moment region as per Eqn (10-129a) given in 1996 AASHTO Specifications Article 10.50.1.1.2, the value of β used is 0.9 for $F_y \geq$ 36,000 psi, and it is 0.7 for 36,000 < $F_y \leq$ 50,000 psi.

The program also assumes that the plastic moment capacity can only be used for the calculation of ratings if all sections over the entire length of the member (whether composite or non-composite) qualify as compact sections.

3.7.1.2 Braced Non-compact Section

The Flexural Strength, Mu, of a member not meeting compact section requirements (1996 AASHTO Specifications Article 10.48.1.1) but meeting the AAHSTO braced non-compact section requirements (1996 AASHTO Specifications Article 10.48.2.1) shall be computed as Fy*S.

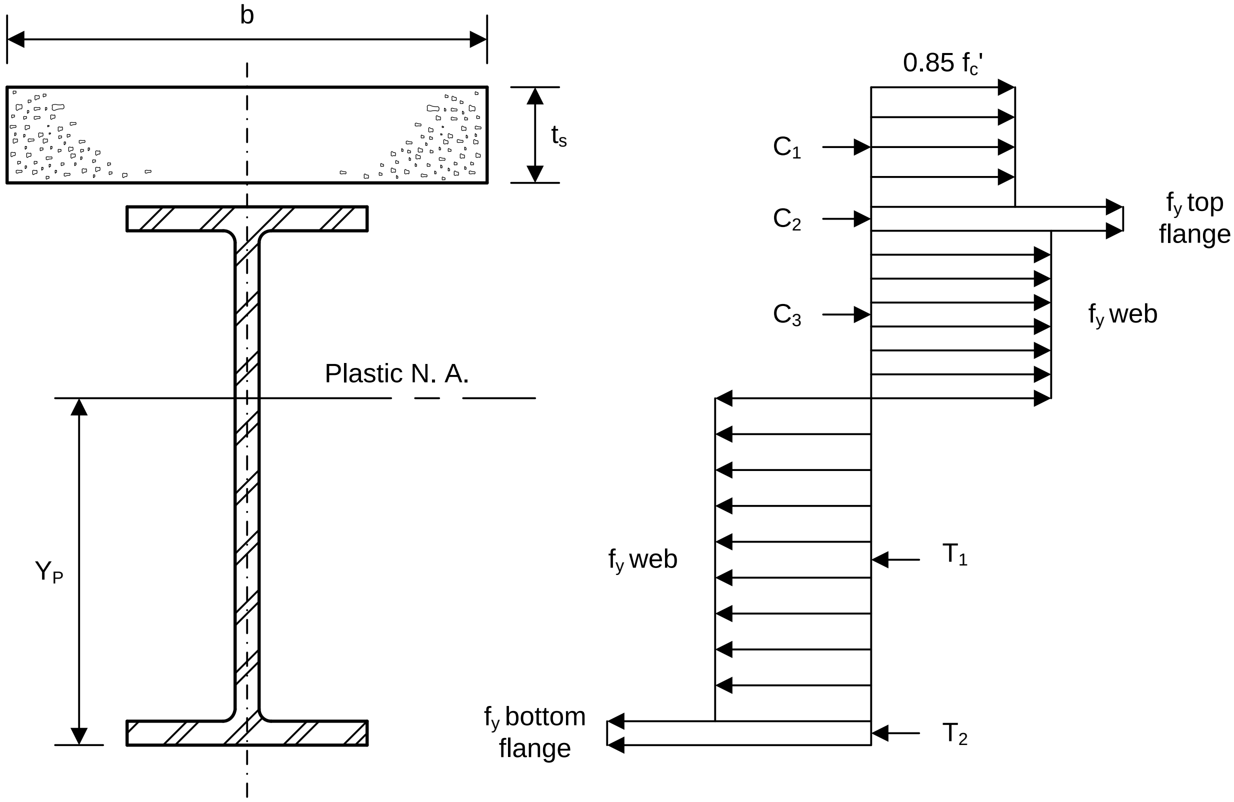
3.7.1.3 Unbraced **Non-compact** Section

The Flexural Strength, M_U, of a member controlled by compression in a partially supported or unsupported flange is calculated per **1996** AASHTO Specifications Article 10.48.4.1. For this, the unbraced length is taken as the distance between bracings. If the 1989 or earlier specifications are used, the program computes M_U per equation 10-102 given in AASHTO Specifications (1989) Article 10.48.4.1. For this, the unbraced length is taken as the minimum of the distance between bracings or the distance between the points of dead load contraflexure to the farthest bracing. The program also has the option to use the equations given in Article D10.48.4.1 of 1988 DM-4. For this, the unbraced length is taken as a minimum of the distance between bracings or the distance between the points of dead load contraflexure to the farthest bracing.

3.7.2 Shear Strength of Steel Member

Based on user input of stiffened or unstiffened condition, the Shear Strength, V_U, is calculated for various points along the length of the steel member **per 1996 AASHTO Specifications Article 10.48.8 Shear**. The program uses the logic given in the flow chart shown in Figure 3.7.2 on page 3-41 to determine the type of section and the shear strength.

Box-shaped cross girders/floorbeams resist a small amount of shear due to torsion. To accommodate torsion in these members, the per web shear strength of the box section is multiplied by 0.9 factor.



CROSS - SECTION **PLASTIC STRESS DISTRIBUTION**

C_1 = 0.85 f_c' b t_s

C_2 = (Area of top flange) (f_y top flange)

C_3 = (Area of web above n. a.) (f_y web)

T_1 = (Area of web below n. a.) (f_y web)

T_2 = (Area of bot. flange) (f_y bot. flange)

Y_P = distance from bottom to plastic n. a.

Y_{C1} = distance from plastic n. a. to C_1

Y_{C2} = distance from plastic n. a. to C_2

Y_{C3} = distance from plastic n. a. to C_3

Y_{T1} = distance from plastic n. a. to T_1

Y_{T2} = distance from plastic n. a. to T_2

$$M_P = C_1Y_{C1} + C_2Y_{C2} + C_3Y_{C3} + T_1Y_{T1} + T_2Y_{T2}$$

Figure 3.7.1 Maximum Moment Strength of Compact Section

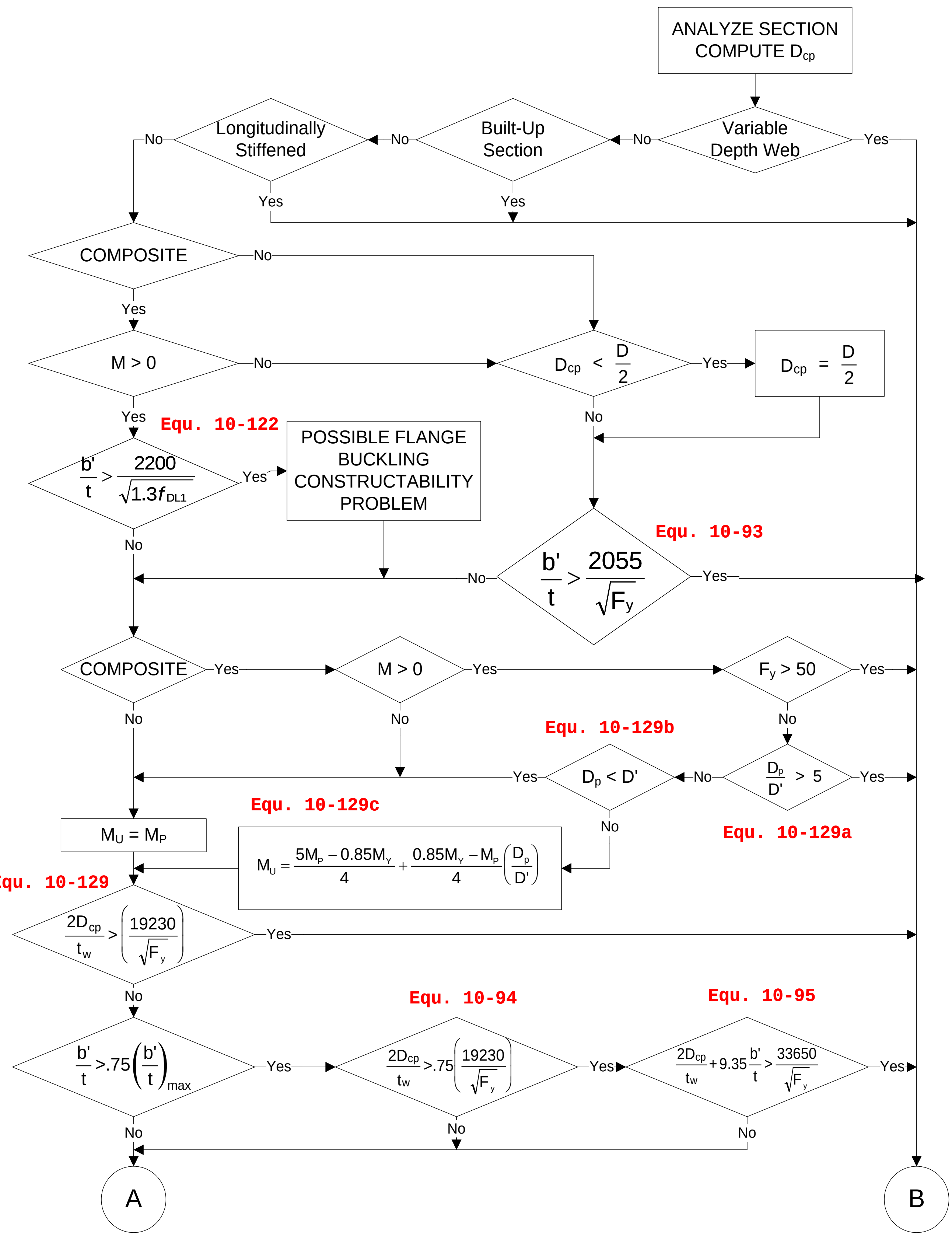


Figure 3.7.2 Load Factor Rating Flow Chart

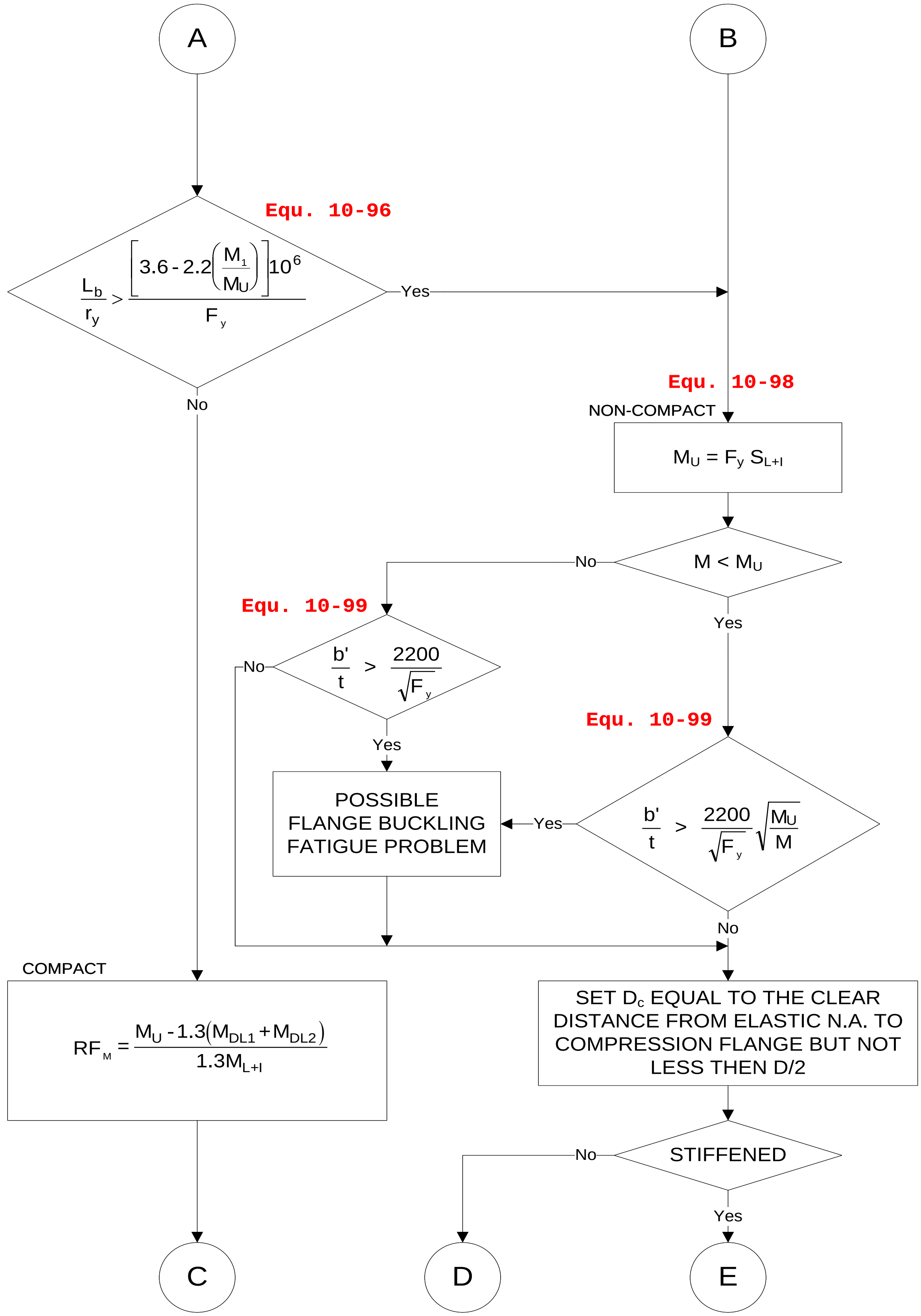


Figure 3.7.2 Load Factor Rating Flow Chart (cont'd)

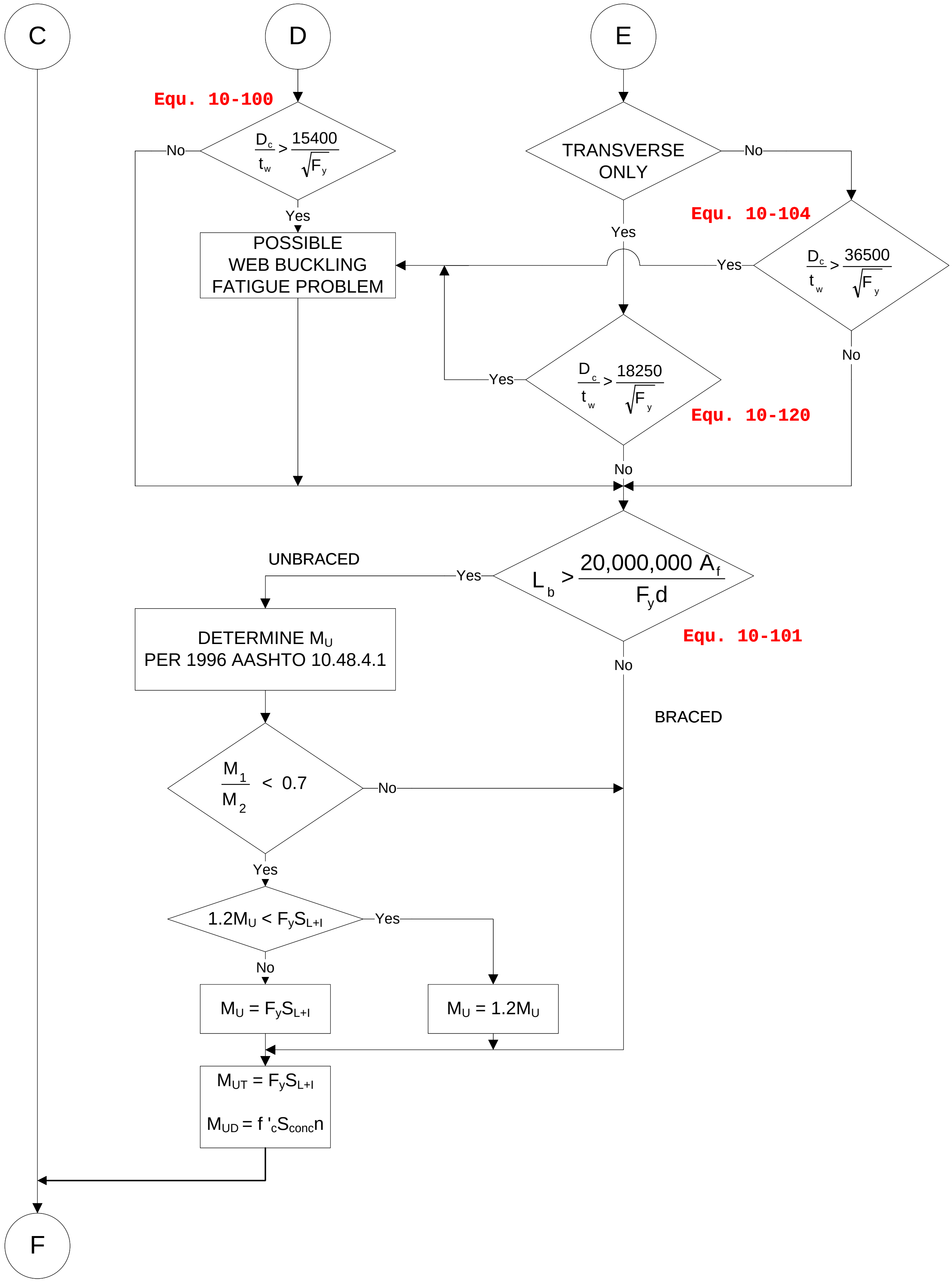


Figure 3.7.2 Load Factor Rating Flow Chart (cont'd)

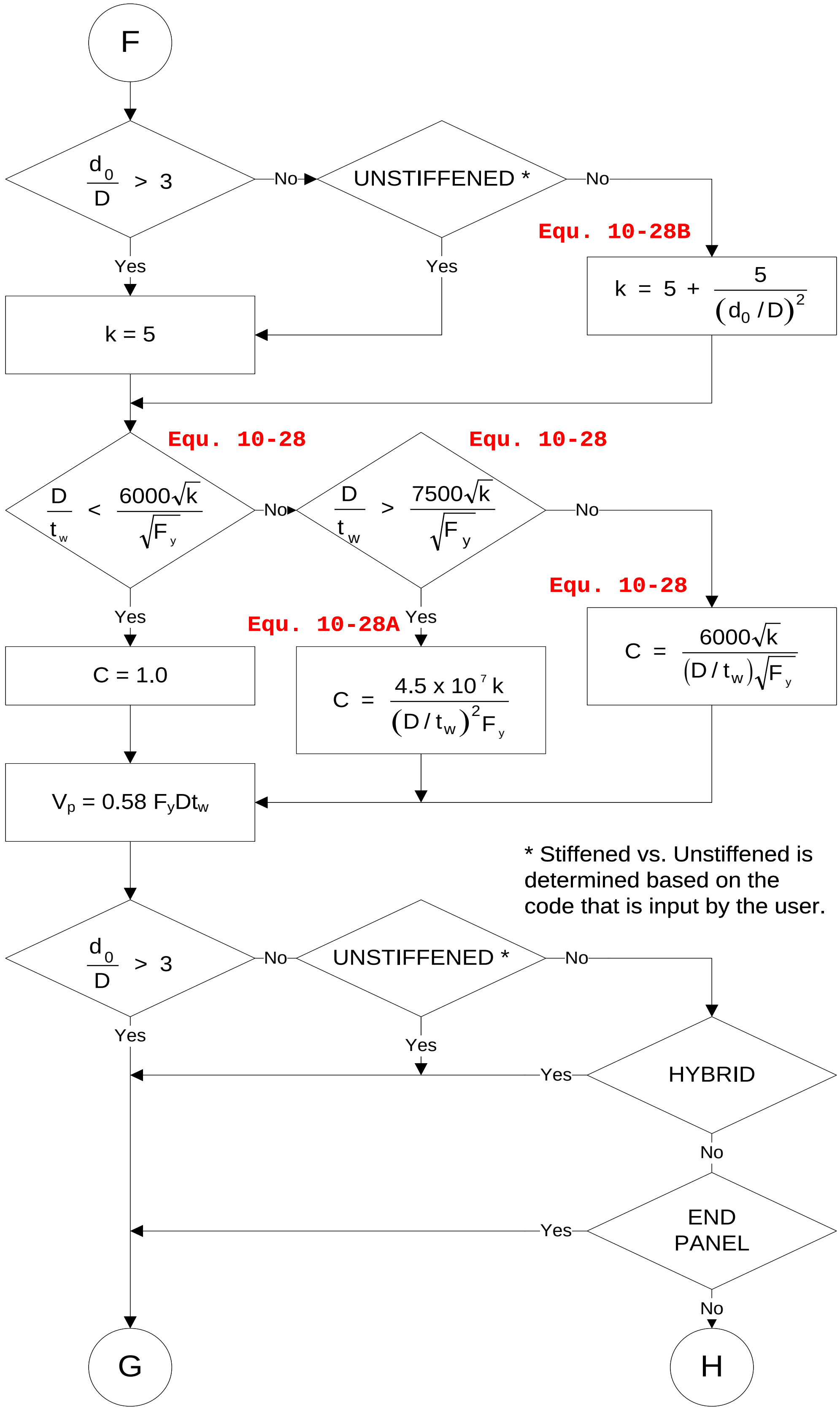


Figure 3.7.2 Load Factor Rating Flow Chart (cont'd)

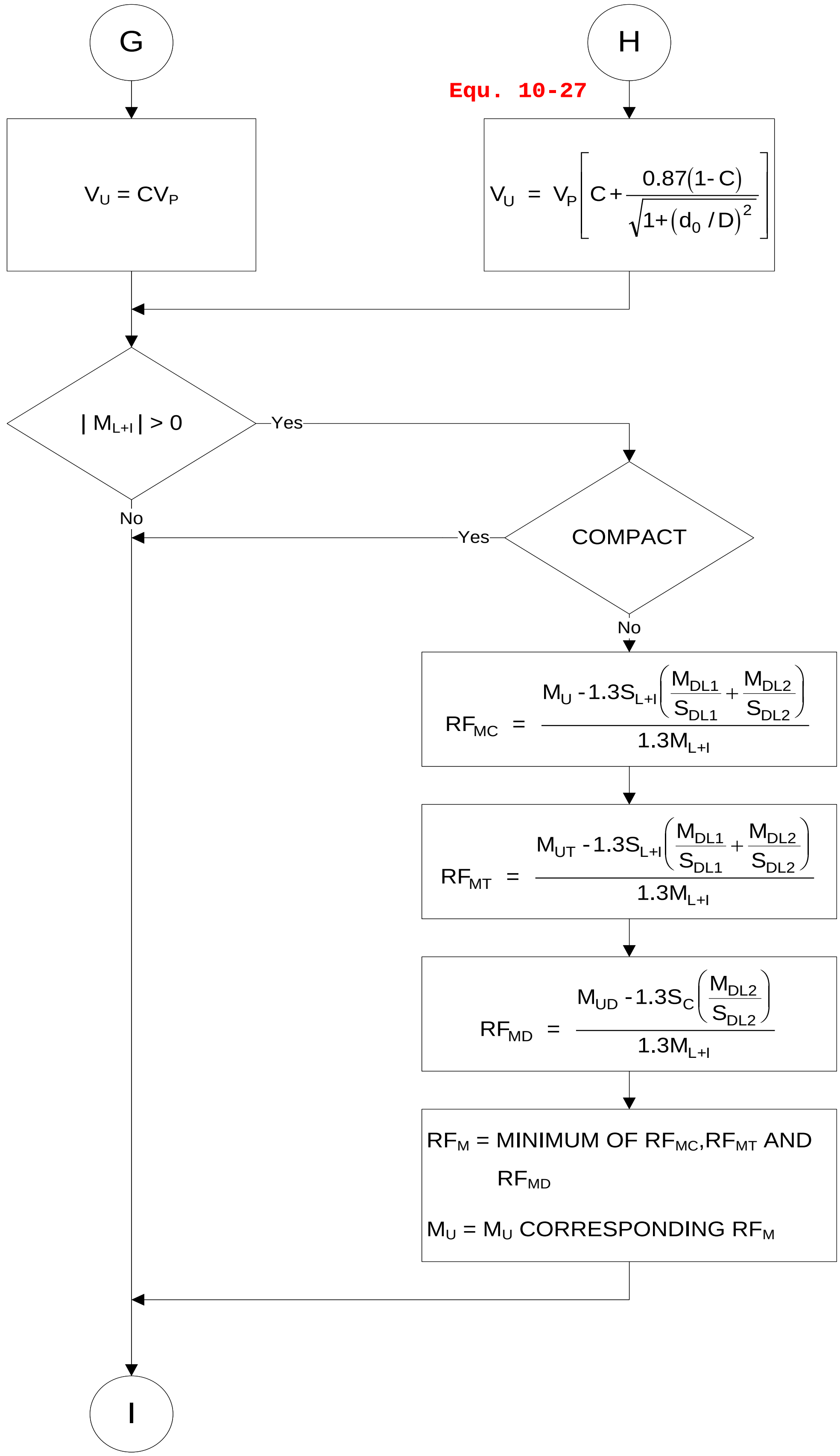


Figure 3.7.2 Load Factor Rating Flow Chart (cont'd)

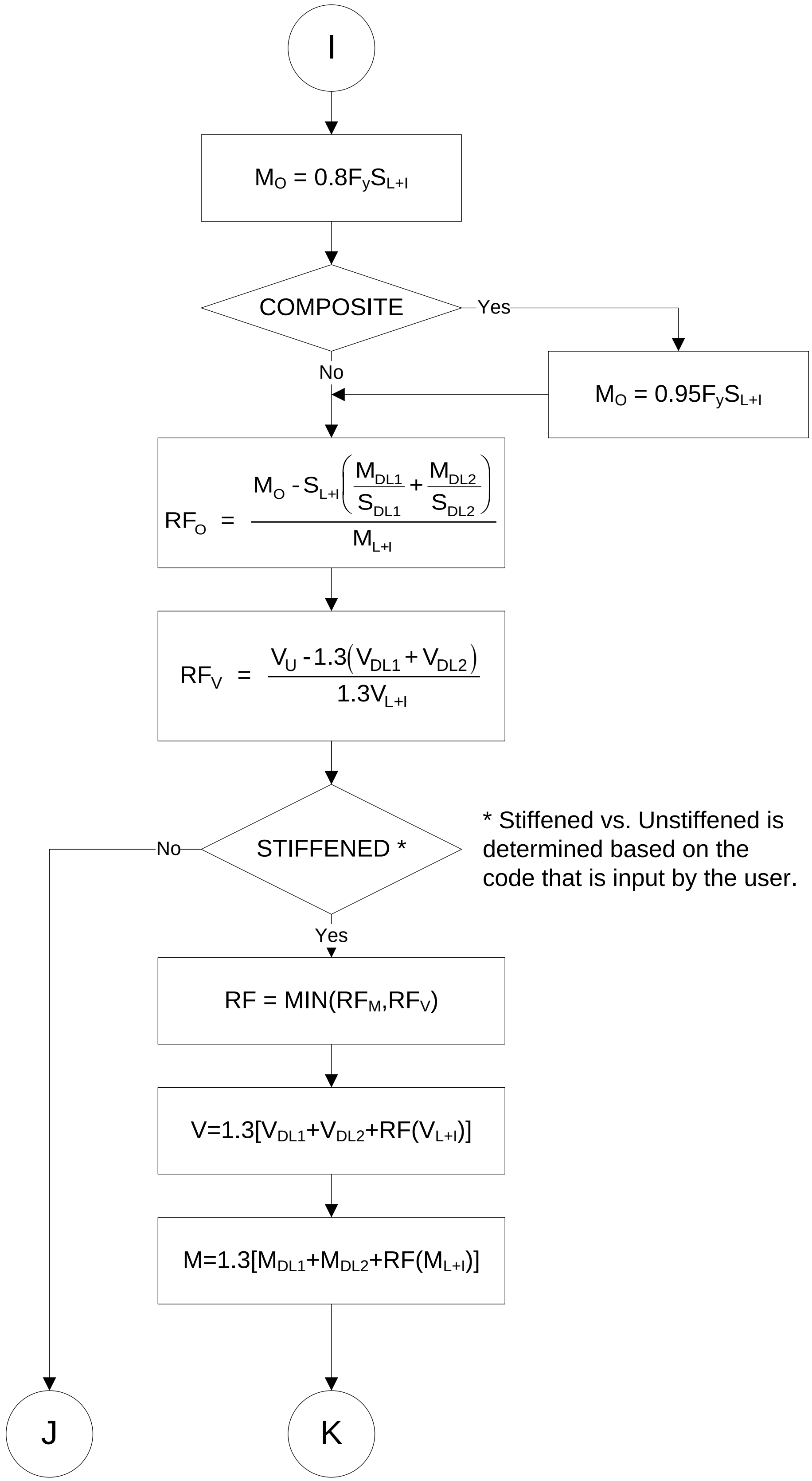


Figure 3.7.2 Load Factor Rating Flow Chart (cont’d)

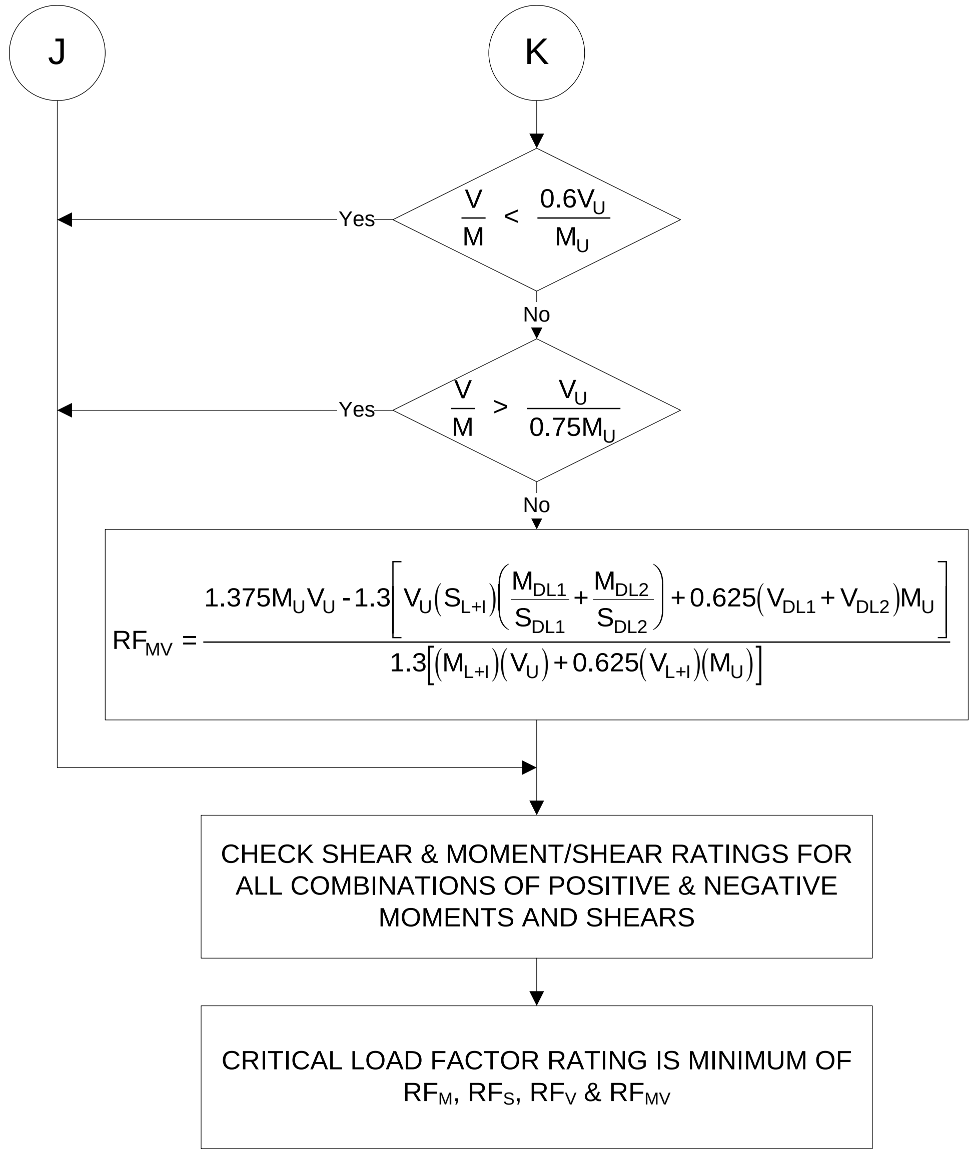


Figure 3.7.2 Load Factor Rating Flow Chart (cont'd)

3.7.3 Overload Moment Strength of Steel Members

The Overload Moment Strength, M_O, is calculated by the following equation.

$$M_O = 0.8\,F_y\,S \qquad \text{(non-composite)}$$

or

$$M_O = 0.95\,F_y\,S \qquad \text{(composite)}$$

The program calculates the Overload Moment Strength based on the section moduli for tension flange, compression flange, concrete deck and tension reinforcement and uses the appropriate strength to determine the critical rating factor. Refer to AASHTO Manual C.2.5 **and 1996 AASHTO Specifications Article 10.57.**

3.7.4 Flexural Strength of Concrete Members

The Flexural Strength, M_U, is calculated by the following equations.

$$\Phi = 0.90$$

$$\beta_1 = 0.85 \qquad \text{for } f_c' \le 4000 \text{ psi}$$

$$= 0.85 - 0.05\,\frac{f_c' - 4000}{1000} \qquad \text{for } f_c' > 4000 \text{ psi}$$

but not less than 0.65

$$aa = \frac{(A_s - A_s')\,f_y}{0.85\,f_c'(Es)}$$

if aa $\le$ t $\quad A_{sf} = 0$

$> t \quad A_{sf} = \dfrac{0.85\,f_c'(Es - b)(t)}{f_y}$

and

$$aa = \frac{(A_s - A_s' - A_{sf})\,f_y}{0.85\,f_c'(Es)}$$

if $\dfrac{A_s - A_s'}{bd} < 0.85\,\beta_1 \left(\dfrac{f_c' d'}{f_y d}\right)\left(\dfrac{87000}{87000 - f_y}\right)$

$A_s' = 0$, recalculate the value of aa based on $A_s' = 0$

$$M_U = \Phi\left[(A_s - A_s' - A_{sf})f_y\left(d - \frac{aa}{2}\right) + A_{sf}\,f_y\left(d - \frac{t}{2}\right) + A_s' f_y (d - d')\right]$$

3.7.5 Shear Strength of Concrete Members

The Shear Strength, V_U, is calculated by the following equation.

$$V_U = \Phi(V_C + V_S) \qquad \text{where} \qquad \Phi = 0.85$$

$$V_C = 2\sqrt{f_c'}\,bd$$

$$V_S = A_{vb} f_y \sin\alpha \qquad \text{but not greater than } 3\sqrt{f_c'}\,bd \quad \text{(for a slab bridge)}$$

$$V_S = \frac{A_{vs} f_y d}{s} + A_{vb} f_y \sin\alpha \qquad \text{but not greater than } 8\sqrt{f_c'}\,bd \quad \text{(for a T-beam bridge)}$$

where s = stirrup spacing

3.7.6 Stresses

Extreme fiber stresses in flexural members (girder, stringer, floorbeam and R.C. beam) are calculated by the following formulas.

$$f_{DL1} = \frac{M_{DL1}}{S_{DL1}} \qquad f_{DL2} = \frac{M_{DL2}}{S_{DL2}} \qquad f_{LL+I} = \frac{M_{LL+I}}{S_{LL+I}}$$

These stresses are computed at the top of steel, bottom of steel, top of slab and center of gravity of slab reinforcement.

The shear stress is computed by the following formula if shear is carried by the web portion of the section.

$$v = \frac{V}{t_w d}$$

3.7.7 **Limiting Bending Stress**

When the shear stress is higher than 0.6*Fv, the limiting bending stress of steel beams subjected to simultaneous action of shear and bending moment shall be 0.754*FY – 0.34(fv/Fv)Fy, given in 1996 AASHTO 10.34.4.4.

fv is the average unit shear stress at the section

Fv is the value from 1996 AASHTO Equation 10-27.

3.7.8 Shear Strength of Encased I-beam

When calculating the shear strength, an encased I-beam is considered as a stiffened composite steel section. As seen in the Load Factor Rating Flow Chart shown in Figure 3.7.2 on page 3-41, there is no difference between composite and non-composite sections when calculating the shear strength.

3.7.9 Axial Capacities of Truss Members

The axial capacities of a truss member are computed in accordance with the provisions of Articles 1.7 & 1.8 of the 1985 AASHTO Guide Specifications for Strength Design of Truss Bridges (Load Factor Design).

For a tension member without eccentricity, the axial capacity is taken as the smaller P calculated by the following formulas:

P = Ag*Fy

P = An*Fu

Where

Ag = Gross section area reduced by the area of hand holes and perforations

An = Net section area reduced by the area of hand holes and perforations

For a tension member with eccentricity, the axial capacity is taken as the smaller P calculated by the following formulas:

P/(Fy*Ag) + M/(Sg*Fy*f) ≤ 1.0

P/(Fu*An) + M/(Sn*Fu*f) ≤ 1.0

Where

Sg = Gross section modulus computed from Ag

Sn = Net section modulus computed from An

f = Plastic shape factor computed on the basis of gross or gross effective properties, Mp/(Fy*Sg)

M = P*e

e = Eccentricity

Simplifying above equations, we have the followings:

P = (Ag*Fy*Sg*Fy*f)/(Sn*Fy*f + e*An*Fy)

P = (An*Fu*Sn*Fu*f)/(Sn*Fu*f + e*An*Fu)

For a compression member without eccentricity, the axial capacity is taken as the smaller P calculated by the following formulas:

P = 0.85*Age*Fcr

P = 0.85*Age*Fy

For a compression member with eccentricity, the axial capacity is taken as the smaller P calculated by the following formulas:

P/(0.85*Fcr*Age) + M*C/Mu/[1-P/(Age*Fe)] ≤ 1.0

P/(0.85*Fy*Age) + M/Mp ≤ 1.0

Where

Age = Gross effective area

Fcr = Critical load per AASHTO Article 10.54.1.1 with a suitable effective length factor, K

C = Equivalent moment factor taken as 0.85 or 1.00 as appropriate

Fe = (0.85)(Pi*Pi)(E)/(KL/r)^2, Pi = 3.1415926583

Mp = Fy*f*Sge

Sge = Section modulus reduced for access holes, if any.

Mu = Maximum bending strength, reduced for lateral buckling as indicated herein.

M = P*e

e = Eccentricity

Simplifying above equations, we have the followings:

-Mu*P^2 + P*[Mu*Age*Fe + 0.85*e*C*Age*Fe*Age*Fcr + 0.85*Mu*Age*Fcr] - 0.85*Age*Fcr*Mu*Age*Fe $\leq$ 0.0, P is taken the smaller of the root.

P = 0.85*Mp*Age*Fy/(Mp+0.85*Age*Fy*e)

The bending strength of truss member, Mu, shall be calculated using the equations given below:

For box-shaped members (SHAPE = 1):

$$Mu = FySge\left[1 - 0.0641\frac{FySgeL\sqrt{\sum(s/t)}}{EA\sqrt{Iy}}\right]$$

Where:

A = Area enclosed within centerlines of plates of box members

s/t = Length of a side divided by its thickness

Iy = Moment of inertia about the axis perpendicular to the bending axis.

L = Length of a member

Sge = Gross effective section modulus about bending axis]

For H-shaped members bent about their minor axis (SHAPE = 2):

Mu = 1.5*Fy*Sge

For H-shaped members, and members with channel flanges and a web plate, bent about their major axis (SHAPE = 3):

If σcr $\leq$ 0.5*Fy, Mu = σcr*Sge

If σcr > 0.5*Fy, Mu = Fy*Sge*[1-Fy/(4*σcr)]

$$\sigma_{\mathrm{cr}} = \frac{1}{S_{ge}} \sqrt{\frac{\pi^2 EIyGJ}{(KL)^2} + \frac{\pi^4 h^2 Iy^2 E^2}{4(KL)^4}}$$

Where:

J = St. Venant torsional constant, approximately summation of b*t^3/3

h = Depth of web plate plus flange thickness

G = Shear modulus.

K = Effective length factor for column buckling about weak axis

Iy = Moment of inertia about the axis perpendicular to the bending axis

σcr = Critical elastic lateral-torsional buckling stress

3.8 LIVE LOAD RATINGS

The program calculates the flexural and shear ratings based on both the Allowable Stress Method and the Load Factor Method. The rating is calculated as a factor that is a ratio of the allowable live load to the actual live load. The rating of a bridge is then obtained by multiplying the gross weight of the live load by the minimum rating factor. The rating factors for the ML80 and TK527 loadings are calculated based on the axle loads shown in Figure 2.4.1 on page 2-11 that include a 3% scale tolerance allowed by the vehicle code. The ratings in tons for the ML80 and TK527 loadings do not include the 3% scale tolerance allowed by the vehicle code.

Rating factors are calculated for the Inventory Rating and the Operating Rating. For ratings, members are divided into three types: flexural steel members (girder, stringer, floorbeam, encased I-beam**, gusset plate for truss**), flexural concrete members (R.C. T -beam, R.C. Slab), and truss members (axial force only).

3.8.1 Flexural Steel Members

Based on the moments, shears, capacities, and strengths calculated as explained earlier, the program computes the following rating factors based on the Allowable Stress and Load Factor Methods.

3.8.1.1 Allowable Stress Method

Inventory Rating

$$IR_1 = \frac{M_{CIR} - S_{LL+I}\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}}$$

$$IR_2 = \frac{V_{CIR} - V_{DL1} - V_{DL2}}{V_{LL+I}}$$

$$IR_3 = \frac{0.754F_y - \left[\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right) + 0.34\left(\dfrac{V_{DL1}}{D\,t_w} + \dfrac{V_{DL2}}{D\,t_w}\right)\left(\dfrac{F_y}{F_V}\right)\right]}{\dfrac{M_{LL+I}}{S_{LL+I}} + 0.34\left(\dfrac{V_{LL+I}}{D\,t_w}\right)\left(\dfrac{F_y}{F_V}\right)}$$

Fv is the value from 1996 AASHTO Equation 10-26.

$$IR = smaller\ of\ IR_1, IR_2\ and\ IR_3$$

Operating Rating

$$OR_1 = \frac{M_{COR} - S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}}$$

$$OR_2 = \frac{V_{COR} - V_{DL1} - V_{DL2}}{V_{LL+I}}$$

$$OR_3 = \frac{0.754F_y - \left[\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right) + 0.34\left(\frac{V_{DL1}}{D\,t_w} + \frac{V_{DL2}}{D\,t_w}\right)\left(\frac{F_y}{F_V}\right)\right]}{\frac{M_{LL+I}}{S_{LL+I}} + 0.34\left(\frac{V_{LL+I}}{D\,t_w}\right)\left(\frac{F_y}{F_V}\right)}$$

Fv is the value from 1996 AASHTO Equation 10-26.

$$OR = smaller\ of\ OR_1, OR_2\ and\ OR_3$$

Safe Load Capacity as IR Level

When SLC LEVEL is expressed as a percentage **increase** of the Inventory Stress.

$$SL = 1 + \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)\,M_{CIR} - S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}}$$

$$SLC_2 = \frac{(SL)\,V_{CIR} - V_{DL1} - V_{DL2}}{V_{LL+I}}$$

$$SLC = smaller\ of\ SLC_1\ and\ SLC_2$$

Safe Load Capacity as OR Level

When SLC LEVEL is expressed as a percentage of the Operating Stress.

$$SL = \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)\,M_{COR} - S_{LL+I}\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}}$$

$$SLC_2 = \frac{(SL)\,V_{COR} - V_{DL1} - V_{DL2}}{V_{LL+I}}$$

$$SLC = smaller\ of\ SLC_1\ and\ SLC_2$$

3.8.1.2 Load Factor Method

The load factor ratings are computed based on the moment strength, shear strength, overload moment strength and moment-shear interaction and by applying appropriate load factors to the dead load and live load effects. The following factors are computed.

Operating Rating

$$OR_1 = \frac{M_U - 1.3 S_{LL+1}\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right)}{1.3\,M_{LL+I}} \qquad \text{(non-compact)}$$

$$OR_1 = \frac{M_U - 1.3(M_{DL1} + M_{DL2})}{1.3\,M_{LL+I}} \qquad \text{(compact)}$$

$$OR_2 = \frac{V_U - 1.3(V_{DL1} + V_{DL2})}{1.3\,V_{LL+I}} \qquad \text{(shear)}$$

$$OR_3 = \frac{M_O - S_{LL+I}\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}} \qquad \text{(overload)}$$

$$OR_4 = \frac{1.375\,M_U V_U - 1.3\left[S_{LL+I}\left(\dfrac{M_{DL1}}{S_{DL1}} + \dfrac{M_{DL2}}{S_{DL2}}\right)V_U + 0.625(V_{DL1} + V_{DL2})(M_U)\right]}{1.3\left[M_{LL+I}V_U + 0.625\,V_{LL+I}M_U\right]} \text{(interaction)}$$

Note: The equation for OR_4 is derived from Eqn. (10-118) **V/Vu = 2.2 – (1.6M/Mu) given** in **1996** AASHTO Specifications Article 10.48.8.2 or AASHTO Manual C.2.3, by substituting

$$V = 1.3\left[V_{DL1} + V_{DL2} + OR_4\left(V_{LL+I}\right)\right]$$

$$M = 1.3\left[S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right) + OR_4\left(M_{LL+I}\right)\right]$$

and factoring the OR_4 term out.

$$OR = \text{smaller of } OR_1, OR_2, OR_3 \text{ and } OR_4$$

Inventory Rating

$$IR = \frac{3}{5}(OR)$$

Please note that internally the program first calculates IR and then obtains OR by multiplying IR by 1.67.

.

Safe Load Capacity as IR Level

When SLC LEVEL is expressed as a percentage **increase** of the Inventory Strength **such as 10%**.

$$SL = 1 + \frac{SLC\ LEVEL}{100}$$

$$SLC = \frac{IR}{(2 - SL)}$$

Safe Load Capacity as OR Level

When SLC LEVEL is expressed as a percentage of the Operating Strength **such as 90%**.

$$SL = \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)\,M_U - 1.3\,S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right)}{1.3\,M_{LL+I}}$$

$$SLC_2 = \frac{(SL)V_U - 1.3\left(V_{DL1} - V_{DL2}\right)}{1.3V_{LL+I}}$$

$$SLC_3 = \frac{(SL)\,M_O - S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right)}{M_{LL+I}}$$

$$SLC_4 = \frac{1.375\,(SL)M_U V_U - 1.3\left[S_{LL+I}\left(\frac{M_{DL1}}{S_{DL1}} + \frac{M_{DL2}}{S_{DL2}}\right)V_U + 0.625(V_{DL1} + V_{DL2})(M_U)\right]}{1.3\left(M_{LL+I}V_U + 0.625 V_{LL+I} M_U\right)}$$

$$SLC = smaller\ of\ SLC_1, SLC_2, SLC_3\ and\ SLC_4$$

3.8.2 Flexural Concrete Members

Based on the moments, shears, capacities, and strengths calculated as explained earlier, the program computes the following rating factors based on the Allowable Stress and Load Factor Methods.

3.8.2.1 Allowable Stress Method

The allowable stress ratings are computed based on various section capacities computed as explained earlier and then subtracting the dead load effect to get the available capacity for live load. The rating factor is obtained by dividing the available capacity by the live load plus impact effect. The following rating factors are computed.

Inventory Rating

$$IR_1 = \frac{M_{CIR} - M_{DL}}{M_{LL+I}}$$

$$IR_2 = \frac{V_{CIR} - V_{DL}}{V_{LL+I}}$$

$$IR = smaller\ of\ IR_1\ and\ IR_2$$

Operating Rating

$$OR_1 = \frac{M_{COR} - M_{DL}}{M_{LL+I}}$$

$$OR_2 = \frac{V_{COR} - V_{DL}}{V_{LL+I}}$$

$$OR = smaller\ of\ OR_1\ and\ OR_2$$

Safe Load Capacity as IR Level

When SLC LEVEL is expressed as a percentage **increase** of the Inventory Stress.

$$SL = 1 + \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)M_{CIR} - M_{DL}}{M_{LL+I}}$$

$$SLC_2 = \frac{(SL)V_{CIR} - V_{DL}}{V_{LL+I}}$$

$$SLC = smaller\ of\ SLC_1\ and\ SLC_2$$

Safe Load Capacity as OR Level

When SLC LEVEL is expressed as a percentage of the Operating Stress.

$$SL = \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)M_{COR} - M_{DL}}{M_{LL+I}}$$

$$SLC_2 = \frac{(SL)V_{COR} - V_{DL}}{V_{LL+I}}$$

$$SLC = smaller\ of\ SLC_1\ and\ SLC_2$$

3.8.2.2 Load Factor Method

The load factor ratings are computed based on the ultimate strength of the member and by applying appropriate load factors to the dead load and live load effects. The following factors are computed.

Inventory Rating

$$IR_1 = \frac{M_U - 1.3M_{DL}}{1.3\,(5/3)\,M_{LL+I}}$$

$$IR_2 = \frac{V_U - 1.3V_{DL}}{1.3\,(5/3)\,V_{LL+I}}$$

$$IR = smaller\ of\ IR_1\ and\ IR_2$$

Operating Rating

$$OR_1 = \frac{M_U - 1.3M_{DL}}{1.3M_{LL+I}}$$

$$OR_2 = \frac{V_U - 1.3V_{DL}}{1.3V_{LL+I}}$$

$$OR = smaller\ of\ OR_1\ and\ OR_2$$

Safe Load Capacity as IR Level

When SLC LEVEL is expressed as a percentage **increase** of the Inventory Strength.

$$SL = 1 + \frac{SLC\ LEVEL}{100}$$

$$SLC = \frac{IR}{(2 - SL)}$$

Safe Load Capacity as OR Level

When SLC LEVEL is expressed as a percentage of the Operating Strength.

$$SL = \frac{SLC\ LEVEL}{100}$$

$$SLC_1 = \frac{(SL)M_U - 1.3M_{DL}}{1.3M_{LL+I}}$$

$$SLC_2 = \frac{(SL)V_U - 1.3V_{DL}}{1.3V_{LL+I}}$$

$$SLC = smaller\ of\ SLC_1\ and\ SLC_2$$

3.8.3 Truss Members

3.8.3.1 Allowable Stress Method

Axial member forces due to the dead loads, F_{DL}, and live load plus impact, F_{LL+I}, are computed as explained earlier. The allowable forces, F_{CIR}, F_{COR}, in each member are computed by multiplying the allowable stress and the cross-sectional area of the member. The rating factors are calculated using the Allowable Stress Method.

For a tension member

$$F_{CIR} = \textit{smaller of } (0.55\, F_y \textit{ x Gross Area}) \textit{ and } (0.50\, F_U \textit{ x NetArea})$$

$$F_{COR} = \textit{smaller of } (0.75\, F_y \textit{ x Gross Area}) \textit{ and } (0.67\, F_U \textit{ x NetArea})$$

3.8.3.1.1 Inventory and Operating Rating

$$IR = \frac{F_{CIR} - F_{DL}}{F_{LL+I}}$$

$$OR = \frac{F_{COR} - F_{DL}}{F_{LL+I}}$$

For a member subjected to both tensile and compressive forces, the rating factors are computed based on the allowable tension and the allowable compression. The minimum rating factor is used.

3.8.3.1.2 Safe Load Capacity as IR Level

SLC LEVEL is expressed as a percentage **increase** of the Inventory Stress.

$$SL = 1 + \frac{SLC\ LEVEL}{100}$$

$$SLC = \frac{(SL)F_{CIR} - F_{DL}}{F_{LL+I}}$$

3.8.3.1.3 Safe Load Capacity as OR Level

SLC LEVEL is expressed as a percentage of the Operating Stress.

$$SL = \frac{SLC\ LEVEL}{100}$$

$$SLC = \frac{(SL)F_{COR} - F_{DL}}{F_{LL+I}}$$

3.8.3.2 Load Factor Method

Axial member forces due to the factored dead loads, P_{DL}, and factored live load plus impact, P_{LL+I}, are computed as explained earlier. The member capacities, Pu, in each member are computed accordingly. The rating factors are calculated using the Load Factor Method.

For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the AASHTO Guide Spec for Truss. Article 1.2. That is:

If $P_{DL} \le 0.77 * (P_{DL} + P_{LL+I})$, then it is case 1:

$P_{TOT} = 1.3*(P_{DL} + (5/3)*P_{LL+I})$

If $P_{DL} > 0.77 * (P_{DL} + P_{LL+I})$, then it is case 2:

$P_{TOT} = 1.5**(P_{DL} + P_{LL+I})$

where: P_{DL} = total force due to factored dead loads

P_{LL+I} = total force due to factored live load (live load + impact)

P_{TOT} = total force due to total factored load

For truss spans less than 500 feet long, use case 1 LFD loads for the supplementary check of capacity.

The load factor ratings are computed based on the ultimate strength of the member and by applying appropriate load factors to the dead load and live load effects. For a member subjected to both tensile and compressive forces, the rating factors are computed based on the tension and the compression. The minimum rating factor is used.

3.8.3.2.1 Inventory Rating

Case 1:

$IR1 = (Pu - 1.3*P_{DL}) / (1.3*(5/3)*P_{LL+I})$

Case 2:

$IR2 = (Pu - 1.5*P_{DL}) / (1.5*P_{LL+I})$

IR = smaller of IR1 and IR2

3.8.3.2.2 Operating Rating

Case1:

$OR1 = (Pu - 1.3*P_{DL}) / (1.3*P_{LL+I})$

Case 2:

$OR2 = (Pu - 1.5*P_{DL}) / (1.5*(5/3)*P_{LL+I})$

OR = smaller of OR1 and OR2

Note: The program did not use the “IR = (3/5)*OR” which can be used to verify the program result manually.

3.8.3.2.3 Safe Load Capacity as IR Level

SLC LEVEL is expressed as a percentage of the Inventory Strength.

SL = 1 + SLC LEVEL/100

SLC = IR/(2-SL)

3.8.3.2.4 Safe Load Capacity as OR Level

SLC LEVEL is expressed as a percentage of the Operating Strength.

SL = SLC LEVEL/100

Case 1:

$SLC1 = (SL*Pu - 1.3*P_{DL}) / (1.3*(5/3)*P_{LL+I})$

Case 2:

$SLC2 = (SL*Pu - 1.5*P_{DL}) / (1.5*(5/3)*P_{LL+I})$

SLC = smaller of SLC1 and SLC2

3.9 DEFLECTIONS

3.9.1 Simple Span Beam or Girder

Deflections of a simple span beam or girder are computed using the conjugate beam method. For this, moments are computed at the 10th point sections assuming a unit uniform load acting on the entire span. Each moment is divided by the flexural rigidity (EI) of the section and a conjugate beam with an M/EI loading is constructed. The moment at any section of the conjugate beam due to M/EI loading is the deflection of the real beam. Actual dead load deflections are computed by multiplying the unit uniform load deflections with the actual dead load acting on the beam.

The influence lines for deflections are generated by applying a unit vertical load at each 10th point section at a time and computing deflections for each loading condition as described above. Each deflection influence line is then analyzed for a live load to obtain the live load plus impact deflection.

3.9.2 Continuous Span Girder

Deflections of a continuous span girder are obtained by the modified flexibility method as described in Section 3.3.1. For each loading condition (either a unit uniform load on the entire girder or a unit vertical load at a given section), the support reactions and joint deflections are computed by multiplying the inverted flexibility matrix and the load matrix. For details of this method, refer to Analysis of Framed Structures by Gere and Weaver, Van Nostrand Publication. Actual dead load deflections are computed by multiplying the unit load deflections with the actual dead load acting on the girder.

The influence lines for deflections are generated by applying a unit vertical load at each 10th point section at a time and solving the matrices explained above. Each deflection influence line is then analyzed for a live load to obtain the live load plus impact deflections.

3.9.3 Truss

The dead load deflections are computed by the unit load method. The live load deflections are computed by the influence line method. Deflections due to temperature change are computed based on the method of virtual work. For these methods refer to any standard textbook on structural engineering.

3.10 FATIGUE LIFE ESTIMATION

The program calculates the fatigue life of a girder or truss based on the criteria set forth in "Policy and Procedures, Chapter 5, Rehabilitation Strategy," of DM4. Figure 3.10.1 on page 3-67 shows the flow chart of the calculations performed by BAR7 for the fatigue life analysis of a girder or truss.

3.10.1 Girder

The fatigue life of a girder is calculated by evaluating each fatigue prone detail specified by the user. The program calculates the design fatigue stress range and the allowable fatigue stress range at each detail. The design fatigue stress range at a detail is calculated as follows. The maximum positive moment and the maximum negative moment at a detail are calculated by parabolic interpolation of the 10th point moments calculated earlier. The live load plus impact moment calculated for fatigue life analysis is based on AASHTO Simplified Method by placing a single HS20 truck with a fixed spacing of 14 feet between its rear axles in one lane. The stresses at a detail due to the dead load plus positive live load moment and due to the dead load plus negative live load moment are then calculated using appropriate section moduli. The algebraic difference of the maximum stress **(DL+LL)** and the minimum stress is the design fatigue stress range. If the detail never experiences a tensile stress, i.e. the detail always remains in compression under dead load and live load plus impact, the program assumes that the design fatigue stress range is zero. The allowable fatigue stress range is calculated per AASHTO Specifications Table 10.3.1A for over 2,000,000 cycles.

The program then compares the design fatigue stress range due to an HS20 truck in one lane to the allowable fatigue stress range. If the design fatigue stress range due to an HS20 truck in one lane is less than or equal to the allowable fatigue stress range, or if the design fatigue stress range is zero, the program assumes that the detail has infinite fatigue life and no further analysis is required. If the **PTF***design fatigue stress range due to an HS20 truck in one lane is greater than the allowable fatigue stress range, the program computes the effective stress range. The effective stress range is the design fatigue stress range due to an HS20 truck in one lane multiplied by the appropriate factors given in DM4. The design fatigue life (minimum number of cycles to failure) and the remaining fatigue life (years) of each detail are calculated using the equations given in Figure 3.10.1 on page 3-67

If the user wants to consider a growth factor in the average daily truck traffic, the program uses the following engineering economy equations to calculate the accumulated cycles and the remaining life in years.

If the ADTT's are known for two calendar years (previous count year n_1 and recent count year n_2), the program calculates the past growth factor, GF_1 by:

$$ADTT(n_2) = [ADTT(n_1)](1 + GF_1)^n \qquad \text{where } n = n_2 - n_1$$

The previous equation is not used if GF_1 is known (or estimated) and is entered. This growth factor, GF_1, is then used to approximate the ADTT for the year the structure was built as follows:

$$ADTT(year\ built) = \frac{ADTT(n_2)}{(1+GF_1)^n} \qquad \text{where } n = n_2 - \text{year built}$$

The number of cycles accumulated up to the year n_2 is computed by:

$$M = (365)[ADTT(year\ built)]\left[\frac{(1+GF_1)^n - 1}{GF_1}\right] \qquad \text{where } n = n_2 - \text{year built}$$

If the estimated ADTT for a future count year, n_3, is entered, the future growth factor, GF_2, is calculated by:

$$ADTT(n_3) = [ADTT(n_2)](1+GF_2)^n \qquad \text{where } n = n_3 - n_2$$

The above equation is not used if GF_2 is known (or estimated) and is entered.

The remaining life (years) is then calculated using the following, which is derived from the engineering economy equation for compound amount:

$$R = \frac{\ln\left[\frac{\Delta\ x\ GF_2}{\lambda} + 1\right]}{\ln(1+GF_2)}$$

where

R	=	remaining years
Δ	=	remaining cycles
	=	design fatigue life – accumulated cycles
	=	N – M
GF_2	=	future growth factor
λ	=	(365)[ADTT (n_2)] (1+GF_2)
ln	=	natural log

The future growth factor can be estimated and entered or can be calculated by the program if the estimated ADTT for future is entered.

The minimum fatigue life for the girder and the location of critical detail are printed out.

3.10.2 Truss

The estimated fatigue life of each truss member for which a fatigue life analysis is requested is calculated in the same manner as described for the girder. The maximum positive (tension) axial force and the maximum negative (compression) axial force due to an HS20 truck with a fixed spacing of 14 feet between its rear axles are calculated for each member using the influence line method. The stresses due to dead load force plus maximum positive live load force and due to dead load force plus maximum negative live load force are then calculated using appropriate cross sectional areas. The algebraic difference of the maximum stress and the minimum stress is the design fatigue stress range. If the detail never experiences a tensile stress, i.e. the detail always remains in compression under dead load and live load plus impact, the program assumes that the design stress range is zero.

The allowable fatigue stress range, the estimated fatigue life and the remaining fatigue life of each member are then calculated in the same manner as described for the girder. The minimum fatigue life for the truss and the critical member are printed out.

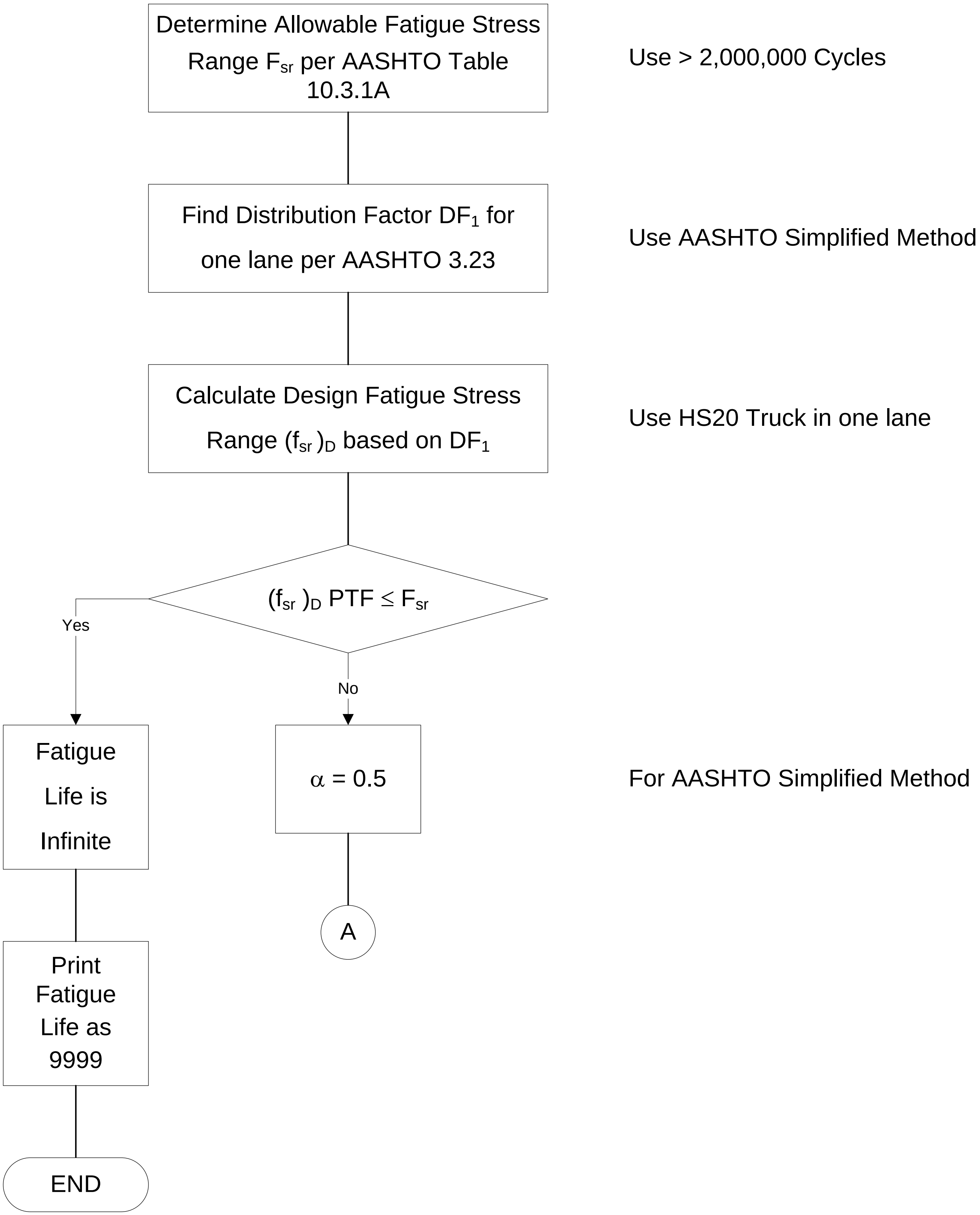


Figure 3.10.1 Fatigue Life Estimation Flow Chart

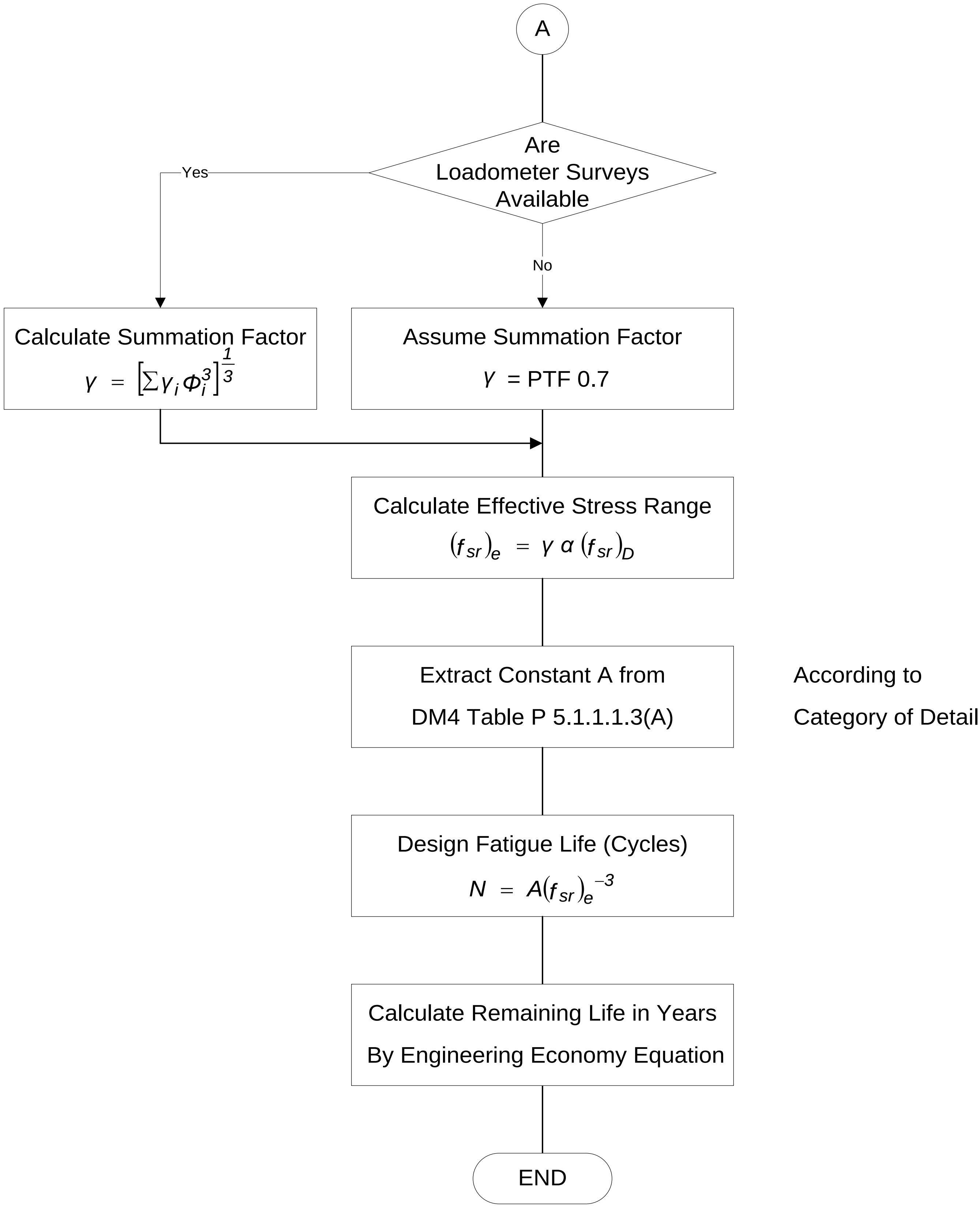


Figure 3.10.1 Fatigue Life Estimation Flow Chart (cont'd)

3.11 GUSSET PLATE ANALYSIS AND OPERATING RATINGS

The program can analyze and providing Load Factor operating ratings for gusset plates. Ratings are provided for shear, tension and compression, block shear, and connections.

3.11.1 Notes

For Section 3.11 Gusset Plate Analysis and Operating Ratings, the following specifications and guidance documents will be abbreviated:

- AASHTO Standard Specifications for Highway Bridges, 17th Ed. ("AASHTO Specifications")
- Guide Specifications for Strength Design of Truss Bridges (Load factor Design), 1985 ("Guide Spec.")
- AASHTO Manual for Condition Evaluation of Bridges, 2nd Ed., 1994 with interims ("AASHTO Manual")
- FHWA Publication FHWA-IF-09-014, "Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges", Part B, February 2009 ("FHWA Guidance")

For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2. That is:

If $DL \leq 0.77 * (DL + LL)$, then

$$P = 1.3\left(DL + \frac{5}{3}LL\right)$$

If $DL > 0.77 * (DL + LL)$, then

$$P = 1.5(DL + LL)$$

where: *DL* = total force due to dead loads

LL = total force due to live load (live load + impact)

P = total factored load

Note: The ratings generated by BAR7 are always operating level ratings, and as such, the load factors as shown in section 3.11.8 are used.

The equilibrating forces in the gusset plate were computed using the free-body diagrams cut along the section A-A, B-B, and C-C. For example, the axial force which is perpendicular to the section A-A was computed by the force components, perpendicular to the section A-A, of the truss members 3, 4, and 5 due to the factored dead loads and live loads plus impact. Factored axial force in plate (perpendicular to the section A-A) = 0.5 (due to two plates) * (factored member force 3*cos(angle3) + factored member force 5*cos(angle5) + factored member force 4).

When computing the equilibrating forces in the gusset plate for section B-B or section C-C, there will be a reduction factor for member forces 1 and 2 using the following simplified approximate

formula: Reduction Factor = ((4*diameter + distance between the first row and last row) - eccentricity) / (4*diameter + distance between the first row and last row)

3.11.2 General

F_y = specified minimum yield stress of the gusset plate material

F_u = specified minimum tensile stress of the gusset plate material (1.4 F_y is used as a default value if F_u was not input)

3.11.3 Shear Capacity

Gusset plates subjected to shear shall be investigated for two conditions: gross shear yielding and net section fracture. The shear capacity is the lesser of these two conditions. A factor of 0.74 will be used for the shear stress distribution.

Gross Shear Yielding (FHWA Guidance, Equation 6):

$$F_{vg} = 0.58\,F_y\,0.74 = 0.429\,F_y$$

$$P_{vg} = F_{vg}\,A_g$$

where: F_{vg} = shear stress capacity

F_y = yield stress of the gusset plate

P_{vg} = shear capacity

A_g = area of the gusset plate resisting the shear

0.74 = a factor used in the absence of a more rigorous analysis or criterion to assure and quantify the stiffness requirements to develop the plastic shear force of the plates

Net Section Fracture (FHWA Guidance, Equation 7):

$$F_{vn} = 0.85\,x\,0.58\,F_u = 0.493\,F_u$$

$$P_{vn} = F_{vn}\,A_n$$

where: F_{vn} = shear stress capacity

F_u = tensile stress of the gusset plate

P_{vn} = shear capacity

A_n = area of the gusset plate (less holes) resisting the shear

0.85 = resistance factor for shear fracture on the net section

3.11.4 Capacity Equations to Analyze Gusset Plates at the End of All Members for Tension and at the End of the Diagonal and Vertical chords for Compression

3.11.4.1 Gusset Plate in Tension

Gusset plates subjected to axial tension shall be investigated for two conditions: yield on the effective gross section and fracture on the net section. For both yielding on the gross section and fracture on the net section, the Whitmore method (i.e. 30° distribution) will be used to determine the "effective width" to calculate the gross area in tension (See Figure 3.11.1 on page 3-76 at the end of this section).

Effective Gross Section Yielding (FHWA Guidance, Equation 2):

$$R_r = A_e F_y$$

where: R_r = effective gross section yield capacity

A_e = effective gross cross-sectional area taking into account the possibility of net section fracture

= $A_n + \beta A_g \leq A_g$

A_n = net cross-sectional area of the plates as specified in AASHTO Specifications Article 10.16.14

β = 0.0 for M 270 Grade 100/100W steels, or when holes exceed 1¼ inch in diameter

= 0.15 for all other steels and when holes are less than or equal to 1¼ inch in diameter

A_g = gross cross-sectional area of the plates

F_y = yield strength of the gusset plate

3.11.4.2 Gusset Plate in Compression

Gusset plates subjected to compression will be analyzed as an idealized column. This method is generally conservative when compared to the capacity obtained using plate buckling theory. The adequacy of the gusset plate at the end of the diagonal due to a compressive diagonal axial force will also be investigated. Buckling at the end of the compression diagonal will be the assumed failure mode in compression. Therefore, compression must be checked on the effective width line (using the Whitmore method, i.e. 30° distribution) at the end of the diagonal (See Figure 3.11.1 on page 3-76 at the end of this section).

According to FHWA Guidance, the effective width of the idealized compression member may be determined in accordance with the Whitmore method. The unbraced length, L_c, may be determined as the average of three distances ($L_{C\#-1}$, $L_{C\#-2}$, $L_{C\#-3}$) as follows:

where: $L_{C\#-2}$ = distance from the last row of fasteners in the compression member under consideration to the first row of fasteners in the closest adjacent member, measured along the line of action of the compressive axial force (See Figure 3.11.1 on page 3-76 at the end of this section).

$L_{C\#\text{-}1}, L_{C\#\text{-}3}$ = distance from each of the ends of the Whitmore width to the first row of fasteners in the closest adjacent member, measured parallel to the line of action of the compressive axial force. When the Whitmore width enters into the adjacent member, the associated distance at that end should be set to zero (See Figure 3.11.1 on page 3-76 at the end of this section).

Use the capacity equation provided in AASHTO Specifications Article 10.54.1.1 for compression in concentrically loaded columns.

P_c = compression strength along effective width based on $A_g\,F_a$

where: A_g = effective width x gusset plate thickness

Determine the compressive capacity, F_a, using column theory:

$$F_a = 0.85\,F_{cr} \qquad \text{AASHTO Eq. 10-150}$$

if:

$$\frac{KL_c}{r} \le C_c$$

then

$$F_{cr} = F_y\left[1 - \left(\frac{F_y}{4\,\pi^2 E}\right)\left(\frac{K\,L_c}{r}\right)^2\right] \qquad \text{AASHTO Eq. 10-151}$$

where: F_{cr} = critical stress

if:

$$\frac{K\,L_c}{r} > C_c$$

$$F_{cr} = \left(\frac{\pi^2 E}{\left(\frac{K\,L_c}{r}\right)^2}\right) \qquad \text{AASHTO Eq. 10-153}$$

where: F_{cr} = critical stress

K = effective length factor, K, used in the column capacity equation for the unsupported length at the end of the compression diagonal is taken to be 2.0 if the gusset plate analysis shows that the plate has yielded due to shear on Section A-A, otherwise it is taken as 1.2. (AASHTO Appendix C, Table C.1)

C_c **=** $\sqrt{\dfrac{2\,\pi^2 E}{F_y}}$

r **=** **radius of gyration of the plate**

= $\dfrac{t}{\sqrt{12}}$

E = modulus of elasticity of steel

L_c = $L_{c3,\,4\ or\ 5}$

= average distance between the last row of fasteners in the diagonal / vertical to the closest row of fasteners in the chord measured along the line of action of the diagonal / vertical (shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100)

3.11.5 Block Shear Rupture Capacity for Any Member Connection at a Joint

For the block shear rupture planes, please refer to Figure 3.11.2 on page 3-77 at the end of this section. The 1.25 factor is used to convert the capacity to an Operating Level capacity and was determined by dividing the Inventory Euler buckling Factor of Safety (2.12) by the Operating Euler buckling Factor of Safety (1.70). (Refer to AASHTO Manual Section 6.6.2.1-1)

if

$$A_{tn} \geq 0.58\,A_{vn}$$

then

$$P_{bs} = 0.85\,\left(0.58\,F_y A_{vg} + F_u A_{tn}\right)$$ FHWA Guidance Eq. 4 at Sec 3.1.2

where: A_{vg} = gross area along the plane resisting shear stress

A_{tn} = net area along the plane resisting tension stress

0.85 = resistance factor for block shear

Otherwise,

$$P_{bs} = 0.85\,\left(0.58\,F_u A_{vn} + F_y A_{tg}\right)$$ FHWA Guidance Eq. 5 at sec 3.1.2

where: A_{vg} = net area along the plane resisting shear stress

A_{tn} = gross area along the plane resisting tension stress

0.85 = resistance factor for block shear

3.11.6 Connection Capacities

In typical connection design, the connection is designed for the average of the design strength of the diagonals and the factored/service loads they carry, however, the axial force shall not be less than 75% of the design strength. The design strength is the lesser of the member strength, column capacity and strength based on the width-thickness ratio b/t.

For rating evaluation, the adequacy of the fasteners under the factored axial load is checked for fastener shear and bearing on connected material. The member forces are assumed to be distributed equally among all fasteners.

Slip-critical connections are assumed for normal truss connection designs, however, if rivets or low-carbon steel bolts (A307) are specified on the plans, the connection is bearing-type, only high strength bolts can support the high preload necessary for slip-critical connections. In any case, bearing should always be checked if the connection slips due to insufficient tension in the fasteners.

This program does not check bearing strength of the fastener.

3.11.6.1 Investigate the Fasteners in Shear

$$P \le R_v$$

where: R_v = shear capacity of all bolts or rivets in connection from AASHTO Specifications Article 10.56.1.3.2

$$R_v = F_{v\_LFD}\, A_f\, N_f \qquad \text{AASHTO Eq. 10-166a}$$

where: F_{v_LFD} = shear capacity of one bolt or rivet (AASHTO Specifications Table 10.56A may be used)

A_f = area of one fastener, bolt or rivet

N_f = total number of shear planes in fasteners connecting the member to the gusset.

3.11.6.2 Investigate Bearing on the Connected Material

The holes should be assumed to be standard size. Also, the total bearing capacity for the connection is equal to the sum of the bearing capacity for the individual fasteners in the connection. Use the provisions of AASHTO Specifications Article 10.56.1.3.2.

$$P \le R_b$$

where: R_b = capacity of connection in bearing

= the result of $0.9\ L_c\ t\ F_u \le 1.8\ d\ t\ F_u$ (AASHTO Eq. 10-166b) multiplied by the respective number of fasteners, N_f. (See N_f in Section 3.11.6.1 for more information) where: L_c = L_e or L_o

= clear distance between the holes, L_o, or between the hole and the edge of the material, L_e, in the direction of the applied bearing force

L_e = 2d for edge holes

L_o = average clear distance between the holes which is calculated by the program as Lo = L# / (NL# - 1) - hole diameter for all other

t = thickness of the connected material

F_u = specified minimum tensile strength of the connected material

d = nominal diameter of the fastener

3.11.7 Unsupported Edge in Compression Adequacy Check

Check b/t for every free edge on the gusset plate. If the check fails, then the edge shall be stiffened (Guide Spec., Article 1.11)

$$\frac{b}{t} \leq \frac{11000}{\sqrt{F_y}}$$

where: b = maximum unsupported length along edge of gusset plate

t = thickness of the gusset plate

F_y = yield strength of the gusset plate

3.11.8 Operating Level Rating Equations

$$RF = \frac{Nominal\ Capacity - 1.3\ Dead\ Load}{1.3\ (Live\ Load + Impact)}$$

AASHTO Manual Articles 6.5.1 and 6.5.2

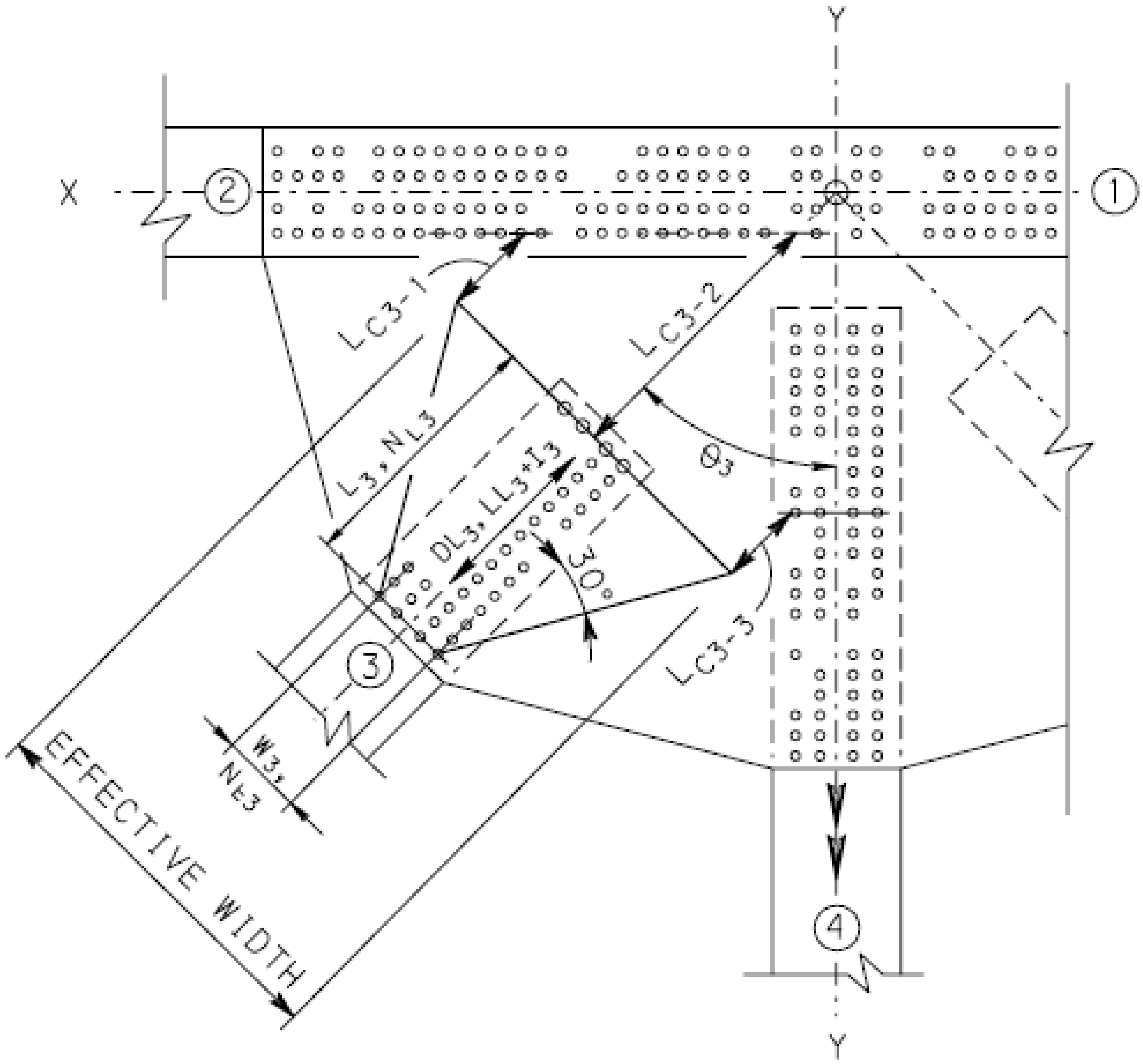


Figure 3.11.1 Gusset Plate Member Effective Width

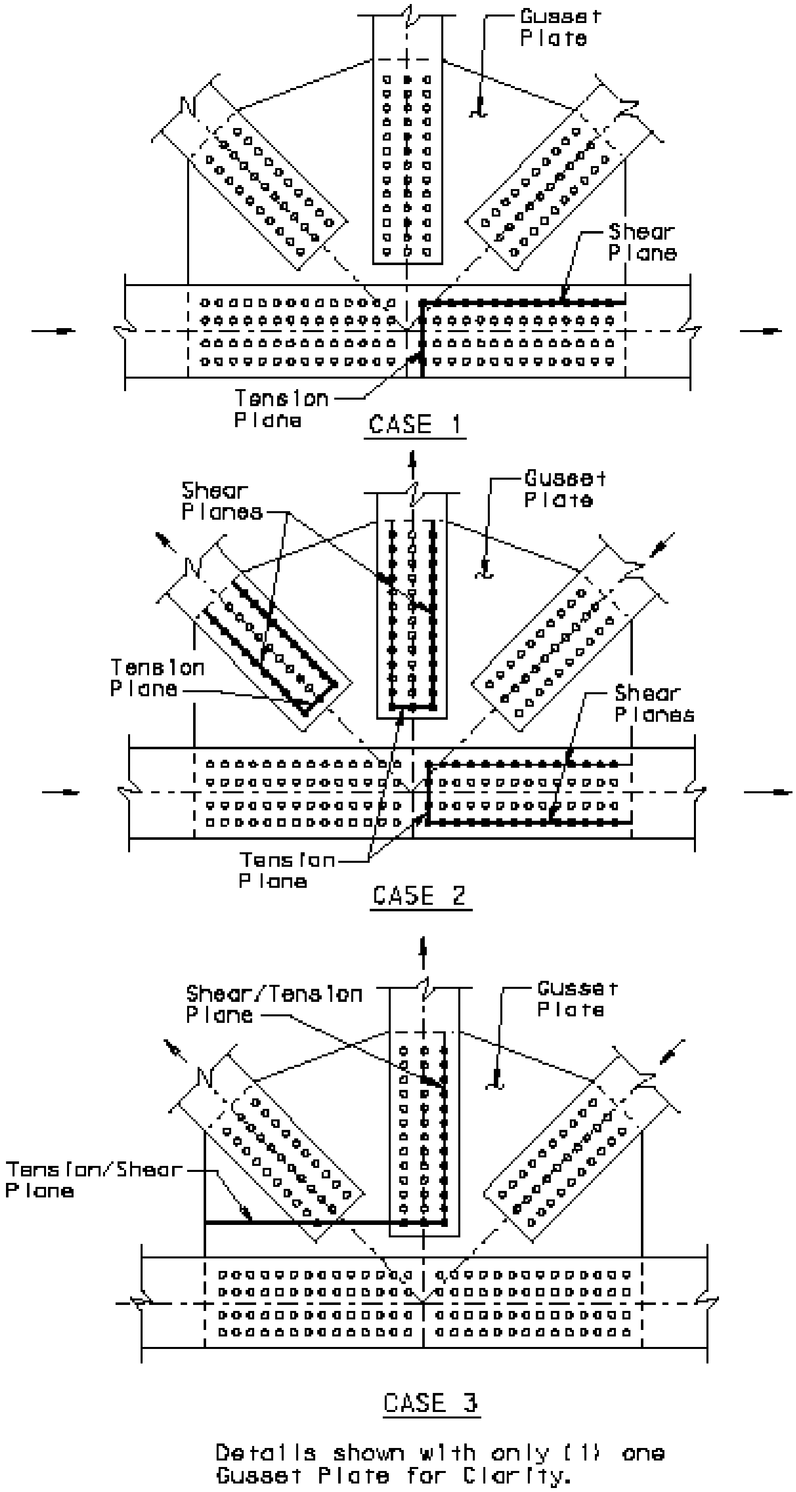


Figure 3.11.2 Gusset Plate Block Shear Cases

3.12 PONY TRUSS STABILITY CHECK

3.12.1 Notes

For the purpose of this section, Pony Truss Stability Check, the following specifications and guidance documents will be used:

- AASHTO Specifications: Article 10.16.12 Half-through Truss Spans
- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, December 2009
- Chapter 14 of the Guide to Stability Design criteria for Metal Structures, 3rd Ed. By Bruce Johnston

The Pony Truss Stability Check can only be performed when the Load Factor Method analysis is selected. Otherwise the program produces an error.

3.12.2 General

AASHTO specified the top chord shall be considered as a column with elastic lateral supports at the panel points. AASHTO also specified that top chords and vertical members at a floorbeam locations of a pony truss shall resist a lateral force applied at the top of the truss verticals. The applied lateral force shall not be less than 0.01/K times the average factored design compressive force in the two adjacent top chords. Therefore, the top chord stability check shall be performed at specified floorbeam location of a pony truss which bridge type is TFS.

Note:

TFF: truss floorbeam steel bridge (no stringers)

No pony truss stability check will be performed because this is a deck truss.

TTT:

No pony truss stability check will be performed because there are no floorbeam and stringer analyses.

TFS: truss floorbeam stringer steel bridge

Only the pony truss will be checked. However, the upper diagonal chord stability check at specified floorbeam location of a pony truss will not be checked because it is a tension member.

3.12.3 Logic

For this stability check, BAR7 will run twice. The first run will compute the spring constant and the member LFD capacity using the BAR7-default K values depending on the pinned or riveted end condition selected from the user. With member capacity and spring constant are known, we can find the computed pony-K value. Compare the BAR7-default K value and computed pony-K value to obtain the controlling K value. The second run will compute using the controlling k values.

3.12.4 Lookup Table for K Values

AASHTO specified the procedure for determining the resistance of a compression chord with a value for the effective factor, K, based on a lateral U-frame. Use the lookup table from the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, December 2009, Table 7.1.2-1: values of 1/K (1.000 to 0.085 for 30 values) for various values of CL/Pc and n (4 to 16). In addition, missing data will be linearly interpolated if needed.

Where

K = effective length factor

C = transverse-frame spring constant which is the lateral stiffness of the U-frame made of the truss vertical and the floorbeam taken as P/delta - kips/in

L = length of the chord between panel points - in

Pc = desired critical buckling load of the truss chord member, which shall be taken as 2.0 times the factored compressive load – kips

n = number of panels in the pony truss

Linear interpolation rules for missing data in the lookup table:

For the values within the same n, the missing CL/Pc values will be linearly interpolated from two nearby values.

For the values corresponding to the same 1/K for n = 5, 7, 9, 11, 13, and 15, the missing CL/Pc values will be the average of the values from two nearby ns. For example: (CL/Pc for n = 5) = [(CL/Pc for n = 4) + (CL/Pc for n = 6)]/2

The number of panels must be between 4 and 16 because the limitations of the lookup table.

3.12.5 Transverse-frame Spring Constant

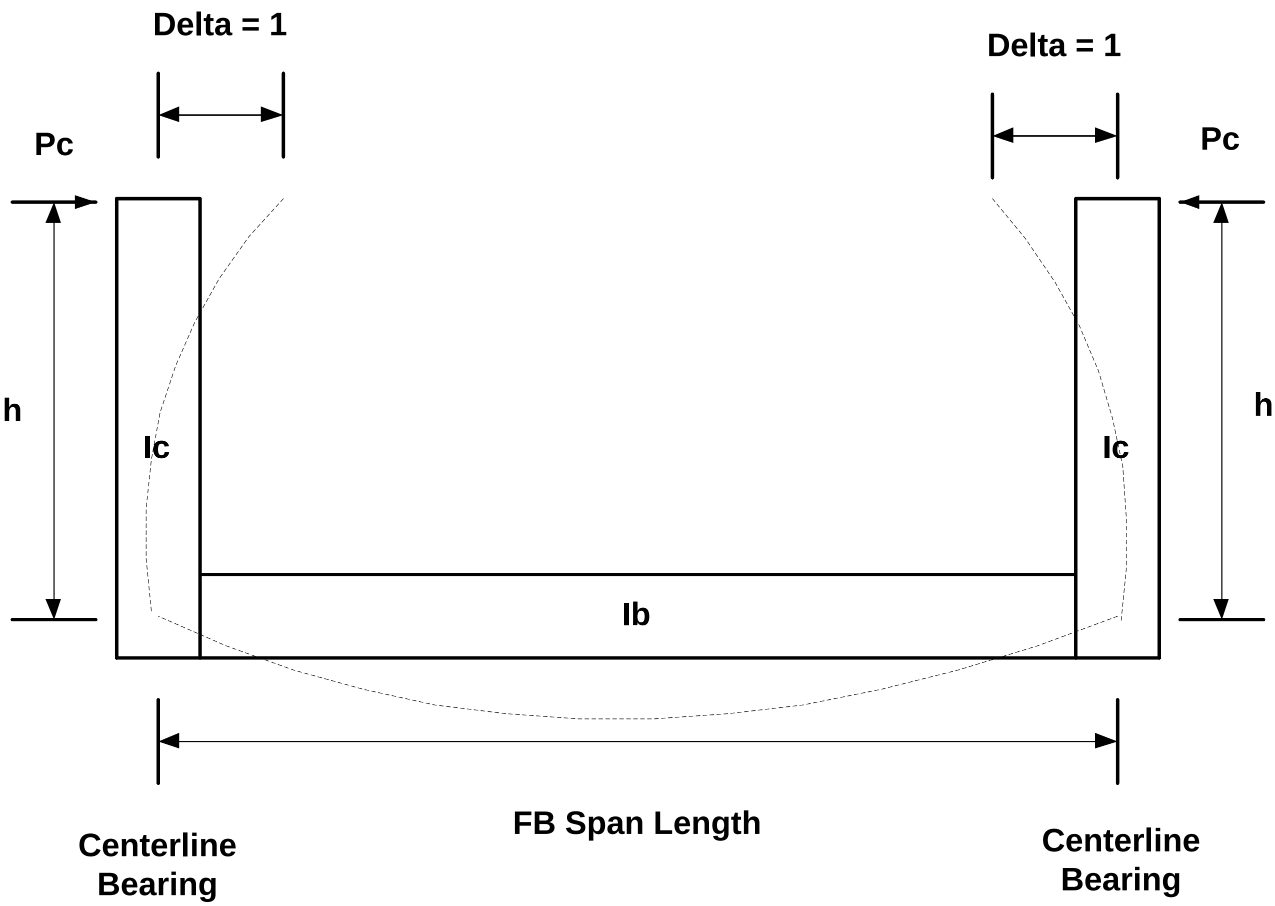


Figure 3.12.1 Lateral U-Frame of the Pony Truss

The Transverse-frame Spring Constant consists of the contribution of the truss vertical and the contribution of the floorbeam, ignoring the contribution of existing top chords and diagonal chords. The Transverse-frame Spring Constant, C, of the lateral U-frame made of the truss verticals and floorbeams in kips/in, is computed using the formula from page 22 of the AASHTO 2009 Guide Spec for the Design of Pedestrian Bridges.

C = E / h*h[h/3*Ic)+b/2*Ib)] ===> from Guide to Stability Design Criteria for Metal Structures, edited by T. V. Galambos, 1968

where

C is the transverse frame spring constant, kip/in

E is the modulus of elasticity, 29,000 ksi

h is the effective height of vertical which is the distance from the center of floorbeam to the lateral force at top chord, in b is the floorbeam span, in

Ic: moment of inertia of the vertical chord, in^4

Ib: moment of inertia of the floorbeam beam, in^4

3.12.6 Computation of Pc

Pc is the desired critical buckling load in kips, i.e. maximum design chord stress multiplier by the desired factor of safety. = max chord load *2.0

Pc = 2.0* axial compressive capacity using load factor method and BAR7-default K values depending on the pinned or riveted end connection selected by the user.

3.12.7 K Values

Once CL/Pc and n was computed, from the lookup table, we can find the corresponding K values for top chords and vertical chords at each floorbeam location. And all truss member capacities (Working stress Method and /or Load Factor Method) will be computed based on the new set of K values.

Per AASHTO 7.1.1: Lateral Frame Design Force, in no case shall the value for 0.01/K be less than 0.003 when determining the minimum lateral force, regardless of the K-value used to determine the compressive capacity of the top chord.

$0.01/K > 0.003 \Rightarrow 1/K > 0.3 \Rightarrow K < 1/3 = 3.33$

This means the maximal K value is 3.33.

3.13 BOX-SHAPED CROSS GIRDER WORKAROUND

The program can currently perform rating analysis for steel I-shapes cross girders/floorbeams. To rate a box-shaped steel cross girder/floorbeam member in the existing version of BAR7, only minor modifications on input data are needed.

3.13.1 Section Properties

Currently, only section properties of the I-shaped steel member can be input into the BAR7 program. However, if the user enters the plate sizes for the box-shaped cross girder top and bottom flanges as well as the web, with two times the thickness to replicate two webs, and also neglects other steel details such as connection angles, then the resulting depth, area, moment of inertia, distance from the bottom of bottom flange to the neutral axis (CBOT), and the section moduli for the top and bottom flanges are all similar to the non-composite box-shaped member section properties hand calculated independently.

The shear capacity of box-shaped cross girders is typically determined per web; therefore, BAR7 should be clear with respect to what inputs are required for the webs (see the summary in 3.13.5).

3.13.2 Flexure

The AASHTO Standard Specifications Article 10.48 for flexural members does not explicitly address non-composite box-shaped steel cross girders. The AASHTO LRFD Bridge Design Specifications Article 6.11 generally apply to composite, longitudinally oriented, steel box-section members and is not applicable to transverse members. Article 6.12 provides provisions for the design of miscellaneous flexural members which includes non-composite, box-shaped members. Article 6.12.1.2.1 provides the general expression for flexural resistance and Article 6.12.2.2.2 provides the nominal flexural resistance for homogeneous doubly symmetric box-shaped members bent about either axis.

M&M investigated Equation 6.12.2.2.2-1 for the nominal flexural resistance and has determined that for most cases, the resistance can be taken simply as FySx. A parametric study was performed to determine the sensitivity of the flexural resistance due to the modification of several key values. The results of the study prove that FySx is sufficient for calculation of the flexural resistance. See Appendix C for a summary of the sensitivity investigation results. Only non-compact moment strength should be considered for box-shaped cross girders. In addition, only the non-composite Overload Moment Strength (0.8FyS) should be considered.

3.13.3 Shear

The AASHTO Standard Specifications Article 10.48.8 does not explicitly address the shear capacity of non-composite box-shaped steel cross girders. The AASHTO LRFD Bridge Design Specifications Article 6.12.1.2.3 addresses shear in non-composite, box-shaped members. This article refers to Article 6.11.9 which is applicable for composite box girders generally oriented parallel to traffic. Article 6.11.9 in-turn refers to the I-shaped girder provisions in Article 6.10.9 which is like what BAR7 currently uses for the shear capacity.

The current shear capacity calculations in BAR7 are applicable to the per web shear capacity of a box-shaped steel cross girder. However, the BAR7 calculated shear forces need to be divided by 2 for the shear ratings to be correct. The user will be required to input plate dimensions for just one web assuming both webs are the same. This could be accomplished with a simple User Manual revision in the Steel Member Properties data card.

3.13.4 Torsion

For this investigation, the box-shaped steel cross girder is assumed to be supported by bearings; i.e., no torsional restraint at the supports. Frame type cross girders exist within the Commonwealth; however, these structures are outside the limits of this study and are also outside of the capability of BAR7.

For cross girders supported by bearings, the torsion comes from differential girder rotation. Torsion in the box effectively adds to shear in one girder web and reduces the shear in the opposite girder web.

M&M investigated the additional shear due to torsion in two (2) non-composite cross girders from the Fort Duquesne Bridge in District 11-0 and determined that the shear due to torsion is very small. For these two cases, the maximum factored dead load pus live load shear is approximately 10% of the per web shear capacity. If the Department requires that torsion be included in the box-shaped cross girder shear ratings, then M&M recommends that a 0.90 reduction factor be applied to the calculated per web shear capacity.

3.13.5 Summary

The following list summarizes the basic steps required to rate box-shaped steel cross girders using BAR7.

(1) When user input the I-section with the web thickness of 0.5” to simulate a section of box-shape (0.5” per web), BAR7 doubles the web thickness to 1” right after the user input and BAR7 sets the composite and compact property to “N”.

(2) Then all section properties (I, Area, Sx, …) and all other AASHTO checks are computed per this 1" web thickness.

(3) Shear:

a. Torsion in unrestrained box-shaped members is typically small; however, it can be addressed with a reduction in the per web shear strength. M&M recommends a 0.90 factor be applied to the shear strength of box-shaped members. The allowable shear stresses and shear strength of this section with 1" web thickness at the inventory and operating levels are reduced by 10% in BAR7 program to account for torsion in the box between longitudinal girders which is not currently calculated by the program.

b. Shear stresses (Allowable Stress Method) or shear forces (Load Factor Method) due to dead load (including the weight of 1" web thickness) and live load are divided by 2 to obtain per web basis.

(4) Moment: Flexural strength is like I-shaped girder – Fy*Sx. The BAR7 program will correctly calculate the section properties of a box-shaped member with minor revisions to the program output to force Fy*Sx to be used. The box-shaped members should be considered as non-composite and non-compact.

The following detailed pdfs by Modjeski and Masters are available upon request:

(1) Memorandum for BAR7 Box-Shaped Cross Girder Rating Workaround dated October 28, 2016.

(2) A detailed Step by Step Procedure for Moment and Shear Rating for BAR7 Box-Shaped Cross Girder Rating Workaround dated January 9, 2017.

3.14 ASSUMPTIONS AND LIMITATIONS

Certain assumptions and limitations of the program are listed here for reference. For details on criteria used in rating a bridge, refer to the AASHTO Manual.

1. For the bridge types "GFS", "GFF", “GGF”, "TFS", and "TFF", the cross section of the bridge is assumed symmetrical about the center of floorbeam span.
2. For the bridge types "GFS", "GFF", "TFS", and "TFF", only the left girder or truss is analyzed.
3. Both the Allowable Stress method and Load Factor method are used for ratings of truss members.
4. Only one unit of truck is considered in a lane for a standard loading. Also, when two or more lanes are loaded, only one unit of truck is considered in each lane.
5. For the bridge types "CTB" and "GGG", the program assumes that all beams or girders are of the same cross section and the interior beam or girder is critical.
6. For the bridge types "GFS" and "TFS", it is assumed that all stringers are of the same cross section.
7. For the bridge types "GFS", "GFF", "TFS", and "TFF", DL2 is divided by one-half of the total number of stringer lines and is then applied to each stringer.
8. The program does not check for horizontal shear between the girder and the slab for a composite girder or encased I-beam.
9. For fatigue life analysis, the maximum and the minimum moments at a detail are calculated from the 10^{th} point moments by parabolic interpolation. However, the stresses are calculated using the actual section moduli of the detail.
10. The fatigue life analysis is performed for steel girders and truss members only. The conventional (line girder) method of structural analysis is used for fatigue life estimations.
11. The program neglects the effects of longitudinal reinforcement in the positive moment region of a continuous composite girder. However, it assumes that the reinforcement acts compositely with the steel section in the negative moment region of a continuous composite girder.
12. The program analyzes and rates each section independently, one section at a time, based on the qualification at that section (compact, braced non-compact, or unbraced non-compact). The program does not consider the provisions of AASHTO Specifications Article 10.48.3 Transitions. Thus, the section must be either compact or non-compact. If the program detects one or more non-compact sections, the moment strength of the section, which would qualify as a compact section by itself, is limited to the moment capacity at first yielding as specified in AASHTO Specifications Article 10.50(f).
13. If the section is composite and is in the positive moment region, the program always checks the AASHTO Equation (10-129a) assuming that the maximum flange stress would always exceed the yield stress for a live load calculated using the rating factor based on moment capacity for compact section. The program assumes that the maximum flange stress check provision of AASHTO Specifications Article 10.50.1.1.2 is a design check only and it is not applicable for rating calculations.

14. The program assumes that the existence of the variable web depth for girder, floorbeam, or stringer does not qualify as a compact section regardless of its section properties and bracing.
15. The program calculates the dead load due to the weight of girder by adding the weights of all ranges entered by the user and dividing by the sum of span lengths. This dead load is applied as a uniform load to all spans of a multi-span continuous girder. If the cross section of one span is significantly different than the other spans, more runs may be required to check for the variation in uniform dead load from one span to other spans.
16. For concentrically loaded bolted and riveted gusset connections, the maximum axial load in each connected member may be assumed to be distributed equally to all fasteners.
17. The bearing on the fasteners at the joint is not investigated. Only bearing on the connected material of the gusset plate is investigated.
18. Only the maximum member forces due to dead load and live load plus impact are used to perform the gusset plate analysis and ratings.
19. BAR 7 does not allow for splice plate data to be entered for gusset plate analysis and rating. If splice plates are present at gusset plate locations and the Operating Ratings for these locations from the BAR 7 output are less than “1.00” then PENNDOT’s TGPAR spreadsheet must be used for the analysis of those plate locations. The splice plate dimensions can be input into the TGPAR spreadsheet in the “optional input information” section of the input screen of the TGPAR spreadsheet.
20. At gusset plate locations where the member is connected by only one gusset plate and not two gusset plates, BAR7 cannot be used to obtain accurate Operating Ratings of the gusset plates. BAR7 assumes two gusset plates are present at each joint and thus divides the forces by 2.

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 Vista, Windows 7 (32 and 64 bit versions), Windows 8, and Windows 10 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 program download and e-mail instructions should be made and used for future installations. You may want to print the software license agreement, record the license number, license key and registered company name and keep it in a safe place.

To install the program, follow the installation instructions provided with the original e-mail from the Department.

The following files will be installed in the destination folder, which defaults to "C:\Program Files\PennDOT\BAR v<version number>\" or "C:\Program Files (x86)\PennDOT\BAR7 v<version number>\" for 64-bit operating systems:

1. BAR7.exe – Executable program (FORTRAN console application).
2. BAR7_DLL.dll – Program Dynamic Link Library.
3. BAR7 Users Manual.pdf – Program User’s Manual (PDF Format).
4. BAR7RevisionRequestForm.dot – 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 (BAR7EX*.dat) will be installed in the program example folder, which defaults to C:\PennDOT\\BAR v<version number> Examples\". Users must have write access to this folder 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. 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. Access to all parts of the Engineering Program User's Manual, where available, is also provided within EngAsst.

EngAsst is not included with this software. It requires a separate license that can be obtained through the Department's standard engineering software licensing procedures. Order forms can be obtained from program support website at http://penndot.engrprograms.com.

4.4 RUNNING THE PROGRAM WITHOUT ENGINEERING ASSISTANT

BAR7 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 Program\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. Next, 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 execution is completed, the output will be displayed on the screen if the user requested it. To cancel this review, enter “Q” to quit.

The user can view the output file from within EngAsst or using a text editor (such as Notepad).

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5 INPUT DATA REQUIREMENTS

5.1 GENERAL

Twelve input forms (Figure 5.1.1 thru Figure 5.1.12 on pages 5-8 to 5-19) are provided to facilitate data preparation for execution of this program. Each input form has data lines with appropriate headings. The data that must be entered depend on the type of bridge (explained earlier) being rated. This section explains each data item.

The following lists the groups of data lines that are required for a given type of bridge.

1. Bridge Type “CPL”, “CSL”, or “CTB”
   - Project Identification
   - Bridge Cross Section and Loading
   - Span Lengths
   - Concrete Member Properties
   - Stirrup Details (optional)
   - Special Live Loading (optional)
   - Concentrated Patch Load (optional)
     Data Type “C”
   - Distributed Patch Load (optional)
     Data Type “C”

2. Bridge Type “EIB”
   - Project Identification
   - Bridge Cross Section and Loading
   - Span Lengths
   - Concrete Member Properties (optional)

- Steel Member Properties

  Data Type “G”
- Lateral Brace Points and Stiffener Spacings (optional)
- Fatigue Data (optional)
- Gross Vehicle Weight Distribution (optional)
- Special Live Loading (optional)
- Concentrated Patch Load (optional)

  Data Type “G”
- Distributed Patch Load (optional)

  Data Type “G”

3. Bridge Type “FSS”
   - Project Identification
   - Bridge Cross Section and Loading
   - **Unsymmetrical Pier Support Configuration (optional)**
   - Traffic Lane Locations
   - Stringer Span Lengths
   - Stringer Locations
   - Concrete Member Properties (optional)
   - Steel Member Properties

     Data Type “F”

     Data Type “S”
   - Lateral Brace Points and Stiffener Spacings (optional)
   - Special Live Loading (optional)
   - **Concentrated Patch Load (optional)**

     Data Type ‘F”
   - **Distributed Patch Load (optional)**

     Data Type “F’

4. Bridge Type “GFF”
   - Project Identification
   - Bridge Cross Section and Loading
   - **Unsymmetrical Pier Support Configuration (optional)**
   - Span Lengths
   - Hinge Locations (optional)
   - Traffic Lane Locations
   - Stringer Span Lengths

- Concrete Member Properties (optional)
- Steel Member Properties

  Data Type “G”

  Data Type “F”
- Lateral Brace Points and Stiffener Spacings
- Fatigue Data (optional)
- Girder Fatigue Detail (optional)
- Gross Vehicle Weight Distribution (optional)
- Special Live Loading (optional)
- Concentrated Patch Load (optional)

  Data Type “G”

  Data Type “F’
- Distributed Patch Load for (optional)

  Data Type “G”

  Data Type “F’

5. Bridge Type “GFS
   - Project Identification
   - Bridge Cross Section and Loading
   - **Unsymmetrical Pier Support Configuration (optional)**
   - Span Lengths
   - Hinge Locations (optional)
   - Traffic Lane Locations
   - Stringer Span Length
   - Stringer Locations
   - Concrete Member Properties (optional)
   - Steel Member Properties

     Data Type “G”

     Data Type “F”

     Data Type “S”
   - Lateral Brace Points and Stiffener Spacings
   - Fatigue Data (optional)
   - Girder Fatigue Detail (optional)
   - Gross Vehicle Weight Distribution (optional)
   - Special Live Loading (optional)
   - Concentrated Patch Load (optional)

     Data Type “G”

Data Type "F'

- Distributed Patch Load (optional)

  Data Type "G"

  Data Type 'F"

6. Bridge Type "GGF"
   - Project Identification
   - Bridge Cross Section and Loading
   - **Unsymmetrical Pier Support Configuration (optional)**
   - Span Lengths
   - Hinge Locations (optional)
   - Traffic Lane Locations
   - Stringer Locations (locate girders on floorbeam)
   - Concrete Member Properties (optional)
   - Steel Member Properties

     Data Type "G"

     Data Type "F"
   - Lateral Brace Points and Stiffener Spacings
   - Fatigue Data (optional)
   - Girder Fatigue Detail (optional)
   - Gross Vehicle Weight Distribution (optional)
   - Special Live Loading (optional)
   - **Concentrated Patch Load (optional)**

     Data Type 'F"
   - **Distributed Patch Load (optional)**

     Data Type "F'

7. Bridge Type "GGG"
   - Project Identification
   - Bridge Cross Section and Loading
   - Span Lengths
   - Hinge Locations (optional)
   - Concrete Member Properties (optional)
   - Steel Member Properties

     Data Type "G"
   - Lateral Brace Points and Stiffener Spacings
   - Fatigue Data (optional)

- Girder Fatigue Detail (optional)
- Gross Vehicle Weight Distribution (optional)
- Special Live Loading (optional)
- Concentrated Patch Load (optional)

  Data Type "G"
- Distributed Patch Load (optional)

  Data Type "G"

8. Bridge Type "TFF"

- Project Identification
- Bridge Cross Section and Loading
- **Unsymmetrical Pier Support Configuration (optional)**
- Span Lengths
- Hinge Locations (optional)
- Traffic Lane Locations
- Stringer Span Lengths
- Concrete Member Properties (optional)
- Truss Geometry
- Truss Dead Loads
- Truss Member Properties
- Additional Truss Member Properties for Load Factor Method (Optional)
- Steel Member Properties

  Data Type "F"
- Lateral Brace Points and Stiffener Spacings (optional)
- Fatigue Data (optional)
- Gross Vehicle Weight Distribution (optional)
- Special Live Loading (optional)
- Gusset Plate Properties (optional)
- Gusset Plate Member Properties (optional)
- Concentrated Patch Load (optional)

  Data Type "T"

  Data Type "F"
- Distributed Patch Load (optional)

  Data Type "T'

  Data Type "F"

9. Bridge Type “TFS”
    - Project Identification
    - Bridge Cross Section and Loading
    - **Unsymmetrical Pier Support Configuration (optional)**
    - Span Lengths
    - Hinge Locations (optional)
    - Traffic Lane Locations
    - Stringer Span Lengths
    - Stringer Locations
    - Concrete Member Properties (optional)
    - Truss Geometry
    - Truss Dead Loads
    - Truss Member Properties
    - Additional Truss Member Properties for Load Factor Method (Optional)
    - Steel Member Properties

      Data Type “F”

      Data Type “S”
    - Lateral Brace Points and Stiffener Spacings (optional)
    - Fatigue Data (optional)
    - Gross Vehicle Weight Distribution (optional)
    - Special Live Loading (optional)
    - Gusset Plate Properties (optional)
    - Gusset Plate Member Properties (optional)
    - Concentrated Patch Load (optional)

      Data Type “T”

      Data Type “F”
    - Distributed Patch Load (optional)

      Data Type “T”

      Data Type “F“

10. **Bridge Type “TTT”**
    - **Project Identification**
    - **Bridge Cross Section and Loading**
    - **Span Lengths**
    - **Hinge Locations (optional)**
    - **Traffic Lane Locations**
    - **Stringer Span Lengths**

- **Stringer Locations**
- **Concrete Member Properties (optional)**
- **Truss Geometry**
- **Truss Dead Loads**
- **Truss Member Properties**
- **Additional Truss Member Properties for Load Factor Method (Optional)**

5.1.1 Input Forms

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

BAR7
BRIDGE ANALYSIS AND RATING

Form 1 of 12

PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STRUCTURE IDENTIFICATION: STATE ROUTE	STRUCTURE IDENTIFICATION: SEGMENT	STRUCTURE IDENTIFICATION: OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB	SKEW CORRECTION FACTOR	PONY TRUSS	PDF	COMPACT
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72	73	77	78	79
=BRRAT																									

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	DISTRIBUTION FACTORS: MOMENT	DISTRIBUTION FACTORS: DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	BRIDGE DEAD LOADS: DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC	GUSSET	PATCH	UNSYM PIER
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74	77	78	79

UNSYMMETRICAL PIER SUPPORT CONFIGURATION

UPC CARD	FB NO	OVERH TYPE	LEFT CANTILEVER SPAN	FB MAIN SPAN	RIGHT CANTILEVER SPAN
1	4	6	7	11	16 20
UPS					
UPS					
UPS					
UPS					
UPS					
UPS					

Figure 5.1.1 Input Form 1

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BRIDGE ANALYSIS AND RATING

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SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66

TRAFFIC LANE LOCATIONS

1			2			3			4			5			6			7		
DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL
1	5	9	12	16	20	23	27	31	34	38	42	45	49	53	56	60	64	67	70	74

STRINGER SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58

Figure 5.1.2 Input Form 2

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

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STRINGER LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5	9	13	17	21	25	29	33	37	41	45	49	53	57
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs		ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
								IR	OR					
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
	.	.	.	.	.	.		.	.		.			.

STIRRUP DETAILS

STIRRUP AREA	fsy	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING
1	6	8	13	18	23	28	33	38	43	48	53	58	63
.		.	.	.	.	.	.	.	.	.	.	.	.

Figure 5.1.3 Input Form 3

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BRIDGE ANALYSIS AND RATING

Form 4 of 12

TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST				PANEL TYPE
		Y OR N	H1	H2	H3	
1	3	7	8	12	16	21

TRUSS DEAD LOADS

LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD
U L	P P		U L	P P		U L	P P		U L	P P	
1	2	4	9	10	12	17	18	20	25	26	28

Figure 5.1.4 Input Form 4

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

TRUSS MEMBER PROPERTIES

MEMBER ID				GROSS AREA COMPR	NET AREA TENSION	MOMENT OF INERTIA Ix	FY	L	ECCEN TRICITY	FLANGE WIDTH	C	CATEGORY	FU	GROSS AREA TENSION	DEPTH	UNSUPP FLANGE LENGTH L	SECTION MODULUS Sxc	MOMENT OF INERTIA Iyc	TORSION INERTIA Jxy	MOMENT OF INERTIA Iy
UML	P P	UML	P P																	
1	2	4	5	7	12	17	23	26	30	33	37	41	43	46	51	54	59	65	71	77 80

Figure 5.1.5 Input Form 5

BAR7
BRIDGE ANALYSIS AND RATING

ADDITIONAL TRUSS MEMBER PROPERTIES FOR LOAD FACTOR METHOD

ATM CARD	MEMBER ID UML	MEMBER ID P P	MEMBER ID UML	MEMBER ID P P	SECTION MODULUS GROSS TENSION	SECTION MODULUS NET TENSION	SECTION MODULUS GROSS COMPR	MU	PLAS SHAPE FAC	EQUI MOM FAC	SHAPE	BOX AREA	BOX S/T	Iy2	MEM HEIGHT
1	4	5	7	8	10	16	22	28	35	38	41	42	47	52	58
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															
A T M															

Figure 5.1.6 Input Form 6

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BAR7
BRIDGE ANALYSIS AND RATING

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STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE		BOTTOM PLATE		COMPOSITE	FY	HYBRID		UNSYMMETRICAL		SHAPE
											WIDTH	THICK	WIDTH	THICK			FY TOP	FY BOT	CG TOP	CG BOT	
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75	80

Figure 5.1.7 Input Form 7

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BRIDGE ANALYSIS AND RATING

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO.	BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
		CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47	52	53	55	60	61	63

Figure 5.1.8 Input Form 8

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BAR7
BRIDGE ANALYSIS AND RATING

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FATIGUE DATA

YEAR BUILT	PREVIOUS COUNT		RECENT COUNT		FUTURE COUNT		R OR N	ONE LANE DISTR FACTOR	NO OF GVWD
	YEAR OR GF	ADTT	YEAR	ADTT	YEAR OR GF	ADTT			
1	5	9	13	17	21	25	29	30	34

GIRDER FATIGUE DETAIL

SPAN NO	DIST FROM CL BRG	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY
1	2	7	12	14	19	21	26	28	33

GROSS VEHICLE WEIGHT DISTRIBUTION

GROSS VEHICLE WEIGHT		NO OF SINGLE UNIT TRUCKS			NO OF SINGLE UNIT TRUCKS		
MIN	MAX	2 AXLE	3 AXLE	4 AXLE	3 AXLE	4 AXLE	5 OR > AXLE
1	6	11	15	19	23	27	31

Figure 5.1.9 Input Form 9

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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

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

Figure 5.1.10 Input Form 10

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BRIDGE ANALYSIS AND RATING

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GUSSET PLATE PROPERTIES

GUS CARD	LOC1	LOC2	YIELD STRESS Fy	TENSILE STRESS Fu	THICK	LENGTH Ha	LENGTH Hb	LENGTH Hc	ECCENTRICITY Ea	ECCENTRICITY Eb	ECCENTRICITY Ec	MAX UNSUPPORTED EDGE B	SHEAR CAPACITY OF FASTENER	FASTENER DIAMETER
1	4	5	7	11	15	19	25	31	37	43	49	55	61	66 69
GUS														
GUS														
GUS														
GUS														

GUSSET PLATE MEMBER PROPERTIES

GAM CARD	LOC1	LOC2	TRUSS MEMBER							TRUSS MEMBER							TRUSS MEMBER						
			NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT
1	4	5	7	8	13	19	21	23	28	31	32	37	43	45	47	52	55	56	61	67	69	71	76 78
GMB																							
GMB																							
GMB																							
GMB																							

Figure 5.1.11 Input Form 11

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 12 of 12

CONCENTRATED PATCH LOADS

PAC CARD	T G F S C	CONCENTRATED PATCH LOAD				CONCENTRATED PATCH LOAD				CONCENTRATED PATCH LOAD				CONCENTRATED PATCH LOAD			
		LOAD TYPE	SPAN NO	DISTANCE	MAGNITUDE	LOAD TYPE	SPAN NO	DISTANCE	MAGNITUDE	LOAD TYPE	SPAN NO	DISTANCE	MAGNITUDE	LOAD TYPE	SPAN NO	DISTANCE	MAGNITUDE
1	4	5	9	11	16	21	25	27	32	37	41	43	48	53	57	59	64
PAC																	
PAC																	
PAC																	
PAC																	
PAC																	
PAC																	
PAC																	
PAC																	

DISTRIBUTED PATCH LOADS

PAD CARD	T G F S C	DISTRIBUTED PATCH LOAD							DISTRIBUTED PATCH LOAD						
		LOAD TYPE	BEG SPAN NO	BEG DISTANCE	BEG MAGNITUDE	END SPAN NO	END DISTANCE	END MAGNITUDE	LOAD TYPE	BEG SPAN NO	BEG DISTANCE	BEG MAGNITUDE	END SPAN NO	END DISTANCE	END MAGNITUDE
1	4	5	9	11	16	22	24	29	35	39	41	46	52	54	59 64
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															
PAD															

Figure 5.1.12 Input Form 12

5.2 PROJECT IDENTIFICATION

PROGRAM IDENT

Enter "=BRRAT" to identify the data for this program. The program checks these characters and will terminate the execution if the proper combination of characters is not present. The message "IDENT ERROR – EXECUTION TERMINATED" will appear.

STRUCTURE IDENTIFICATION

Enter a 14-digit Structure Identification number the same as that used in the Bridge Management System (BMS). This number is comprised of 4 data items for each bridge. The 4 data items are COUNTY, STATE ROUTE, SEGMENT and OFFSET. Entering this data correctly and saving the BAR7 input data, as permanent members in an Engineering Dialog Input Library will enable BAR7 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.

BRIDGE TYPE

Enter the type of bridge being rated. Enter one of the following 12 codes:

"CPL" - for a precast concrete slab bridge
"CSL" - for a concrete slab bridge
"CTB" - for a concrete T -beam bridge
"EIB" - for an encased I-beam bridge
"FSS" - for a floorbeam-stringer type bridge with no truss or main girder
"GFF" - for a girder-floorbeam type bridge (no stringers)
"GFS" - for a girder-floorbeam-stringer type bridge
"GGF" - for a multigirder bridge on floorbeams that are supported on columns
"GGG" - for a multigirder bridge
"TFF" - for a truss-floorbeam type bridge (no stringers)
"TFS" - for a truss-floorbeam-stringer type bridge
"TTT" - for a truss bridge (no floorbeam and stringer analysis)

SLC LEVEL

Enter a code, as explained below, if the Safe Load Capacity (SLC) of the bridge is desired and it 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 percentage increase of the Inventory Capacity, enter "I" followed by a two-digit number which 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 "0" followed by a two-digit number that indicates the percent of Operating Capacity that can be used in determining the Safe Load Capacity of the bridge. For example, enter 085 if the stress or strength level to determine the Safe Load Capacity of the bridge can be 85 percent of the Operating Capacity.

If a value is entered here, also enter an "L" for LANES (explained next) and appropriate values in the Traffic Lane Locations line. The program uses these to calculate SLC in the Rating Summary.

If a value is entered here, but LANES (explained next) is entered as "D" or blank, the program does not calculate SLC and does not print SLC value in the Rating Summary.

If the SLC level is expresses as a percent of Operating Rating Factor, enter the letter “A” followed by a two-digit number which indicate the percent of Operating Rating Factor 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 Factor.

LANES

For the bridge types of "CPL", "CSL", "CTB", "EIB", and "GGG" leave this blank and go to the next item.

For all other bridge types of "FSS", "GFF", "GFS", "GGF", "TFF", "TFS", and “TTT’, enter "D" or "L" depending on the following:

If the ratings are to be calculated based on the number of possible design lanes and the stress or strength levels as defined by AASHTO Manual, enter "D". For a normal rating analysis or design check, use this option. When this option is used, the program checks all possible numbers and positions of the design lane locations on the bridge and all load positions within a lane in accordance with AASHTO Manual.

If the ratings are to be calculated based on the fixed number and positions of traffic lanes as defined by the user, enter “L” here and enter TRAFFIC LANE LOCATIONS described later. When this option is used, the program only checks the load possible within the fixed lane locations. This option should be used only for a special analysis, e.g. checking a safe passage of a permit load on a bridge. When this option is used, the program may only identify the critical rating for one component of a bridge (e.g. truss member or floorbeam).

When an "L" is entered here, the program will calculate the Inventory and Operating ratings based on the values entered under TRAFFIC LANE LOCATIONS and the stress or strength levels as specified in the AASHTO Manual.

If a value is entered for SLC LEVEL and an "L" is entered here, the program will calculate and print the Safe Load Capacity (SLC) of the bridge that is calculated based on the values entered for SLC LEVEL and TRAFFIC LANE LOCATIONS.

LIVE LOAD

If analyses are desired for standard loadings H20, HS20, ML80, and TK527, leave this blank and go to the next item.

If the bridge is to be analyzed for anyone 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
- "D" - consider a P-82 loading only
- "E" - consider H20, HS20, AASHTO Type 3, Type 3S2, and Type 3-3 loadings
- "F" - consider an HS20 and an Alternate Military Load loadings
- "G" - consider HS25, Increased Military Load, ML80, TK527, and P-82 loadings
- "H" - consider H20, HS20, ML80, TK527, and P-82 loadings
- "I" - consider HS20 and ML80 loadings
- "J" - consider HS25, IML, and ML80 loadings
- “K” - consider HS20, ML80, TK527, PA58, and AASHTO Type 3 Unit, Type 3S2 Unit, and Type 3-3 Unit loadings.
- “L” - consider EV2, EV3, and SU6TV loadings
- **“M” - consider PA2016-13 permit loading (reserve for future use)**
- "T" - consider a TK527 loading only

As mentioned earlier, only one unit of truck 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.

The axle weights of 75.48 k (73.28*1.03) for ML80 and 82.4 k (80*1.03) for TK527 in the diagram including 3% additional for scale tolerance allowed by the vehicle code were used for the analysis and rating. The INCR3 for ML80 or TK527 are set to “Y". However, the tonnage in the rating summary was scaled back to the maximum legal weights of 73.28 k for ML80 and 80 k for TK527.

If the bridge is to be analyzed for any special live loadings that cannot be defined by any of the standard live loadings stored in the program, enter the number of special loadings (up to a maximum of eight for which the data is provided later). When a number is entered here, the analyses for standard loadings defined above are not provided. The sets of data for special live loadings entered later should correspond to the number entered here.

OUTPUT

Enter one of the options given in Figure 5.2.1 on page 5-24 depending on the level and type of output desired.

OUTPUT OPTIONS

OUTPUT OPTS	INPUT ECHO	SECT PROP	LOAD EFFECT	STRESS	STRENGTH	DEFL	FATIGUE	GUSSET PLATE	SUMMARY
0	X	X	X	X	X	X	X	X	X
1	Spec LL Config								X
2	X				X			X	X
3	X	X			X			X	X
4	X			X				X	X
5	X	X	X	X				X	X
6	X	Girder Only					Detailed Fatigue		
7	X		X		X	X		X	X
8	X		X	X		X		X	X
9	X		Influence Lines						
A	X			Detailed Rating	Detailed Rating			X	X
B	X								X

Output Options Steel

0 Detailed Output (No influence lines)

1 Permit Load Analysis (Summary only)

2 Load Factor Rating without Section Properties

3 Load Factor Rating with Section Properties

4 Allowable Stress Rating without Section Properties

5 Allowable Stress Rating with Section Properties

6 Fatigue Life Estimation only

7 Structural Analysis Load Factor Method

8 Structural Analysis Allowable Stress Method

9 Influence Lines with Load Effects

A Detailed Rating Analysis

B Summary with Input Echo

P APRAS Only (See 5.21 Special LL)

Output Options Concrete **(CPL, CSL, or CTB)**

0 Normal Output

1 Summary Output

2 Critical Moment and Shear Ratings

9 Detail Output (Including influence lines)

B Summary with Input Echo

P APRAS Only (See 5.21 Special LL)

Figure 5.2.1 Output Options

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. If left blank, the impact factor will be computed by the program using the appropriate loaded length as explained earlier in this manual.

GAGE DISTANCE

Enter the lateral distance between the wheels of a truck. See Figure 5.2.2 below. 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. For a special loading, enter this value if it is other than 6 feet.

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). See Figure 5.2.2 below.

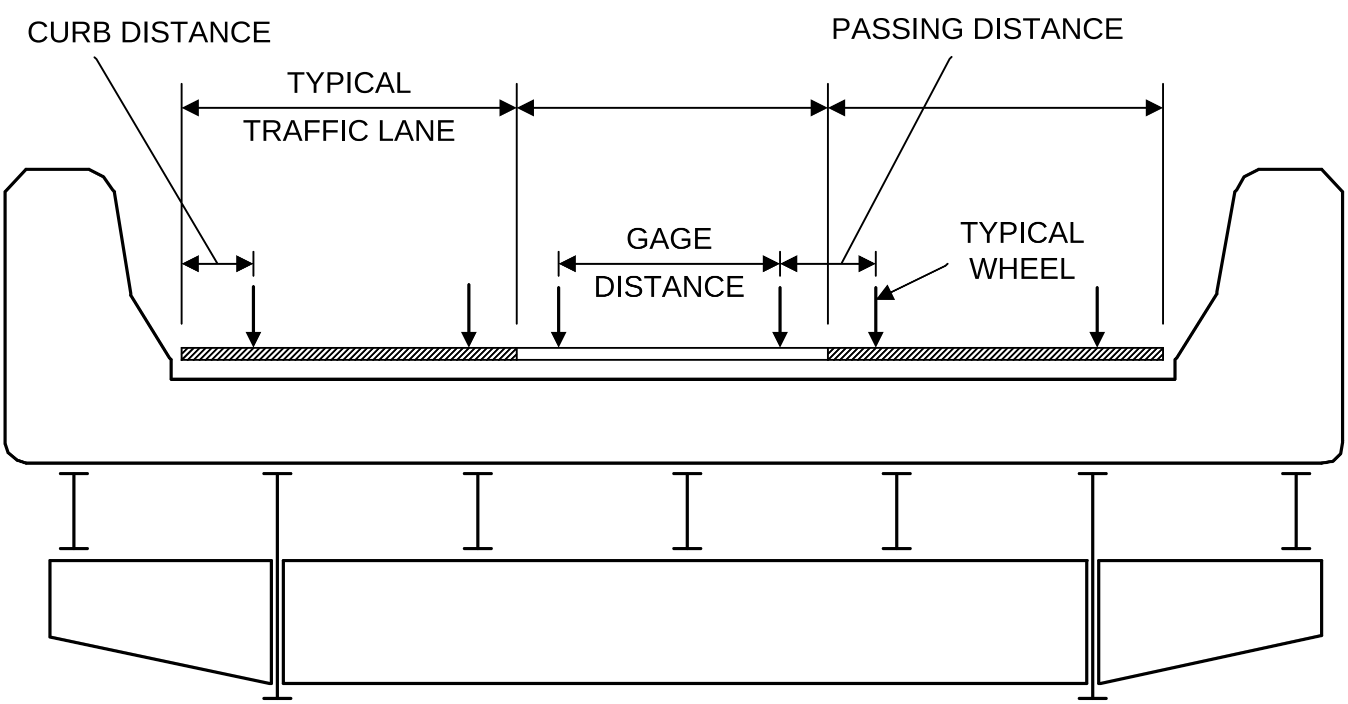


Figure 5.2.2 Lateral Placement of Wheels

If this value is not entered, the program will compute it in accordance with AASHTO Manual 6.7.2.2. For standard loadings, the following values will be 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

For a special loading, even if only one lane is loaded, this must be entered.

The passing distance is used in calculating the distribution factor (fraction of axle load) for the main girder or truss and in calculating the floorbeam moment.

FATIGUE

If the fatigue life analysis is desired for the girder of bridge types "GFS", "GFF", "GGG", and “GGF" or for the truss of bridge types "TFS", “TFF” and "TTT", enter "Y" here and provide the fatigue data as required on Form 8.

Leave blank if the fatigue life analysis is not required.

CONC DECK

If the bridge has a reinforced concrete deck, and if the deck acts compositely with girder, stringer or floorbeam, enter "Y" here and enter the CONCRETE MEMBER PROPERTIES data card. The program uses the reinforcement data entered in the CONCRETE MEMBER PROPERTIES line to calculate the composite section properties for negative moment or composite section properties of a floorbeam.

If the bridge does not have a reinforced concrete deck or if the reinforced concrete deck does not act compositely with girder, stringer or floorbeam, leave this blank and do not enter the CONCRETE MEMBER PROPERTIES.

SPEC

Enter 0 or leave blank if the equations given in AASHTO Specifications Article 10.48.4.1 are to be used in calculating the maximum strength of unbraced sections.

Enter 9 if the equation (10-102) of the 1989 AASHTO Specifications is to be used in calculating the maximum strength of unbraced sections.

Enter 8 if the following equations, which were in Article D10.48.4.1 of 1988 DM-4, are to be used in calculating the maximum moment strength of unbraced sections.

For member not meeting the lateral bracing requirements of AASHTO Specifications Article 10.48.2.1(c), the maximum bending strength is computed as:

$$M_U = F_b S$$

$$F_b = F_{bt} \qquad \text{when } F_{bt} \leq 0.5F_y$$

where:

$$F_{bt} = \frac{286{,}000{,}000}{(L_b / r_t)^2}$$

and r_t is the radius of gyration of a "T" composed of the compression flange and 1/3 of the compression part of the web.

or

$$F_b = F_y\left(1 - F_y / 4F_{bt}\right) \qquad \text{when } F_{bt} > 0.5F_y$$

When the ratio of stresses at the two ends of the braced length, L_b is less than 0.7, the maximum strength, M_u, as computed by the above formula is increased by 20 percent, but is limited to $F_y S$.

REDIST

Enter Y if the moments in a continuous girder with a compact section are to be redistributed as per AASHTO Specifications Article 10.48.1.3. This option is to be used only if the girder is known to be a compact section meeting the requirements of AASHTO Specifications Article 10.48.1. If Y is entered here, the program will redistribute moments at all sections as per equations given in the method of solution section regardless whether the section is compact or noncompact.

Enter N or leave blank if the moments are not to be redistributed.

Since the program checks all sections of a girder for compactness and identifies each section if it meets the requirements of AASHTO Specifications Article 10.48.1, the program could be run with a no redistribution option first to check if the girder is a compact section and then with a redistribution option if the girder qualifies as a compact section.

The redistribution of negative moments should only be used for permit loads or for postings of a limited duration. The redistributed moments are only used for Load Factor rating calculations. Moments are not redistributed for fatigue life analysis. Unfactored moments and deflections printed in the output are without any redistribution of moments.

DIRECT

Normally the live load analysis is performed by moving the load in both directions and the critical effects are used for ratings. For a special analysis where the live load is to be moved only in one direction, enter the following codes to restrict the direction of the moving load.

Enter “L” for moving the live load from left to right.

Enter “R” for moving the live load from right to left.

Leave blank to move the loads both ways.

S OVER FACTOR

For a bridge type "FSS”, “GFS", or "TFS", if the user wants the program to calculate the distribution factor for moment for an interior stringer, enter the denominator part of the wheel load distribution factor formula (S/Factor) given in AASHTO Specifications Table 3.23.1. This value varies from 3.75 to 5.5 depending on the kind of floor and the number of lanes for which the bridge is designed.

The program will use the following formula to calculate the live load distribution factor for moment (DFM) and will apply to an interior stringer.

$$DFM = \frac{1}{2}\left[\frac{SPACING}{S\ OVER\ FACTOR}\right]$$

For a given interior stringer, the SPACING is taken as the average of two adjacent spacings calculated from the Stringer Locations entered by the user.

If the value of SPACING, is greater than the limit given in AASHTO Specifications Table 3.23.1, then the stringer must be analyzed separately with the distribution factor entered based on AASHTO Specifications Table 3.23.1, footnote f.

For bridge types "FSS", "GFS", or “TFS", if a value of S OVER FACTOR is not entered in the Project Identification line, both the exterior and interior stringers will use the DFS_M. If a value of S OVER FACTOR is entered in the Project Identification line, the exterior stringers will use the DFS_M and the interior stringers will use the value calculated using S OVER FACTOR. When only one stringer entered in the Steel Member Properties line, this stringer will use the DFS_M, regardless of the interior or exterior stringer.

END PANEL

Enter “Y” if AASHTO Specifications Article 10.48.8.1 Equation (10-113) is to be used to calculate the shear capacity in the end panel. This allows the shear capacity to include post buckling strength. Enter “N” or leave blank if post buckling strength is not to be included in the end panel and the program is to use AASHTO Specifications Article 10.48.8.3 Equation (10-118).

HYB

Enter “Y” if AASHTO Specifications Article 10.48.8.1 Equation (10-113) is to be used to calculate the shear capacity for transversely stiffened hybrid girders. Enter “N” or leave blank to use AASHTO Specifications Article 10.53.1.4 Equation (10-149).

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 to the AASHTO LRFD Section 4.6.2.2.3c for bridge types of "CTB" and "GGG".

The default of skew correction factor is 1.

PONY TRUSS STABILITY CHECK

Enter "Y" if a Pony Truss Stability Check is to be calculated. Enter "N" or leave it blank if no Pony Truss Stability Check is to be done. If "Y" is entered Additional Truss Properties must be entered for analysis to done.

PDF OUTPUT

Enter "Y" to produce a PDF file of the output in addition to the filename.OUT file. Enter "N" to produce only the standard filename.OUT file.

COMPACT

Enter "Y" or leave blank to produce rating summary using the all-or-none compact section requirements. Enter "N" to produce the rating summary not using the all-or-none compact section requirements.

5.3 BRIDGE CROSS SECTION AND LOADING

Refer to Figure 5.3.1 on page 5-32 for input items on this line.

DECK WIDTH

Enter the total width of the deck including the sidewalk and parapet - feet. The program uses this dimension to compute the dead load due to the deck. This must be entered for the bridge types “CPL”, "FSS", "GFF”, “GFS", "GGF", "TFF", "TFS", and ”TTT”.

Leave blank for the bridge types "CSL", "CTB", "EIB", and "GGG".

OVERHANG OR SPACING

For the bridge types "FSS", "GFS", "GFF", "GGF", "TFF", "TFS", and ”TTT”, enter the length of the floorbeam overhang that extends outside the main girder, truss or support - feet. When OVERHANG is entered for the above bridge types, the program assumes that the floorbeam is continuous across the main girders, trusses or supports, i.e. the portions of the floorbeam inside and outside of the main girder, truss or support are connected by a tie plate and the overhang acts as a cantilever. Leave this blank if the continuity of the floorbeam is not to be considered.

If a value is entered here, the program will calculate the dead load due to the weight of overhang and add it to the value of DL1 entered for the girder. If the continuity of the floorbeam is not considered and if there are brackets supporting the overhang portion of the deck include the weight of brackets in DL1 entered for the main girder.

For the bridge types "CTB", "EIB" and "GGG", enter the width of deck slab carried by the beam or girder - feet. By entering the appropriate width and live load distribution factors (explained later), either an interior or an exterior beam or girder can be analyzed.

Leave blank for bridge types "CPL" and "CSL".

CL OF GIRDER OR TRUSS TO CURB

Enter the distance from the centerline of the main girder, truss or support to the inside face of the curb - feet. This distance is negative if the girder, truss or support is placed inside the roadway and it is positive if the girder, truss or support is placed outside of the roadway. This must be entered for bridge types "FSS", "GFF", "GFS", "GGF", "TFF", "TFS", and ”TTT”.

Leave blank for bridge types "CPL", "CSL", "CTB", "EIB", and "GGG".

NOTE: To accommodate negative values less than -9.99, omit the minus sign and use an alphabetic character in the first column of this item as follows: Enter A for a value -10.00 thru -19.99, B for a value -

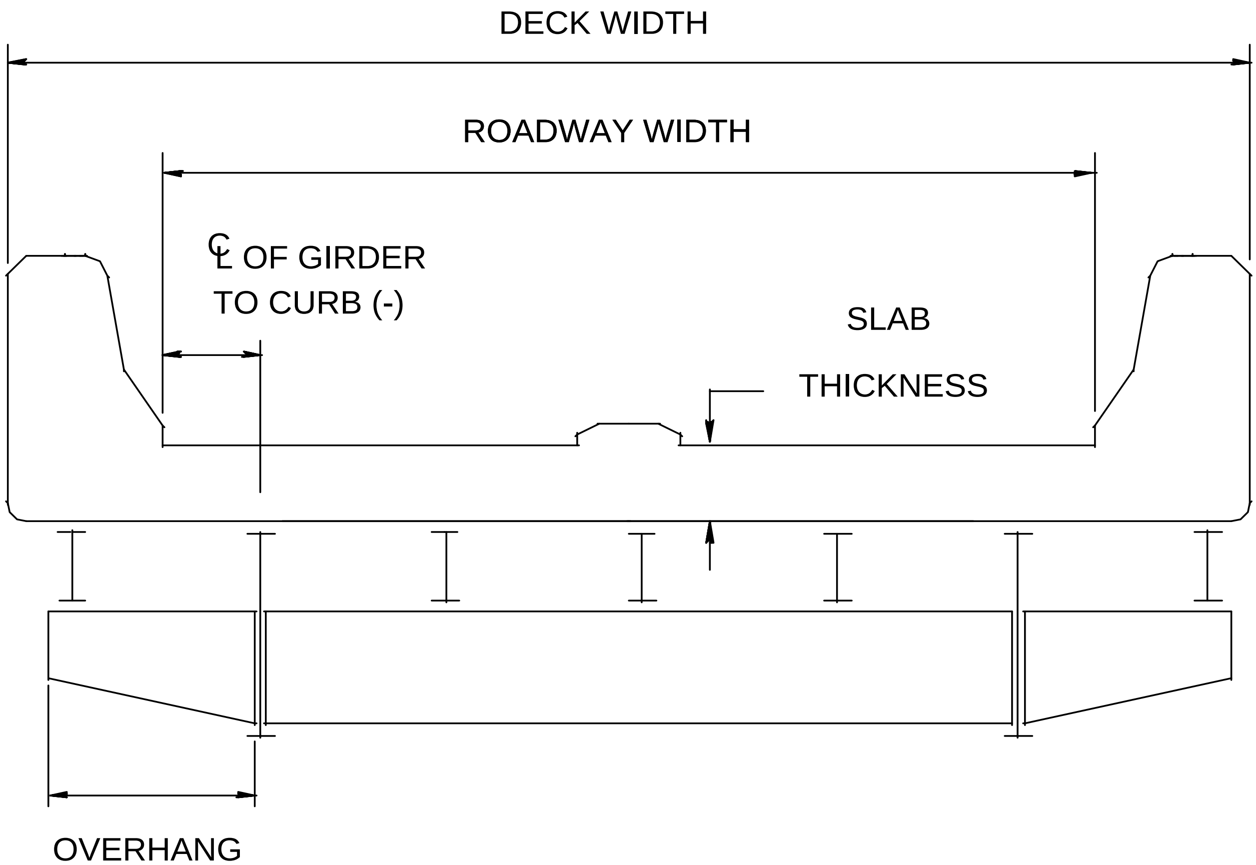
20.00 thru -29.99, C for a value -30.00 thru -39.99, etc. As an example, to enter the negative distance -17.55, code A755 for this input item. The negative distance –22.25 should be coded B225.

ROADWAY WIDTH

Enter the width of the roadway from curb to curb - feet. The program uses this dimension together with the above CL OF GIRDER OR TRUSS TO CURB dimension to compute the center-to-center spacing of main girders or trusses.

If the girder, truss or support is placed inside the roadway, then ROADWAY WIDTH = SPACING BETWEEN MAIN GIRDERS OR TRUSSES + 2.0*absolute value of (CL OF GIRDER OR TRUSS TO CURB)

If the girder, truss or support is placed outside the roadway, then ROADWAY WIDTH = SPACING BETWEEN MAIN GIRDERS OR TRUSSES - 2.0*absolute value of (CL OF GIRDER OR TRUSS TO CURB)



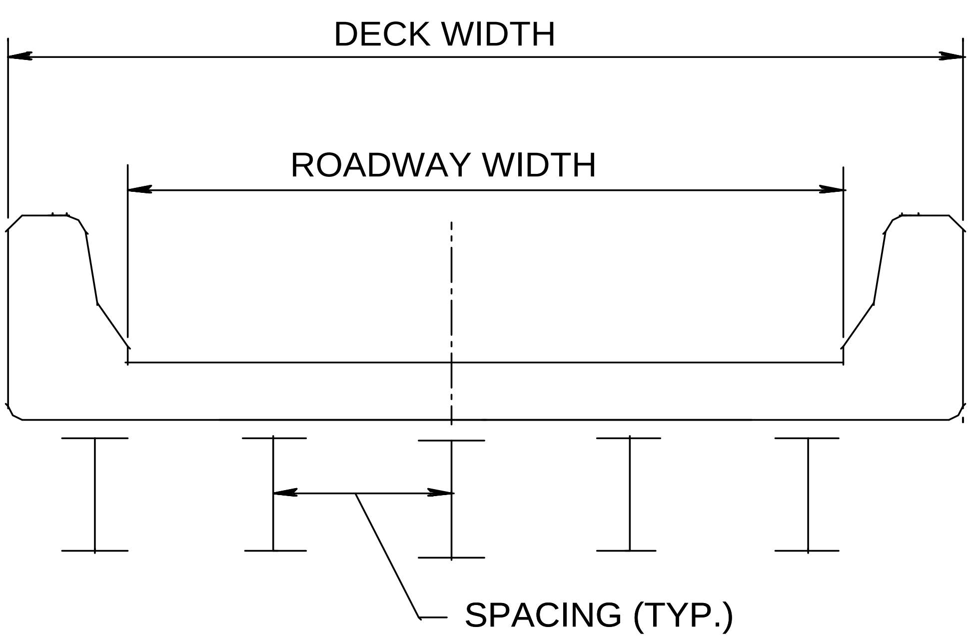


Figure 5.3.1 Bridge Cross Section

DISTRIBUTION FACTORS

After the consideration of the number of lanes and multi-lane reduction factor, **e**nter the live load distribution factor expressed as the fraction of an axle (lane) load to be applied to:

(1) The precast concrete slab **(C)** of the bridge type “CPL”.
(2) A one-foot strip of a concrete slab **(C)** of the bridge type "CSL".
(3) The T -beam **(C)** of the bridge type "CTB".
(4) The encased I-beam **(G)** of the bridge type "EIB".
(5) The floorbeam **(F)** of the bridge type "GFF" or "TFF".
(6) The stringer **(S)** of the bridge types "FSS", "GFS"**,** and "TFS".
(7) The girder **(G)** of the bridge types "GGG" and "GGF".

The AASHTO Specifications refer to this distribution as a fraction of a wheel load to be applied. The axle (lane) load distribution factor is equal to one-half of the wheel load distribution factor.

Enter the appropriate distribution factor depending on whether an interior or an exterior beam or girder is to be analyzed. The program can analyze only one type of beam or girder at a time.

If the values are left blank for a precast concrete slab bridge (bridge type "CPL"), the distribution factors are computed by the program as per AASHTO Specifications Article 3.23.4.3.

If the values are left blank for a concrete slab bridge (bridge type "CSL"), the distribution factors are computed by the program as per AASHTO Specifications Article 3.24.3.2.

The distribution factors for the main girder of the bridge type "GFF" or "GFS" and the truss of the bridge type "TFS", ”TFF”, or "TTT" are computed by the program from the bridge cross section data with the consideration of the number of traffic lanes and multi-lane reduction factor.

The following three (3) types of distribution factors are to be entered:

SHEAR**, DFS_R**

The live load distribution factor to be used in computing reactions at end supports and shears at sections adjacent to end supports for a concrete T-beam, a precast slab bridge, a one-foot strip of a concrete slab bridge, or a stringer. Refer to **1996** AASHTO Specifications Article 3.23.1. Enter one-half of the wheel load distribution factor.

If this value is left blank for a concrete slab bridge (bridge type "CSL"), this factor is calculated by the program as per **1996** AASHTO Specifications Article 3.24.3.2 assuming a non-skewed bridge.

If this value is left blank for a precast concrete slab bridge (bridge type "CPL"), this factor is calculated by the program as per **1996** AASHTO Specifications Article 3.23.4.3 assuming a non-skewed bridge.

MOMENT**, DFS_M**

The live load distribution factor to be used in computing moments in a one-foot strip of a concrete slab bridge or in stringers and longitudinal beams (see **1996** AASHTO Specifications Table 3.23.1 **Distribution of Wheel Loads in Longitudinal Beams**).

If this value is left blank for a precast concrete slab bridge (bridge type "CPL"), this factor is calculated by the program as per the **1996** AASHTO Specifications Article 3.23.4.3 assuming a non-skewed bridge.

If this value is left blank for a concrete slab bridge (bridge type "CSL"), this factor is calculated by the program as per **1996** AASHTO Specifications Article 3.24.3.2 assuming a non-skewed bridge.

For the floorbeam member (F) of the bridge type "GFF' and "TFF" where the floor is directly supported on floorbeams, enter here one-half of the wheel load distribution factor (i,e. the axle (lane) load distribution factor) specified in 1996 AASHTO Specifications Table 3.23.3.1 Distribution of Wheel Loads in Transverse Beams or leave blank if the program should calculate the reactions (distribution factor x axle loads) at each floorbeam by the influence line method based on the flooring to act as a simple span or continuous span (refer to footnote of 1996 AASHTO Specifications Table 3.23.3.1).

For **the stringer (S) of the** bridge types "FSS", "GFS", or "TFS", **if a value of S OVER FACTOR is not entered in the Project Identification line,** both the exterior **and interior** str**ingers will use the DFS_M. If a value of** S OVER FACTOR **is entered** in the Project Identification line, the **exterior stringers will use the DFS_M and the interior stringers will use the value calculated using S OVER FACTOR. When only one stringer entered in the Steel Member Properties line, this stringer will use the DFS_M, regardless of the interior or exterior stringer**

For **the girder (G) of the** bridge type "GGF", enter the **distribution** factor for the critical girder, either interior or exterior. The program will determine the critical girder based on the inputted girder spacings. It may take an additional run of the program if the results of the first run show that the critical girder is different than what was assumed for this factor. **Please note that program will copy this value to DL1ST.**

DEFLECT**, DFS_D**

The distribution factor to be used in computing live load deflections in a one-foot strip of a concrete slab bridge or in stringers and longitudinal beams. This is equal to the number of design lanes divided by the number of beams.

If this value is left blank for a precast concrete slab bridge (bridge type "CPL"), this factor is calculated by the program as per AASHTO Specifications Article 3.23.4.3 assuming a non-skewed bridge.

If this value is left blank for a concrete slab bridge (bridge type "CSL"), this factor is calculated by the program as per AASHTO Specifications Article 3.24.3.2 assuming a non-skewed bridge.

SLAB THICK

For steel bridges, concrete T -beam bridges and encased I-beam bridges, enter the total thickness of the concrete slab - inches. The total thickness will be used to compute the dead load due to the slab. For concrete T-beam bridges and composite sections, one-half inch will be subtracted from the total thickness to find the effective slab thickness.

For steel bridges with other types of floors, such as timber or steel grid, do not enter a slab thickness. The dead load due to the floor must be included in the DEAD LOADS DL2.

HAUNCH

The distance from the top of the girder to the bottom of the slab – inches. This value is negative if the bottom of the slab is below the top of the girder. Leave blank if no haunch is to be considered for the composite section. For the bridge type "EIB", enter this distance without a negative sign. The program will assume a negative value for type "EIB". Entering a negative HAUNCH for bridge type "EIB" will indicate that the top of beam is below the bottom of the slab.

When the haunch changes due to camber or variable top flange thickness, enter the minimum haunch so that the analysis is conservative. If a section becomes critical and the actual haunch at that section is greater than the minimum, the program can be rerun using the actual haunch to analyze that particular section.

BRIDGE DEAD LOADS - DL1, DL2

Enter the dead loads acting on the bridge.

For the purpose of analyzing a beam type member, such as a girder, stringer, T -beam or slab, the dead loads are divided into two categories: DL1 and DL2.

The dead loads acting on the truss are entered as panel point loads under TRUSS DEAD LOADS described later in this section.

The following two types of loads are entered depending on the type of bridge.

DL1

<u>DL1 are dead loads that are applied to the girder or beam.</u> DL1 includes dead loads due to the weight of beam, girder, slab, haunch, permanent formwork, stringers, floorbeams, diaphragms, bracings, stiffeners, <u>(sidewalk, if poured integrally with the deck),</u> and other hardware attached to the beam. <u>The weight of</u>

sidewalk and sidewalk live load should also be included for bridge types “GFS” and “GFF” where the sidewalk is cantilevered out from the outside of the girder.

Enter the dead load due to the weight of diaphragms, haunch, permanent formwork, bracings, and stiffeners and or other hardware attached to the girder or beam. Include the weight of sidewalk and sidewalk live load for bridge types “GFS” and “GFF” where the sidewalk is cantilevered out from the outside of the girder. Do not include the weight of beam, girder, slab, stringers and floorbeams. These weights are computed by the program. Also, do not include the weight of the truss. The dead loads acting on the truss are entered separately under TRUSS DEAD LOADS.

Enter this load as follows depending on the type of bridge:

1. For the bridge types "CPL", “CTB”, "EIB", and "GGG", enter the load per girder or beam per foot length - kips/ft.
2. For the bridge type "CSL", enter the load per square foot of the slab - kips/ft^2.
3. For the bridge type “FSS”, leave it blank. The **DL1** dead loads **applied to** the floorbeams are entered separately under **FLOORBEAM** DL1. The **DL1** dead loads **applied to** the stringers are entered separately under STRINGER DL1.
4. For the bridge types "GFF" and "GFS", compute the load per foot of length of the bridge for the entire cross section of the bridge, divide by two and enter the value - kips/ft. The program applies this **DL1 dead** load to the left main girder **only**. **The DL1 dead loads applied to the floorbeams are entered separately under FLOORBEAM DL1. The DL1 dead loads applied to the stringers are entered separately under STRINGER DL1.**
5. **For the bridge type “GGF", enter the load per girder or beam per foot length - kips/ft. The program applies this load to the critical stringer above the floorbeam GGF has multiple beams (or stringers) supported by the floorbeams below. Since the girder analysis subroutine is used instead of the stringer analysis subroutine, DL1 entered by the user was used and STRINGER DL1 was not used in the girder analysis subroutine.**
   The DL1 dead loads applied to the floorbeams are entered separately under FLOORBEAM DL1.
6. For the bridge types “TFF”, “TFS”, and “TTT”, leave it blank. The **DL1** dead loads **applied to** the truss are entered separately under TRUSS DEAD LOADS**. The DL1 dead loads applied to the floorbeams are entered separately under FLOORBEAM DL1. The DL1 dead loads applied to the stringers are entered separately under STRINGER DL1.**

DL2

DL2 are dead loads that are applied to the deck. DL2 includes dead loads due to the future wearing surface, weight of parapet, (sidewalk, if placed on top of the deck), median, railing, steel grid flooring, timber flooring, other structure permanently attached to the deck and the sidewalk live load. **Program does not compute any DL2 load.**

Enter the dead load due to the future wearing surface, weight of parapet, sidewalk, median, railing, steel grid flooring, timber flooring, other structures permanently attached to the deck, and the sidewalk live load. If the bridge has a concrete deck and a sidewalk, consider the weight of sidewalk only due to the additional thickness (total thickness at sidewalk less the SLAB THICKness entered earlier) of the deck at the sidewalk. If the bridge has a sidewalk and the sidewalk live load is applicable, compute the total width (include both if the bridge has sidewalks on both sides) of sidewalk and multiply by the per square foot value of the sidewalk live load given in the AASHTO Specifications.

Enter this load as follows depending on the type of bridge:

1. For the bridge types, "CPL", "CTB", "EIB", "GGF", and "GGG", enter the load per girder or beam per foot length - kips/ft.
2. For the bridge type "CSL", enter the load per square foot of the slab - kips/ft^2.
3. For the bridge type "FSS", enter the load per foot of the floorbeam –kips/ft^2. For end floorbeams, the load is computed based on the area bounded by half the span length of the end span. For interior floorbeams the load is computed based on the area bounded by average of the sum of two adjacent interior span lengths.
4. For the bridge types "GFF" **and** "GFS", compute the load per foot of length of the bridge for the entire cross section of the bridge, divide by two and enter the value - kips/ft. For the bridge types "GFF" and "GFS", the program applies this load to the left main girder. DL2 acting on the stringer and floorbeam is computed by the program from the value entered here.
5. **For the bridge types "TFF", "TFS", and "TTT", compute the load per foot of length of the bridge for the entire cross section of the bridge, divide by two and enter the value - kips/ft. The DL2 dead loads acting on the truss are entered separately under TRUSS DEAD LOADS. DL2 acting on the stringer and floorbeam is computed by the program from the value entered here.**

F'C

Enter the compressive strength of concrete - ksi. This applies to the slab of composite steel structure and the entire concrete superstructure.

There is no default for this item. For a concrete or composite steel structure, this item must be entered.

N

Enter the ratio of the modulus of elasticity of steel to that of concrete. Enter an appropriate value corresponding to F'C entered above. This value must be entered.

SYMMETRY

This applies to the symmetry of a bridge about a center point for the length of the bridge. Enter "Y" if the bridge is symmetrical as follows:

For the bridge types "EIB", "FSS", "GFF", "GFS", "GGF" and "GGG", the bridge is considered symmetrical if the section properties, span lengths of the girder and lateral brace points and stiffener spacings are symmetric about the center point of bridge length. For example, a five span multigirder bridge can be symmetric about the midpoint in span 3. A four span "GFS" type bridge can be symmetric about a support between spans 2 and 3.

For the bridge types "TFF", "TFS", and "TTT", the bridge is considered symmetric if the member properties, truss geometry and truss dead loads are symmetric about the center point (or panel) of the truss.

For the bridge types "CPL", "CSL" and "CTB" the symmetry does not apply.

Leave blank if the bridge is unsymmetrical or the symmetry does not apply.

The next seven items **(LL LOCATE to END BRG)** are entered only for the bridge types "TFF", "TFS", and "TTT". Leave blank for all other types of bridges.

LL LOCAT

Enter "U" if the live load is moving across the upper joints of the truss and enter "L" if it is moving across the lower joints of the truss.

NO. OF PANELS

Enter the number of panels in the truss. There may be a maximum of 99 panels.

END COND.

Enter "P" or leave blank if the truss members have pinned end connections.
Enter "R" if the truss members have riveted end connections.

CORS

Enter this option to indicate the formula to be used in determining the allowable compression in a truss member with end eccentricity. Refer to Article 6.6.2.1 of the AASHTO Manuals (1983 and 1994) before filling out this option.

For the purpose of this program, the provisions of Article 10.36 of the AASHTO Specifications are referred to as "Combined Stresses Formula" and the formula (A) as specified in Appendix A11 of the AASHTO Manual is referred to as "Secant Formula", Input and output of this program will use this terminology.

Enter "C" if the Combined Stresses Formula with allowable compressive stress from 1983 AASHTO Manual is to be used.
Enter "S" or leave blank if the Secant Formula is to be used.
Enter "X" if the Combined Stresses Formula with allowable compressive stress from 1994 AASHTO Manual is to be used.
Leave blank if ALL members are concentrically loaded.

HINGE AT

Enter the joint at which the hinged support is to be assumed for truss analysis, e.g. L 0, U12, U 0. Refer to the section on TRUSS GEOMETRY for definition of joint designations.

UL

Enter "U" if the hinge is at the upper panel joint.

Enter "L" if the hinge is at the lower panel joint.

A hinge cannot be at the middle panel point.

PP

The panel number where this joint belongs.

This data must be entered right justified. For example, for a hinge at L3, enter "L" under UL and enter 3 in the rightmost column under PP.

TEMP CHANGE

Enter the degrees in Fahrenheit for which the deflections are to be computed for a difference between the current temperature and the normal erection temperature for a truss. Enter a negative value if the current temperature is less than the erection temperature. The deflections due to temperature change are computed and added to the dead load deflections. The effect of change in temperature is considered only for deflection computations.

Leave blank if the effect of temperature change is not to be considered for deflection computations.

END BRG

Enter the location of the bearing at the abutment. Enter "U" if the bearing at the abutment is located at the upper joint, and enter "L" if the bearing at the abutment is located at the lower joint. The program will assume "L" if this input value is left blank.

STRINGER DL1**, DL1ST**

For bridge types of “GGF”, “FSS”, “GFS”, and “TFS”, enter the dead load due to the weight of haunch, permanent formwork and other connections acting on the stringer - kips/ft.

Do not include the weight of the stringer and deck.

For girder analysis of “GGF”, this load entered here shall not be used. For floorbeam anlysis of “GGF”, this load entered in the floorbeam analysis (the computation of DL1 concentrated dead load reactions acting on the floorbeams from stringers above) at floorbeam subroutine. If DL1ST was not entered by the user, DL1ST will be restored by the value of DL1 entered by the user.

For girder analysis of GFS", this load entered here is multiplied by one-half of the number of stringer locations entered and **is added to other dead loads acting on the main girder**.

For floorbeam analysis of "FSS", "GFS", and "TFS", this load is also multiplied by half of the adjacent stringer span lengths for interior floorbeams or half of the end stringer span length for end floorbeam to compute the dead load reactions on the floorbeam from stringers.

For stringer analysis of "FSS", "GFS", and "TFS", this load entered here is added to other dead loads acting on the stringer calculated by the program and total dead load is applied to the stringer.

The value of DL1 entered under BRIDGE DEAD LOADS has no effect on the stringer.

FLOORBEAM DL1**, DL1FB**

For bridge types "GFF", "GGF", or "TFF", enter the dead load due to the weight of haunch, permanent formwork, bracing, stiffeners and other hardware attached to the floorbeam - kips/ft.

For bridge types "FSS", "GFS", or "TFS", enter the dead load due to the weight of bracing, stiffeners and other hardware attached to the floorbeam - kips/ft.

Do not include the weight of the floorbeam and deck. The load entered here is added to the dead load acting on the floorbeam calculated by the program and the total dead load is applied to the non-composite section of the floorbeam.

For girder analysis of "GFF" and GFS", the value entered here is multiplied by one-half of the floorbeam length (including overhang) and then divided by the average floorbeam spacing and the result is applied with the uniform DL1 acting on the main girder.

For floorbeam analysis, this value will be added into the uniform DL1 to compute dead load moments and shears at analysis points of the floorbeam due to DL1.

The value of DL1 entered under BRIDGE DEAD LOADS has no effect on the floorbeam.

UNIT WEIGHT DECK CONC

The unit weight of concrete in the slab – lbs/ft^3. The default value is 150 lbs/ft^3. When entered, this value will also be used for the unit weight of concrete in concrete T -beam (CTB) or concrete slab (CSL or CPL) bridges.

GUSSET PLATE ANALYSIS

Enter "Y" for performing gusset plate analysis and operating ratings for truss bridges. Enter "N" or leave it blank if gusset plate analysis and operating ratings is not needed.

UNSYM PIER

Enter "Y" for performing unsymmetrical pier support analysis and rating for bridges with floorbeams when the full floorbeam analysis is required such as patch loads at floorbeam or unsymmetrical floorbeam configuration.

Enter "N" or leave it blank if unsymmetrical pier support analysis and rating is not needed or if bridges do not have floorbeams.

Note: When UNSYM PIER = Y, the Unsymmetrical Pier Support Configuration data card must be filled.

5.4 UNSYMMETRICAL PIER SUPPORT CONFIGURATION

This command is used to input 1. floorbeam members with unsymmetrical pier support configuration for the bridge types of “FSS” and “GGF”, 2. Floorbeam members with symmetrical pier support configuration for the bridge types of “FSS”, “GGF”, “GFF”, “GFS”, “TFF”, and "TFS" where patch loads at floorbeams are applied. This command can be defined for only Five (5) floorbeam member and the whole floorbeam analysis and rating are performed. However, when the roadway information (such as roadway width, …) are different for the floorbeam member input, only one floorbeam member shall be defined at each run.

All span lengths must be entered even if the bridge is symmetrical i.e. "Y" is entered for SYMMETRY in the BRIDGE CROSS SECTION AND LOADING line.

UPS CARD IDENT:

Enter the identification of the Card, "UPS"

FLOORBEAM NUMBER:

The floorbeam number that will be analyzed. This number must be the same as the floorbeam number in the STEEL MEMBER PROPERTIES.

Leave blank for all other bridge types.

FB_OVERHANG_EXIST

Enter the flag to indicate the overhang type of the floorbeam, ranging 0 to 3

Enter 0 for no overhang exists, i.e. there are no left overhang and right overhang.

Enter 1 for left overhang: yes, right overhang: no

Enter 2 for left overhang: no, right overhang: yes

Enter 3 for left overhang: yes, right overhang: yes

LEFT CANTILEVER SPAN LENGTH

Enter the distance between the left end of the left cantilever span and the centerline of the left support - feet.

FB MAIN SPAN LENGTH

Enter the distance between the centerline of the left support and the centerline of the right support - feet.

RIGHT CANTILEVER SPAN LENGTH

Enter the distance between the right end of the right cantilever span and the centerline of the right support - feet.

5.5 SPAN LENGTHS

Enter the center-to-center distances of bearings as span lengths as follows. All span lengths must be entered even if the bridge is symmetrical i.e., the "Y" was entered for SYMMETRY earlier.

1. For the bridge type "CSL" and "CPL", enter the span length of the concrete slab. Only one span may be entered.
2. For the bridge type "CTB", enter the span length of the T-beam. Only one span may be entered.
3. For the bridge type "EIB", enter the span length of the encased I-beam. Only one span may be entered.
4. For the bridge types "GFF" and "GFS", enter the span lengths of the main girder. A maximum of fifteen spans may be entered.
5. For the bridge types "GGF" and "GGG" enter the span lengths of the girder. A maximum of fifteen spans may be entered.
6. For the bridge types "TFF" and "TFS", enter the span lengths of the truss. A maximum of fifteen continuous truss spans may be entered.
7. Do not enter span lengths for bridge type “FSS”.

CONT

Enter the continuity code as follows:

For bridge types "GFF", "GFS", "GGG", and "GGF":

Enter "C" if the girder is to be analyzed as continuous spans.

Enter "S" if it is to be analyzed as a series of simple spans.

Enter "H" if the span lengths being defined are for a girder with in-span hinges.

For bridge types "TFF" and "TFS":

Enter "C" if the truss has spans that are continuous.

Enter "S" if the truss has one simple span.

Enter "H" if the span lengths being defined are for a cantilever truss.

A series of simple span trusses must be analyzed separately with each span as a bridge.

If more than one span is entered for a truss, the truss is considered continuous.

If "H" is entered here, also enter data for HINGE LOCATIONS described later.

Leave blank for the bridge types “CPL”, "CSL", "CTB", and "EIB".

1,2 ... 15

Span lengths – feet.

5.6 HINGE LOCATIONS

Enter the distances of the beginning and the end of the suspended span of a cantilever truss or the distances of in-span hinges for the girder if "H" was entered for continuity code (CONT) earlier. The distances are measured from the centerline of left bearing in Span 1 - feet. All hinge locations must be entered even if the bridge is symmetrical, i.e., the "Y" was entered for SYMMETRY earlier.

5.7 TRAFFIC LANE LOCATIONS

Enter these data only for the bridge types "FSS", "GFF", "GFS", "GGF", "TFF", "TFS", and "TTT'. Do not enter this line for all other bridge types.

If "D" is entered for LANES in the Project Identification line, enter a blank line. Otherwise a format error will occur. This requirement is kept in the program to process older input files with a 'D' for LANES and the traffic lane locations data.

Program will determine the number of traffic lanes per the following:

1. **Roadway widths less than 18 feet should carry one traffic lane only.**
2. **Roadway widths from 18 to 24 feet should have two design lanes, each lane equals to half of the roadway width.**
3. **Roadway widths over 24 feet will use 12 feet for each lane and fractional parts of the design lanes shall not be used**

References:

2000 AASHTO Manual 6.7.2.2 Truck Loads.

1. **Roadway widths from 18 to 20 feet should have two design lanes, each lane equals to half of the roadway width.**
2. **Roadway widths less than 18 feet should carry one traffic lane only.**
3. **Fewer traffic lane may be considered for special situation.**

1996 AASHTO Spec 3.6 Traffic Lanes:

1. **Roadway widths from 18 to 24 feet shall have two design lanes, each lane equals to half of the roadway width (1996 AASHTO 3.6.2).**
2. **Roadway widths over 24 feet will use 12 feet for each lane and fractional parts of the design lanes shall not be used (1996 AASHTO 3.6.2 & 3.6.3).**

If "L" is entered for LANES and if the Inventory and Operating ratings are to be calculated based on loaded lanes, enter the locations of traffic lanes that are to be loaded (as in the case of analyzing the bridge for a permit load). This will be used for the computations of IR (LOADED) and OR (LOADED).

If "L" is entered for LANES and If a value is entered for SLC LEVEL, enter the locations of traffic lanes that are in service on the bridge. This will be used for the computation of SLC.

Enter the locations of traffic lanes to be used for the computations of SLC, IR (LOADED) and OR (LOADED) as explained earlier. See Figure 5.7.1 on page 5-46.

There may be a maximum of **seven** traffic lanes.

DIST

Enter the distance from the left curb to the left edge of each traffic lane - feet.

WIDTH

Enter the width of each traffic lane - feet.

% LL

Enter the percentage of the live load to be applied to each traffic lane. For one loaded traffic lane both the traffic lane width, WIDTH, and %LL shall not be zero. Otherwise, program crashes due to division by zero. For multiple loaded traffic lanes, the WIDTH and %LL of at least one loaded lane shall not be zero. It is possible that some loaded lanes can have %LL = 0%.

To analyze a truss or girder bridge for a single truck loading such as a special permit loading, two runs of the program are required. To analyze the truss or girder, a run should be made using a distance that will place the center of the traffic lane as close as possible to the centerline of truss or girder. A second run should be made to analyze the floorbeam and stringer, placing the traffic lane in the center of the roadway.

In the case of a thru truss, enter a DIST of 0.0 in the first run to analyze the truss. For stringer and floorbeam analysis, enter a DIST equal to half the roadway width minus WIDTH/2 in the second run.

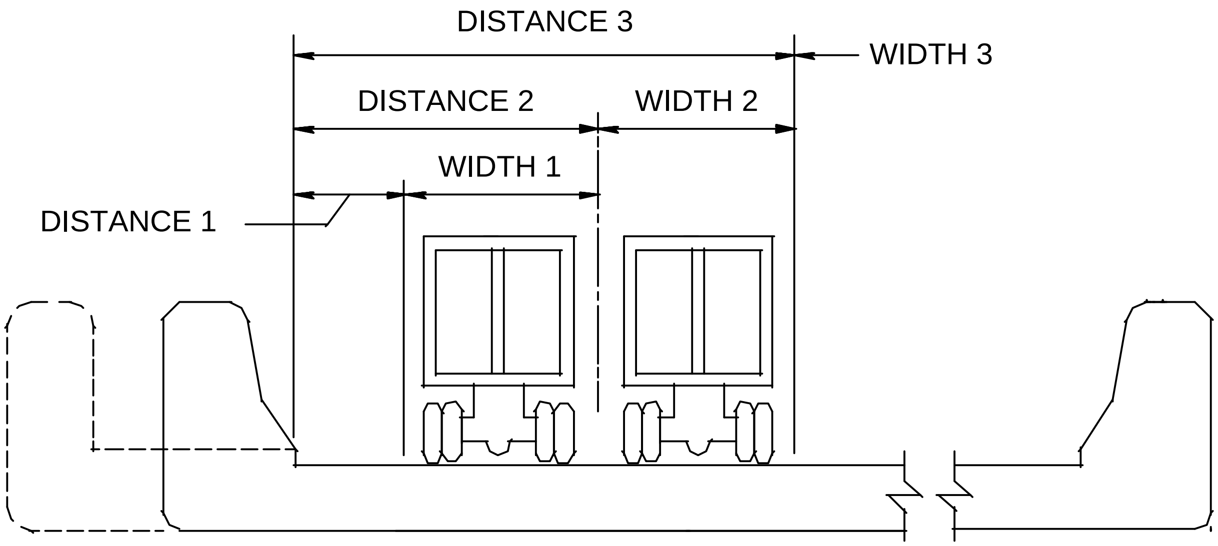


Figure 5.7.1 Traffic Lane Locations

5.8 STRINGER SPAN LENGTHS

Enter the stringer span lengths for the bridge types “FSS”, "GFS", and "TFS" or the floorbeam spacings for the bridge types "GFF" and "TFF". See Figure 5.8.1 on page 5-48. Do not enter this line for all other bridge types.

A maximum of fifteen spans (or spacings) may be entered.

The span lengths (or spacings) entered here should correspond to floorbeams (entered later in Steel Beam Properties) to be rated. For example, if the floorbeams 2 and 3 are to be rated, spans 1, 2, 3 and 4 must be entered.

CONT

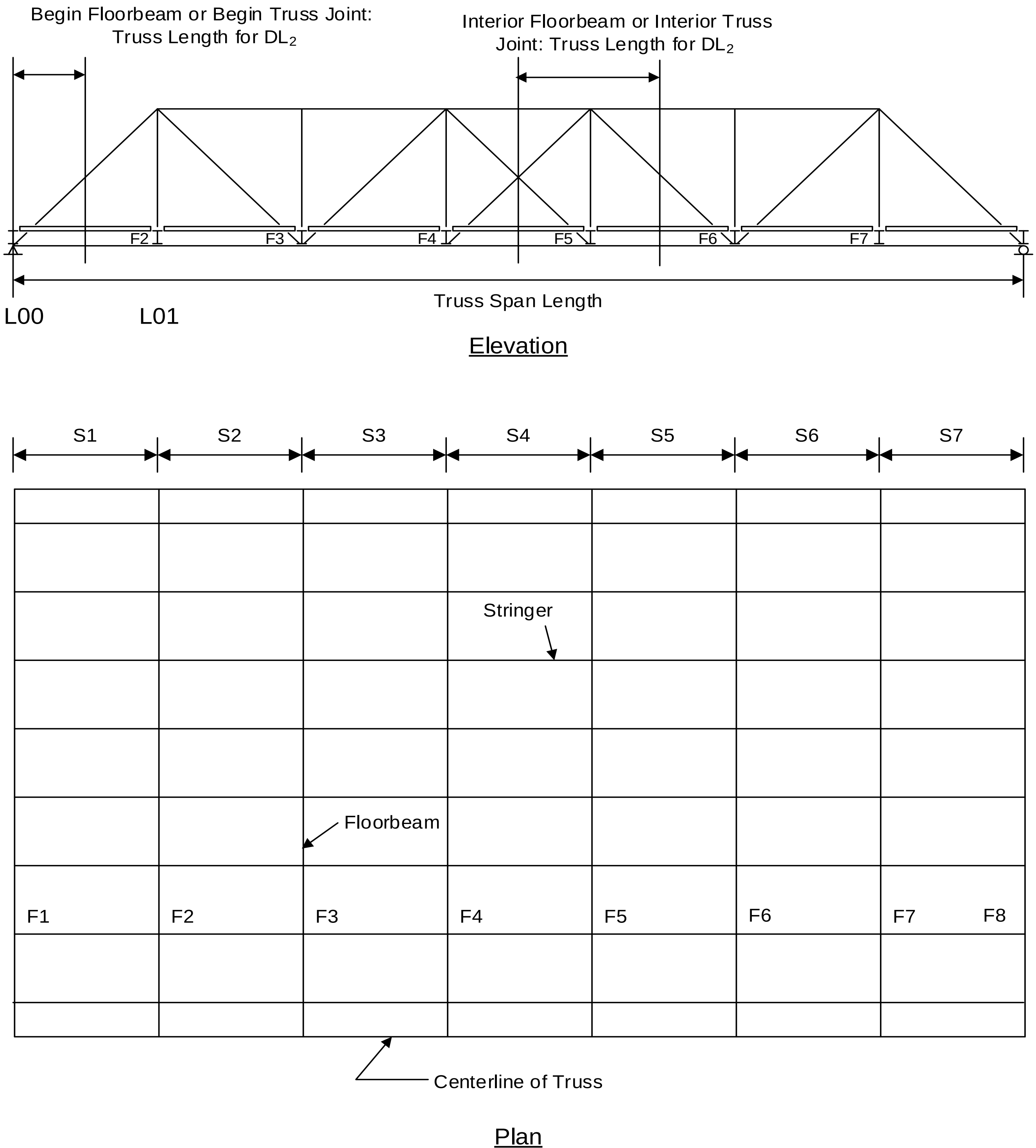
Enter "C" if the stringer or the deck is to be analyzed as continuous spans over floorbeams.

Enter "S" if the stringer or the deck is to be analyzed as simple spans over floorbeams.

This code is used to determine how the reaction on the floorbeam from the stringer or the deck is to be computed.

1, 2 ….15

Stringer span lengths or floorbeam spacings - feet.



Legend: F2 - FLOORBEAM NO. 2 (TYP.) UNDER TRUSS JOINT L01
S1 - STRINGER SPAN LENGTH 1 BETWEEN F1 AND F2

Figure 5.8.1 Span Lengths

5.9 STRINGER LOCATIONS

Enter stringer locations for the bridge types "FSS", "GFS" and "TFS" or girder locations for bridge type "GGF". Do not enter this line for all other bridge types. There may be a maximum of fifteen stringers/girders (stringer lines). Refer to Figure 5.9.1 on page 5-50 for stringer/girder (stringer line) locations. If the deck is directly supported by the main girder, the locations of the main girders should also be entered as stringer locations. The numbers in Figure 5.9.1 Stringer Locations on page 5-50 indicate the stringer locations.

1,2 ... 15

The distance from the centerline of the left main girder**,** truss**, or support** to the centerline of each stringer/girder - feet. This distance is negative for stringers/girders to the left of the girder, truss or support and positive for stringers/girders to the right of the girder, truss or support.

NOTE: To accommodate negative values less than -9.99, omit the minus sign and use an alphabetic character in the first column of this item as follows: Enter A for a value -10.00 thru -19.99, B for a value -20.00 thru -29.99, C for a value -30.00 thru -39.99, etc. As an example, to enter the negative distance -17.55, code A755 for this input item. The negative distance –22.25 should be coded B225.

NOTE: The distance measured from the left edge of the deck to the first stringer/girder must be equal to the distance measured from the right edge of the deck to the last stringer/girder.

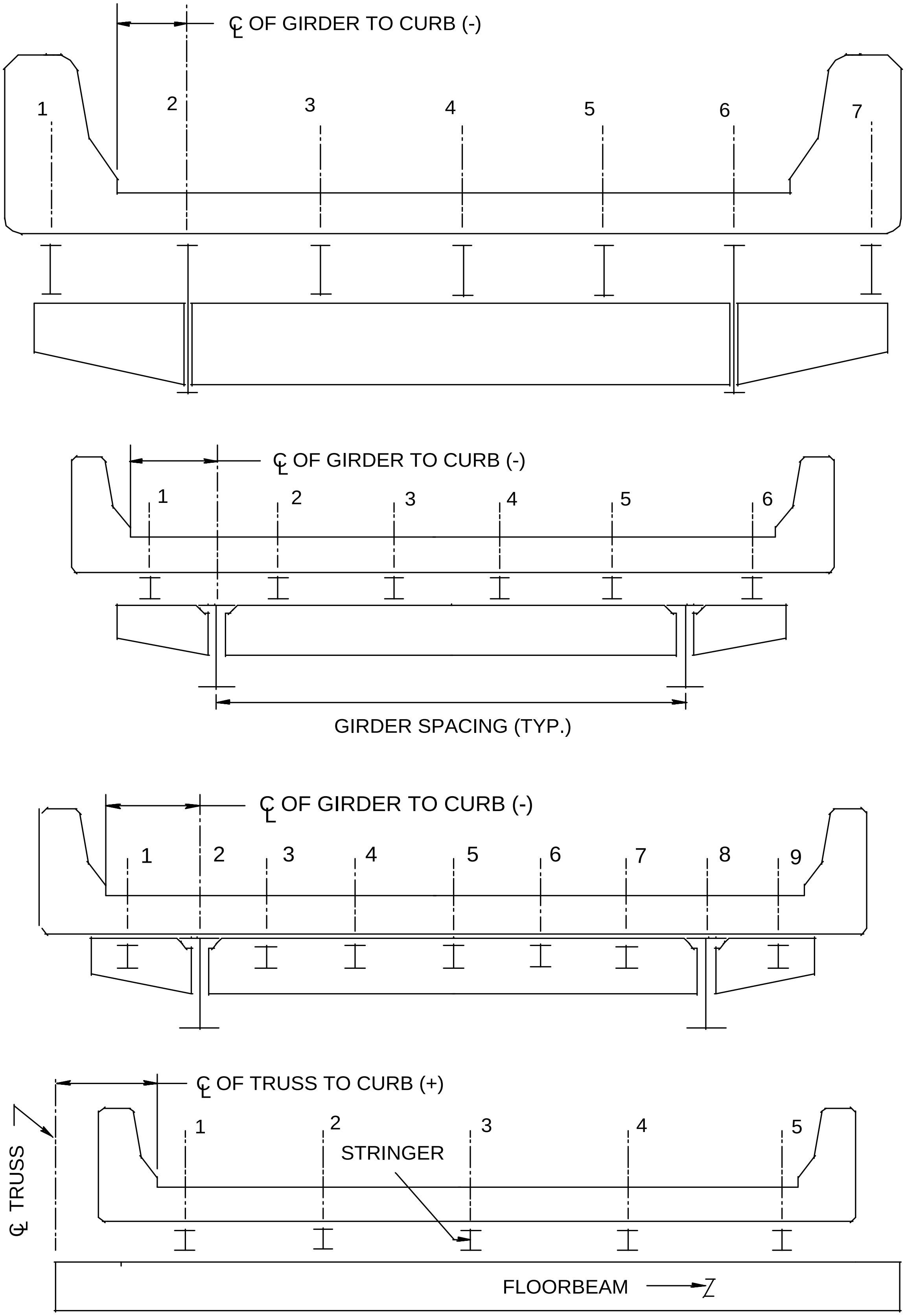


Figure 5.9.1 Stringer Locations

5.10 CONCRETE MEMBER PROPERTIES

This line must be entered for the Bridge Type "CPL", "CSL", or "CTB". See Figure 5.10.1 on page 5-54. This line must be entered for other bridge types if a "Y" is entered for CONC DECK in the Project Identification line. For other bridge types, if a "Y" is not entered for CONC DECK in the Project Identification line, do not enter this line.

TYPE

Enter "T" if the properties entered are for a T-beam **("CTB")** bridge.

Enter "S" if the properties entered are for a Slab **("CPL" or "CSL")** bridge.

Enter "O" if the properties entered are for a steel bridge.

DEPTH

The distance from the top of the slab to the bottom of the web on a T-beam bridge - inches.

The depth of the slab for bridge types "CPL" and "CSL" – inches.

Leave blank for all other bridge types.

B

The width of the web for the bridge type "CTB" - inches.

The width of the precast concrete slab for the bridge type "CPL" - inches.

Leave blank for all other bridge types.

D

For bridge type "CPL", "CSL", or "CTB", enter the distance of the tension reinforcement (AS) from the top of the section excluding the integral wearing surface - inches.

For other bridge types, enter the distance of the center of gravity of the transverse reinforcement from the top of the slab excluding the integral wearing surface - inches. This value is used in calculating the section modulus at the center of gravity of reinforcement for composite section in a negative moment region of a transverse member (composite cantilever floorbeam).

AS

For bridge types "CPL", or "CSL" or "CTB", enter the area of the tension reinforcement – in^2. For concrete slab bridges (type "CSL"), enter the area of reinforcement per foot of slab width. For precast concrete slab bridges (type "CPL"), enter the area of tension reinforcement for width B entered above. For concrete T-beams (type "CTB"), enter the area of tension reinforcement in the web.

For other bridge types, enter the area of the transverse reinforcement per foot of slab that is to be included in calculating the stress/strength of a composite section in a negative moment region of a transverse member (composite cantilever floorbeam) - in^2.

D'

For bridge type "CPL", "CSL" or "CTB", enter the distance of the compression reinforcement (A'S) from the top of the section excluding the integral wearing surface - inches. Leave blank if there is no compression reinforcement or if it is desired not to include the compression reinforcement in the analysis.

For other bridge types, enter the distance of the center of gravity of the longitudinal reinforcement from the top of the slab excluding the integral wearing surface - inches. This value is used in calculating the section modulus at the center of gravity of reinforcement for composite section in a negative moment region of a girder or stringer.

A'S

For bridge type "CPL", "CSL", or "CTB", enter the area of the compression reinforcement - in^2. For concrete slab bridges (type "CSL"), enter the area of reinforcement per foot of slab width. For precast concrete slab bridges (type "CPL") or concrete T-beams (type "CTB"), enter the area of compression reinforcement for width B entered above.

For other bridge types, enter the area of longitudinal reinforcement per foot of slab that is to be included in calculating the stress/strength of a composite section in a negative moment region of a girder or stringer - in^2.

FY REINF

Enter the yield strength of reinforcing steel - ksi. The program assumes a value of 33 ksi if this is left blank. The program uses this value to calculate the Load Factor ratings.

ALLOWABLE Fs – IR

Enter the allowable stress in reinforcement at the Inventory stress level - ksi. The program assumes a value corresponding to Fy as given in Section 3.6.1 Allowable Stresses if this is left blank. The program uses this value to calculate the Inventory Rating based on the Allowable Stress Method.

ALLOWABLE Fs – OR

Enter the allowable stress in reinforcement at the Operating stress level - ksi. The program assumes a value corresponding to Fy as given in Section 3.6.1 Allowable Stresses if this is left blank. The program uses this value to calculate the Operating Rating based on the Allowable Stress Method.

ST DET

For bridge type "CTB" or "CPL", enter "Y" if stirrups are used for shear reinforcement. If "Y" is entered here, also enter data on the STIRRUP DETAILS line.

Leave blank for all other bridge types.

Av

For bridge type "CTB", "CPL" or "CSL", enter the area of bent up bars that are used for shear reinforcement – in^2. Enter the area of shear reinforcement per foot width of the slab for bridge type "CSL". Only one set of bent up bars is considered. The area of bent up bars is assumed to be effective from the centerline of bearing to a distance equal to DEPTH/Tan(ALPHA). If more than one set of bent up bars is to be considered for the bridge, only those bent up bars within the distance equal to DEPTH/Tan(ALPHA) should be included in Av. Other sets of bent up bars should be accounted for by entering a modified stirrup spacing that will provide actual shear resistance in that region.

Leave blank for all other bridge types.

SPECS

For bridge type "CPL", "CSL" or "CTB", enter a code to indicate the specifications to be used when calculating shear ratings. Leave blank for all other bridge types.

Enter "4" or leave blank if the program should use the 1974 interim or later AASHTO Specifications for shear ratings of a reinforced concrete member.

Enter "3" if the program should use the 1973 or earlier AASHTO Specifications for shear ratings of a reinforced concrete member. This should only be used for the rating of an existing bridge that was designed using the 1973 or earlier AASHTO Specifications.

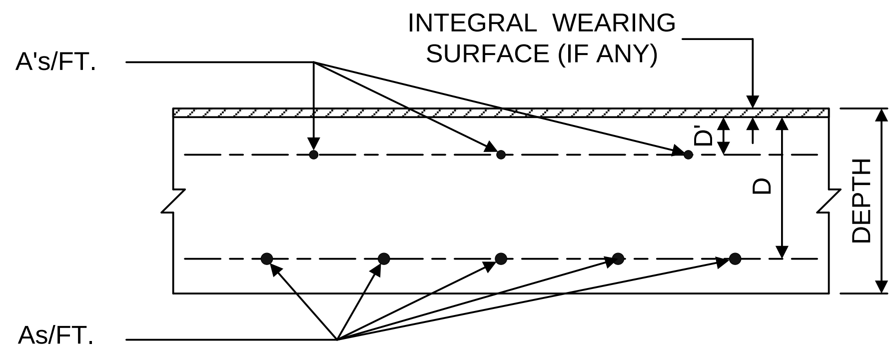
ALPHA

For bridge type "CPL", "CSL", or "CTB", enter the angle of bent up bars to be used as shear reinforcement - degrees. The angle is measured from the horizontal line parallel to the slab. The default is 45º. Leave blank for all other bridge types.

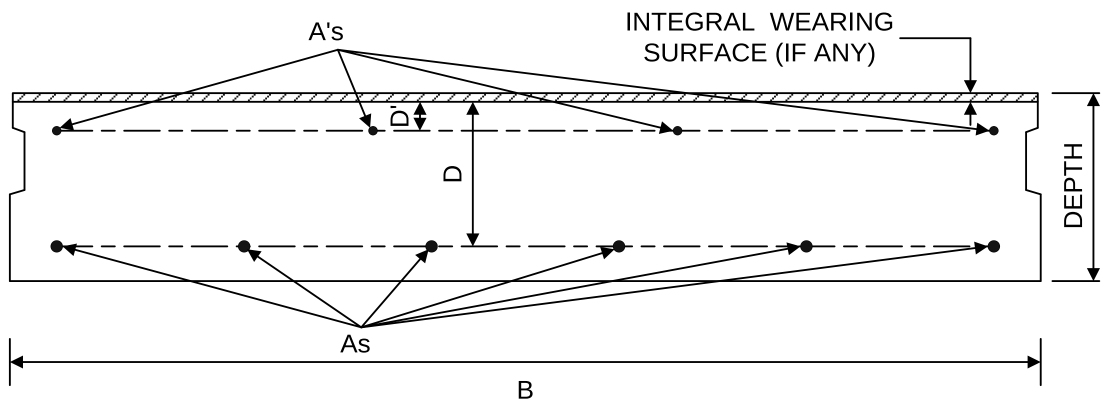
INT WEAR SURFACE

For bridge type "CPL", "CSL", or "CTB", enter the depth of the integral wearing surface - inches. The program assumes a value of 0.5 inches if this is left blank.

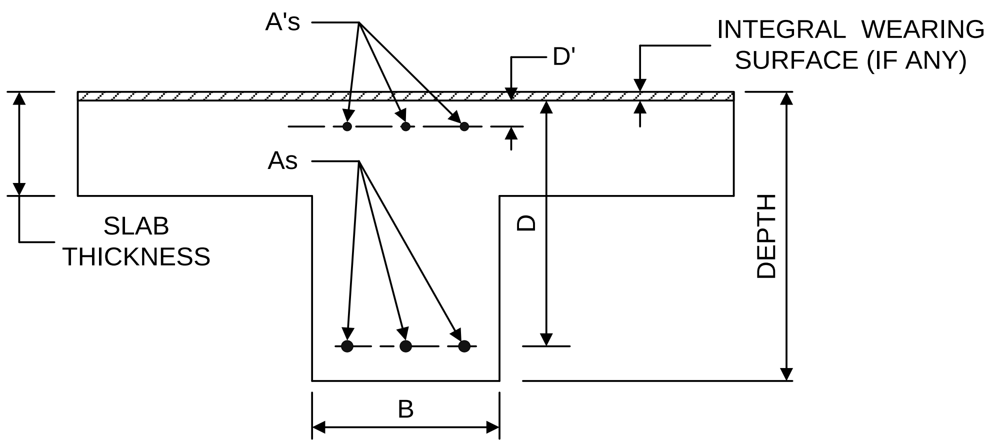
For all other bridges with a composite concrete deck, enter the depth of the integral wearing surface – inches. The program assumes a default value of 0.5 inches if this is left blank for this type of bridge. For the calculation of the composite section properties, this thickness will be deducted from the slab thickness.



CONCRETE SLAB BRIDGE



PRECAST CONCRETE SLAB BRIDGE



CONCRETE T-BEAM BRIDGE

Figure 5.10.1 Concrete Member Properties

5.11 STIRRUP DETAILS

If shear ratings of a reinforced concrete T-beam or slab bridge are desired, and if "Y" was entered for ST DET on the CONCRETE MEMBER PROPERTIES line, enter stirrup details as follows.

STIRRUP AREA

The cross-sectional area of each leg of stirrup – in^2. The program assumes a two-legged vertical stirrup and multiplies the entered values by 2 to calculate the area of shear reinforcement, Av. **The program assumes a default value of 0.2 in^2 if this is left blank.**

fsy

Enter the yield strength of stirrups - ksi. **The program assumes a default value pf 60 ksi if this is left blank.**

LOCATION

The distance of the beginning of stirrup spacing entered next from the centerline of bearing - feet. The value of LOCATION for the first stirrup spacing is always zero.

SPACING

The stirrup spacing corresponding to the LOCATION entered before - inches. As an example for a 100' span, if the stirrup spacings are 10 inches up to the quarter point of the span and 20 inches from the quarter point to mid span, enter 0.00 and 10.000 for the first LOCATION and SPACING and enter 25.00 and 20.000 for the second LOCATION and SPACING respectively.

For a constant stirrup spacing, enter zero for LOCATION and the corresponding stirrup spacing for SPACING. Leave other data blank.

5.12 TRUSS GEOMETRY

The terminology used for describing the geometry of a truss is similar to that commonly used in the engineering drawings. A truss consists of a number of panels (sub-frames). Each panel consists of a top chord, a bottom chord, one or two diagonals and one or two vertical members that form the right-hand side of the panel. See Figure 5.12.1 on page 5-57. Panels are numbered in a sequential order starting with 0 at the left end of a truss. A joint is designated as L0, U1, L2, M3 etc., where the letter indicates the joint's vertical position (U for the upper joint, L for the lower joint and M for the middle joint) and the number indicates the panel where this joint lies. A member is designated as U1U2, L2L3, and M4U5 etc. indicating the joints it connects. The arrangement of members within a panel is designated by a panel type. Refer to Figure 5.12.2 on page 5-58 for different panel types. The geometry of a truss is defined by entering the width, height and type of each panel. If the truss has a vertical member at the left end, an imaginary panel (number 0) having zero width and height equal to length of that vertical (L0U0) member is assumed.

Figure 5.12.1 on page 5-57 shows the left half of a 10-panel truss. U0, U1, U2 etc. are upper joints and L0, L1, L2 etc. are lower joints. Panel numbers are shown as 1, 2, 3 etc. Panel types are shown as 6, 8, 11 etc. The geometry of panels 1 and 4 are also shown in Figure 5.12.1 on page 5-57. Member L0U0 belongs to panel number 0.

Enter one line of data for each panel.

If the truss is symmetric and SYMMETRY was entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, describe the geometry of the truss as follows. If the truss has an odd number of panels, enter the data from the left most panel to the right end of the central panel. If the truss has an even number of panels, enter the data from the left most panel to the central panel point. Refer to Figure 5.12.3 on page 5-60 through Figure 5.12.5 on page 5-62.

Enter the geometry of all panels if the truss is not symmetric.

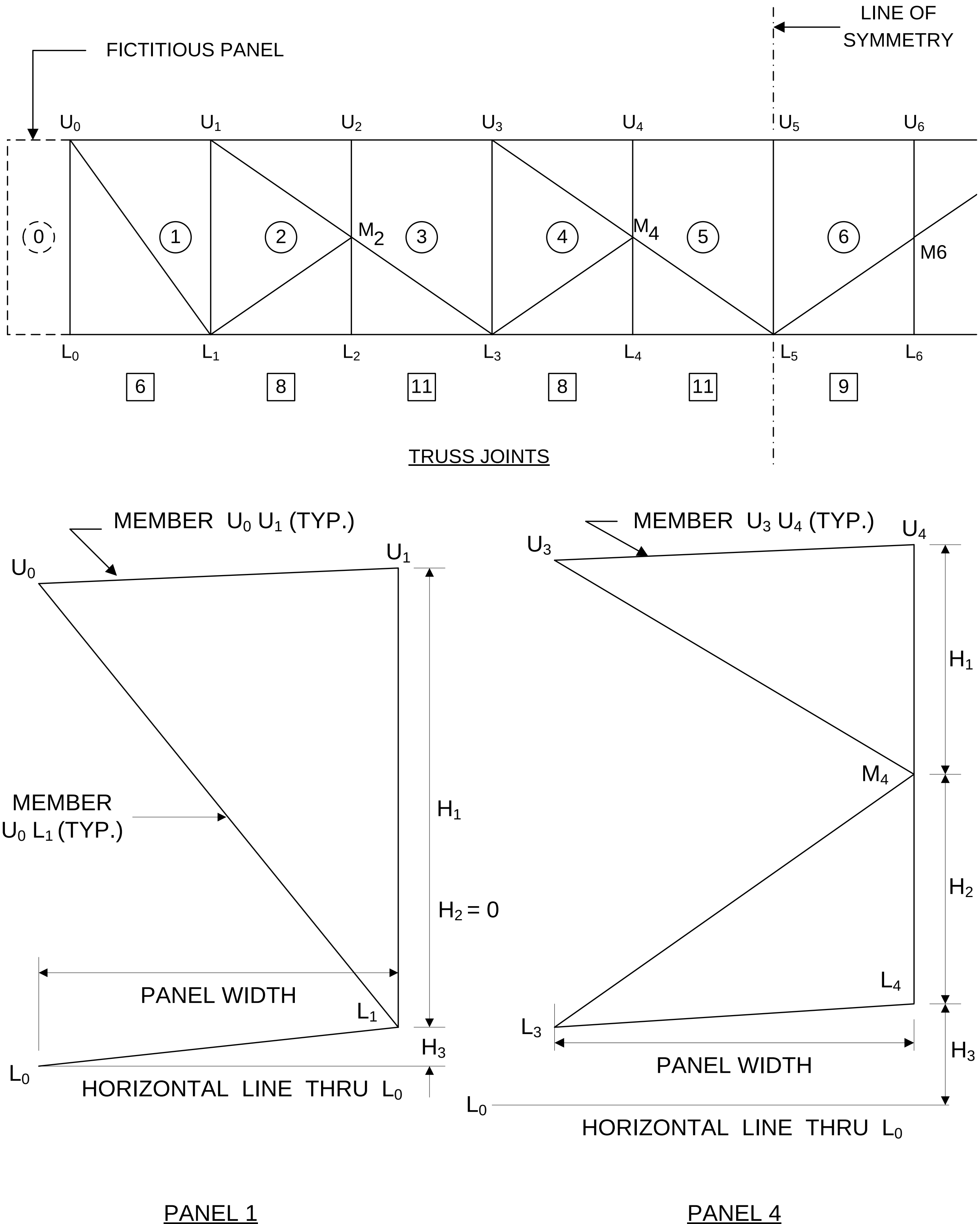


Figure 5.12.1 Truss Geometry

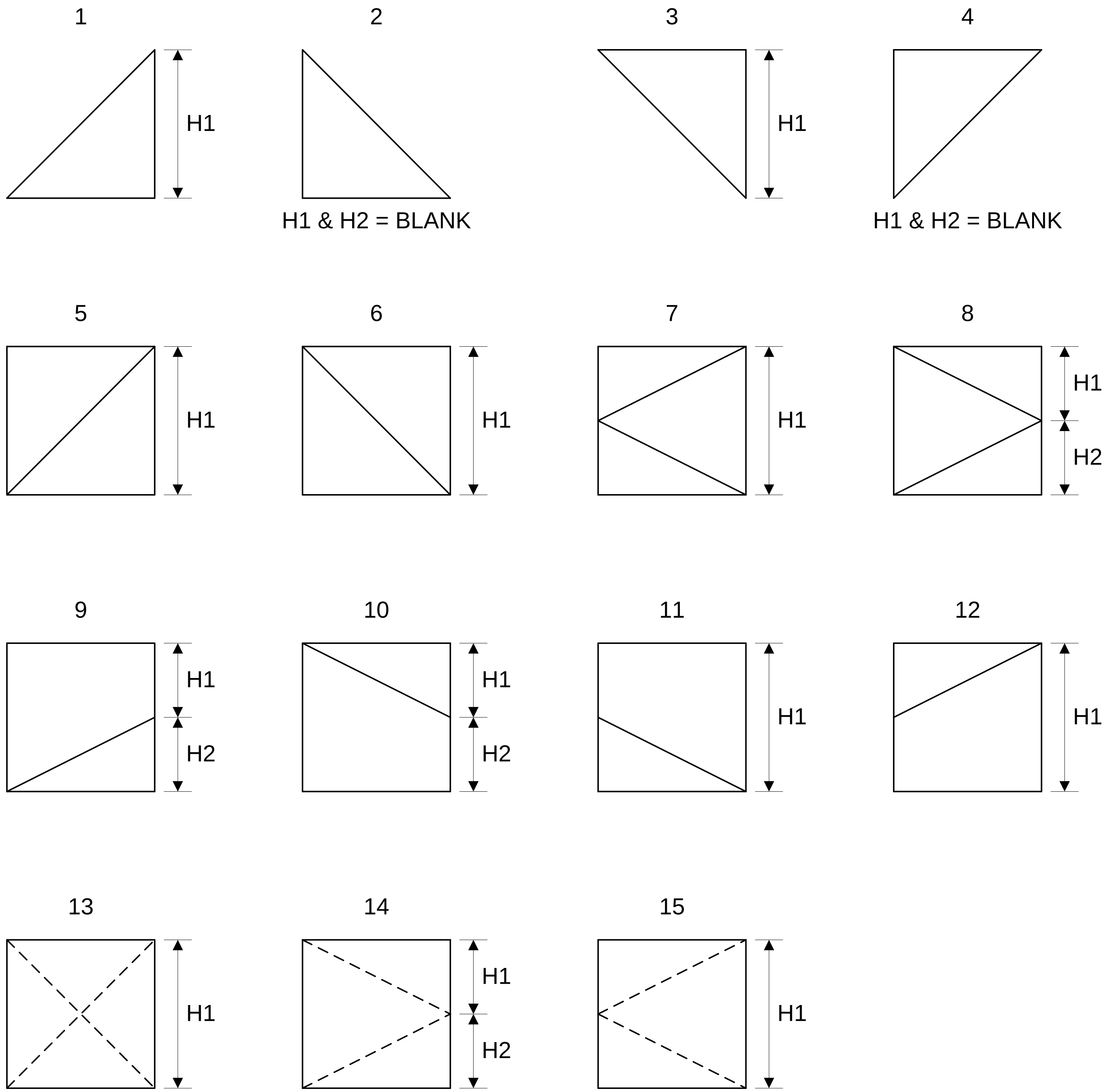


Figure 5.12.2 Truss Geometry - Panel Types

PANEL NUMBER

The panel number (up to 99) for which the geometry is being described. Panels must be numbered sequentially beginning with "0" if there is a vertical member L0U0 at the left end of the truss or beginning with "1" if there is no vertical member L0U0.

Panel 00 has only one member, L00U00.

PANEL WIDTH

The width of the panel - feet.

Enter zero if the panel number "0" is being described.

The panel width entered here must be such that the sum of all panel widths in a given span is equal to the truss span length entered earlier.

VERTICAL POST

Y OR N

For the panel types 1, 3, 5, 6, 7, 11, 13 or 15 enter "Y" if the vertical member on the right side of the panel is present and "N" if it is not present.

Enter "Y" if the panel "0" is being described.

If "L" is entered for LL LOCAT and the panel type is 8, 9, 10 or 14, enter "Y" if the upper vertical member on the right side of the panel is present and enter "N" if it is not present.

If "U" is entered for LL LOCAT and the panel type is 8, 9, 10 or 14, enter "Y" if the lower vertical member on the right side of the panel is present and enter "N" if it is not present.

Leave blank for panel types 2 and 4.

H1

The length of the vertical member on the right side of panel types 1, 3, 5, 6, 7, 11, 12, 13 or 15 or the upper vertical member on the right side of panel types 8, 9, 10 or 14 - feet. H1 must be entered for these panel types even if the vertical member is not present. See Figure 5.12.4 on page 5-61.

For panel number "0", enter the length of member L0U0.

Leave blank for panel types 2 and 4.

H2

The length of the lower vertical member on the right side of panel types 8, 9, 10 or 14 - feet. H2 must be entered for these panel types even if the vertical member is not present.

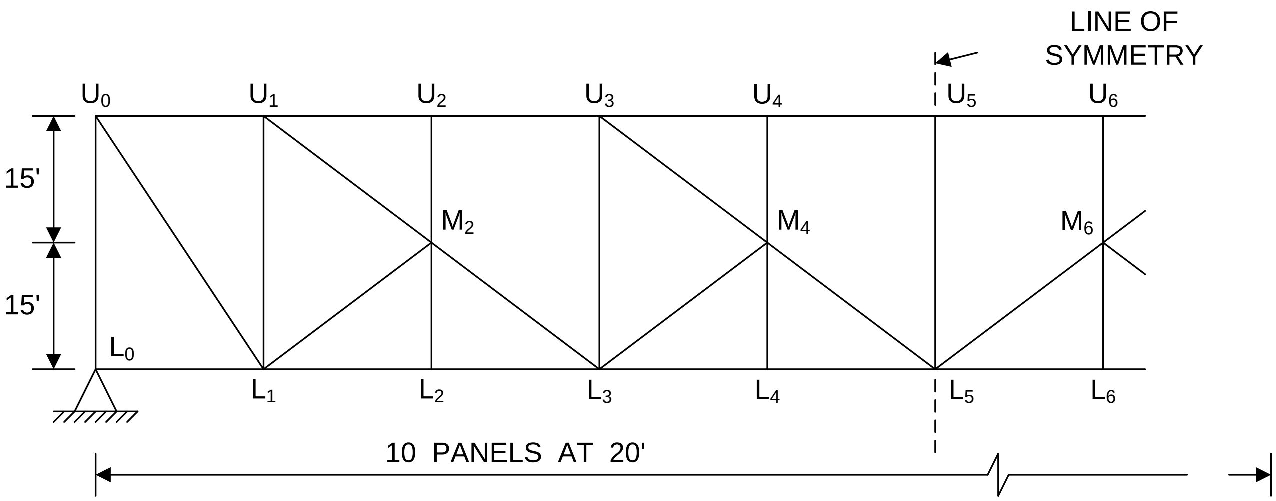
Leave blank for all other panel types.

H3

The elevation of the lower joint on the right-hand side of the panel minus the elevation of the leftmost support joint (L0 for a through truss and U0 for a deck truss) - feet. H3 is negative if the elevation of the joint under consideration is lower than the elevation of the leftmost support joint.

PANEL TYPE

The type of panel. See Figure 5.12.2 on page 5-58. A dashed line in panel types 13, 14 and 15 indicates a counter (a diagonal member that can resist very little compression). Panel types 14 and 15 must occur together in the order 14 followed by 15. Leave blank if panel number 0 is being described.

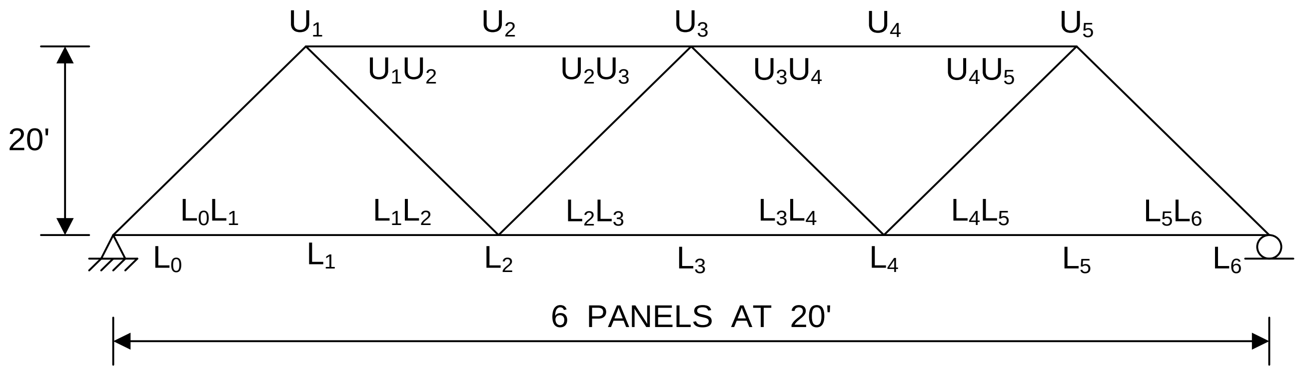


TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST: Y OR N	VERTICAL POST: H1	VERTICAL POST: H2	VERTICAL POST: H3	PANEL TYPE
1	3	7	8	12	16	21
0	0.00	Y	30.00	0.00	0.00	
1	20.00	Y	30.00	0.00	0.00	6
2	20.00	Y	15.00	15.00	0.00	8
3	20.00	Y	30.00	0.00	0.00	11
4	20.00	Y	15.00	15.00	0.00	8
5	20.00	Y	30.00	0.00	0.00	11

Figure 5.12.3 Truss Geometry (Example 1)

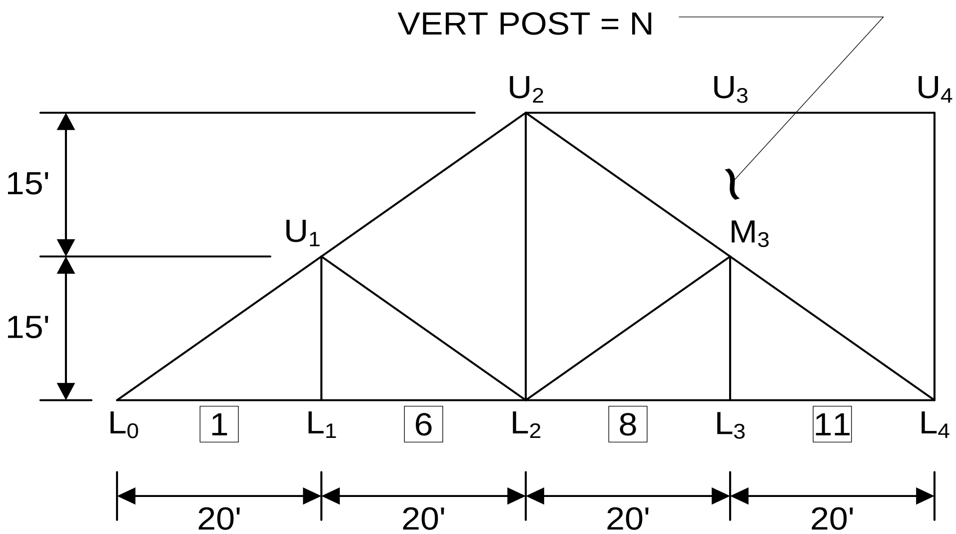
The top and bottom chords for a truss of this type, though commonly referred to as U1U3, U3U5, L0L2, L2L4 and L4L6, must be entered as U1U2 & U2U3, U3U4 & U4U5, L0L1 & L1L2, L2L3 & L3L4 and L4L5 & L5L6, respectively, in the Truss Member Properties input. The actual length of each member (40 feet for all top and bottom chords in this example) will be computed by the program. Dead loads may not be entered at joints U2, U4, L1, L3 and L5.



TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST				PANEL TYPE
		Y OR N	H1	H2	H3	
1	3	7	8	12	16	21
1	20.00	N	20.00	.	0.00	1
2	20.00	N	20.00	.	0.00	6
3	20.00	N	20.00	.	0.00	5
4	20.00	N	20.00	.	0.00	6
5	20.00	N	20.00	.	0.00	5
6	20.00		.	.	.	2
	.		.	.	.	

Figure 5.12.4 Truss Geometry (Example 2)

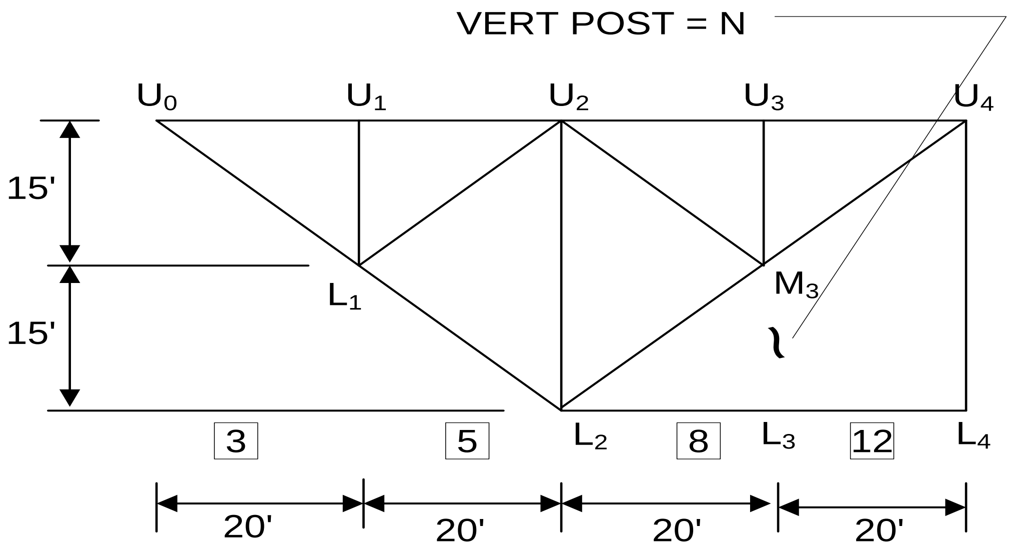


Bearings are at L0 and L4.

TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST				PANEL TYPE
		Y OR N	H1	H2	H3	
1	3	7	8	12	16	21
1	20.00	Y	15.00		0.00	1
2	20.00	Y	30.00		0.00	6
3	20.00	Y	15.00	15.00	0.00	8
4	20.00	Y	30.00		0.00	11

Figure 5.12.5 Truss Geometry (Example 3)



Bearings are at U0 and U4.

TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST Y OR N	VERTICAL POST H1	VERTICAL POST H2	VERTICAL POST H3 0	PANEL TYPE
1	3	7	8	12	16	21
1	20.00	Y	15.00	.	-15.00	3
2	20.00	Y	30.00	.	-30.00	5
3	20.00	N	15.00	15.00	-30.00	8
4	20.00	Y	30.00	.	-30.00	12
	.		.	.	.	
	.		.	.	.	
	.		.	.	.	

Figure 5.12.6 Truss Geometry (Example 4)

5.13 TRUSS DEAD LOADS

Compute the dead load acting on each joint of the truss due to the weight of deck (slab, steel grid or timber flooring), stringers, floorbeams, parapet, sidewalk, median, diaphragms, bracings, other hardware and attachments, sidewalk live load and the truss itself and enter here.

If the truss is symmetric and SYMMETRY is entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, enter the dead loads for the left half of the truss only as follows: If the truss has an odd number of panels, enter the dead loads for joints that are on the left-hand side of the central panel about which the truss is symmetric. If the truss has an even number of panels, enter the dead load up to and including the joint about which the truss is symmetric.

A dead load should not be entered for a joint where both the vertical and diagonal members are not present. See Figure 5.12.4 on page 5-61. Entering a load at such a joint will cause a bending moment in the chord member which is not allowed. A truss member is assumed to resist axial force only.

Enter the dead loads for all joints if the truss is not symmetric.

Enter all dead loads across one line first before going to the next line. Only joints that have dead loads greater than zero should be entered.

LOCAT

The panel point designation as defined earlier.

UL

Enter "U" if the dead load is applied at the upper panel joint.
Enter "L" if the dead load is applied at the lower panel joint.

A dead load cannot be applied at the middle panel point.

PP

The panel number where this joint belongs. **The panel between FB1 and FB2 is panel 1.**

This data must be entered right justified. For example, for a vertical load at L3, enter "L" under UL and enter 3 in the rightmost column under PP.

CONC LOAD

Enter the joint dead load – kips.

5.14 TRUSS MEMBER PROPERTIES

Enter the properties of a truss member here. One line of data is required for each member.

If the truss is symmetric and SYMMETRY is entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, enter the member properties for the left half of the truss as follows: If the truss has an odd number of panels, enter the properties of all members up to and including the central panel about which the truss is symmetric. If the truss has an even number of panels, enter the member properties for all panels up to the joint about which the truss is symmetric. Remember that the vertical members that form the right-hand side of the panel belong to that panel.

Enter the properties of all members if the truss is not symmetric.

Members can be entered in any order. However, for the convenience of verifying the input data, all top chord members may be entered first, followed by all bottom chord members, etc. Also, a member can be designated in any way indicating its end joints. For example, a vertical member in panel number 5 can be designated as U5L5 or L5U5.

MEMBER ID

Enter the member designation indicating its end joints. Member designation is entered as follows:

UML

Indicate the joint location for each end of the member. Enter "U" if it is an upper joint, "M" if it is a middle joint or "L" if it is a lower joint.

PP

Indicate the panel number to which this joint belongs. This data must be entered right justified. For example, the top chord in panel 2 must be entered as Ub1Ub2 or U01U02, and not as U1bU2b where b denotes a blank column under PP. See Figure 5.12.1 on page 5-57.

GROSS AREA COMPR

Enter the gross cross sectional area that is to be used in conjunction with F_y to calculate the allowable compression in the member - in^2. This data must be entered for all members. Enter the effective gross area if the member has deteriorated.

NET AREA TENSION

Enter the net cross sectional area that is to be used in conjunction with F_U to calculate the allowable tension in the member – in^2. This data must be entered for all members. For axial tension members with holes for high strength bolts or rivets, the net area tension can be taken as the total cross section area minus the area of holes. Enter the effective net area if the member has deteriorated.

MOMENT OF INERTIA

Enter the moment of inertia of the member – in^4. This data must be entered for all members. This data is used for the computation of allowable force in a compression member and thus the moment of inertia should be considered about the weak axis of the member. Also, if the end eccentricity exists in a compression member, the ECCENTRICITY, FLANGE WIDTH and C values entered next must correspond to the axis about which the moment of inertia is entered. The program can check the allowable compression based on the data entered for one axis only. If the engineer wants to investigate the allowable compression based on these data about the other axis, it must be run as a separate problem.

FY

Enter the yield strength of the member - ksi. The allowable stresses for IR, OR, and SLC ratings are based on the yield strength of the material. If the strength of the member is questionable, enter the appropriate yield strength here to compensate for this.

L

Enter the actual unbraced length of the member - feet. This data is also used for the computation of allowable force in a compression member.

The program computes the length of each member from the TRUSS GEOMETRY data entered earlier and uses the computed length if the unbraced length of the member is not entered.

The allowable force in a compression member largely depends on the unbraced length of the member and thus care should be exercised in entering the proper value.

For some trusses (as shown in Figure 5.12.4 on page 5-61), the unbraced length of the member may be greater than the geometric length computed by the program. For the truss shown in Figure 5.12.4 on page 5-61, the program will compute the length of U1U2 as 20 feet. However, since a vertical is not present in panel 2 and is coded as such in the TRUSS GEOMETRY line, the program will compute an unsupported length of 40 feet from the actual geometry. In this case the value of L should be left blank if the joint U2 is not adequately braced.

The following three items must be entered for a compression member where an end eccentricity exists due to end conditions (i.e., the line joining the centers of end connections does not coincide with the neutral axis of the member).

If the eccentricity does not exist, leave next three items blank.

ECCENTRICITY

Enter the distance of the centerline of end connections to the neutral axis about which the MOMENT OF INERTIA is computed and entered earlier - inches.

If the eccentricity exists about both the axes of a member, enter the larger eccentricity and the corresponding values of MOMENT OF INERTIA, FLANGE WIDTH and C. If the effect of eccentricity about the other axis is to be checked, rerun the program entering the corresponding values of MOMENT OF INERTIA, FLANGE WIDTH and C.

FLANGE WIDTH

The width of a compression flange - inches. Refer to Table 10.32.1A of the AASHTO Specifications.

C

The distance from the neutral axis of the member to the extreme fiber in compression - inches.

CATEGORY

If the fatigue life analysis is required for this member, enter a code that corresponds to the stress category given in AASHTO Specifications Tables 10.3.1A and 10.3.1B. Enter the code left justified. Acceptable codes are "A ", "B ", "BP", "C ", "CT", "D ", "E ", “EP”, “B’” and "E'", where "CT" is the stress category C in AASHTO Specifications Table 10.3.1A for transverse stiffener welds on girder webs and flanges. Note: “BP” is equivalent to “B’” and “EP” is equivalent to “E’”.

Leave blank if the fatigue life analysis is not required for this member.

FU

Enter the ultimate tensile strength of the member - ksi. The program uses this value to calculate the allowable tension in a truss member as per the equations given in AASHTO Manual Tables 6.6.2.1-1 and 6.6.2.1-2.

If the ultimate tensile strength of the member is known, enter a value here. If the strength of the member is questionable and an adjusted value was entered for FY, also enter an adjusted value for FU.

If the ultimate tensile strength of the member is not entered, the program will use the rounded values given in the following table for the allowable tension in a truss member corresponding to the value entered for FY. The values given in the table are derived from AASHTO Manual Tables 6.6.2.1-1 and 6.6.2.1-2 assuming a lower value for a given FY. If your FY does not match one of the values in this table, you must enter a value for FU.

FY	0.55 FY	0.75FY	0.50FU	0.67FU
26.0	14.0	19.5	26.0	35.0
30.0	16.0	22.5	30.0	40.0
33.0	18.0	24.5	30.0	40.0
36.0	20.0	27.0	30.0	38.0
40.0	22.0	30.0	30.0	40.0
42.0	23.0	31.5	31.5	42.0
45.0	24.0	33.5	30.0	40.0
46.0	25.0	34.5	33.5	44.5
47.0	25.0	35.0	36.0	48.0
50.0	27.0	37.5	35.0	46.5
55.0	30.0	41.0	35.0	46.5
60.0	33.0	45.0	37.5	50.0
65.0	36.0	48.5	40.0	53.0

GROSS AREA TENSION

The gross cross sectional area that is to be used in conjunction with F_y to calculate the allowable tension in the member – in^2. No reduction in the cross-section area shall be made for bolt holes unless the area of holes deducted for high strength bolts or rivets is more than 15 percent of the gross area, and that area more than 15 percent should be deducted to calculate this GROSS AREA TENSION. In addition, any open holes larger than 1.25 inch in diameter, such as perforations or hand holes, should be deducted. If the member has deteriorated, the area of deterioration shall also be deducted. If this value is not entered, the program will use the value entered for NET AREA TENSION.

The following five items must be entered for a compression member when CORS = “X”.

If the CORS is not equal to “X”, leave next five items blank.

DEPTH

Enter the depth of the truss member – in.

UNSUPP FLANGE LENGTH, l

Enter the length of unsupported flange between lateral connections, knee braces, or other points of support – in.

SECTION MODULUS, Sxc

Enter the section modulus with respect to the compression flange – in^3.

MOMENT OF INERTIA, Iyc

Enter the moment of inertia of compression flange about the vertical axis in the plane of web – in^4.

TORSION INERTIA, Jxy

Enter the torsional inertia, in^4, which is equal to $[(bt^3)_c + (bt^3)_t + Dt_w^3]/3$, where b and t represent the flange width and thickness of the compression and tension flange, D is the web depth, and t_w is the web thickness.

MOMENT OF INERTIA, Iy

Enter the moment of inertia (in^4) for vertical members whose floorbeams require the pony truss stability analysis. This data shall be computed assuming bending along the floorbeam direction.

Leave this field blank if the pony truss stability analysis is not needed or if the member is not a vertical member.

5.15 ADDITIONAL TRUSS MEMBER PROPERTIES FOR LOAD FACTOR METHOD

Refer to Articles 1.7 and 1.8 in the Guide specifications for Strength Design of Truss bridges (Load Factor Design), 1985. Enter the additional properties of a truss member here for load factor rating purpose. One line of data is required for each member.

If the truss is symmetric and SYMMETRY is entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, enter the member properties for the left half of the truss as follows: If the truss has an odd number of panels, enter the properties of all members up to and including the central panel about which the truss is symmetric. If the truss has an even number of panels, enter the member properties for all panels up to the joint about which the truss is symmetric. Remember that the vertical members that form the right-hand-side of the panel belong to that panel.

Enter the properties of all members if the truss is not symmetric.

ATM CARD IDENT

Enter the identification of the card, "ATM".

MEMBER ID

Enter the member designation indicating its end joints. Member designation is entered as follows:

Members can be entered in any order. However, for the convenience of verifying the input data, all top chord members may be entered first, followed by all bottom chord members, etc. Also, a member can be designated in any way indicating its end joints. For example, a vertical member in panel number 5 can be designated as U5L5 or L5U5.

UML

Indicate the joint location for each end of the member. Enter "U" if it is an upper joint, "M" if it is a middle joint or "L" if it is a lower joint.

PP

Indicate the panel number to which this joint belongs. This data must be entered right justified. For example, the top chord in panel 2 must be entered as Ub1Ub2 and not as U1bU2b where b denotes a blank column under PP.

SECTION MODULUS GROSS AREA TENSION

Enter the section modulus, based on the gross cross sectional area, which is to be used in conjunction with F_y to calculate axial tension capacity of the member – in^3. This data must be entered for all members. Use the gross area with hand holes and perforations removed. Use effective gross area if the member has deteriorated.

Note: The gross area shall not be used if the holes occupy more than 15% of the gross area. When they do, the excess above 15% of the holes not greater than 1.25 in, and all of area of larger holes, should be deducted from the gross area.

SECTION MODULUS NET AREA TENSION

Enter the section modulus, based on the net cross sectional area that is to be used in conjunction with F_u to calculate axial tension capacity of the member – in^3. This data must be entered for all members. Use the net area with bolt holes and/or rivets holes removed. Use effective gross area if the member has deteriorated. For axial tension members with holes for high strength bolts or rivets, the net area tension can be taken as the total cross section area minus the area of holes.

SECTION MODULUS GROSS AREA COMPRESSION

Enter the section modulus, based on the gross cross sectional area that is to be used in conjunction with F_y to calculate axial compression capacity of the member – in^3. This data must be entered for all members. Use the gross area with hand holes and perforations removed on the assumption that the body of the fastener fills the hole. Use effective gross area if the member has deteriorated.

MU

Enter the maximum bending strength, reduced for lateral buckling in kips-in. Normally BAR7 computes this item per 1985 AASHTO Strength Design of Truss Bridges. But the user has the override option by entering a non-zero positive value.

PLAS SHAPE FAC

Enter the plastic shape factor, f, computed based on gross or gross effective properties. The plastic shape factor is equal to Mp/My (= plastic moment/yield moment = Fy*plastic modulus/Fy* section modulus based on gross area). This value shall be always larger than 1.0. For example, this item is 1.5 for a rectangular section and 1.7 for a circular section.

EQUI MOM FAC

Enter the equivalent moment factor and it shall be taken as 0.85 or 1.00 as appropriate.

SHAPE

Enter the shapes of the truss members. This item is used to compute the MU of each truss member if MU is not enterd by the user. Use 1 for box shaped members, use 2 for H-shaped members bent about their minor axis, use 3 for H-shaped members, and members with channel flanges and a web plate, bent about their major axis, and use 4 for others. Refer to Article 1.8 in the 1985 AASHTO Strength Design of Truss Bridges.

BOX AREA

For box-shaped members with SHAPE = “1”, enter the box area enclosed within the centerlines of plates of the box members in square inches.

For non box-shaped member, leave it blank.

BOX S/T

For box-shaped members with SHAPE = “1”, enter the summation of the length of a side divided by its thickness for all sides in inches.

For non box-shaped member, leave it blank.

Iy2

For members with SHAPE = “1” or “3”, enter the moment of inertia about the axis perpendicular to the bending axis in in^4.

For others, leave it blank.

MEM H

For members with SHAPE = “3”, enter the depth of web plate plus flange thickness in inches.

For others, leave it blank.

5.16 STEEL MEMBER PROPERTIES

Enter this data to describe the section properties of the girder, encased I-beam, floorbeams, and stringers.

For the purpose of describing the steel member properties, each span is divided into a number of segments with each segment having a constant cross section. Each segment is defined by entering the distance of the right end of the segment from the left support of the span where this segment lies. This distance is defined as the range of the section. Properties are entered for each range within a span. Each range must have the same dimensions for each of the section elements (web, top flange, angles, bottom flange, cover plate) except for the web depth which can vary (straight or parabolic haunch) within a range.

For the bridge type "GGG", enter the section properties of the girder under consideration. Only one girder can be analyzed in a given run.

For the bridge type "EIB", enter the section properties of the encased I-beam. Only one beam can be analyzed in a given run. The bridge must have a simple span.

For the bridge type "GFS", enter the section properties of the main girder, floorbeams and stringers. Only one main girder, up to a maximum of **five** floorbeams and fifteen stringers can be analyzed in each run. Girder properties must be entered first, followed by floorbeams and stringers.

For the bridge type "GFF", enter the section properties of the main girder and floorbeams. Only one main girder and up to a maximum of **five** floorbeams can be analyzed in each run. Section properties of stringers are not entered for this type of bridge. Enter girder properties first.

For the bridge type "TFS", enter the section properties of the floorbeams and stringers. Up to a maximum of **five** floorbeams and fifteen stringers can be analyzed in each run. Enter floorbeam properties first.

For the bridge type "TFF", enter the section properties of the floorbeams only. Up to a maximum of **five** floorbeams can be analyzed. Section properties of stringers are not entered for this type of bridge.

For the bridge type "GGF", enter the section properties of the girder under consideration and the floorbeams. Only one girder can be analyzed in each run and up to a maximum of **five** floorbeams can be analyzed. Girder section properties must be entered first followed by floorbeam properties. Section properties of stringers are not entered for this type of bridge.

For the bridge type "FSS", enter the section properties of the floorbeams and stringers. Up to a maximum of **five** floorbeams and fifteen stringers can be analyzed in one run. Enter floorbeam properties first.

If SYMMETRY is entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, it applies only to the section properties of the girder. If the symmetry applies, enter the section properties of the girder for one-half of the bridge. For example, for a five-span symmetric bridge, enter the section properties of the girder up to the midpoint of span 3. For a single span bridge, enter the properties for the left half of the span. For a two-span symmetric bridge, enter the section properties of the girder up to the interior support. If the symmetry does not apply, enter the section properties of the girder for the entire bridge.

As stated earlier, one to **five** floorbeams may be analyzed. However, the floorbeam designated must correspond to the stringer span lengths (or floorbeam spacings) entered earlier. For example, if the floorbeam 5 is to be analyzed, stringer spans (or floorbeam spacings) 1, 2, 3, 4 and 5 must be described. Since the floorbeams are numbered such that the left floorbeam for each span has the same number as the span number, only the floorbeam at the left abutment and the interior floorbeams can be analyzed. Also, the program can analyze only floorbeams for which the stringer span lengths (or the floorbeam spacings) have been defined. A floorbeam can have a variable cross section. However, the number of different cross sections, including the cantilever portion (if any), in a floorbeam is limited to 5.

There may be a maximum of fifteen stringers on a bridge, but each stringer must have a constant cross section. If the stringer has a variable cross section, brace points within a span or stiffeners, analyze it by entering as bridge type "GGG".

Section properties of the girder must be described first followed by the section properties of all floorbeams. The section properties of stringers must be described last. For the bridge types "GFF", "GGF", and "TFF", the section properties of stringers are not entered. For the bridge types "TFS", "TFF" and "FSS", the section properties of the girder are not entered.

Enter one line of data for each range.

Members may be described by entering various combinations of section properties and member dimensions. The following three cases may occur:

Case 1: A standard beam for which basic section properties are known may be described by the following data. Refer to Figure 5.16.1 on page 5-76.

SECT TYPE (W)**: wide flange beam**
WF BEAM M OF I (basic beam)
WF BEAM AREA (basic beam)
FLANGE THICK (basic beam)
FLANGE WIDTH (basic beam)
WF BEAM DEPTH (depth of basic beam)

WEB THICK **(basic beam)**
TOP PLATE WIDTH (cover plate)
TOP PLATE THICK (cover plate)
BOTTOM PLATE WIDTH (cover plate)
BOTTOM PLATE THICK (cover plate)

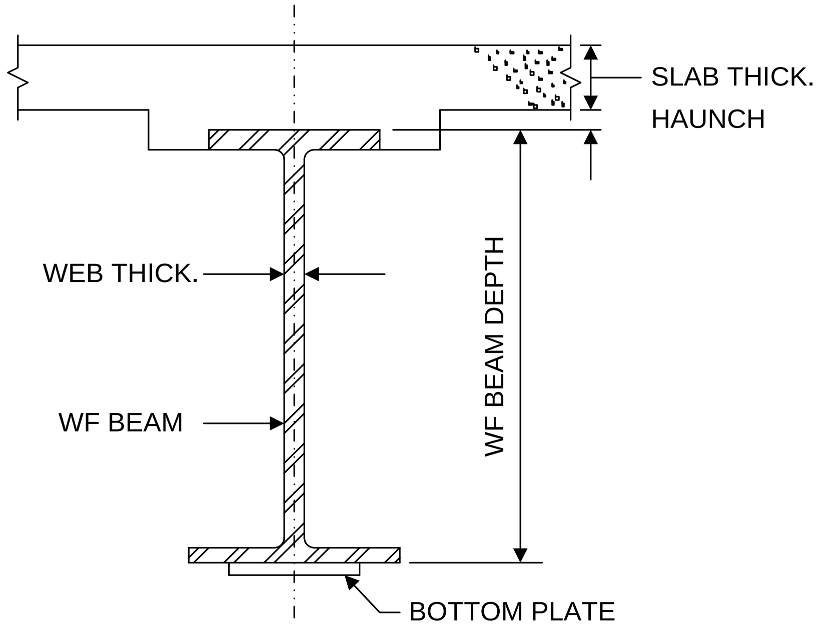
Case 2: A built-up section made up of web plate (constant depth or straight or parabolic haunch), angles and flange plates may be described by the following data. In a built-up section, angles are assumed to occur in pairs at both the top and the bottom, and all angles are assumed to be of the same cross section. Refer to Figure 5.16.1 on page 5-76.

SECT TYPE (B)**: built-up section**
ANGLE VERT LEG
ANGLE HORZ LEG
ANGLE THICK
VARIES (web plate depth variation)
WEB PLATE DEPTH (depth of web)
WEB THICK
TOP PLATE WIDTH
TOP PLATE THICK
BOTTOM PLATE WIDTH
BOTTOM PLATE THICK

Case 3: A plate girder section made up of a web plate (constant depth or straight or parabolic haunch) and flange plates may be described by the following data. Refer to Figure 5.16.1 on page 5-76.

SECT TYPE (P)**: plate girder**
VARIES (web plate depth variation)
WEB PLATE DEPTH (web)
WEB THICK **(web)**

TOP PLATE WIDTH (top flange)
TOP PLATE THICK (top flange)
BOTTOM PLATE WIDTH (bottom flange)
BOTTOM PLATE THICK (bottom flange)



WIDE FLANGE BEAM (COMPOSITE)

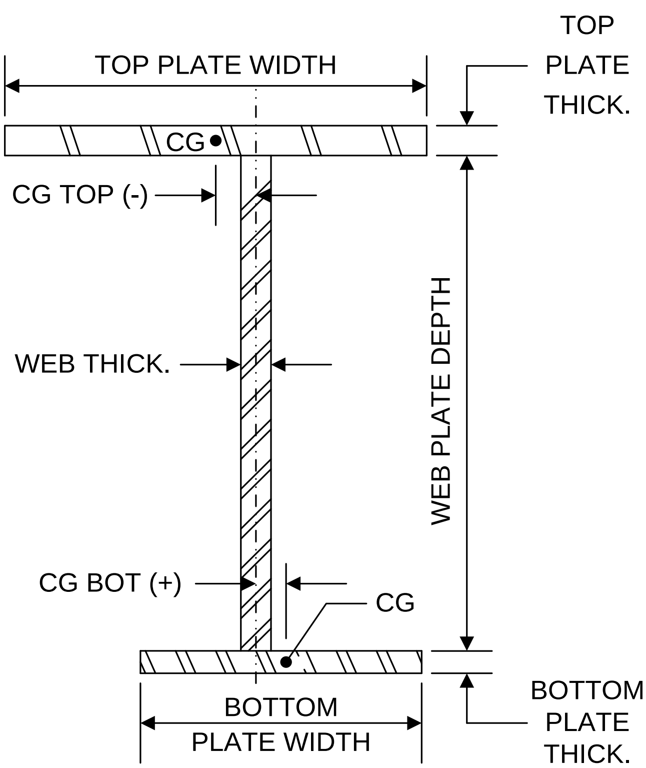
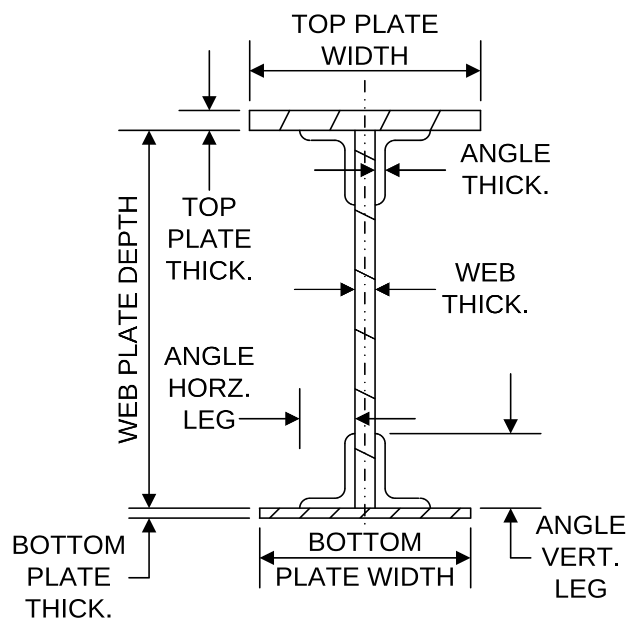


PLATE GIRDER



BUILT-UP SECTION

Figure 5.16.1 Steel Member Properties

G F OR S

Enter the following codes to describe the section properties in the following order. Entering in any other order will result in error conditions.

1. Enter "G" if a girder or an encased I-beam is being described. A maximum of 300 lines (150 if SYMMETRY is entered as "Y") are permitted to define the girder section properties.
2. Enter "F" if a floorbeam is being described. The maximum number of floorbeams that can be analyzed is limited to **5**. Do not enter this line for the bridge type "EIB", "FSS" or "GGG".
3. Enter "S" if a stringer is being described. These must be the last lines of data defining the steel member properties for the bridge types "FSS", "GFS", and "TFS". Do not enter this line for the bridge types "EIB", "GFF", "GGF", "GGG", and "TFF".

SPAN NO

If a girder is being described, enter the span number of the girder. Use the letter "A", "B", "C", "D", "E" and "F" for span 10, 11, 12, 13, 14 and 15 respectively.

If a floorbeam is being described, enter the number of the stringer span to the right of the floorbeam (from "1" to "**G**"). If SPAN NO equals "1", the floorbeam is analyzed as an exterior (end, usually at **begin** abutment **or truss joint 00**) floorbeam.

If a stringer is being described and a specific stringer is to be analyzed, enter the number of the stringer line to be analyzed. Refer to Stringer Locations data and count sequentially from the left to the stringer to be analyzed. If this item is left blank, the program will determine the critical stringer and analyze only that stringer line.

SPAN NO must be entered sequentially.

RANGE

The distance from the left **girder, truss, or** support of the span to the right end of this segment - feet.

GIRDER:

Girders are described in ascending span number, working from left to right. The RANGE cannot be greater than the span length. The RANGE for the last segment in each span must be equal to the span length. The first RANGE in each girder span must not be zero. The maximum number of girder RANGEs for a given girder is one hundred.

If the girder has a parabolic or straight haunch and if the top and/or bottom plate dimensions vary within the haunched segment, the haunched segment shall be divided into separate RANGEs with each RANGE having constant top and bottom plate dimensions.

FLOOR BEAM:

If a floorbeam is being described, start with a section at the centerline **of the left girder, truss, or support** (zero RANGE).

For left cantilever span, describe all sections in the cantilever portion of the **floorbeam** by entering a negative value for the RANGE. The last negative value of the RANGE must be equal to the value of OVERHANG entered in the BRIDGE CROSS SECTION AND LOADING line.

For symmetric floor beam span, describe all sections of the floorbeam between the **centerline of the left girder, truss, or support** and the midpoint of the floorbeam span **by entering positive value**. The last positive value of the RANGE must be equal to one-half the center-to-center distance between girders or trusses. The maximum number of floorbeam RANGEs for a given floorbeam is five.

When the whole floorbeam analysis is needed (i.e. UNSYM PIER = "Y" OR Patch load for floorbeam), describe all sections in the floorbeam including all cantilevers.

For unsymmetrical floorbeam span, describe all sections of the floorbeam between the centerline of the left girder, truss, or support and the centerline of the right girder, truss, or support by entering positive values. The last positive value of the RANGE must be equal to the center-to-center distance between left girder (or truss or support) or right girder (or truss or support).

For right cantilever span, describe all sections in the cantilever portion of the floorbeam by entering a positive value for the RANGE. The last positive value of the RANGE must be equal to the end of right cantilever span.

STRINGER:

If a stringer is being described, leave blank. **No variation in section properties is allowed in a stringer.**

SECT TYPE

Enter one of the following codes to define the type of section.

1. Enter "W" if the section is a wide flange beam.
2. Enter "B" if the section is a built-up section made up of web plate, angles and flange plates.
3. Enter "P" if the section is a welded plate girder.

This code must be entered on the first line of data for each member type (girder, floorbeam or stringer), i.e. whenever either "G", "F" or "S" is entered the first time for the input item G, F OR S. Thereafter, if this item is left blank, the program will assume the section type of the previous RANGE having a non-blank SECT TYPE. For each RANGE a different SECT TYPE may be entered.

WF BEAM M OF I OR ANGLE VERT LEG

If "W" is entered for SECT TYPE, enter the moment of inertia of the wide flange beam – in^4.

If "B" is entered for SECT TYPE, enter the length of the vertical leg of the angle - inches.

If "P" is entered for SECT TYPE, leave blank.

WF BEAM AREA OR ANGLE HORZ LEG

If "W" is entered for SECT TYPE, enter the area of the wide flange beam - in^4.

If "B" is entered for SECT TYPE, enter the length of the horizontal leg of the angle - inches.

If "P" is entered for SECT TYPE, leave blank.

FLANGE OR ANGLE THICK

If "W" is entered for SECT TYPE, enter the flange thickness of the wide flange beam - inches.

If "B" is entered for SECT TYPE, enter the thickness of the angle - inches.

If "P" is entered for SECT TYPE, leave blank.

FLANGE WIDTH

If "W" is entered for SECT TYPE, enter the flange width of the wide flange beam - inches.

If "B" or "P" is entered for SECT TYPE, leave blank.

VARIES

For a non-prismatic **segment** where the left **depth of the previous range** and right depth **of the current range** are different, enter "P" if the variation in depth **within this segment** is parabolic and "S" if it is straight. Leave blank for a constant depth. The program uses the equation $y = cx^2$ for the parabolic haunch.

	parabolically varied @ X=60		vs	not varied	
RANGE	**X**	**DEPTH**		**X**	**DEPTH**
	0.00	**44.75**		**0.00**	**44.75**
	12.00	**44.75**		**12.00**	**44.75**
	24.00	**44.75**		**24.00**	**44.75**
30	**30.00L**	**44.75**		**30.00L**	**44.75**
	30.00R	**44.75**		**30.00R**	**54.75**
	36.00	**45.15**		**36.00**	**54.75**
	48.00	**48.35**		**48.00**	**54.75**

60	**60.00L**	**54.75**	**60.00L**	**54.75**
	60.00R	**64.75**	**60.00R**	**64.75**

WF BEAM OR WEB PLATE DEPTH

Enter the depth of the wide flange beam or the web plate at the right end of the segment (at a given RANGE) being described - inches. If the section being described is in a parabolic or straight haunch and the RANGE entered is not the end of the parabolic or straight haunch, leave this blank. If the RANGE entered is the end of the haunch, enter the depth of web at the end of the haunch. If in a built-up section, there is a gap between the web plate and the flanges, enter the actual distance between the bottom of the top flange and the top of the bottom flange.

WEB THICK

The thickness of the web - inches. This must be entered for all sections.

For box-shaped steel cross girders/floorbeams, enter the web thickness of only one web.

TOP PLATE

Enter the top cover plate dimensions, if one exists, for case 1.

Enter the top plate dimensions for case 2 or 3.

WIDTH

The width of the top plate or cover plate - inches.

THICK

The thickness of the top plate or cover plate - inches.

BOTTOM PLATE

Enter the bottom cover plate dimensions, if one exists, for case 1.

Enter the bottom plate dimensions for case 2 or 3.

WIDTH

The width of the bottom plate or cover plate - inches.

THICK

The thickness of the bottom plate or cover plate - inches.

COMPOSITE

For the bridge type "EIB" the program always uses the composite section properties to calculate the stresses due to DL2 and LL+I. For this bridge type, this input value is used to differentiate between shored and unshored construction. If shored construction, enter "Y" and the program uses the composite section properties, (n=3n), to calculate the stresses due to DL1. If unshored construction, enter "N" and the program uses the non-composite section properties to calculate the stresses due to DL1. This value must be entered as "Y" or "N" for the entire length of the encased beam.

For all other bridge types, enter "Y" if the section is composite with the slab, "N" **or leave it blank** if it is non-composite. The program assumes unshored construction and always uses the non-composite section properties to calculate the stresses due to DL1.

FY

The yield strength of the material for the segment being described - ksi.

For a homogeneous section, enter the yield strength of the entire section.

For a hybrid section, enter the yield strength of the web.

HYBRID FY TOP

For a hybrid section, enter the yield strength of the top plate or cover plate - ksi.

For a homogeneous section, leave this blank.

HYBRID FY BOT

For a hybrid section, enter the yield strength of the bottom plate or cover plate - ksi.

For a homogeneous section, leave this blank.

UNSYMMETRICAL CG TOP

For a section unsymmetrical about the vertical (Y-Y) axis, enter the distance of the center of gravity of the top plate or cover plate from the vertical centerline of the web - inches. The distance is positive to the right and negative to the left of the web centerline.

UNSYMMETRICAL CG BOT

For a section unsymmetrical about the vertical (Y-Y) axis, enter the distance of the center of gravity of the bottom plate or cover plate from the vertical centerline of the web - inches. The distance is positive to the right and negative to the left of the web centerline.

NOTE: Deteriorated wide flange sections with deterioration in the flange can be described either with negative cover plate thickness or by entering as a plate girder with unsymmetrical CG depending on the location and type of deterioration. If a negative cover plate thickness is entered for a wide flange section and the cover plate width is not entered, the program will assume that the section loss is over the entire width of the flange. Currently, the program does not have any provision to enter deterioration in the web. However, if the user enters a reduced WEB THICK to account for deterioration in the web, then the user must also account for this loss in the input of WF BEAM M OF I and WF BEAM AREA.

SECTION SHAPE

Enter I or leave it blank when the cross girder is I-shape.

Enter B when the cross girder is box-shape. This will allow the simulation of non-composite, box-shaped steel cross girder (i.e. floorbeams at supports) using BAR7 to perform a rating for a non-compact section using I-shape steel girder.

5.17 LATERAL BRACE POINTS AND STIFFENER SPACINGS

These lines are required to describe the lateral brace points and stiffener spacings for a girder or floorbeam **(exclude EIB)**. These data are required for the Load Factor rating of a member subjected to flexure and shear. The type of data (brace points or stiffener spacings) being described is indicated by a two-character code at the beginning of each line. Also, the data is entered for each span in succession beginning with span number one. Each span is described by the number of spaces of a given spacing followed by the number of spaces of another spacing and so on until the entire span is described.

Since each line has a two-character code and a span number, the order of input is not important. However, for simplicity of coding and understanding of the input, the following sequence is suggested. Start with a girder and describe all brace points first for all spans followed by stiffener spacings for all spans. Then describe the brace points for all floorbeams beginning with the first floorbeam for which the section properties are entered. Follow these by stiffener spacings for all floorbeams in the same order.

The top and bottom flanges of a floorbeam shall be braced at supports and the end of the overhang.

The program does not have a provision for entering this data for a stringer of the bridge type "FSS", "GFS", or "TFS". The program will assume that the top flange of a stringer is continuously braced. The program will also assume that the bottom flange of a stringer is braced at the ends of each span. The program also assumes that a stringer is unstiffened. If a stringer has brace points and stiffeners different than what the program will assume, then the stringer in question could be analyzed by entering as bridge type "GGG".

The following is a description of each data item on this line. Figure 5.17.1 on page 5-85 shows the coding of these items for two girders.

BRACING OR STIFF CODE

This is a two-character code which denotes the member and the type of data (brace point or stiffener spacing) being described on this line. Enter one of the following codes.

"BG" for describing the brace points of a girder

"SG" for describing the stiffener spacings in a girder

"BF" for describing the brace points of a floorbeam

"SF" for describing the stiffener spacings in a floorbeam

SPAN NO

If a girder is being described, enter the span number of the girder. Use the letter "A", "B", "C", "D", "E" and "F" for span 10, 11, 12, 13, 14 and 15 respectively.

If a floorbeam is being described, enter the number of the stringer span to the right of the floorbeam (from "1" to "F"). If SPAN NO equals "1", the floorbeam is analyzed as an exterior (end, usually at abutment **or truss joint 00**) floorbeam.

SPAN NO must be entered sequentially.

BRACE POINT OR STIFFENER CODE

Enter one of the following codes if "BG" or "BF" is entered for the BRACING OR STIFF CODE.

Enter "T" if the brace points are described for the top flange.

Enter "B" if the brace points are described for the bottom flange.

Enter "C" if the top flange is continuously braced for this number of spaces. The bottom flange cannot be continuously braced.

Enter one of the following codes if "SG" or "SF" is entered for the BRACING OR STIFF CODE.

Enter "T" if the web is transversely stiffened for this number of spaces.

Enter "L" if the web is transversely and longitudinally stiffened for this number of spaces.

Enter "N" if the web is unstiffened for this number of spaces.

NO. OF SPACES

Enter the number of spaces having a constant spacing described next. If this data is being described for the cantilever portion of a cantilevered floorbeam, enter a negative value.

Note: Up to **18** different brace point spacings or stiffener spacings can be entered per floorbeam.

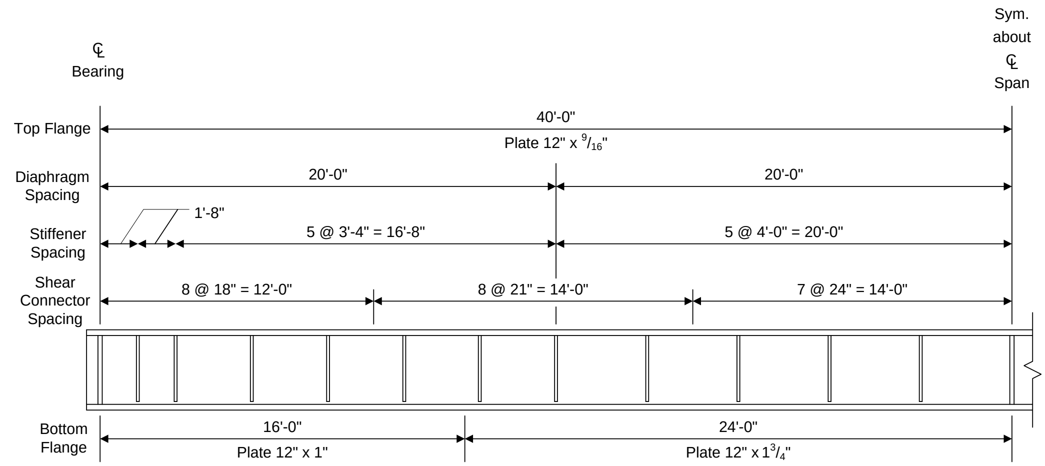
SPACING

Enter the constant spacing - feet.

Any combination of NO. OF SPACES and SPACING can be used to define brace points and stiffener spacings. However, the sum of products of NO. OF SPACES and SPACING for a given span number must be within a foot of the span length. For a symmetrical member, the sum of products of NO. OF SPACES and SPACING must be greater than or equal to the distance to the point of symmetry. The program will assume an end of a brace point and stiffener spacing at the right end of each span.

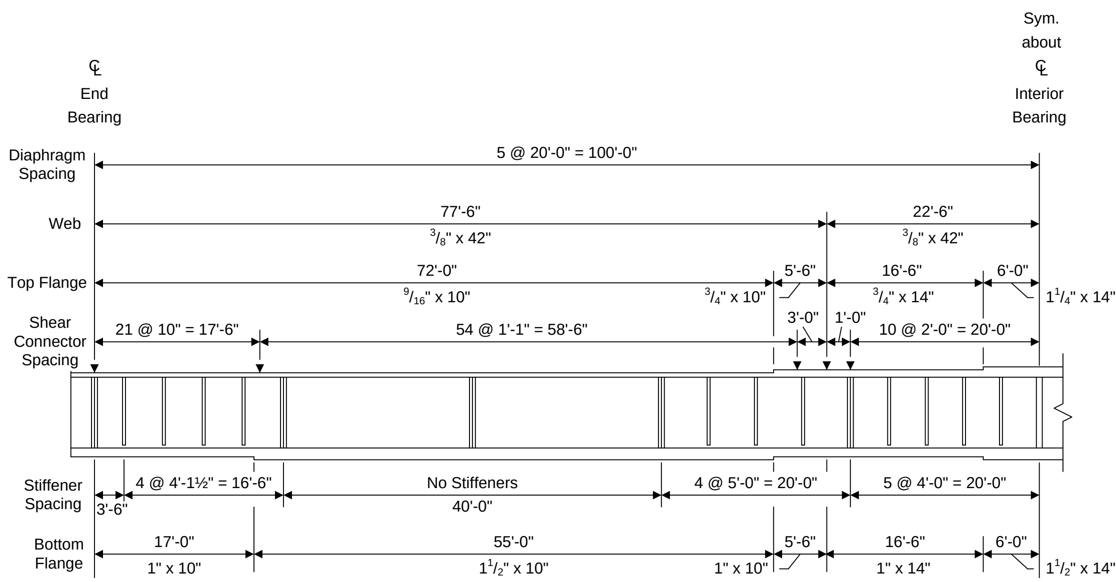
For floorbeams with patch loads or the unsymmetrical pier configuration:

1. **The sum of products of NO. OF SPACES and SPACING for left cantilever span must be within a foot of the floorbeam main span length plus right cantilever span length.**
2. **The sum of products of NO. OF SPACES and SPACING for floorbeam main span and right cantilever must be within a foot of the floorbeam main span length + right cantilever span length.**



LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO	CODE	NO. OF SPANS	SPACING	CODE	NO. OF SPANS	SPACING	CODE	NO. OF SPANS	SPACING	CODE	NO. OF SPANS	SPACING	CODE	NO. OF SPANS	SPACING	CODE	NO. OF SPANS	SPACING
		BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47
BG	1	C	1	40.00	B	2	20.00												
SG	1	T	2	1.67	T	5	3.33	T	5	4.00									



BG	1	C	1	100.00	B	5	20.00												
SG	1	T	1	3.50	T	4	4.13	N	1	40.00	T	4	5.00	T	5	4.00			

Figure 5.17.1 Lateral Brace Points and Stiffener Spacings

5.18 FATIGUE DATA

If "Y" is entered for FATIGUE in the PROJECT IDENTIFICATION line, this line of data must be entered. Enter the following as required.

YEAR BUILT

Enter the calendar year in which the bridge was built. If it is unknown, enter an estimated year. The program uses this value to calculate the average daily truck traffic (ADTT) for the year the bridge was built. This must be entered.

PREVIOUS COUNT - YEAR OR GF

If an ADTT for a previous count is known, enter the year in which this count was taken.

If the rate of growth in ADTT for the past is known, enter the rate expressed as 100 times the percent growth. For example, if the past growth in ADTT was 2.5%, enter 0250. The program will divide the entered value by 100 and use it as a growth factor, in percent.

If the ADTT was constant (no growth) in the past, enter zero or leave blank.

PREVIOUS COUNT - ADTT

If a year is entered for PREVIOUS COUNT - YEAR OR GF, enter the average daily truck traffic count for the previous count.

If a growth factor is entered for PREVIOUS COUNT - YEAR OR GF, leave this blank.

The program uses this data to determine whether the past growth factor is entered or it is to be calculated.

For the purpose of fatigue analysis, ADTT is a one directional average daily truck traffic on the bridge in number of trucks per day.

RECENT COUNT - YEAR

Enter the year in which the most recent ADTT count was taken. This must be entered.

RECENT COUNT - ADTT

Enter the average daily truck traffic count for the year when the most recent ADTT count was taken. This must be entered. If the PREVIOUS COUNT - GF is entered as zero, the program will use this ADTT from the year built to the year of recent count.

FUTURE COUNT - YEAR OR GF

If an ADTT for the future can be predicted, enter the year for which the ADTT is predicted. Preferably this should not be later than 10 years into the future.

If the rate of growth in ADTT for the future can be predicted, enter the rate expressed as 100 times the percent growth. For example, if the future growth in ADTT is predicted to be 5%, enter 0500. Enter zero or leave blank if no growth factor is to be considered for the future.

FUTURE COUNT - ADTT

If an ADTT value for the future can be predicted, enter the ADTT for FUTURE COUNT - YEAR.

If FUTURE COUNT - YEAR OR GF is left blank, enter the ADTT that will remain constant in the future.

R OR N

Specify whether the structure in question has redundant load paths or non-redundant load paths.

Enter "R" if the structure has redundant load paths.

Enter "N" if the structure has non-redundant load paths.

This data is used in determining the allowable fatigue stress range of a detail.

ONE LANE DISTR FACTOR

The live load distribution factor is for loading only one lane on the bridge. Enter this as a fraction of axle load, i.e. one-half of the wheel load distribution factor.

For the bridge type "GGG", enter one-half of the wheel load distribution factor for one lane (e.g. S/14 for steel girder bridge with concrete deck).

For the main girder of the bridge types "GFS" and "GFF" and for the truss of the bridge types "TFS" and "TFF", use the simple beam reaction at the girder or truss due to a single HS20 truck in a lane positioned closest to the girder or truss.

This data must be entered. This is used in calculating the design fatigue stress range due to an HS20 truck in one lane.

NO OF GVWD

If the loadometer surveys of the gross vehicle weight distribution on the bridge are available and if the gamma factor in the effective stress range equation is to be calculated using a rigorous method described in DM4, enter the number of gross vehicle weight ranges that were used in the loadometer surveys.

If the loadometer surveys are not available or if the rigorous method for calculating the effective stress range is not to be used, leave this blank. If this is left blank, the program will use a gamma factor of 0.7 times the Pennsylvania Traffic Factor (PTF) to calculate the effective stress range.

If a number greater than zero is entered here, also enter GROSS VEHICLE WEIGHT DISTRIBUTION data as described later.

5.19 GIRDER FATIGUE DETAIL

If "Y" is entered for FATIGUE in the PROJECT IDENTIFICATION line and if the bridge type is "GFS", "GFF", "GGG" or "GGF", fatigue prone details in the girder must be entered here. The program performs the fatigue life analysis of each detail described here and calculates the minimum remaining life of the bridge. The location of a detail is described by giving a horizontal distance of the section from the left centerline of bearing of the span where this section is located and a vertical distance measured from the bottom most fiber of the section where this detail is located. Only the details for which the fatigue life analysis is required may be entered here. The last section entered here must be the right centerline of bearing of the last span regardless whether a fatigue prone detail exists there or not. If SYMMETRY is entered as "Y" in the BRIDGE CROSS SECTION AND LOADING line, then the last section entered here must be the center of the bridge. A maximum of 80 sections can be entered with a maximum of 4 details at each section. Enter the following data.

SPAN NO

The span number where this section is located. Use the letter "A", "B", "C", "D", "E" and "F" for span 10, 11, 12, 13, 14 and 15 respectively.

DIST FROM CL BEARING

The distance of the section from the left centerline of bearing of the span where this section is located - feet. The last distance entered here must be equal to the length of the last span if the bridge is unsymmetrical (i.e. if "Y" is not entered for SYMMETRY in the BRIDGE CROSS SECTION AND LOADING line) or must be equal to the distance of the symmetry point if the bridge is symmetric (i.e. if "Y" is entered for SYMMETRY in the BRIDGE CROSS SECTION line).

DIST FROM BOTTOM

For each detail at a given section, enter the vertical distance from the bottom most fiber at that section - inches. If the section where this detail is located falls at a junction of two different cross sectional areas (such as cover plate transitions or cut-offs), measure the vertical distance from the bottom fiber of the smaller cross sectional area. The value entered should always be positive. The fatigue stress range is calculated at this level for the fatigue life analysis.

CATEGORY

Enter a code that corresponds to the stress category given in AASHTO Specifications Tables 10.3.1A and 10.3.1B. Enter the code left justified. Acceptable codes are "A ", "B ", "BP", "C ", "CT", "D ", "E ", “EP”, “B’” and "E'", where "CT" is the stress category C in AASHTO Specifications Table 10.3.1A for transverse stiffener welds on girder webs and flanges. Note: “BP” is equivalent to “B’” and “EP” is equivalent to “E’”.

Do not leave this blank.

5.20 GROSS VEHICLE WEIGHT DISTRIBUTION

If the loadometer surveys of the gross vehicle weight distribution on the bridge are available and if a number greater than zero is entered for NO OF GVWD in the FATIGUE DATA line, enter the following.

GROSS VEHICLE WEIGHT – MIN

The minimum gross vehicle weight in this range used for surveys - kips. If this is the last range that includes all weights over a certain value, enter that "over value" here.

GROSS VEHICLE WEIGHT - MAX

The maximum gross vehicle weight in this range used for surveys - kips. If this is the last range which includes all vehicle weights over a certain value, enter that "over value" here also.

NO OF SINGLE UNIT TRUCKS - 2 AXLE, 3 AXLE, 4 AXLE

The number of single unit trucks with 2 axles, 3 axles and 4 axles respectively in this range of gross vehicle weights.

NO OF TRACTOR TRAILER COMB - 3 AXLE, 4 AXLE, 5 OR > AXLE

The number of tractor-trailer combinations with 3 axles, 4 axles, and 5 or more axles respectively in this range of gross vehicle weights.

5.21 SPECIAL LIVE LOADING

This form is used to describe the parameters of special live loadings that 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 separate input form 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 a set of special live loadings to be run 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.

5.21.1 Lane Loading

SP LL NO

Enter the identification number for the special live loading, from 1 to 8.

NUMBER OF AXLES

Enter the number of axles on the Truck Load of the special live loading. There may be a minimum of 2 axles and a maximum of 80 axles on a Truck Load.

3% INCR

Enter Y if all entered axle loads are to be increased by 3%. This option allows checking permit loads for a 3% over weight. If a Y is entered here, the Rating Factors calculated by the program are based on the entered axle loads increased by 3%. If a Y is entered here, the ratings in tons are based on the entered axle loads.

Leave blank if the entered axle loads are not to be increased.

UNIFORM LANE LOAD

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

The concentrated load to be used in combination with the uniform lane load to produce the maximum moment (or truss chord member forces) at an analysis point - kips.

For the determination of maximum negative moment (or maximum top chord tension or bottom chord compression) in a continuous span structure, the program will use two concentrated loads of the entered value to produce the maximum effect.

CONC LOAD SHEAR

The concentrated load to be used in combination with the uniform lane load to produce the maximum shear (or diagonal and vertical member forces) at an analysis point - kips.

GAGE DISTANCE

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

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 this blank.

If a "Y" is entered here 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 - ft. Otherwise, leave blank.

When ‘P’ (APRAS only) is entered for OUTPUT in the PROJECT IDENTIFICATION line, an abbreviated Lane Loading input should be entered as follows:

NUMBER OF AXLES

The number of axles on the Truck Load of the special live loading. There may be a maximum of 80 axles on a Truck Load.

This must be entered as two integer digits in columns one and two of this input record.

3% INCR

Enter Y if all entered axle loads are to be increased by 3%. This option allows checking permit loads for a 3% over weight. If a Y is entered here, the Rating Factors calculated by the program are based on the entered axle loads increased by 3%. If a Y is entered here, the ratings in tons are based on the entered axle loads.

Leave blank if the entered axle loads are not to be increased.

This must be entered as a single character in column three of this input record.

GAGE DISTANCE

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.

This must be entered as a three-digit real number with an implied decimal point between the second and third digits in columns four through six of this input record.

PASSING DISTANCE

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.

This must be entered as a three-digit real number with an implied decimal point between the second and third digits in columns seven through nine of this input record.

5.21.2 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.

The actual axle spacing, for special loadings, may exceed the BAR7 maximum input value of 99.9 feet in a superload. For this case, insert a dummy axle with a negligible weight (minimum = 0.01 kips) to divide the axle spacing into two axle spacings, each less than or equal to 99.9 feet. See Figure 5.21.1 below.

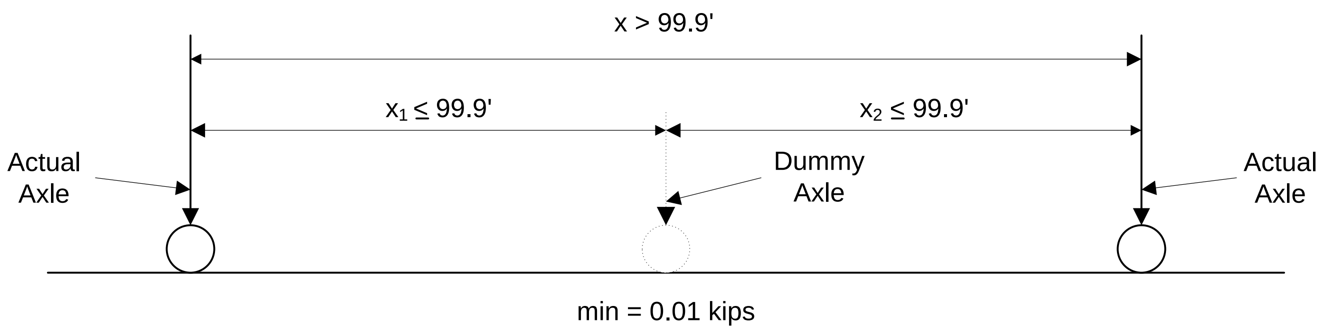


Figure 5.21.1 Axle Spacings Exceeding 99.9 Feet

5.22 GUSSET PLATE PROPERTIES

This command is used to define the geometry of the gusset plate. Only one gusset plate can be defined at each upper or lower joint. This command can be repeated to define up to 122 joints, 61 upper and 61 lower.

If "Y" is entered for GUSSET in the BRIDGE CROSS SECTION AND LOADING line, enter these data only for the bridge types of "TFF", "TFS" and "TTT"

If "Y" is entered for SYMMETRY in the BRIDGE CROSS SECTION AND LOADING line, you must enter only the gusset plate properties for the panels left of the point of symmetry.

GUS CARD IDENT

Enter the identification of this card, "GUS"

GUSSET PLATE LOC1

Enter the location of the gusset plate by the joint, "U" or "L".

Note: The program can't handle the gusset plate at the middle joint, "M".

GUSSET PLATE LOC2

Enter the location of the gusset plate by the joint, 00, 01, 02, ...

Fy

Enter the minimum yield strength of the material for the gusset plate being described - ksi.

Fu

Enter the minimum ultimate strength of the material for the gusset plate being described - ksi.

Note: 1.4*Fy is used as a default value if Fu is not input.

THICK, t

Enter the thickness of the gusset plate at one side of joint which has the double-sided symmetrical gusset plate - in. If there are different thicknesses of gusset plate per side of the double-sided gusset plate joint, then input the average thickness of these two plates. If there are two gusset plates per side of the double-sided gusset plate joint, then input the total thickness of these two plates.

At gusset plate locations where the members are connected by only one gusset plate and not two gusset plates BAR 7 cannot be used to obtain accurate Operating Ratings of the Gusset Plates. BAR7 assumes two gusset plates are present at each joint and thus divides the forces by 2.

Lower Limit: 0.25 in and Upper Limit: 4 in.

LENGTH, Ha

Enter the length of the gusset plate along a horizontal cut at or near the edge of the chord (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100, Section A-A) - in. Input the length of the larger plate if two gusset plates are used per side.

Lower Limit: 12 in and Upper Limit: 200 in.

LENGTH, Hb

Enter the length of the gusset plate along a vertical cut on the Section B-B side of the vertical member (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100, Section B-B) - in. Input the length of the larger plate if two gusset plates are used per side.

Lower Limit: 0 in and Upper Limit: 200 in.

LENGTH, Hc

Enter the length of the gusset plate along a vertical cut on the Section C-C side of the vertical member (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100, Section C-C) - in. Input the length of the larger plate if two gusset plates are used per side.

Lower Limit: 0 in and Upper Limit: 200 in.

ECCENTRICITY, Ea

Enter the vertical distance from the line of action in the chord to the edge of the chord adjacent to the diagonal/vertical members (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) - in. This distance, typically taken as half of the member width, defines where Section A-A is taken. Used to calculate the bending moment on the horizontal cut at Section A-A due to the vertical component of the diagonal.

Lower Limit: 0 in and Upper Limit: 50 in.

ECCENTRICITY, Eb

Enter the distance from the line of action in the vertical member to the edge of the vertical member (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) - in. Used to calculate the bending moment on the vertical cut at Section B-B due to the horizontal component of the diagonal.

Lower Limit: 0 in and Upper Limit: 20 in.

ECCENTRICITY, Ec

Enter the distance from the line of action in the vertical member to the edge of the vertical member (Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) - in. Used to calculate the bending moment on the vertical cut at Section C-C due to the horizontal component of the diagonal.

Lower Limit: 0 in and Upper Limit: 20 in.

MAXIMUM UNSUPPORTED EDGE, B

Enter the maximum unsupported length along the edge of the gusset plate. For post and hanger type gusset plates, B may be taken as zero in most cases (Figure 5.22.5 on page 5-101).

The “max” unsupported edge distance, B, should only be entered for the following two cases:

a. Where a diagonal connects into the gusset plate.
b. Where no diagonal is present and the vertical member and the chord are in compression.

The engineer must use his/her judgment when determining the distance, B. If there is a staggered rivet/bolt pattern for the members used in determining the distance, B, the distance is to be measured between the closest rivets/bolts in the pattern.

Lower Limit: 0 in and Upper Limit: 100 in.

SHEAR CAPACITY OF FASTENER, Fv

The connection is checked as bearing-type (i.e. the connection has slipped), therefore, input the bolt or rivet capacities for load factor method using Table 10.56A for rivets, low-strength bolts, and high strength bolts from the AASHTO Standard Specifications whenever applicable.

Lower Limit: 15 ksi and Upper Limit: 60 ksi.

FASTENER DIAMETER, d

Enter the minimum nominal diameter of the fasteners at the joint.

Lower Limit: 0.625 in and Upper Limit: 2 in.

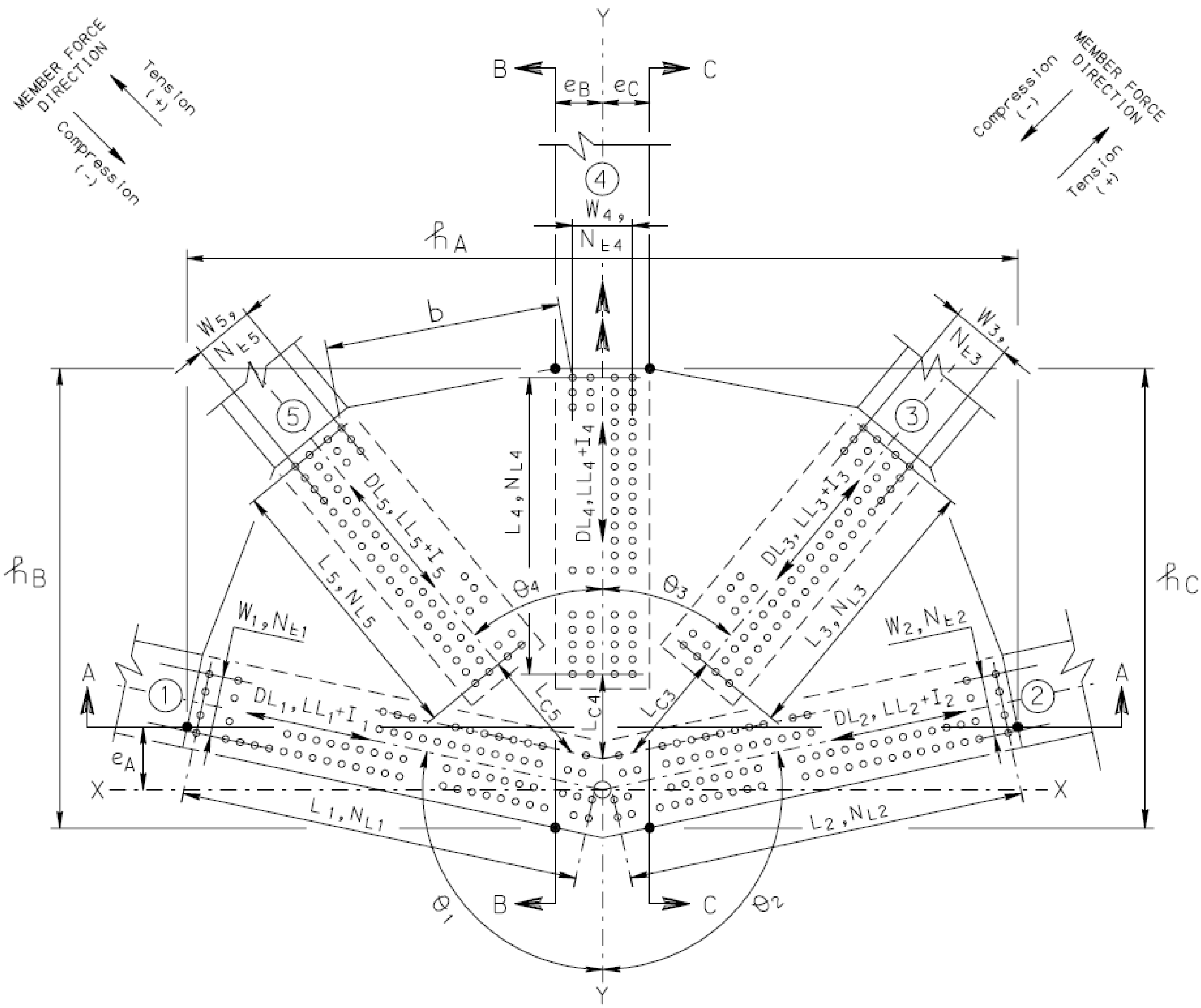


Figure 5.22.1 Gusset Plate Geometry: Angled Lower Chord

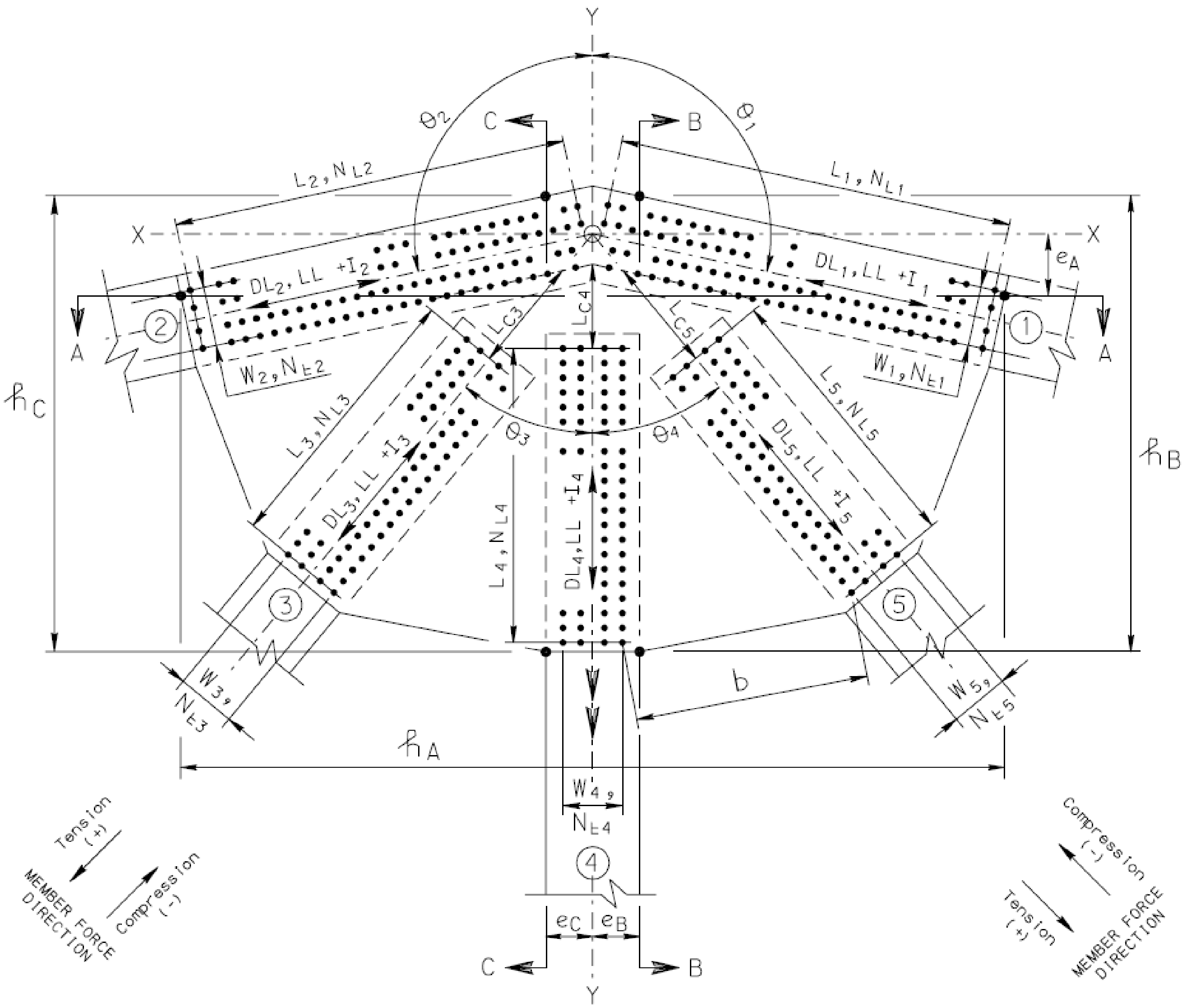


Figure 5.22.2 Gusset Plate Geometry: Angled Upper Chord

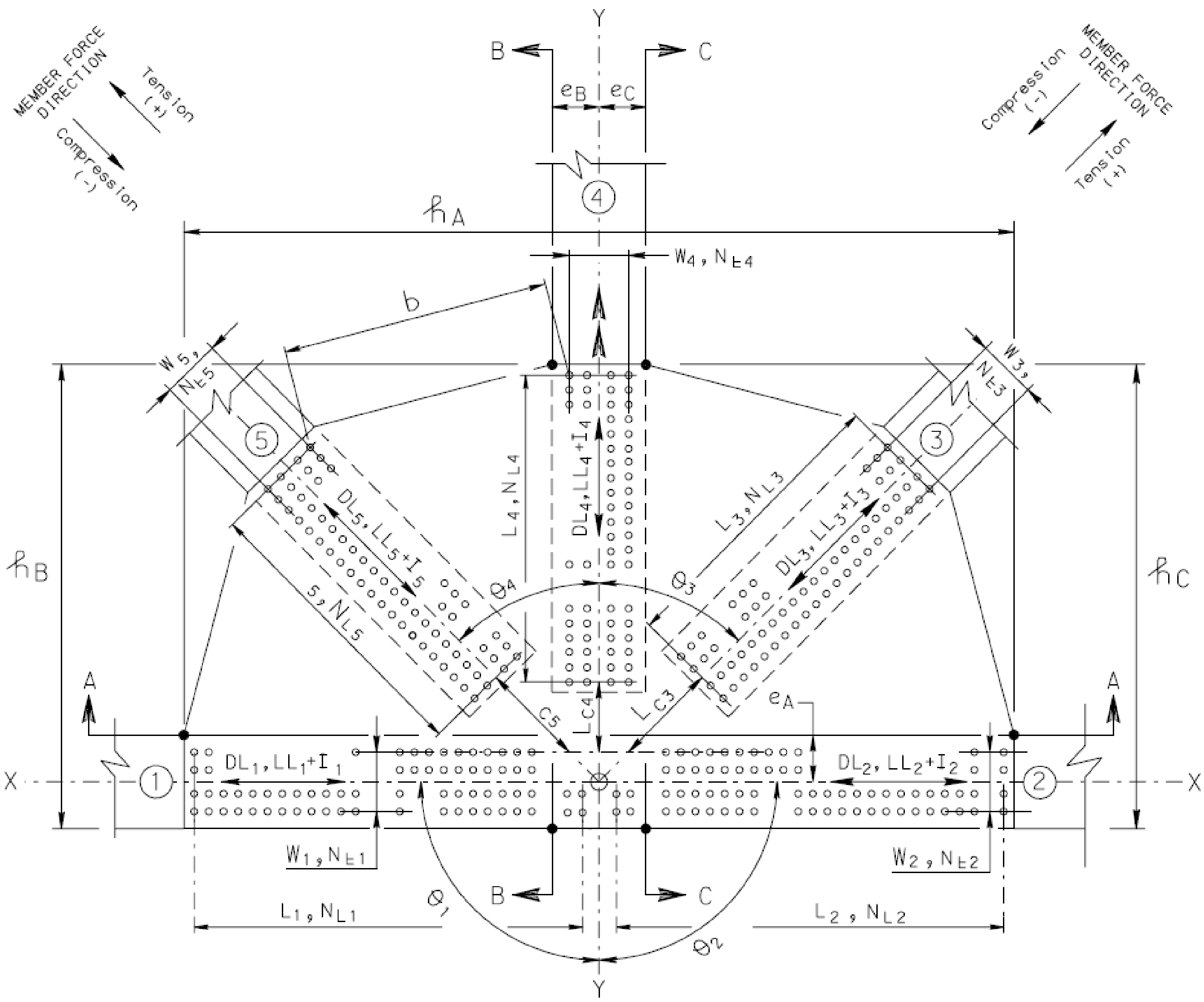


Figure 5.22.3 Gusset Plate Geometry: Horizontal Lower Chord

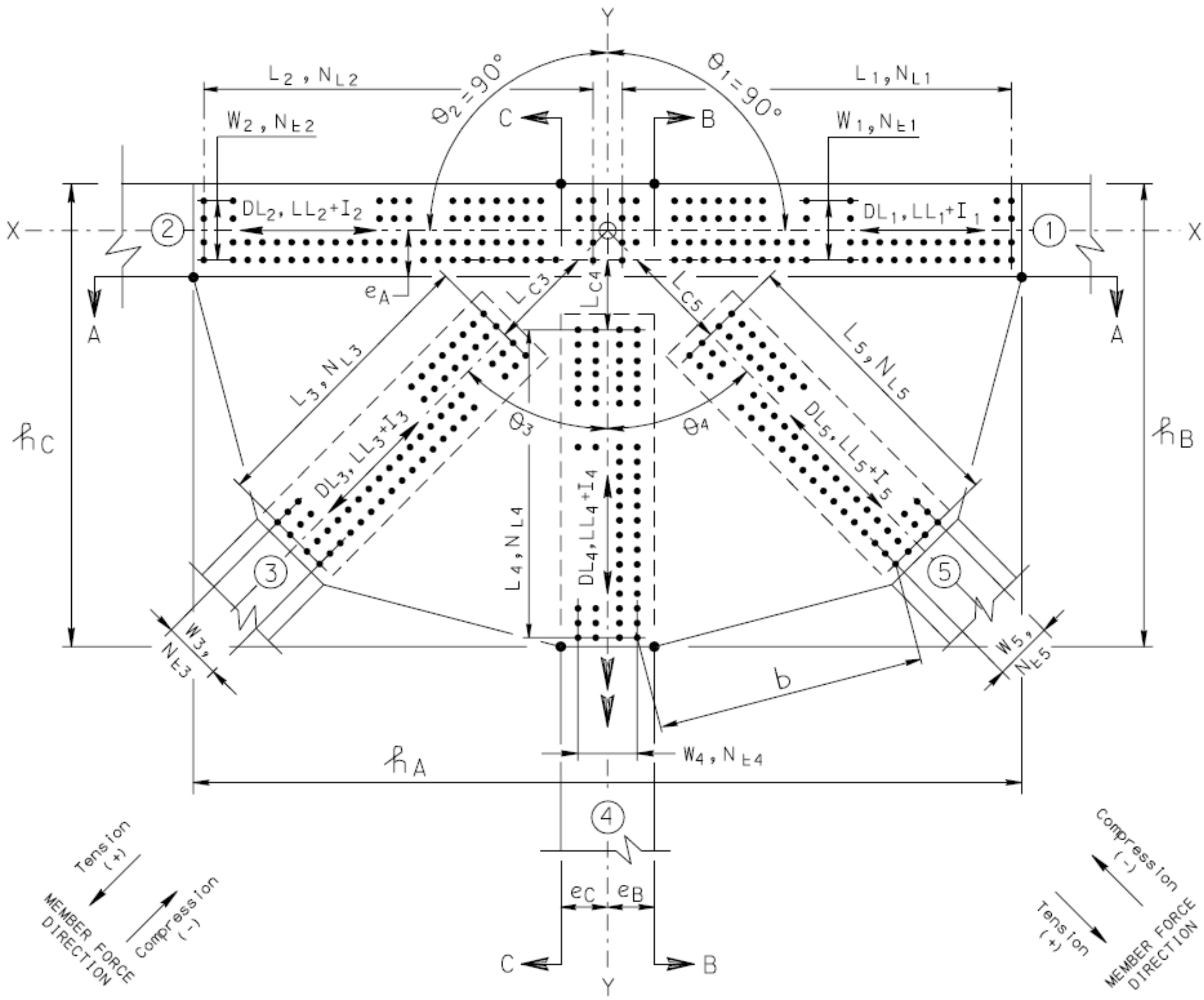


Figure 5.22.4 Gusset Plate Geometry: Horizontal Upper Chord

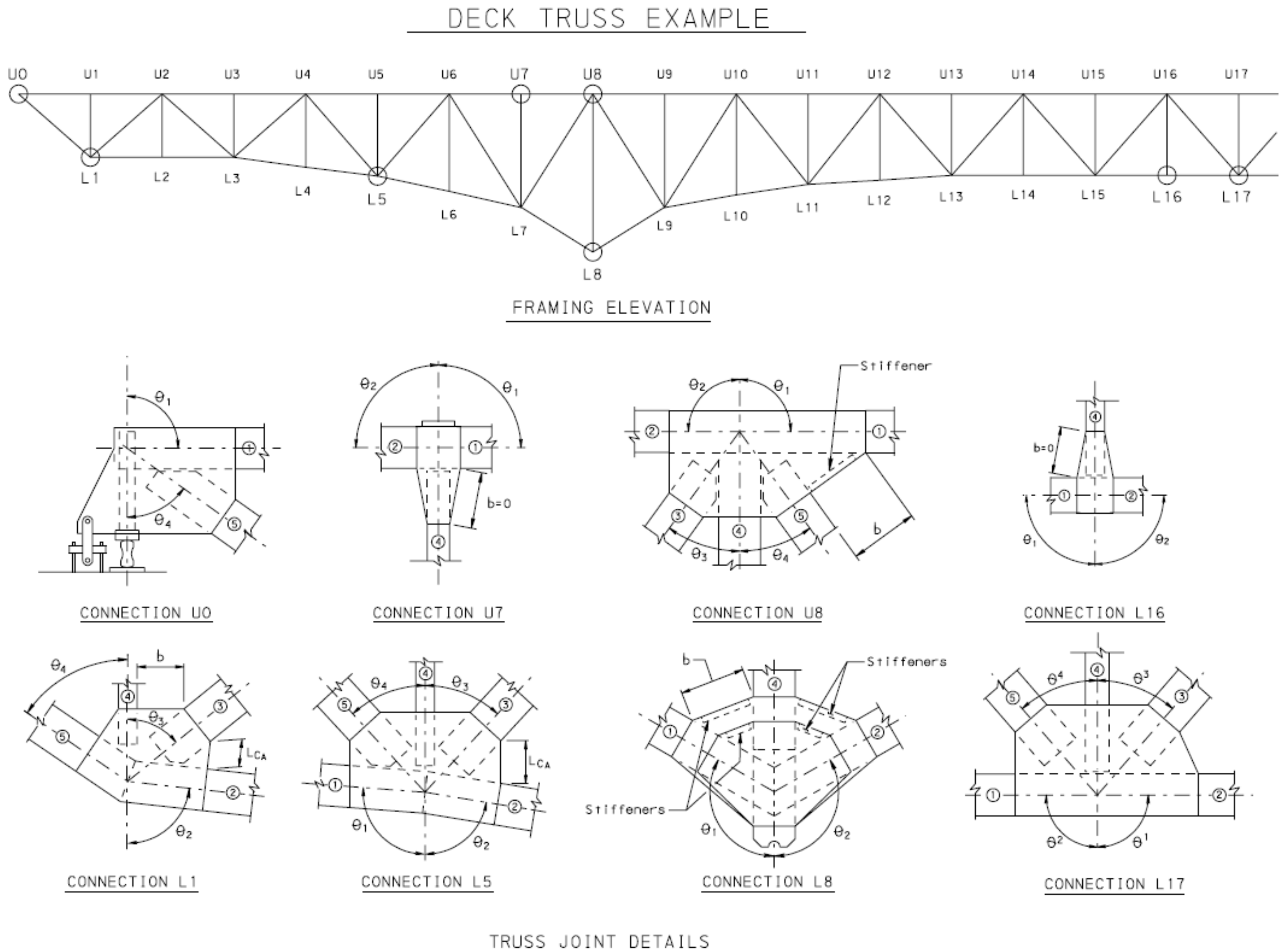


Figure 5.22.5 Gusset Plate Geometry: Deck Truss Example

5.23 GUSSET PLATE MEMBER PROPERTIES

This command is used to input the members connected to the gusset plate. If a member is not present, do not enter any information for that member. See Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100 for explanations of all dimension inputs. This command can be repeated to define members for up to 122 gusset plates and joints, 61 upper and 61 lower.

If "Y" is entered for GUSSET in the BRIDGE CROSS SECTION AND LOADING line, enter these data only for the bridge types of "TFF", "TFS", and "TTT"

If "Y" is entered for SYMMETRY in the BRIDGE CROSS SECTION AND LOADING line, you must enter only the gusset plate member properties for the panels left of the symmetry point.

There may be a maximum of 5 members per joint. Enter the first three members first. If needed, enter the rest of members into the second line.

At gusset plate locations where the chord is continuous through the gusset plate the fastener dimensions for L_1 and L_2 are entered as the total width of the fasteners across both members 1 and 2, i.e. $L_1 = L_2 = L_1 + L_2$. W_1 and W_2 should be the same for members 1 and 2. N_{t1} and N_{t2} should be entered as the sum of the fasteners connecting members 1 and 2, i.e. $N_{t1} = N_{t2} = (N_{t1}+N_{t2})$.

GMB CARD IDENT

Enter the identification of this Card, "GMB"

GUSSET PLATE LOC1

Enter the location of the gusset plate members by the joint, "U" or "L".

Note: The program can't handle the gusset plate members at the middle joint, "M".

GUSSET PLATE LOC2

Enter the location of the gusset plate by the joint, 00, 01, 02, ...

Lower Limit: 00 and Upper Limit: 60

TRUSS MEMBER NO

Enter the member number being considered. Member number can't be repeated for the same joint.

Lower Limit: 1 and Upper Limit: 5

DISTANCE, W

Enter the distance between outermost rows of fasteners measured perpendicular to the line of action on the member.

Lower Limit: 0 in and Upper Limit: 60 in.

DISTANCE, L

Enter the distance between the first and last row of fasteners in the member.

Lower Limit: 0 in and Upper Limit: 125 in.

NUMBER OF LINES OF FASTENERS, NT

Enter the number of lines of fasteners along the width of member (perpendicular to the line of action of the member).

Lower Limit: 0 and Upper Limit: 20.

NUMBER OF ROWS OF FASTENERS, NL

Enter the number of rows of fasteners along the length of member (parallel to the line of action of the member).

Lower Limit: 0 and Upper Limit: 40.

LENGTH, Lc

Enter the unsupported length between the last row of fasteners for the diagonal and the first row of fasteners in the chord measured along the line of action of the diagonal, calculated as average per section 3.11.4.2.

Lc must be 0 for member number 1 and 2 (i.e. top and bottom chords).

Lower Limit: 0 in and Upper Limit: 60 in.

NTT

Enter the total number of fasteners connecting the individual truss member to the gusset plate.

5.24 CONCENTRATED PATCH LOADS

This command is used to input concentrated patch loads acting on the bridge for one patch load case. If the patch load is not present, do not enter any information. See Figure 5.24.1 on page 5-106 for explanations of all dimension inputs. This command can have 4 concentrated patch loads in one line and can be repeated up to 8 times to define up to 30 concentrated patch loads.

The effects of concentrated patch loads are considered as the effects of dead loads. If you have multiple patch load cases, then you need to run this program for each patch load case.

A patch load case is defined as the followings:

1. A series of concentrated patch loads
2. A series of distributed patch loads
3. A series of concentrated patch loads and a series of distributed patch loads.

PAC CARD IDENT

Enter the identification of the Card, "PAC"

MEM TYPE

Enter T, G, F, S, or C, where T is for truss member, G is for girder, F is for floorbeam, S is for stringer, and C is for concrete slab or concrete T-beam

Please note that S are reserved for future use.

LOAD TYPE

Enter the type of dead load **left justified** per WSD or LFD Specifications:

DC1:

DC1S:

DC2:

MC1: Miscellaneous dead loads

MC2: Miscellaneous dead loads

FWS: Dead loads of future wearing surfaces

OTH1: Other loads

OTH2: Other loads

Note:

1. For DC1, DC1S, MC1, and OTH1 **of bridge types other than EIB**, non-composite section properties will be used.

2. For DC1, DC1S, MC1, and OTH1 of the EIB **un**shored construction **where COMPOSITE field in the STEEL MEMBER PROPERTIES line is "N" or blank**, then non-composite section properties **will be used.**
3. **For DC1, DC1S, MC1, and OTH1 of the EIB shored construction where COMPOSITE field in the STEEL MEMBER PROPERTIES line is "Y",** then DL2 composite section properties **will be used**.
4. For DC2, FWS, MC2, and OTH2, if the section is not composite, then use non-composite section properties and if the section is composite, then use long-term composite (3n) section properties.

SPAN NO

If MEM TYPE is T, G, S, or C, enter the span number where the concentrated patch load is located.

Lower Limit: 01 and Upper Limit: 15

If MEM TYPE is F, enter the number of stringer span to the right of the floorbeam (**from "1" to "G") where the concentrated patch load is located.**

Lower Limit: 01 and Upper Limit: 1**6**

DISTANCE

If MEM TYPE is T, G, S, or C, enter the distance in feet measured from the left support of this span to the concentrated load.

Lower Limit: 0 and Upper Limit: Maximum Span Length

If MEM TYPE is F, enter the distance in feet measured from the left girder, truss, or support to the concentrated load.

Note: the distance measured at the left cantilever span is always negative.

Lower Limit: -left cantilever span length and Upper Limit: Main Floorbeam Span **Length + Right Cantilever Span Length**

MAGNITUDE

Enter the magnitude in kips of the concentrated patch load acing on the bridge.

Lower Limit: -99.99 and Upper Limit: 999.99

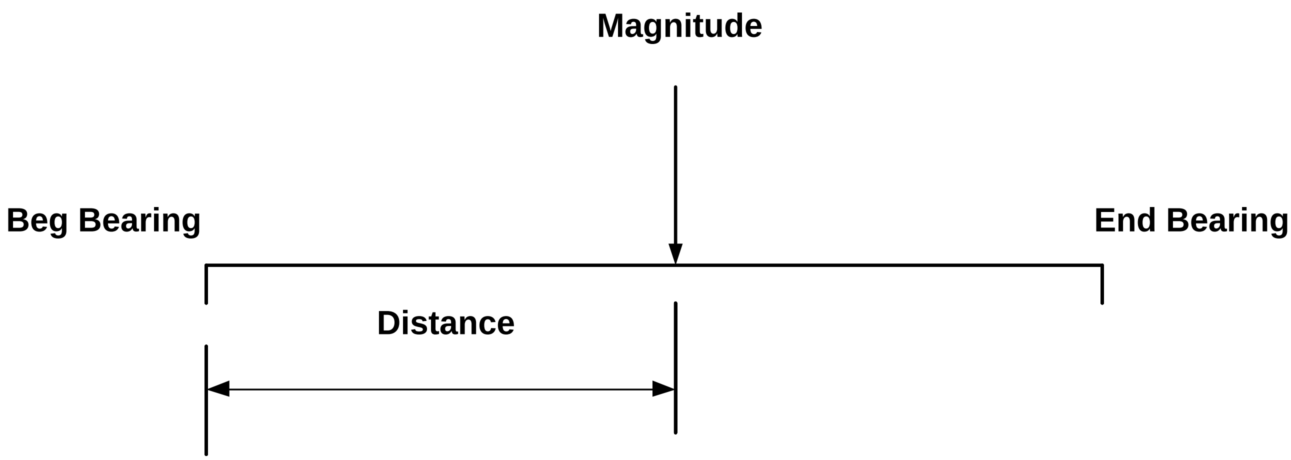


Figure 5.24.1 Concentrated Patch Load

5.25 DISTRIBUTED PATCH LOADS

This command is used to input distributed patch loads acting on the bridge for one patch load case. If the patch load is not present, do not enter any information. See Figure 5.25.1 on page 5-110 for explanations of all dimension inputs. This command can have 2 distributed patch loads in one line and can be repeated to define up to 30 distributed patch loads.

The effects of distributed patch loads are considered as the effects of dead loads. If you have multiple patch load cases, then you need to run this program for each patch load case.

PAD CARD IDENT

Enter the identification of the Card, "PAD"

MEM TYPE

Enter T, G, F, S, or C, where T is for truss member, G is for girder, F is for floorbeam, S is for stringer, and C is for concrete slab or concrete T-beam

Please note that S are reserved for future use.

LOAD TYPE

Enter the type of dead load **left justified** per WSD or LFD Specifications:

DC1:

DC1S:

DC2:

MC1: Miscellaneous dead loads

MC2: Miscellaneous dead loads

FWS: Dead loads of future wearing surfaces

OTH1: Other loads

OTH2: Other loads

Note:

1. **For DC1, DC1S, MC1, and OTH1 of bridge types other than EIB, non-composite section properties will be used.**
2. **For DC1, DC1S, MC1, and OTH1 of the EIB unshored construction where COMPOSITE field in the STEEL MEMBER PROPERTIES line is “N” or blank, then non-composite section properties will be used.**
3. **For DC1, DC1S, MC1, and OTH1 of the EIB shored construction where COMPOSITE field in the STEEL MEMBER PROPERTIES line is “Y”, then DL2 composite section properties will be used.**
4. **For DC2, FWS, MC2, and OTH2, if the section is not composite, then use non-composite section properties and if the section is composite, then use long-term composite (3n) section properties.**

BEG SPAN NO

If MEM TYPE is T, G, S, or C, enter the span number where the distributed patch load begins.

Lower Limit: 01 and Upper Limit: 15

If MEM TYPE is F, enter the number of stringer span to the right of the floorbeam (from “1” to “G”) where the distributed patch load is located.

Lower Limit: 01 and Upper Limit: 16

BEG DISTANCE

If MEM TYPE is T, G, S, or C, enter the distance in feet measured from the left support of this span to the begin location of this distributed patch load.

Lower Limit: 0 and Upper Limit: Maximum Span Length

If MEM TYPE is F, enter the distance in feet measured from the left girder, truss, or support to the begin location of this distributed patch load.

Note: the distance measured at the left cantilever span is always negative.

Lower Limit: -left cantilever span length and Upper Limit: Floorbeam Main Span Length + Right Cantilever Span Length

BEG MAGNITUDE

Enter the magnitude in kips of the begin location of the distributed load acing on the bridge.

Lower Limit: -99.999 and Upper Limit: 999.999

END SPAN NO

If MEM TYPE is T, G, S, or C, enter the span number where the distributed patch load ends.
Lower Limit: 01 and Upper Limit: 15

If MEM TYPE is F, enter the number of stringer span to the right of the floorbeam (from “1” to “G”) where the distributed patch load is located.

Lower Limit: 01 and Upper Limit: 16

END DISTANCE

If MEM TYPE is T, G, S, or C, enter the distance in feet measured from the left support of this span to the end location of this distributed patch load.

Lower Limit: 0 and Upper Limit: Maximum Span Length

If MEM TYPE is F, enter the distance in feet measured from the left girder, truss, or support to the end location of this distributed patch load.

Note: the distance measured at the left cantilever span is always negative.

Lower Limit: -left cantilever span length and Upper Limit: Floorbeam Main Span Length + Right Cantilever Span Length

END MAGNITUDE

Enter the magnitude in kips of the end location of the distributed patch load acing on the bridge.

Lower Limit: -99.999 and Upper Limit: 999.999

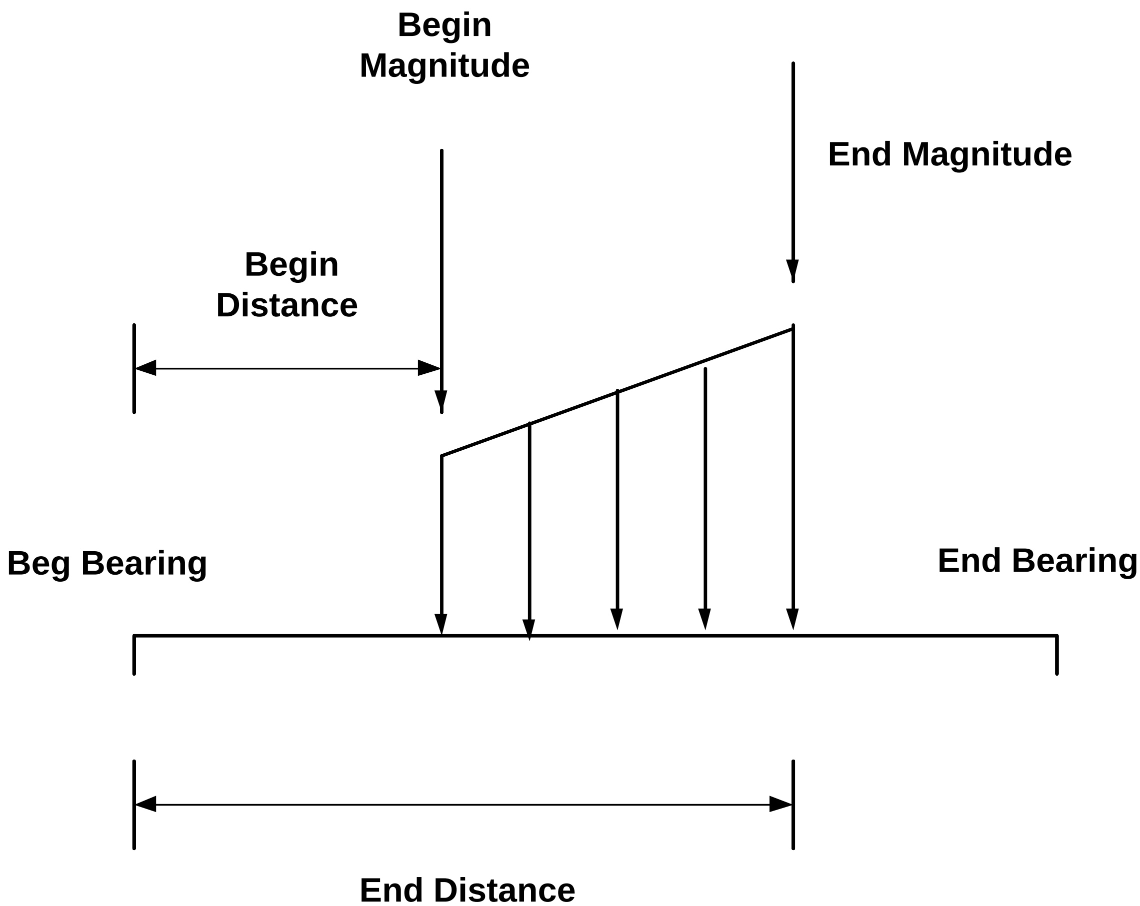


Figure 5.25.1 Distributed Patch Load

6 DESCRIPTION OF OUTPUT

The printed output consists of heading information such as the copyright notice, program title, license agreement number, program number, date and time of run, date when the program was last updated, documentation date for the latest revision, and the input name. It also includes a repeat of all input values, default values assumed by the program, and the computed values explained in the following sections. Only the output that is applicable to a given type of bridge is printed. Most headings are self-explanatory. The terms IR, OR and SLC refer to the Inventory Rating, Operating Rating and Safe Load Capacity respectively. Dashes printed under DEFAULT VALUES indicate that these values were entered. **Values replaced by the stars printed indicate these output values is too big for the space allowed.**

The following sign conventions apply:

MOMENT

A positive moment causes a compressive stress in the extreme top fiber of a flexural member.

REACTION

A reaction acting in the upward direction is positive.

LOAD

A load acting in the downward direction in positive.

SHEAR

A shearing force acting upward on the right face of the free body in equilibrium is positive.

DEFLECTION

Downward **vertical** deflection is positive. Horizontal deflection to the right is positive.

FORCE

A truss member force is positive if the member is tension.

STRESS

A tensile stress is positive.

These calculated values are printed for **each analysis** point**, range point, and transition (change in section properties) point** along the span. The distances of the analysis points are measured from the left end of each span.

Influence line ordinates for a given effect at a section in the girder or beam are printed in rows, with each row representing the span (e.g. the first row represents the span 1) and each value representing the effect (moment, shear, etc.) due to a unit load at a tenth point in that span. Thus, the fourth value in row 2 will represent the influence line ordinate for a given effect due to a unit load at $^{3}/_{10}$ of span number 2.

Influence line ordinates for a truss member force are also printed in the same manner except each row represents ten (10) consecutive ordinates and the values are the effects due to a unit load at either the upper or lower truss joints.

Special live loadings are designated as SP-1, SP-2 etc. on the output, where SP-1 is the special live loading 1, SP-2 is the special live loading 2 and so on. Alternate Military Loading is designated as ALTM on the output.

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6.1 BRIDGE TYPE "CPL", "CSL", OR "CTB"

If the output option is specified as 0, the following values are printed for each live load.

6.1.1 Concrete Section Properties

DEPTH OF N.A.

The depth to the neutral axis of the section measured from the top of the section excluding the integral wearing surface - inches.

MOMENT OF INERTIA

The moment of inertia of the section – in^4.

SECTION MODULUS CONCRETE

The section modulus of the concrete section – in^3.

SECTION MODULUS TENSION STEEL

The section modulus of the tension steel – in^3.

SECTION MODULUS COMPRESSION STEEL

The section modulus of the compression steel – in^3.

6.1.2 Maximum Reactions

SUPPORT

The support number always started as 1 indicating the left support of the span.

For simple spans:

MAXIMUM REACTIONS - D.L.

The reaction due to DL1 + DL2 - kips.

MAXIMUM REACTIONS - LL+I

The reaction due to live load plus impact - kips.

For continuous spans:

MAXIMUM REACTIONS - D.L.1

The reaction due to DL1 - kips.

MAXIMUM REACTIONS - D.L.2

The reaction due to DL2 - kips.

MAXIMUM REACTIONS - +(LL+I)

The reaction due to live load plus impact - kips.

MAXIMUM REACTIONS - -(LL+I)

The reaction due to live load plus impact - kips.

+I.F.

The positive impact factor used for calculating +(LL + I) reaction.

-I.F.

The impact factor used for calculating –(LL + I) reaction.

6.1.3 Moment, Shear, Flexural Stress, Shear Stress, and Deflection at Each Section for Each Live Load

X

The distance of the section from the left support of the span - feet.

D.L. MOMENT

The moment due to DL1 + DL2 - kip-ft.

LL+I MOMENT

The live load plus impact moment - kip-ft.

D.L. SHEAR

The shear due to DL1 + DL2 - kips.

LL+I SHEAR

The live load plus impact shear - kips.

I.F.

The impact factor used for calculating LL + I SHEAR.

FLEX STRESS - CONC

The maximum compressive stress in concrete due to the dead load and live load plus impact - ksi.

FLEX STRESS - STEEL

The maximum tensile stress in reinforcement due to the dead load and live load plus impact - ksi.

SHEAR STRESS - D.L.

The maximum shear stress due to DL1 + DL2 - ksi.

SHEAR STRESS - LL + I

The maximum shear stress due to live load plus impact - ksi.

DEFLECTIONS - D.L.

The maximum deflection due to DL1 + DL2 - inches.

DEFLECTIONS - LL+I

The maximum deflection due to live load plus impact - inches.

6.1.4 Moment Capacity, Shear Capacity, and Rating Factors at Each Section for Each Live Load

MOMENT CAPACITY - IR

The maximum allowable moment for the Inventory Rating - kip-ft.

MOMENT CAPACITY - OR

The maximum allowable moment for the Operating Rating - kip-ft.

MOMENT CAPACITY - ULT

The ultimate moment capacity of the section - kip-ft.

SHEAR CAPACITY - IR

The maximum allowable shear for the Inventory Rating - kips.

SHEAR CAPACITY - OR

The maximum allowable shear for the Operating Rating - kips.

SHEAR CAPACITY - ULT

The ultimate shear capacity of the section - kips.

RATING FACTORS

The inventory (IR) and operating (OR) rating factors for moment and shear based on the Allowable Stress Method and the Load Factor Method. The Rating Factors for the ML80 and TK527 loadings are based on the axle loads shown in Figure 2.4.1 on page 2-11. The Rating Factors for Special Live Loadings are based on the entered axle loads increased by 3% if a Y is entered for 3% INCR described in Section 4.18.1 of this User's Manual.

6.1.5 Moment Capacity, Shear Capacity, and Rating Factors at Critical Sections for Each Live Load

If the output option is specified as 2, the values in 6.1.5 will be printed at critical sections for moments and shears.

6.1.6 Rating Summary

The rating summary is printed showing the rating factor, rating in tons and critical section for each live load. It also shows if the ratings are based on design lanes or loaded lanes and prints the safe load capacity (SLC) of the member if it was requested. The ratings in tons for the ML80 and TK527 loadings do not include the 3% scale tolerance allowed by the Vehicle Code. The ratings in tons for a Special Live loading do not include the 3% increase in the entered axle loads.

6.1.7 Influence Line

If the output option is specified as 9 to print influence lines, the following values are printed for a given live load.

INFLUENCE LINE FOR REACTION AT SUPPORT 1

The influence line ordinates for reactions at the left support due to a unit load (1 kip) applied at 10th points - kips.

POS AREA

The sum of positive area under influence line.

NEG AREA

The sum of negative area under influence line.

LANE POS

The maximum positive effect of an equivalent lane loading, if applicable.

LANE NEG

The maximum negative effect of an equivalent lane loading, if applicable.

TRUCK POS

The maximum positive effect of a truck loading.

AXLE 1 @

The distance of axle number 1 (the front axle) from the left support of span to produce the given maximum effect - feet.

MOVING

Indicates the direction in which the truck is moving. L TO R indicates that the truck is moving from left to right. R TO L indicates that the truck is moving from right to left.

TRUCK NEG

The maximum negative effect of a truck loading.

SUPPORT, MAXIMUM REACTIONS - DL, LL+I

These values are the same as explained for the output option equal to 0.

For each section the following values are printed.

SECTION NUMBER

Self-explanatory.

INFLUENCE LINE FOR MOMENT

The influence line ordinates for moments at a section due to a unit load (1 kip) applied at 10th points - kip-ft.

INFLUENCE LINE FOR SHEAR

The influence line ordinates for shears at a section due to a unit load (1 kip) applied at 10th points - kips.

When a unit load is applied at the section under consideration there should be two values of shears to be considered, one for a unit load just to the left of the section (negative shear) and another for a unit load just to the right of the section (positive shear). The program stores and prints the negative value of shear ordinates. The positive ordinate can be obtained by algebraically adding the value of unit load and the negative ordinate.

INFLUENCE LINE FOR DEFLECTION

The influence line ordinates for deflections at a section due to 1000 kip applied at the 10th points - inches.

6.2 BRIDGE TYPE "EIB" OR "GGG"

The following values are printed for this type of bridge.

6.2.1 Dead Loads Acting on Girder

This is the individual dead loads acting on the girder. Some values are input and some values are computed by the program.

INPUT DL1

The dead load acting on the non-composite section - kips/ft. This is equal to the input value as entered in the BRIDGE CROSS SECTION AND LOADING line.

GIRDER WEIGHT

The average weight of girder, i.e. the total weight of one girder divided by its length - kips/ft.

SLAB WEIGHT

The dead load due to the weight of slab - kips/ft.

FL BEAM WEIGHT

The dead load due to the weight of floorbeam acting as a uniformly distributed load - kips/ft. This is printed as zero for this bridge type.

STRINGER WEIGHT

The dead load due to the weight of stringer - kips/ft. This is printed as zero for this bridge type.

TOTAL DL1

The total dead load acting on the non-composite section - kips/ft.
This is equal to the sum of INPUT DL1, GIRDER WEIGHT and SLAB WEIGHT.

TOTAL DL2

The total dead load acting on the composite section - kips/ft.
This is equal to the input value as entered in the BRIDGE CROSS SECTION AND LOADING line.

6.2.2 Girder Section Properties

The following are printed for each span when the output option is specified as 0.

6.2.2.1 Non-Composite Section Properties

The section properties for steel section alone. The DL1 effects are carried by this section.

X

The distance of the section from the centerline of left bearing of the span where this section is located - feet.

DEPTH

The total depth of the section - inches.

AREA

The **gross** cross sectional area of the section – in^2.

M OF I

The moment of inertia about the neutral axis of the section – in^4.

C BOT

The distance of the extreme bottom fiber from the neutral axis - inches.

S TOP

The section modulus (ratio of moment of inertia to distance of extreme fiber from the neutral axis) of the extreme top fiber – in^3. **This value may be negative if the neutral axis is outside the steel beam.**

S BOT

The section modulus of the extreme bottom fiber – in^3.

S CONC

The section modulus of the extreme top fiber of concrete for a composite section subjected to a positive moment – in^3.

S REIN

The section modulus of the center of gravity of tension reinforcement for a composite section subjected to a negative moment - in^3.

6.2.2.2 Composite Section Properties (N=xx)

The section properties of the composite section with a modular ratio of n as printed. The live load plus impact effects are carried by this section.

EFFECTIVE SLAB WIDTH, THICKNESS

The effective width and thickness of the slab used in calculating the composite section properties - inches.

6.2.2.3 Composite Section Properties (3N=xx)

The section properties of the composite section with a modular ratio of 3n as printed. The DL2 effects are carried by this section.

6.2.2.4 Composite Section Properties (Composite, Negative Moment)

The section properties of the composite section if the concrete slab does not carry tensile stress and the slab reinforcement acts compositely with the steel section. Negative moments caused by the dead load combined with maximum negative live load plus impact are carried by this section.

6.2.3 Deflections

The following are printed for each span when the output option is specified as 0.

DEFLECTIONS

The deflections at analysis points.

SPAN X - LIVE LOAD IMPACT FACTOR FOR DEFLECTION

Self-explanatory.

X

The distance of the analysis point from the left bearing of the span - feet.

DEFLECTIONS DL1, DL2, +(LL+I)

The deflections due to DL1, DL2 and live load plus impact respectively - in. A negative value indicates a upward deflection.

6.2.4 Girder – Live Load Xxxx

The following are printed for each live load when the output option is specified as 0.

6.2.4.1 Maximum Reactions

SUPPORT

This is the support number. If the girder is continuous, reactions for all supports are printed. If the girder is a single span or a series of simple spans, the reactions are printed for the left support in each span.

MAXIMUM REACTIONS - DL1, DL2, +(LL+I), Lane Loading Code, -(LL+I), Lane Loading Code, Reaction +I.F. and -I.F., and Moment +I.F. and -I.F.

The reactions due to DL1 and DL2, positive live load plus impact reaction and the impact factor for positive reaction, and the negative live load plus impact reaction (uplift) and the impact factor for negative reaction. For HS loading, if the reaction is governed by the lane loading, the code "L" is printed next to the value. If "L" is not printed, it is assumed that the truck loading governs. Live load plus impact is in kips. Also, the impact factors used for positive and negative moments at interior supports.

For each span, the following values are printed for all sections. If SYMMETRY is entered as "Y", these values are printed up to the point of symmetry.

6.2.4.2 Unfactored Moments and Shears

The moments and shears at 10th points along the span.

SPAN X - LIVE LOAD IMPACT FACTORS

The positive moment impact factor for this span based on "L" equal to the length of this span. Up to three negative moment impact factors for this span based on "L" equal to the loaded span (previous span, this span, or the next span) for the given tenth point. If there is more than one negative moment impact factor, a code will be printed next to the negative moment value to indicate which of the listed negative moment impact factors (1, 2 or 3) is used at that tenth point.

X

The distance of the section from the left support of the span - feet.

DL1 MOMENT

The moment due to DL1 - kip-ft.

DL2 MOMENT

The moment due to DL2 - kip-ft.

+(LL+I) MOMENT

The maximum positive moment due to the live load plus impact - kip-ft.

For HS loading, if the moment is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

-(LL+I) MOMENT

The maximum negative moment due to the live load plus impact - kip-ft.

IM

For HS loading, if the moment is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs. If this is a tenth point and there is more than one negative moment impact factor listed for this span, a code is printed next to this value to indicate which of the negative moment impact factors is used (1, 2 or 3) for this point. If this is not a tenth point, the moment value is interpolated from the calculated tenth point values. If this is a support point for a continuous girder, an "S" code is printed to indicate that the negative moment impact factor calculated for the support is used. Continuous girder moment impact factors for the supports are listed with the Maximum Reactions.

DL1 SHEAR

The shear due to DL1 - kips. All shear values (including DL2 and LL+I) are for a section just to the right of a given section except for all intermediate support sections and the rightmost support section, where the shear values are for a section just to the left of the given section.

DL2 SHEAR

The shear due to DL2 - kips.

+(LL+I) SHEAR

The maximum positive shear due to the live load plus impact - kips.

-(LL+I) SHEAR

The maximum negative shear due to the live load plus impact - kips.

I.F.

The impact factor used in calculating +(LL+I) SHEAR and -(LL+I) SHEAR.

SIMULTANEOUS MOMENT

The moment that occurs simultaneously with the maximum shear at a section - kip-ft. This is used in calculating the rating factor for moment-shear interaction.

SIMULTANEOUS SHEAR

The shear that occurs simultaneously with the maximum moment at a section - kips. This is used in calculating the rating factor for moment-shear interaction.

6.2.4.3 Flexural Stresses - Beam

The extreme fiber stresses at analysis points.

TOP FIBER STEEL STRESS - DL1, DL2, +(LL+I), -(LL+I)

The maximum stress at the top fiber of steel section due to DL1 moment, DL2 moment, positive live load plus impact moment, and negative live load plus impact moment respectively - ksi.

BOTTOM FIBER STEEL STRESS - DL1, DL2, +(LL+I), -(LL+I)

The maximum stress at the bottom fiber of steel section due to DL1 moment, DL2 moment, positive live load plus impact moment, and negative live load plus impact moment respectively - ksi.

6.2.4.4 Flexural Stresses – Slab

CONC STRESS - DL2, +(LL+I)

The maximum compressive stress in the top fiber of concrete for a composite section due to DL2 and positive live load plus impact moments respectively - ksi.

SLAB REINF STRESS - DL2, -(LL+I)

The maximum tensile stress in the reinforcement due to DL2 and negative live load plus impact moments respectively - ksi.

6.2.4.5 Shear Stresses and Allowable Stress Ratings

The shear stresses and rating factors based on the Allowable Stress Method.

SHEAR STRESSES - DL1, DL2, +(LL+I), -(LL+I)

The maximum shear stress in the web due to DL1, DL2, positive live load plus impact and negative live load plus impact shear respectively - ksi.

ALLOWABLE COMPRESSION REDUCTION

The reduction factor for allowable compression in a partially supported or unsupported compression flange. This factor when multiplied by 0.55 F_y. and 0.75 F_y. gives the allowable stresses for the Inventory and Operating ratings respectively.

RATING FACTORS - IR, OR

The inventory and operating rating factors at an analysis point based on the Allowable Stress Method.

RATING FACTOR CODE

See legend on the output.

6.2.4.6 Strengths and Load Factor Ratings

The section strengths and rating factors at an analysis point.

NON-COMP MOMENT STRENGTH

The moment strength of the non-compact section - kip-ft.

NON-COMP MOMENT STRENGTH CODE

Section qualification, i.e. whether it is braced non-compact (B) or unbraced non-compact (U) as per AASHTO Specifications.

OVERLOAD MOMENT STRENGTH

The overload moment strength of the section - kip-ft.

SHEAR STRENGTH

The shear strength of the section - kips.

NON-COMPACT RATING FACTORS - IR, OR

The inventory and operating rating factors at an analysis point based on the Load Factor Method, assuming that the section is non-compact. If any section does not qualify as compact, then the summary will reflect the lowest non-compact rating factor.

NOTE: When a section does not meet flange or web buckling criteria of the current AASHTO Specifications for load factor method, the section is identified by printing a rating factor of 888.88. For these sections, the ratings based on strength only are also printed out, but the bridge may have fatigue problems.

NON-COMPACT RATING FACTOR CODE

See the legend on the output.

COMPACT MOMENT STRENGTH

For a section that qualifies as compact, the compact moment strength - kip-ft. For a non-compact section this is blank.

COMPACT RATING FACTORS - IR, OR

For a section that qualifies as compact, the inventory and operating rating factors at an analysis point based on the Load Factor Method, assuming that the section is compact. For a non-compact section this is blank.

COMPACT RATING FACTOR CODE

See the legend on the output.

6.2.5 Fatigue Life Analysis

Based on HS20 truck loading with fixed (14.0 feet) spacing between 32-kip axles.

6.2.5.1 Unfactored Moments and Shears

The unfactored moments and shears at 10th points along the span.

6.2.5.2 Fatigue Life Estimation

FATIGUE LIFE ESTIMATION

The following values are printed if the fatigue life analysis is requested for the girder.

LIVE LOAD DISTRIBUTION

The live load distribution factor (fraction of axle loads) for loading one lane that is used for calculating the fatigue stress range.

PA TRAFFIC FACTOR

The Pennsylvania Traffic Factor (PTF) that is used in calculating the effective stress range for the fatigue life equation. This value is 1.0 for ADTT less than or equal to 2500 (Case II or III Highways) and it is equal to 1.1 for ADTT greater than 2500 (Case I Highways).

ALPHA FACTOR

The alpha factor that is used in calculating the effective stress range for the fatigue life equation. This is equal to 0.5 since the program uses the conventional method of structural analysis.

GAMMA FACTOR

The gamma factor that is used in calculating the effective stress range for the fatigue life equation. This is equal to 0.7 times the Pennsylvania Traffic Factor (PTF) if the Gross Vehicle Weight Distribution data are not entered. This is the calculated value as per DM4 if the Gross Vehicle Weight Distribution data are entered.

PAST GROWTH FACTOR or PAST CONSTANT ADTT

The growth factor for past ADTT in percent or the constant ADTT for the past.

FUTURE GROWTH FACTOR or FUTURE CONSTANT ADTT

The growth factor for future ADTT in percent or the constant ADTT for the future.

X

The horizontal distance from the left centerline of bearing of the span to the section where this detail is located - feet.

Y

The vertical distance of the detail from the bottom most fiber at this section - inches.

CATEGORY

The stress category of detail as entered.

DL1+DL2 STRESS

The stress at this detail due to DL1+DL2 - ksi.

HS20 TRK STRESS +(LL+I)

The stress at this detail caused by the maximum positive live load plus impact moment due to an HS20 truck loading. This value is based on the distribution factor for one lane - kip-ft.

HS20 TRK STRESS -(LL+I)

The stress at this detail caused by the maximum negative live load plus impact moment due to an HS20 truck loading. This value is based on the distribution factor for one lane - kip-ft.

STRESS RANGE - FSRD

The design fatigue stress range calculated using the live load distribution factor for one lane - ksi. The value printed here is an algebraic difference of the maximum and the minimum stresses due to dead loads and live load plus impact at this detail due to an HS20 truck placed in one lane. If the detail never experiences a tensile stress, i.e. if the maximum and minimum stresses at this detail are compressive, the fatigue stress range is assumed to be zero.

STRESS RANGE - FSR

The allowable fatigue stress range for cycles greater than 2,000,000 for the above category of detail - ksi.

STRESS RANGE - FSRE

The effective fatigue stress range as defined in DM4 - ksi. This value is equal to the design fatigue stress range due to an HS20 truck in one lane multiplied by the ALPHA FACTOR and GAMMA FACTOR printed above. If FSRD is zero or is less than FSR, this is printed as zero indicating that the detail has infinite fatigue life.

DES FATIGUE LIFE CYCLES

The fatigue life in terms of cumulative truck cycles (number of times a design truck may pass over the bridge). If FSR is greater than FSRD or if FSRD is zero, this is printed as 9999999999 signifying that the detail has infinite fatigue life.

REMAIN YEARS

The remaining fatigue life of the detail - years.

The location of critical detail, estimated ADTT for the year the bridge was built, design fatigue life of the critical detail, accumulated cycles and estimated remaining life of the girder are printed next.

If the fatigue life is infinite, "THE FATIGUE LIFE OF GIRDER IS INFINITE." Is printed

6.2.6 Rating Summary

The rating summary is printed showing the rating factor, rating in tons and critical section for each live load. It also shows if the ratings are based on design lanes or loaded lanes and prints the safe load capacity (SLC) of the member if it was requested. The ratings in tons for the ML80 and TK527 loadings do not include the 3% scale tolerance allowed by the Vehicle Code. The ratings in tons for a Special Live loading do not include the 3% increase in the entered axle loads.

When COMPACT in PROJECT IDENTIFICATION is "Y" or blank, rating summary follows the all-or-none compact section requirements:

If all sections in all spans are qualified as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings. If one or more sections are not qualified as compact sections, then the summary will reflect the lowest rating factor from all individual non-compact section ratings even if some sections by itself would be qualified as compact sections.

When COMPACT in PROJECT IDENTIFICATION is "N", rating summary does not follow the all-or-none compact section requirements:

If all sections in all spans are qualified as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings. If one or more sections do not qualify as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings if qualified as a compact section and all individual non-compact section rating if not qualified as a compact section.

The critical section, its location and rating factors are printed for each live load for the girder and the critical stringer. All headings are self-explanatory except the following:

IR (CRITICAL)

The absolute minimum Inventory Rating for the member. It could be based on moment, shear or moment-shear interaction.

OR (CRITICAL)

The absolute minimum Operating Rating for the member. It could be based on moment, shear or moment-shear interaction.

IR (POS MOM)

The minimum Inventory Rating for the member based on the positive moment.

OR (POS MOM)

The minimum Operating Rating for the member based on the positive moment.

IR (NEG MOM)

The minimum Inventory Rating for the member based on the negative moment.

OR (NEG MOM)

The minimum Operating Rating for the member based on the negative moment.

Note: All ratings are based on the number of design lanes or the actual traffic lanes as defined by "D" or "L" entered for LANES in the Project Identification line.

6.2.7 Influence Line

The following values are printed when influence lines are requested.

INFLUENCE LINE FOR MOMENT

The influence line ordinate for moment at a section due to a unit load applied at a 10th point of the span - kip-ft. The values printed are the influence line ordinate followed by the unit load position (printed in parenthesis). The unit load position is printed in the form "s.n", where s is the span number and n is the tenth point in that span. This explanation applies to all influence line values. The units of the values correspond to the type of the influence line.

POS AREA

The sum of positive area under influence line.

NEG AREA

The sum of negative area under influence line.

LANE POS

The maximum positive effect of an equivalent lane loading, if applicable.

LANE NEG

The maximum negative effect of an equivalent lane loading, if applicable.

TRUCK POS

The maximum positive effect of a truck loading.

AXLE 1 @

The distance of axle number 1 (the front axle) from the left support of span 1 to produce the given maximum effect - feet.

MOVING

Indicates the direction in which the truck is moving. L TO R indicates that the truck is moving from left to right. R TO L indicates that the truck is moving from right to left.

TRUCK NEG

The maximum negative effect of a truck loading.

INFLUENCE LINE FOR SHEAR

The influence line ordinate for shear at a section due to a unit (1 kip) load applied at each 10th point - kips. At a given section there should be two values of shear influence line ordinates, one for a unit load just to the left of the section and another for a unit load just to the right of the section. The program stores and prints the shear value (negative shear) for a unit load just to the left of the section under consideration. The program computes the ordinate just to the right of the section when it analyzes the influence line for a given live load effect.

INFLUENCE LINE FOR DEFLECTION

The influence ordinate for a deflection in inches at a section due to 1000 kips applied at each 10th point.

6.3 BRIDGE TYPE "FSS", GFF", "GFS", OR "GGF"

After the printout of all input values, the following computed values are printed. The values for the girder of bridge type "GGF" are the same as shown for bridge type "GGG".

6.3.1 Girder Analysis

6.3.1.1 Live Load Distribution Factors

LIVE LOAD DISTRIBUTION FACTORS BASED ON DESIGN LANES

The lateral live load distribution factors (including the reduction in live load intensity) based on loading the design lanes. The number of design lanes and their placements are done in accordance with AASHTO to produce the maximum effect. These factors are used in calculating the live load effects that are used to calculate the ratings IR (DESIGN) and OR (DESIGN).

LIVE LOAD DISTRIBUTION FACTORS BASED ON LOADED LANES

The live load distribution factors based on the traffic lanes that are defined by the user. These factors are used in calculating the live load effects that are used to calculate the ratings IR (LOADED) and OR (LOADED).

GIRDER MOMENT

The fraction of an axle load (or lane) to be applied for computations of live load moments and shears in the main girder, and the number of governing lanes (printed in parenthesis) for reduction in live load intensity.

GIRDER DEFLECTION

The fraction of an axle load (or lane) to be applied for the computation of live load deflection of the main girder, and the number of governing lanes (printed in parenthesis) for reduction in live load intensity.

6.3.1.2 Dead Loads Acting On Girder

The individual dead loads acting on the girder. Some values are input and some values are computed by the program.

INPUT DL1

The dead load acting on the non-composite section - kips/ft. This is equal to the input value as entered in the **DL1 of the** BRIDGE CROSS SECTION AND LOADING line.

GIRDER WEIGHT

The average weight of girder, i.e. the total weight of one girder divided by its length - kips/ft.

SLAB WEIGHT

The dead load due to the weight of slab - kips/ft.

FL BEAM WEIGHT

The dead load due to the weight of floorbeam acting as a uniformly distributed load - kip/ft. This is equal to one-half of the weight of one floorbeam divided by the average floorbeam spacing.

STRINGER WEIGHT

The dead load due to the weight of stringer - kips/ft. This is equal to one-half of the number of stringers in the bridge cross section multiplied by the weight of stringer per foot.

TOTAL DL1

The total dead load acting on the non-composite section - kips/ft. This is equal to the sum of INPUT DL1, GIRDER WEIGHT, FLOORBEAM WEIGHT, STRINGER WEIGHT, and SLAB WEIGHT.

TOTAL DL2

The total dead load acting on the composite section - kips/ft. This is equal to the input value as entered in the **DL2 of the** BRIDGE CROSS SECTION AND LOADING line.

6.3.1.3 M**ain Girder**

The tables of section properties, reactions, moments, shears, stresses, strengths, deflections, ratings, and fatigue analysis are then printed for the main girder. The output looks identical to that given for the bridge type "GGG".

6.3.2 Stringer Analysis

Next, similar tables are printed for the critical stringer if the bridge type is "GFS". For the bridge type "GFF", these values are not printed.

6.3.3 Floorbeam Analysis

Similar tables are printed for each floorbeam **in the same sequence of input**. The distance of the analysis point is measured from the centerline of the left girder, truss, or support. This distance is negative if the analysis point is on the overhang portion of the **left** cantilever floorbeam.

6.3.3.1 Floorbeam Span Information

LEFT CANTILEVER

The distance is measured between the centerline of the left **girder, truss, or** support and the end of the left cantilever - ft.

FLOORBEAM MAIN SPAN

The distance is measured between the centerline of the left **girder, truss, or** support and right support - ft.

RIGHT CANTILEVER

The distance is measured between the centerline of the right **girder, truss, or** support and the end of the right cantilever - ft.

TOTAL FLOORBEAM SPAN (INCLUDING ANY EXIST CANTILEVER)

The sum of LEFT CANTILEVER, FLOORBEAM MAIN SPAN, AND RIGHT CANTILEVER

NUMBER OF TRAFFIC LANES

LANE WIDTH BASED ON DESIGN/LOADED LANE

DECK WIDTH

ROAD**WAY** WIDTH

CL OF GIRDER OR TRUSS TO CURB

MINIMAL X1 AT ROADWAY

The minimal distance away from the left curb that the left wheel load can locate **- ft**.

MAXIMAL X2 AT ROADWAY

The maximal distance away from the left curb that the right wheel load can locate **- ft**.

Note: The wheel load positions, (X1 and x2), must be between MINIMAL X1 AT ROADWAY and MAXIMAL X2 AT ROADWAY

6.3.3.2 Floorbeam Live Load Moment and Shear Factors

As explained in the Method of Solution section for Live Load Analysis of Floorbeam, the program computes the maximum live load moments and shears in a floorbeam by first calculating the effect of wheels placed across the bridge and then multiplying these effects by the maximum reaction of one live load on the floorbeam. The effect of a set of wheels placed across the bridge to find the maximum moment or shear expressed in terms of the number of axles is referred to as a moment or shear factor. This factor when multiplied by the live load plus impact reaction on the floorbeam due to one truck will give the live load moment or shear at a given section.

X

The distance of the analysis point measured from the centerline of the left girder**,** truss**, or support** - feet.

FACTOR

The **moment and shear** effect of a set of wheels placed across the bridge given as a number of axles.

WHEEL LOAD POSITIONS**, X1 and X2**

The distance of each wheel measured from the centerline of the left girder**,** truss**, or support** - feet.

LANE 1/4/7, 2/5/8, 3/6**/9**

Six values of wheel positions **(three pairs of X1 and X2)** are printed across **each** line. The first line refers to wheel positions in lanes 1, 2, and 3, the second line refers to wheel positions in lanes 4, 5, and 6, and the third line refers to wheel positions in lanes 7, 8, and **9**. Lanes are numbered 1 to **9** from left to right.

6.3.3.3 Floorbeam Section Properties

Section properties for each analysis points and range points (except the points at left support (0') and right support) are printed. When the moment capacity of the current range of a not varied and non-uniform section is less than the moment capacity of the next range, it is conservative to use the section properties of the next range to replace the section properties of the current range.

6.3.3.4 Dead Loads Acting on Floorbeam

The uniform and concentrated dead loads (separated as DL1 and DL2) acting on the floorbeam - kips/ft and kips, respectively.

DIST

The distance of the concentrated load (usually at stringer line) measured from the centerline of the left girder or truss - feet.

6.3.3.5 Floorbeam - Live Load Xxxx

The following are printed for each live load when the output option is specified as 0.

LIVE LOAD REACTION FROM DECK (ONE TRUCK)

The maximum live load reaction on the floorbeam by moving one truck in the longitudinal direction (parallel to main girder or truss) - kips. This reaction when multiplied by the impact factor and the floorbeam live load moment and shear factors will give the live load moment and shear at a given point on the floorbeam. The word LANE is printed in place of TRUCK if the lane loading governs for an H or HS loading.

LIVE LOAD IMPACT FACTOR

The impact factors for positive and negative moment are listed.

For each span, the following values are printed for all sections. If SYMMETRY is entered as "Y", these values are printed up to the point of symmetry.

6.3.3.5.1 Unfactored Moments and Shears

The moments and shears at 10th points and range points along the span.

SPAN X - LIVE LOAD IMPACT FACTORS

The positive moment impact factor for this span based on "L" equal to the length of this span. Up to three negative moment impact factors for this span based on "L" equal to the loaded span (previous span, this span, or the next span) for the given tenth point. If there is more than one negative moment impact factor, a code will be printed next to the negative moment value to indicate which of the listed negative moment impact factors (1, 2 or 3) is used at that tenth point.

X

The distance of the section from the left girder, truss, or support of the span - feet.

RANGE POINT INDICATOR

Indicator whether is a range point or an analysis point

R: it is only a range point

B: it is both a range point and an analysis point

DL1 MOMENT

The moment due to DL1 - kip-ft.

DL2 MOMENT

The moment due to DL2 - kip-ft.

LL+I MOMENT

The maximum positive or negative moment due to the live load plus impact - kip-ft. For HS loading,

DL1 SHEAR

The shear due to DL1 - kips. All shear values (including DL2 and LL+I) are for a section just to the right of a given section except for all intermediate support sections and the rightmost support section, where the shear values are for a section just to the left of the given section.

DL2 SHEAR

The shear due to DL2 - kips.

LL+I SHEAR

The maximum positive or negative shear due to the live load plus impact - kips.

I.F.

The impact factor used in calculating LL+I SHEAR.

6.3.3.5.2 Flexural Stresses - Beam

The extreme fiber stresses at analysis points.

TOP FIBER STEEL STRESS - DL1, DL2, +(LL+I), -(LL+I)

The maximum stress at the top fiber of steel section due to DL1 moment, DL2 moment, positive live load plus impact moment, and negative live load plus impact moment respectively - ksi.

BOTTOM FIBER STEEL STRESS - DL1, DL2, +(LL+I), -(LL+I)

The maximum stress at the bottom fiber of steel section due to DL1 moment, DL2 moment, positive live load plus impact moment, and negative live load plus impact moment respectively - ksi.

6.3.3.5.3 Flexural Stresses – Slab

CONC STRESS - DL2, +(LL+I)

The maximum compressive stress in the top fiber of concrete for a composite section due to DL2 and positive live load plus impact moments respectively - ksi.

SLAB REINF STRESS - DL2, -(LL+I)

The maximum tensile stress in the reinforcement due to DL2 and negative live load plus impact moments respectively - ksi.

6.3.3.5.4 Shear Stresses And Allowable Stress Ratings

The shear stresses and rating factors based on the Allowable Stress Method.

SHEAR STRESSES - DL1, DL2, +(LL+I), -(LL+I)

The maximum shear stress in the web due to DL1, DL2, positive live load plus impact and negative live load plus impact shear respectively - ksi.

ALLOWABLE COMPRESSION REDUCTION

The reduction factor for allowable compression in a partially supported or unsupported compression flange. This factor when multiplied by 0.55 F_y. and 0.75 F_y. gives the allowable stresses for the Inventory and Operating ratings respectively.

RATING FACTORS - IR, OR

The inventory and operating rating factors at an analysis point based on the Allowable Stress Method.

RATING FACTOR CODE

See legend on the output.

6.3.3.5.5 Strengths and Load Factor Ratings

The section strengths and rating factors at an analysis point.

NON-COMP MOMENT STRENGTH

The moment strength of the non-compact section - kip-ft.

NON-COMP MOMENT STRENGTH CODE

Section qualification, i.e. whether it is braced non-compact (B) or unbraced non-compact (U) as per AASHTO Specifications.

OVERLOAD MOMENT STRENGTH

The overload moment strength of the section - kip-ft.

SHEAR STRENGTH

The shear strength of the section - kips.

NON-COMPACT RATING FACTORS - IR, OR

The inventory and operating rating factors at an analysis point based on the Load Factor Method, if the section is non-compact. If any section does not qualify as compact, then the summary will reflect the lowest non-compact rating factor.

NOTE: When a section does not meet flange or web buckling criteria of the current AASHTO Specifications for load factor method, the section is identified by printing a rating factor of 888.88. For these sections, the ratings based on strength only are also printed out, but the bridge may have fatigue problems.

NON-COMPACT RATING FACTOR CODE

See the legend on the output.

COMPACT MOMENT STRENGTH

For a section that qualifies as compact, the compact moment strength - kip-ft. For a non-compact section this is blank.

COMPACT RATING FACTORS - IR, OR

For a section that qualifies as compact, the inventory and operating rating factors at an analysis point based on the Load Factor Method, if the section is compact. For a non-compact section this is blank. If all sections qualify as compact sections, then the summary will reflect the lowest rating factor based on a compact section. If one or more sections in a girder or stringer do not qualify as compact sections, then the summary will reflect the lowest rating factor based on a non-compact section even if that section by itself would qualify as a compact section.

COMPACT RATING FACTOR CODE

See the legend on the output.

6.3.4 Fatigue Life Analysis

If "Y" is entered for FATIGUE in the PROJECT IDENTIFICATION line, the fatigue life analysis results are printed for the main girder. The output printed is like the fatigue life analysis output for the bridge type "GGG".

6.3.5 Rating Summary

When COMPACT in PROJECT IDENTIFICATION is “Y” or blank, rating summary follows the all-or-none compact section requirements:

If all sections in all spans qualify as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings. If one or more sections do not qualify as compact sections, then the summary will reflect the lowest rating factor from all individual non-compact section ratings even if some sections by itself would qualify as a compact section.

When COMPACT in PROJECT IDENTIFICATION is “N”, rating summary does not follow the all-or-none compact section requirements:

If all sections in all spans qualify as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings. If one or more sections do not qualify as compact sections, then the summary will reflect the lowest rating factor from all individual compact section ratings if qualified as a compact section and all individual non-compact section rating if not qualified as a compact section.

The critical section, its location and rating factors are printed for each live load for the girder, critical floorbeam and the critical stringer. All headings are self-explanatory except the following:

IR (CRITICAL)

The absolute minimum Inventory Rating for the member. It could be based on moment, shear or moment-shear interaction.

OR (CRITICAL)

The absolute minimum Operating Rating for the member. It could be based on moment, shear or moment-shear interaction.

IR (POS MOM)

The minimum Inventory Rating for the member based on the positive moment.

OR (POS MOM)

The minimum Operating Rating for the member based on the positive moment.

IR (NEG MOM)

The minimum Inventory Rating for the member based on the negative moment.

OR (NEG MOM)

The minimum Operating Rating for the member based on the negative moment.

Note: All ratings are based on the number of design lanes or the actual traffic lanes as defined by "D" or "L" entered for LANES in the Project Identification line.

6.4 BRIDGE TYPE "TFF", "TFS", OR "TTT"

After the printout of all input values, the following live load distribution factors computed based on the number of design lanes (including the reduction in live load intensity) and based on the number of loaded lanes are printed:

TRUSS FORCE

The fraction of an axle load (or lane) to be applied for the computation of a live load force in a truss member, and the number of governing lanes (printed in parenthesis) for reduction in live load intensity.

TRUSS DEFLECTION

The fraction of an axle load (or lane) to be applied for the computation of live load deflection of the truss joint, and the number of governing lanes (printed in parenthesis) for reduction in live load intensity.

FLOORBEAM MOMENT

See explanation under BRIDGE TYPE "GFS" OR "GFF".

The TRUSS FORCE and FLOORBEAM MOMENT factors computed based on the number of loaded lanes are also printed. These are used for computations of IR (LOADED) and OR (LOADED) ratings.

The following values are printed for the left truss.

6.4.1 Member Forces and Allowable Stress Ratings

They are calculated using allowable stress method.

MEMBER ID

The identification of the member such as L01L02.

MEMBER LENGTH

The length of the truss member calculated by the program – ft.

DL FORCE

Member force due to the dead loads - kips.

LL+IMPACT FORCE - COMP

The maximum live load plus impact compression force in the member - kips. Two values, one based on the number of design traffic lanes and another based on the number of traffic lanes that are loaded or are in service, are printed. For HS loading, if the force is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

LL+IMPACT FORCE - TENS

The maximum live load plus impact tension force in the member - kips. Two values are printed. For HS loading, if the force is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

ALLOWABLE FORCE - COMP

The allowable compression force in the member - kips. The values for the IR, OR and SLC are printed.

ALLOWABLE FORCE - TENS

The allowable tension force in the member - kips. The values for the IR, OR and SLC are printed.

RATING FACTORS

Self-explanatory.

NOTE: If a given live loading does not produce any force in a truss member, IR (DESIGN) is printed as 999.99. The dead load force and the allowable member forces are printed for reference only. Theoretically, this member has an infinite rating for the given loading.

6.4.2 Member Strength and Load Factor Ratings

They are calculated using load factor method.

MEMBER ID

The identification of the member such as L01L02.

MEMBER LENGTH

The length of the truss member calculated by the program – ft.

DL FORCE

Member force due to the dead loads - kips.

LL+IMPACT FORCE - COMP

The maximum live load plus impact compression force in the member - kips. Two values, one based on the number of design traffic lanes and another based on the number of traffic lanes that are loaded or are in service, are printed. For HS loading, if the force is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

LL+IMPACT FORCE - TENS

The maximum live load plus impact tension force in the member - kips. Two values are printed. For HS loading, if the force is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

AXIAL CAPACITY - COMP

The axial compression capacity in the member - kips. The values for the IR, OR and SLC are printed.

AXIAL CAPACITY - TENS

The axial tension capacity in the member - kips. The values for the IR, OR and SLC are printed.

RATING FACTORS

Self-explanatory.

RATING FACTOR CODE

S – Group I factored load combination case I governs

B – Group I factored load combination case II governs

A – Rating factor cannot be computed

NOTE: If a given live loading does not produce any force in a truss member, IR (DESIGN) is printed as 999.99. The dead load force and the allowable member forces are printed for reference only. Theoretically, this member has an infinite rating for the given loading.

6.4.3 Support Reactions

List the maximum reactions of each support due to DL or LL+I - kips.

SUPPORT

Designation of the support joint such as L00 and L01

D.L.

The maximum reaction due to dead load - kips.

LL+I

The maximum reaction due to live load plus impact - kips. For HS loading, if the reaction is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

6.4.4 Panel Point Deflections

List the maximum deflections for each joint along the span - inches.

PANEL POINT

The joint designation such as L00 and L01.

DEAD LOAD + TEMP - VERT, HOR

The vertical and horizontal joint deflections due to the combined effect of dead load plus temperature change - inches.

LIVE LOAD + IMPACT

The maximum deflections due to the live load plus impact - inches. For HS loading, if the deflection is governed by the lane loading, the code "L" is printed. If "L" is not printed, it is assumed that the truck loading governs.

VERT +

The maximum downward deflection - inches.

VERT -

The maximum upward deflection - inches.

HOR +

The maximum horizontal deflection to the right - inches.

HOR -

The maximum horizontal deflection to the left - inches.

6.4.5 Influence Line

If the output option is specified as 9, the following values are also printed.

REACTION INFLUENCE LINE FOR SUPPORT XXX

FORCE INFLUENCE LINE FOR MEMBER XXXXXX

INFLUENCE LINE FOR VERTICAL DEFLECTION AT XXX

INFLUENCE LINE FOR HORIZONTAL DEFLECTION AT XXX

The influence line ordinates for a given effect, where XXX represents a panel point and XXXXXX represents the identification of the member. The values printed are the influence line ordinate followed by a joint number in parenthesis. The ordinate represents the effect of a unit load applied at the joint.

POS AREA, NEG AREA etc.

For a truss without counters, each influence line is analyzed to find the maximum effect of a given live load. The results of this analysis are printed here. These items are explained under the output option 9 for the bridge type "GGG".

For a truss with counters, these values are not printed.

For the bridge type "TFS", the computed values for the stringer and floorbeam are printed in the same way as explained for the bridge type "GFS".

For the bridge type "TFF", only the values for the floorbeam are printed.

6.4.6 Fatigue Life Estimation

FATIGUE LIFE ESTIMATION

The following values are printed if the fatigue life analysis is requested for the truss.

LIVE LOAD DISTRIBUTION

The live load distribution factor (fraction of axle loads) for loading one lane that is used for calculating the stress range.

PA TRAFFIC FACTOR

The Pennsylvania Traffic Factor (PTF) that is used in calculating the effective stress range for the fatigue life equation. This value is 1.0 for ADTT less than or equal to 2500 (Case II or III Highways) and it is equal to 1.1 for ADTT greater than 2500 (Case I Highways).

ALPHA FACTOR

The alpha factor that is used in calculating the effective stress range for the fatigue life equation. This is equal to 0.5 since the program uses the conventional method of structural analysis.

GAMMA FACTOR

The gamma factor that is used in calculating the effective stress range for the fatigue life equation. This is equal to 0.7 times the Pennsylvania Traffic Factor (PTF) if the Gross Vehicle Weight Distribution data are not entered. This is the calculated value as per DM4 if the Gross Vehicle Weight Distribution data are entered.

PAST GROWTH FACTOR or PAST CONSTANT ADTT

The growth factor for past ADTT in percent or the constant ADTT for the past.

FUTURE GROWTH FACTOR or FUTURE CONSTANT ADTT

The growth factor for future ADTT in percent or the constant ADTT for the future.

MEMBER

The identification of the member.

DL + HS20 TRUCK FORCE - MAXIMUM

The maximum axial force in the member due to dead loads and live load plus impact for an HS20 truck loading. This value is based on the distribution factor for loading one lane - kips.

DL + HS20 TRUCK FORCE - MINIMUM

The minimum axial force in the member due to dead loads and live load plus impact for an HS20 truck loading. This value is based on the distribution factor for loading one lane - kips.

CATEGORY

The stress category of detail as entered.

STRESS RANGE – FSRD

The design fatigue stress range calculated using the live load distribution factor for one lane - ksi. The value printed here is an algebraic difference of the maximum and the minimum stresses due to dead loads and live load plus impact at this detail due to an HS20 truck placed in one lane. If the detail never experiences a tensile stress, i.e. if the maximum and minimum stresses at this detail are compressive, the fatigue stress range is assumed to be zero.

STRESS RANGE – FSR

The allowable fatigue stress range for cycles greater than 2,000,000 for the above category of detail - ksi.

STRESS RANGE – FSRE

The effective fatigue stress range as defined in DM4 - ksi. This value is equal to the design fatigue stress range due to an HS20 truck in one lane multiplied by PA TRAFFIC FACTOR, ALPHA FACTOR and GAMMA FACTOR printed above. If FSRD is zero or is less than FSR, this is printed as zero indicating that the detail has infinite fatigue life.

DES FATIGUE LIFE CYCLES

The fatigue life in terms of cumulative truck cycles (number of times a design truck may pass over the bridge). If FSR is greater than FSRD or if FSRD is zero, this is printed as 9999999999 signifying that the detail has infinite fatigue life.

REMAIN YEARS

The remaining fatigue life of the detail - years.

The identification of critical member, estimated ADTT for the year the bridge was built, design fatigue life of the critical member, accumulated cycles and estimated remaining life of the truss are printed next.

6.4.7 Pony Truss Stability Check

6.4.7.1 Lookup Table

This is the reprint of Table 7.1.2-1: Values of 1/K (1.000 to 0.085 for 30 values) for various values of CL/Pc and N (4 to 16) with missing data linearly interpolated.

6.4.7.2 At Floorbeam Location

First Part:

1. TRUSS HEIGHT, h: The height of truss at the specified floorbeam support measured from the top of the vertical chord to the half of the floorbeam depth – inches.
2. VERT MEMBER, Ic – the moment of inertia of the vertical member bending toward the midspan of the floorbeam – in^4
3. FB SPAN, b – the floorbeam span between two supports – inches.

4. FLOORBEAM, Ib – the moment of inertia of the floorbeam bending in positive flexure - inch^4
5. SPRING CONSTANT, c – Transverse Frame Spring Constant – kips/in
6. Pc – “2.00(CAP)” was printed here

Second Part:

1. MEMBER – MEMBER ID such as L01U01
2. ** - Legend of member types: T for top chord, E for end post, and V for vertical chord.
3. CHORD, Lu – unsupported length of the truss member - inches
4. MEMBER CAPACITY – the factor of safety (2.0) * the original LFD member capacity computed using the BAR7-default K values depending on the pinned or riveted end connection selected from the user – kips.
5. CL/Pc – the value of (SPRING CONSTANT*CHORD/MEMBER CAPACITY).
6. COMPUTED 1/K VALUE – the value obtained from the lookup table
7. COMPUTED PONY-K VALUE – the value of 1/(COMPUTED 1/K VALUE)
8. BAR7 DEFAULT-K VALUE – for pinned connection, it is 0.875 and for riveted connection, it is 0.75.
9. CONTROLLING K VALUE – the largest value between COMPUTED PONY-K VALUE and BAR7 DEFAULT-K VALUE
10. FACTORED CHORD VALUE, K*Lu – the value of CONTROLLING K VALUES*Lu - inches

6.4.7.3 Final K Values Used in the Analysis and Rating

1. MEMBER – Member ID such as L01U01
2. CHORD, Lu – Unsupported length of the truss member - inches
3. CONTROLLING K VALUES: For each member, select the largest K values from each joint analyzed if multiple values exist.
4. FACTORED CHORD VALUE, K*Lu - the value of CONTROLLING K VALUES *Lu- inches

6.5 GUSSET PLATE ANALYSIS AND OPERATING RATINGS

The LFD gusset plate analysis and ratings consist of the dead and live load analysis results (forces and moments for gusset plate sections and connected members) as well as the capacity and operating level ratings of the gusset plate and connected members. The program outputs appropriate live loads defined by the user. These different live loads are indicated in each of the headings as "LL = …"

6.5.1 DL & LL Forces and Angles - Part 1, 2, and 3 of 3 (LL = …)

This output record contains the unfactored dead loads, unfactored live loads, and angles for each gusset plate member ii.

1. Plate Location - the gusset plate designation, denoted by the joint of the truss.
2. Member ID - the specific truss member that corresponds to each gusset plate member ii.
3. Dead Load Forces, DC - the dead load (DC) axial force applied to member ii.
4. Dead Load Forces, DW - the dead load (DW) axial force applied to member ii.
5. Live Load Forces, Tension - the live load tensile force applied to member ii.
6. Live Load Forces, Compression - the live load compressive force applied to member ii.
7. Angle Theta - angles measured from a vertical line at the centerline of the gusset to the line of action of the member.

6.5.2 Shear At Section A-A: LL Match DL (LL = …)

This output record contains section properties, factored effects, operating capacity and operating level rating factor for each gusset plate. Live loads from each member have the same sign as the dead loads in each member. Section A-A is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

1. Plate Location - the gusset plate designation, denoted by the joint of the truss.
2. Section Properties, Ag - the gross cross-sectional area of **one gusset plate along the** Section A-A**, = Ha*t**.
3. Section Properties, An - the net cross-sectional area of **one gusset plate along the** Section A-A**, = Ag - (number of holes)*(hole diamters)*t**.
4. Section Properties, S - the section modulus **of one** gusset plate with respect to section A-A**, = (Ha*Ha*t)/6**
5. Equilibrating Forces, Axial - the maximum **factored** axial force, tension or compression. **These equilibrating axial forces were computed from the free body diagram along the section A-A..**
6. Equilibrating Forces, Shear - the maximum **factored** shear force. **These equilibrating shear forces were computed from the free body diagram along the section A-A..**
7. Equilibrating Forces, Moment - the maximum **factored** moment. **These equilibrating moments were computed from the free body diagram along the section A-A.**

8. Nominal Capacity, Minimum - the nominal shear capacity at operating level, a minimum between P_{vg} and P_{vn}, the gross area shear capacity at operating level and the net area shear capacity.
9. Nominal Capacity, Governing - the governing area, gross or net (denoted by "g" or "n") from which the nominal shear capacity is calculated.
10. Capacity Check - a check indicating if the nominal capacity is greater than the factored shear force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
11. Operating Level Rating - the rating factor for shear force based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.

6.5.3 Shear At Section A-A: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.2, except that the calculations reported on this table utilize the compressive live load **member** force instead of the matching live load **member** force. Section A-A is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.4 Shear At Section A-A: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.2, except that the calculations reported on this table utilize the tensile live load **member** force instead of the matching live load **member** force. Section A-A is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.5 Shear At Section B-B: LL Match DL (LL = …)

The same information is printed on this table as described in Section 6.5.2, except that the calculations reported on this table come from section B-B. Section B-B is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.6 Shear At Section B-B: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.3, except that the calculations reported on this table come from section B-B. Section B-B is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.7 Shear At Section B-B: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.4, except that the calculations reported on this table come from section B-B. Section B-B is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.8 Shear At Section C-C: LL Match DL (LL = …)

The same information is printed on this table as described in Section 6.5.2, except that the calculations reported on this table come from section C-C. Section C-C is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.9 Shear At Section C-C: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.3, except that the calculations reported on this table come from section C-C. Section C-C is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.10 Shear At Section C-C: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.4, except that the calculations reported on this table come from section C-C. Section C-C is shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.

6.5.11 Tension and Compression: LL Match DL (LL = …)

This output record contains the factored effects for each member, up to five members, connected to the gusset plate, the capacity of gusset plate at each member and the operating level rating factor resulting from these loads. Live loads from each member have the same sign as the dead loads in each member.

1. Plate Location - the gusset plate designation, denoted by the joint of the truss.
2. Member - the gusset plate member designation, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Axial Force - the maximum factored axial force acting upon the end of the specified member.
4. Operating Level Capacity, Minimum - the nominal axial capacity of gusset plate at each member, either tension or compression.
5. Operating Level Capacity, Governing - the governing area. If the governing nominal capacity is tensile, the governing area will be either gross or net area (denoted by "Tg" or "Tn") respectively. If the governing nominal capacity is compressive, the governing area will be denoted by "C".
6. Capacity Check - a check indicating that the nominal capacity is greater than the factored axial force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
7. Operating Level, Rating - the rating factor for tension and compression of gusset plate at each member ends based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.
8. Operating Level, Governing - the governing axial force condition by which the rating was computed, either tension or compression ("T" or "C").

6.5.12 Tension and Compression: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.11, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.13 Tension and Compression: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.11, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.14 Block Shear: LL Match DL (LL = …)

This output record contains the factored effects for each member, up to five members, connected to the gusset plate, the capacity of gusset plate at each member and the resulting operating level rating factor. In addition, the combination of a vertical and diagonal member (referred to as "VRT-DGL" in the output record) and its corresponding effect and operating level rating factor is also computed by the program. Live loads from each member have the same sign as the dead loads in each member.

1. Plate Location - the gusset plate designation, denoted by the joint of the truss.
2. Member - the gusset plate member designation, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Block Shear Force - the maximum factored block shear force acting upon the end of the specified gusset plate member, either tensile (T) or compressive (C).
4. Operating Level Capacity, Pbs - the nominal block shear capacity.
5. Operating Level Capacity, Governing - the governing block shear case. For members 1 and 2, block shear case 1 ("B1") or 2 ("B2"). For members 3-5, case 2 ("B2"). For the vertical-diagonal member, block shear case 3 ("B3"). See Figure 3.11.2 on page 3-77.
6. Capacity Check - a check indicating that the nominal capacity is greater than the factored block shear force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
7. Operating Level Rating - the rating factor for block shear based upon the operating level capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.

6.5.15 Block Shear: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.14, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.16 Block Shear: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.14, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.17 Connections: LL Match DL (LL = …)

This output record contains the factored effects for each member, up to five members, connected to the gusset plate, the connection capacity at each member and the operating level rating factor resulting from these loads. Live loads from each member have the same sign as the dead loads in each member.

1. Plate Location - the gusset plate designation, denoted by the joint of the truss.
2. Member - the gusset plate member designation, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Axial Force - the maximum factored axial force applied to the gusset plate member.
4. Operating Level Capacity, Minimum (Rv, Rb) - the nominal connection capacity, a minimum between R_v (the shear capacity of all bolts or rivets) and R_b (the capacity of the connection in bearing).
5. Operating Level Capacity, Governing - the governing connection type, fastener shear ("FS") or bearing on material ("MB"), by which the nominal capacity was computed.
6. Capacity Check - a check indicating that the nominal capacity is greater than the factored axial force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
7. Operating Level, Rating - the rating factor for the gusset plate connection based upon the Operating Level capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.
8. Operating Level, Governing - the governing operating level rating type, fastener shear ("FS") or bearing on material ("MB"), by which the rating was computed.

6.5.18 Connections: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.17, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.19 Connections: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.17, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.20 Summary Part 1 of 3: LL Match DL (LL = …)

This output record contains the governing factored effects, capacity and operating level rating for each gusset plate for shear and tension. Live loads have the same sign as the dead loads when factoring the forces.

1. Plate Location - the gusset plate location designation, denoted by the joint of the truss.
2. Shear, Shear Force - the maximum factored shear force at Section A-A, Section B-B, or Section C-C, denoted by "A", "B", or "C" respectively. Sections A-A, B-B and C-C are shown in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Shear, Operating Level Capacity - the operating level shear capacity, a minimum between P_{vg} and P_{vn}, the gross area shear force capacity and net area shear force capacity, indicated by "g" or "n" respectively.
4. Shear, Capacity Check - a check indicating if the nominal capacity is greater than the shear force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
5. Shear, Operating Level Rating - the rating factor for shear (at Section A-A, Section B-B, or Section C-C denoted by "A", "B", or "C" respectively) based upon the nominal capacity, dead load, and live load results. Sections A-A, B-B and C-C are shown in Figure 5.22.1 on page 5-97 to Figure 5.22.5 on page 5-101. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.
6. Tension, Axial Load - the maximum factored tensile axial force acting upon the end of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
7. Tension, Operating Level Capacity - the operating level axial tensile capacity of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
8. Tension, Capacity Check - a check indicating that the nominal capacity is greater than the factored axial force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
9. Tension, Operating Level Rating – the rating factor for tension of member ends (denoted by M.1, M.2, M.3, M.4, and M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.

6.5.21 Summary Part 1 of 3: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.20, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.22 Summary Part 1 of 3: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.20, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.23 Summary Part 2 of 3: LL Match DL (LL = …)

This output record contains the governing factored effects, capacity and operating level rating for each gusset plate for compression and block shear. Live loads have the same sign as the dead loads when factoring the axial forces.

1. Plate Location - the gusset plate location designation, denoted by the joint of the truss.
2. Compression, Axial Load - the maximum compressive factored axial force acting upon the end of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Compression, Operating Level Capacity - the operating level axial compressive capacity of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
4. Compression, Capacity Check - a check indicating if the nominal capacity is greater than the factored axial force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
5. Compression, Operating Level Rating – the rating factor for compression of member ends (denoted by M.1, M.2, M.3, M.4, and M.5 for members 1 through 5 as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.
6. Block Shear, Block Shear Force - the maximum factored block shear force acting upon the end of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100, or B.3 for block shear case 3.
7. Block Shear, Operating Level Capacity - the operating level block shear capacity of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100, or B.3 for block shear case 3.
8. Block Shear, Capacity Check - a check indicating if the nominal capacity is greater than the factored block shear force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
9. Block Shear, Operating Level Rating - the rating factor for block shear (denoted by M.1, M.2, M.3, M.4, and M.5 for members 1 through 5 as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.5 on page 5-101) or B.3 for block shear case 3) based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.

6.5.24 Summary Part 2 of 3: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.23, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.25 Summary Part 2 of 3: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.23, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.26 Summary Part 3 of 3: LL Match DL (LL = …)

This output record contains the governing factored effects, capacity and operating level rating for each gusset plate for connections, as well as the overall critical operating rating for each gusset plate. Live loads have the same sign as the dead loads when factoring the axial forces.

1. Plate Location - the gusset plate location designation, denoted by the joint of the truss.
2. Connections, Axial Load - the maximum factored axial force acting on the connection of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
3. Connections, Operating Level Capacity - the operating level connection capacity of the gusset plate member, denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100.
4. Connections, Capacity Check - a check indicating if the operating level capacity is greater than the factored axial force. NOTE: For truss spans over 500 feet long, LFD loads used for the supplementary check of capacity have been factored per Group I in accordance with the Guide Spec. Article 1.2.
5. Connections, Operating Level Rating - the minimum rating factor for the connections (denoted by M.1, M.2, M.3, M.4, M.5 for members 1 through 5, as specified in Figure 5.22.1 on page 5-97 to Figure 5.22.4 on page 5-100) based upon the nominal capacity, dead load, and live load results. If the rating factor cannot be calculated because the live load force is equal to 0.0, +++ will print in this column.

6.5.27 Summary Part 3 of 3: LL Compressive (LL = …)

The same information is printed on this table as described in Section 6.5.26, except that the calculations reported on this table utilize the compressive live load force instead of the matching live load force.

6.5.28 Summary Part 3 of 3: LL Tensile (LL = …)

The same information is printed on this table as described in Section 6.5.26, except that the calculations reported on this table utilize the tensile live load force instead of the matching live load force.

6.5.29 Governing Operating Ratings: All Cases, LL = …

This output record contains the governing operating rating for each gusset plate and the live load condition that produces it. The record also contains the unsupported edge in compression adequacy check for each plate.

1. Plate Location - the gusset plate location designation, denoted by the joint of the truss.
2. Unsupported Edge In Compression Adequacy Check - a check indicating that the unsupported edges in compression do not require stiffening.
3. Minimum Operating Ratings, LL Match DL - the minimum operating rating for the case where the sign of the live load matches the sign of the dead load. The check resulting in the rating is denoted by "Blks" for the block shear check, "Comp" for the compression check, "Conn" for the connection check, "Shea" for the shear check or "Tens" for the tension check.
4. Minimum Operating Ratings, LL Compressive - same as parameter 3, except that the live load for this case is always compressive.
5. Minimum Operating Ratings, LL Tensile - same as parameter 3, except that the live load for this case is always tensile.
6. Minimum Operating Ratings, Overall - the final governing operating rating for the gusset plate; the minimum of parameters 4, 5, and 6.

```
    GUSSET PLATES: DL & LL FORCES AND ANGLES - PART 1 OF 3 (LL = aaaaaaaa)
    ----------------------------------------------------------------------
            M    E    M    B    E    R        #    1     |     M    E    M    B    E    R        #    2
  PL.   MEMBER  DEAD LOAD FORCES  LIVE LOAD FORCES  ANGLE | MEMBER  DEAD LOAD FORCES  LIVE LOAD FORCES  ANGLE
  LOC     ID      DC       DW      TENS     COMP    THETA |   ID      DC       DW      TENS     COMP    THETA
                 (kip)    (kip)    (kip)    (kip)   (deg) |          (kip)    (kip)    (kip)    (kip)   (deg)
  aii   aiiaii   xxxx.x   xxxx.x   xxxx.x   xxxx.x  xxx.x | aiiaii   xxxx.x   xxxx.x   xxxx.x   xxxx.x  xxx.x


    GUSSET PLATES: DL & LL FORCES AND ANGLES - PART 2 OF 3 (LL = aaaaaaaa)
    ----------------------------------------------------------------------
            M    E    M    B    E    R        #    3     |     M    E    M    B    E    R        #    4
  PL.   MEMBER  DEAD LOAD FORCES  LIVE LOAD FORCES  ANGLE | MEMBER  DEAD LOAD FORCES  LIVE LOAD FORCES  ANGLE
  LOC     ID      DC       DW      TENS     COMP    THETA |   ID      DC       DW      TENS     COMP    THETA
                 (kip)    (kip)    (kip)    (kip)   (deg) |          (kip)    (kip)    (kip)    (kip)   (deg)
  aii   aiiaii   xxxx.x   xxxx.x   xxxx.x   xxxx.x  xxx.x | aiiaii   xxxx.x   xxxx.x   xxxx.x   xxxx.x  xxx.x


    GUSSET PLATES: DL & LL FORCES AND ANGLES - PART 3 OF 3 (LL = aaaaaaaa)
    ----------------------------------------------------------------------
            M    E    M    B    E    R        #    5
  PL.   MEMBER  DEAD LOAD FORCES  LIVE LOAD FORCES  ANGLE |
  LOC     ID      DC       DW       TENS    COMP    THETA |
                 (kip)    (kip)    (kip)    (kip)   (deg) |
  aii   aiiaii   xxxx.x   xxxx.x   xxxx.x   xxxx.x  xxx.x |
```

```
GUSSET PLATES: SHEAR @ SECTION A-A: LL SAME AS DL (LL = aaaaaaaa)
-----------------------------------------------------------------
GUSSET PLATES: SHEAR @ SECTION A-A: LL COMPRESSIVE (LL = aaaaaaaa)
------------------------------------------------------------------
  GUSSET PLATES: SHEAR @ SECTION A-A: LL TENSILE (LL = aaaaaaaa)
  --------------------------------------------------------------
GUSSET PLATES: SHEAR @ SECTION B-B: LL SAME AS DL (LL = aaaaaaaa)
-----------------------------------------------------------------
GUSSET PLATES: SHEAR @ SECTION B-B: LL COMPRESSIVE (LL = aaaaaaaa)
------------------------------------------------------------------
  GUSSET PLATES: SHEAR @ SECTION B-B: LL TENSILE (LL = aaaaaaaa)
  --------------------------------------------------------------
GUSSET PLATES: SHEAR @ SECTION C-C: LL SAME AS LL (LL = aaaaaaaa)
-----------------------------------------------------------------
GUSSET PLATES: SHEAR @ SECTION C-C: LL COMPRESSIVE (LL = aaaaaaaa)
------------------------------------------------------------------
  GUSSET PLATES: SHEAR @ SECTION C-C: LL TENSILE (LL = aaaaaaaa)
  --------------------------------------------------------------
             SECTION PROPERTIES           EQUILIBRATING FORCES   OPERATING LEVEL CAPACITY    OPERATING
PLATE     (One Side of Joint Only)      AXIAL    SHEAR     MOMENT     MIN(Pvg, Pvn)            LEVEL
LOCATION     Ag       An        S        FORCE    FORCE     FORCE       MIN    GOV*   CHECK**  RATING
          (in^2)   (in^2)    (in^3)     (kip)    (kip)    (kip-in)    (kip)
 aii      xxx.xx    xxx.xx    xxx.xx   xxxx.xx   xxxx.xx   xxxx.xx     xxxx.xx a       aa      xx.xx

      * Legend of Governing Operating Level Capacity:
          g.  Gross Area (Pvg)
          n.  Net Area (Pvn)

     ** Legend of Capacity Check
          OK. Sufficient Shear Capacity
          %%. Insufficient Shear Capacity
```

```
NOTE: For truss spans over 500 feet long, LFD loads used for the
      supplementary check of capacity have been factored
      per Group I in accordance with the Guide Spec. Article 1.2.

     +++ Rating factor not calculated because live load effect = 0.0

GUSSET PLATES: TENSION & COMPRESSION: LL SAME AS DL (LL = aaaaaaaa)
-------------------------------------------------------------------
GUSSET PLATES: TENSION & COMPRESSION: LL COMPRESSIVE (LL = aaaaaaaa)
--------------------------------------------------------------------
  GUSSET PLATES: TENSION & COMPRESSION: LL TENSILE (LL = aaaaaaaa)
  ----------------------------------------------------------------
                   FACTORED    OPERATING LEVEL CAPACITY         OPERATING
 PLATE              AXIAL            MIN (Pt, Pc)                 LEVEL
LOCATION   MEMBER   FORCE*             MIN  GOV**     CHECK*** RATING  GOV*
                    (kip)             (kip)
  aii        1     xxxx.xx a         xxxx.xx aa         aa      xx.xx   a
             2     xxxx.xx a         xxxx.xx aa         aa      xx.xx   a
             3     xxxx.xx a         xxxx.xx aa         aa      xx.xx   a
             4     xxxx.xx a         xxxx.xx aa         aa      xx.xx   a
             5     xxxx.xx a         xxxx.xx aa         aa      xx.xx   a

       * Legend of Governing Factored Axial Force:
           C.  Compression
           T.  Tension

      ** Legend of Governing Operating Level Capacity:
           C.  Compression, (Pc)
           Tg. Tension, Gross Area (Pt)
           Tn. Tension, Net Area (Pt)
```

```
      *** Legend of Capacity Check
            OK. Sufficient Axial Capacity
            %%. Insufficient Axial Capacity
  NOTE: For truss spans over 500 feet long, LFD loads used for the
        supplementary check of capacity have been factored
        per Group I in accordance with the Guide Spec. Article 1.2.

      +++ Rating factor not calculated because live load effect = 0.0

      GUSSET PLATES: BLOCK SHEAR: LL SAME AS DL (LL = aaaaaaaa)
      ---------------------------------------------------------
      GUSSET PLATES: BLOCK SHEAR: LL COMPRESSIVE (LL = aaaaaaaa)
      ----------------------------------------------------------
        GUSSET PLATES: BLOCK SHEAR: LL TENSILE (LL = aaaaaaaa)
        ------------------------------------------------------
                  FACTORED BLOCK  OPERATING LEVEL         OPERATING
   PLATE               SHEAR         CAPACITY               LEVEL
  LOCATION   MEMBER    FORCE*        Pbs   GOV**   CHECK***  RATING
                       (kip)        (kip)
    aii        1      xxxx.xx a    xxxx.xx aa       aa       xx.xx
               2      xxxx.xx a    xxxx.xx aa       aa       xx.xx
               3      xxxx.xx a    xxxx.xx aa       aa       xx.xx
               4      xxxx.xx a    xxxx.xx aa       aa       xx.xx
               5      xxxx.xx a    xxxx.xx aa       aa       xx.xx
             VRT-DGL  xxxx.xx a    xxxx.xx aa       aa       xx.xx

        * Legend of Governing Factored Block Shear:
            C.  Compression
            T.  Tension
```

```
         ** Legend of Governing Operating Level Capacity:
              B1. Block Shear Case 1 (members 1 - 2 only)
              B2. Block Shear Case 2 (members 1 - 5 only)
              B3. Block Shear Case 3 (member VRT-DGL only)

        *** Legend of Capacity Check
              OK. Sufficient Block Shear Capacity
              %%. Insufficient Block Shear Capacity

    NOTE: For truss spans over 500 feet long, LFD loads used for the
          supplementary check of capacity have been factored
          per Group I in accordance with the Guide Spec. Article 1.2.

        +++ Rating factor not calculated because live load effect = 0.0


        GUSSET PLATES: CONNECTIONS: LL SAME AS DL (LL = aaaaaaaa)
        ---------------------------------------------------------
        GUSSET PLATES: CONNECTIONS: LL COMPRESSIVE (LL = aaaaaaaa)
        ----------------------------------------------------------
          GUSSET PLATES: CONNECTIONS: LL TENSILE (LL = aaaaaaaa)
         ------------------------------------------------------
                     FACTORED  OPERATING LEVEL CAPACITY      OPERATING
     PLATE            AXIAL         MIN (Rv, Rb)               LEVEL
    LOCATION   MEMBER   FORCE*           MIN  GOV**   CHECK*** RATING  GOV**
                      (kip)          (kip)
      aii        1     xxxx.xx a      xxxx.xx aa       aa      xx.xx  aa
                 2     xxxx.xx a      xxxx.xx aa       aa      xx.xx  aa
                 3     xxxx.xx a      xxxx.xx aa       aa      xx.xx  aa
                 4     xxxx.xx a      xxxx.xx aa       aa      xx.xx  aa
                 5     xxxx.xx a      xxxx.xx aa       aa      xx.xx  aa
```

```
  * Legend of Governing factored Axial Force:
      C.  Compression
      T.  Tension

 ** Legend of Governing Operating Level Capacity:
      FS. Fastener Shear (Rv)
      MB. Bearing on Material (Rb)

*** Legend of Capacity Check
      OK. Sufficient Connection Capacity
      NG. Insufficient Connection Capacity

+++ Rating factor not calculated because live load effect = 0.0
```

```
GUSSET PLATES: SUMMARY PART 1 OF 3: LL SAME AS DL (LL = aaaaaaaa)
-----------------------------------------------------------------
GUSSET PLATES: SUMMARY PART 1 OF 3: LL COMPRESSIVE (LL = aaaaaaaa)
------------------------------------------------------------------
  GUSSET PLATES: SUMMARY PART 1 OF 3: LL TENSILE (LL = aaaaaaaa)
  --------------------------------------------------------------
                    S  H  E  A  R                             T  E  N  S  I  O  N
                                         OPERATING                                    OPERATING
PLATE      SHEAR  OPERATING LEVEL         LEVEL          AXIAL    OPERATING LEVEL        LEVEL
LOCATION   FORCE*    CAPACITY*   CHECK*** RATING*        LOAD**     CAPACITY** CHECK*** RATING**
           (kip)       (kip)                             (kip)       (kip)
 aii     xxx.xx a     xxx.xx a    aa      xx.xx a      xxx.xx a.a   xxx.xx a.a   aa  |  xx.xx a.a

      * Factored Shear Force, Operating Level Capacity, and Operating Level Rating:
          A.   Shear @ Section A-A
          B.   Shear @ Section B-B
          C.   Shear @ Section C-C
          g.   Gross Area
          n.   Net Area

     ** Legend of Factored Tension Axial Load, Operating Level Capacity, and Operating Level Rating:
          M.1. Member 1
          M.2. Member 2
          M.3. Member 3
          M.4. Member 4
          M.5. Member 5

    *** Legend of Capacity Check
          OK. Sufficient Capacity
          %%. Insufficient Capacity
```

```
NOTE: For truss spans over 500 feet long, LFD loads used for the
      supplementary check of capacity have been factored
      per Group I in accordance with the Guide Spec. Article 1.2.

     +++ Rating factor not calculated because live load effect = 0.0



 GUSSET PLATES: SUMMARY PART 2 OF 3: LL SAME AS DL (LL = aaaaaaaa)
 -----------------------------------------------------------------
 GUSSET PLATES: SUMMARY PART 2 OF 3: LL COMPRESSIVE (LL = aaaaaaaa)
 ------------------------------------------------------------------
   GUSSET PLATES: SUMMARY PART 2 OF 3: LL TENSILE (LL = aaaaaaaa)
   --------------------------------------------------------------
                  C O M P R E S S I O N                     B L O C K    S H E A R
                                         OPERATING       BLOCK                       OPERATING
 PLATE      AXIAL  OPERATING LEVEL          LEVEL        SHEAR   OPERATING LEVEL        LEVEL
LOCATION    LOAD*     CAPACITY*   CHECK**  RATING*       FORCE*     CAPACITY*  CHECK**  RATING*
            (kip)       (kip)                            (kip)       (kip)
  aii     xxx.xx a.a   xxx.xx a.a  aa  |   xx.xx a.a    xxx.xx a.a   xxx.xx a.a   aa  |  xx.xx a.a

       * Legend of Factored Axial Load, Operating Level Capacity, and Operating Level Rating:
           M.1. Member 1
           M.2. Member 2
           M.3. Member 3
           M.4. Member 4
           M.5. Member 5
           B.3. Block Shear Case 3 (Block Shear Only)

      ** Legend of Capacity Check
           OK. Sufficient Capacity
           %%. Insufficient Capacity
```

```
NOTE: For truss spans over 500 feet long, LFD loads used for the
      supplementary check of capacity have been factored
      per Group I in accordance with the Guide Spec. Article 1.2.

     +++ Rating factor not calculated because live load effect = 0.0

 GUSSET PLATES: SUMMARY PART 3 OF 3: LL SAME AS DL (LL = aaaaaaaa)
 -----------------------------------------------------------------
 GUSSET PLATES: SUMMARY PART 3 OF 3: LL COMPRESSIVE (LL = aaaaaaaa)
 ------------------------------------------------------------------
   GUSSET PLATES: SUMMARY PART 3 OF 3: LL TENSILE (LL = aaaaaaaa)
   --------------------------------------------------------------
              C O N N E C T I O N S
                                          OPERATING
 PLATE      AXIAL  OPERATING LEVEL         LEVEL
LOCATION    LOAD*     CAPACITY*   CHECK**  RATING*
            (kip)       (kip)
  aii     xxx.xx a.a   xxx.xx a.a  aa  |   xx.xx a.a
  aii     xxx.xx a.a   xxx.xx a.a  aa  |   xx.xx a.a

       * Legend of Factored Axial Load, Operating Level Capacity, and Operating Level Rating:
           M.1. Member 1
           M.2. Member 2
           M.3. Member 3
           M.4. Member 4
           M.5. Member 5

      ** Legend of Supplementary Capacity Check
           OK. Sufficient Capacity
           %%. Insufficient Capacity
```

```
NOTE: For truss spans over 500 feet long, LFD loads used for the
      supplementary check of capacity have been factored
      per Group I in accordance with the Guide Spec. Article 1.2.

     +++ Rating factor not calculated because live load effect = 0.0

   GUSSET PLATES: GOVERNING OPERATING RATINGS: ALL CASES, LL = aaaaaaaa
   --------------------------------------------------------------------
          UNSUPPORTED EDGE      M I N I M U M  O P E R A T I N G  R A T I N G S
 PLATE     IN COMPRESSION         LL            LL              LL
LOCATION   ADEQUACY CHECK*     MATCH DL**   COMPRESSIVE**   TENSILE**     OVERALL
  aii           aa           aaaaaa aaaa    aaaaaa aaaa   aaaaaa aaaa  |  aaaaaa

       * Legend of Unsupported Edge In Compression Adequacy Check:
           OK. The unsupported edge does not require stiffening
           NG. The unsupported edge requires stiffening

      ** Legend of Minimum Operating Level Ratings:
           Blks. Block Shear
           Comp. Compression
           Conn. Connections
           Shea. Shear
           Tens. Tension

     +++ Rating factor not calculated because live load effect = 0.0
```

7 EXAMPLE PROBLEMS

This chapter contains seven (7) example problems to aid users in preparing data for their problems. Descriptions of the bridge and 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 seven example problems are included in this chapter.

1. Example Problem 1 – Analysis and rating of a concrete T-beam bridge, CTB.

2. Example Problem 2 – Analysis and rating of an encased I-beam bridge, EIB.

3. Example Problem 3 – Analysis and rating of a multigirder steel bridge, GGG. Two-span continuous wide flange beams with a 6 ¼ inch slab composite in the positive moment region.

4. Example Problem 4 – Analysis and rating of a girder-floorbeam-stringer type bridge, GFS, with some fatigue prone details. Six span welded plate girder with a parabolic haunch and two in-span hinges.

5. Example Problem 5 – Analysis and rating of a single span thru truss-floorbeam-stringer type bridge, TFS, including the gusset plate analysis and rating. The truss consists of six panels. It is symmetrical and the center two panels have counters.

6. Example Problem 6 – An example that analyzes the bridge in Example Problem 5 using a separate data file for the special live loadings data.

7. Example Problem 7 – Analysis and rating a single-span pony truss type bridge, TFS, including the gusset plate analysis and rating, pony truss stability check at floorbeam location 2, live load = “K”, and load factor method rating for members with or without eccentricity. The truss consists of seven panels and is symmetrical.

The actual input data files and resulting output for the example problems are not listed in this manual, but input files are included electronically with the executable program and can be run so that the output can be viewed.

7.1 EXAMPLE PROBLEM 1

7.1.1 Problem Description

This is an example of a concrete T-beam type bridge. The bridge has a span length of 45.00 feet. The beams are spaced at 5'-1" center-to-center.

7.1.2 Input

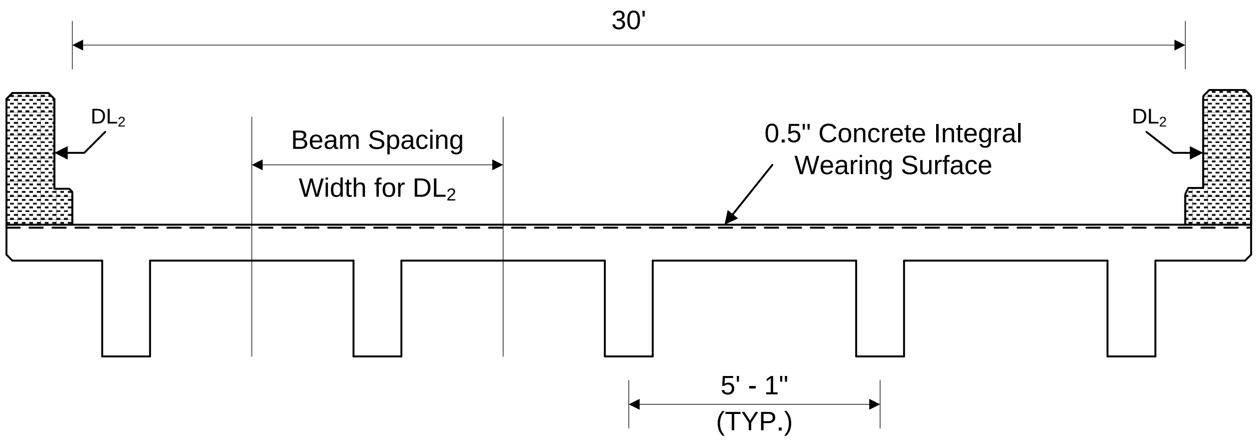
The following input lines are entered. Refer to the completed input data sheets shown in Figure 7.1.3 on page 7-5.

1. Project Identification
   - BRIDGE TYPE is "CTB".
   - SLC STRESS LEVEL is equal to the allowable stresses for Inventory Rating. This is the default when left blank for concrete bridges.
   - Ratings are desired for standard loadings. This is the default when LIVE LOAD is left blank.
   - OUTPUT option is 0, to print the normal output.
   - Standard AASHTO IMPACT FACTORs are to be used. This is the default when left blank.
2. Bridge Cross Section and Loading
   - Beam SPACING, ROADWAY WIDTH and SLAB THICKness are taken from plans as shown in Figure 7.1.1 on page 7-4.
   - DISTRIBUTION FACTORS for SHEAR, MOMENT and DEFLECTion are computed according to AASHTO Specifications. Refer to Figure 7.1.1 on page 7-4.
   - DL1 is entered as zero because the weight of the beam and slab are computed by the program. No other dead loads of this type exist.
   - DL2 consists of the weight of parapets and railing and was computed to be 0.404 kips per foot of beam.
   - F'C is unknown, so it is left blank (the program will use a default value of 2.375). The value of N = 15 is taken corresponding to F'C = 2.375.
3. Span Lengths
   - The span length of 45.00 feet measured center-to-center of bearing is taken from plans.
4. Concrete Member Properties
   - The TYPE of beam is T.
   - Beam dimensions (DEPTH, B and D) and area of reinforcement (AS) are taken from plans as shown in Figure 7.1.1 on page 7-4
   - Yield strength of reinforcement is unknown, so FY REINF. is left blank. The program will use allowable IR and OR stresses per AASHTO Manual 5.4.4.

5. Stirrup Details
    - Stirrups consist of #4 bars with a yield strength of 33 ksi.
    - The first stirrup is 4 inches from the centerline of bearing.
    - The next six stirrups are spaced 9 inches apart.
    - Four more stirrups are spaced 12 inches apart followed by four stirrups at 18 inches, one stirrup at 20 inches and three stirrups at 24 inches.

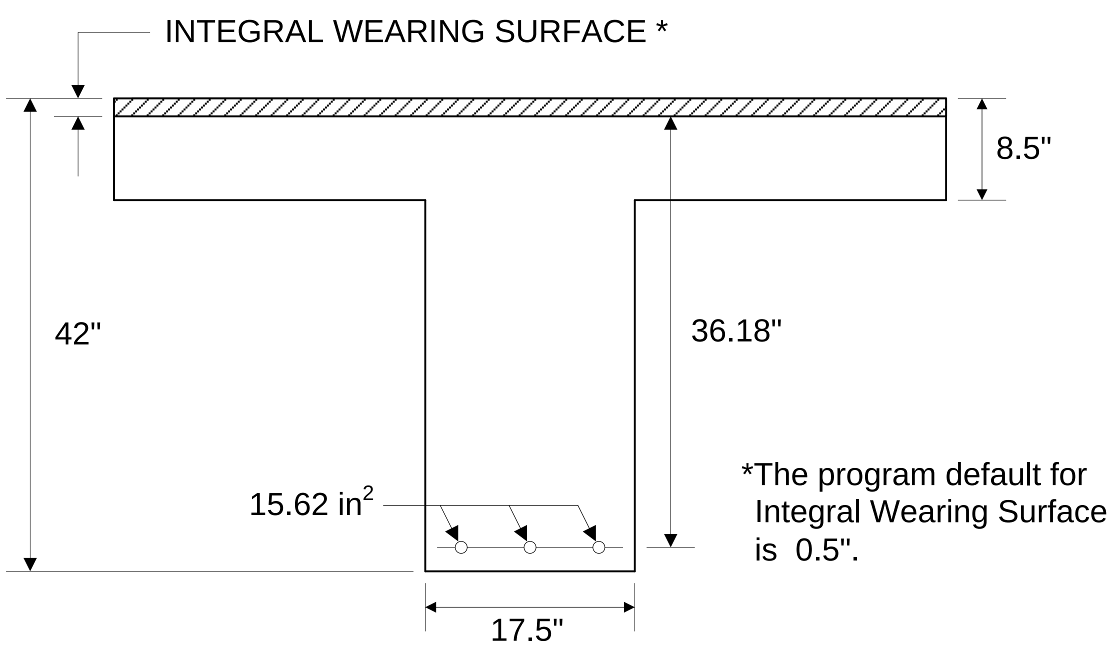
Input DL_1: None.

Input DL_2: Weight of parapet, sidewalks, overlay and utilities per foot length of T-beam.



Note: The dead loads due to the weight of the slab (including integral wearing surface) and the weight of the beam are computed by the program and added to the input DL_1.

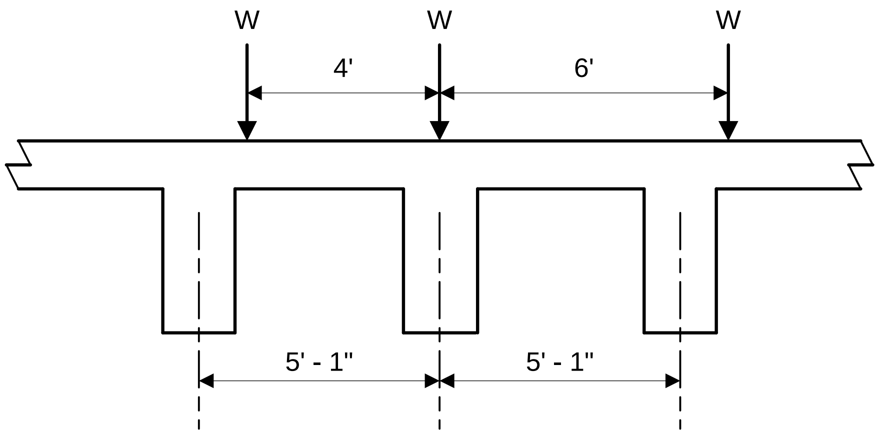
CONCRETE T-BEAM BRIDGE CROSS SECTION



TYPICAL T-BEAM

Figure 7.1.1 Example Problem 1 - Details

DISTRIBUTION FACTOR FOR SHEAR



$$\text{D. F.} = 1 + \frac{(5.083 - 4)}{5.083} \text{ Wheels} = \frac{1.213}{2} \text{ Axles} = 0.607$$

DISTRIBUTION FACTOR FOR MOMENT

$$\text{D. F.} = \frac{S}{6} = \frac{5.083}{6.0} = 0.847 \text{ Wheels} = \frac{0.847}{2} \text{ Axles} = 0.424$$

DISTRIBUTION FACTOR FOR DEFLECTION

$$\text{D. F.} = \frac{(\text{No. Lanes})\,(\text{Reduction Factor})}{\text{No. Beams}} = \frac{(2)\,(1.0)}{7} = 0.286$$

Figure 7.1.2 Example Problem 1 - Input Calculations

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PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STRUCTURE IDENTIFICATION: STATE ROUTE	STRUCTURE IDENTIFICATION: SEGMENT	STRUCTURE IDENTIFICATION: OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72
=BRRAT	14	0027	0001	0400	EXAMPLE PROBLEM 1	CTB				0											

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	DISTRIBUTION FACTORS: MOMENT	DISTRIBUTION FACTORS: DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	BRIDGE DEAD LOADS: DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74
	5.08		30.00	0.607	0.424	0.286	08.50		0.000	00.404	2.375	15											

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
	45.00														

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66

Figure 7.1.3 Example Problem 1 - Input

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CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs IR	ALLOWABLE Fs OR	ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
T	42.00	17.50	36.18	15.62	.	.	33	.	.	Y	.		.	.

STIRRUP DETAILS

STIRRUP AREA	fsy	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING
1	6	8	13	18	23	28	33	38	43	48	53	58	63
00.200	33	0.00	4.000	0.33	9.000	4.83	12.000	8.83	18.000	14.83	20.000	16.50	24.000

Figure 7.1.3 Example Problem 1 - Input (Cont.)

7.2 EXAMPLE PROBLEM 2

7.2.1 Problem Description

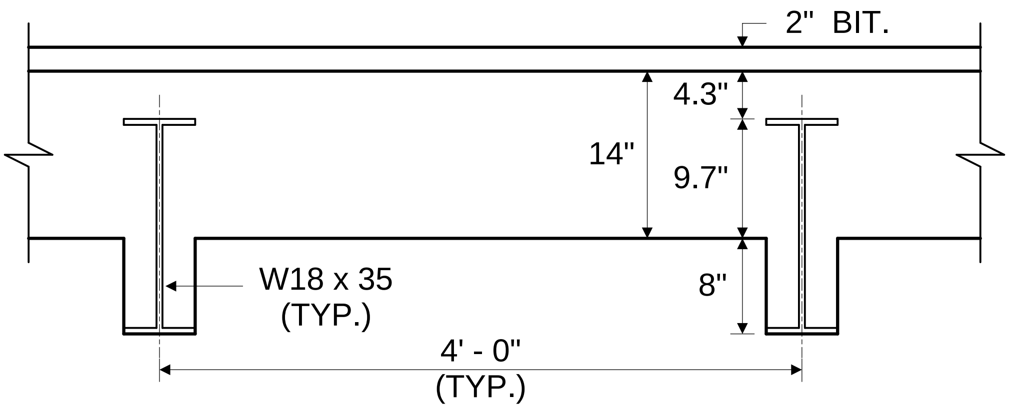
This is an example of an encased I-beam bridge. Steel I-beams are encased in a 14-inch thick slab with the bottom of the beam projecting 8 inches below the slab. The bridge is a simple span. Figure 7.2.1 on page 7-10 shows the cross section of the bridge. Since the bottom flange shows and apparently has always been visible, unshored construction is assumed.

7.2.2 Input

The following input lines are entered. Refer to the completed input data sheets (Figure 7.2.3 on page 7-12).

1. Project Identification
   - BRIDGE TYPE is "EIB" since the bridge is made up of encased steel I-beams.
   - SLC STRESS LEVEL is to be used as 90% of the allowable stress for the Operating Rating.
   - The bridge is to be analyzed for a permit load, therefore 1 is entered for LIVE LOAD.
   - The output is desired for section properties, moments, shears and strengths, therefore 3 is entered for OUTPUT.
   - Only 10% impact is to be applied for the live load.
2. Bridge Cross Section and Loading
   - Beam SPACING, SLAB THICKness and HAUNCH are taken from plans as shown in Figure 7.2.1 on page 7-10. Note that the value for haunch will be assumed negative by the program when BRIDGE TYPE is "EIB".
   - DISTRIBUTION FACTORS for SHEAR, MOMENT and DEFLECTion are computed according to AASHTO Specifications. Refer to Figure 7.2.2 on page 7-11.
   - The program will compute the dead loads due to the slab weight and beam weight. The dead load due to the concrete section covering the projecting web and flange below the bottom surface of the slab is to be entered as DL1.
   - DL2 consists of the 2 inch bituminous surface, guide rail and steel channel curb.
   - Concrete strength is unknown, therefore F'C is assumed to be 2.375 ksi to limit the allowable compression in concrete for operating rating to be approximately 1.3 ksi (0.55 f_c').
   - The value of modular ratio N is entered as 15 per AASHTO Manual since f_c' is between 2000 psi and 2400 psi.
3. Span Lengths
   - An "S" is entered for CONT. because it is a simple span bridge.
   - One span length is entered.

4. Concrete Member Properties
   - Since "Y" is entered for CONC DECK in the Project Identification line, this line must be entered. The values entered here do not contribute anything to the rating analysis since the longitudinal reinforcement in the concrete deck is not considered for a positive moment section. The bridge type "EIB" can only be a simple span bridge and thus all sections are subjected to positive moment only.
   - An "S" is entered for TYPE and the rest of the line is left blank.
   - If "Y" is not entered for CONC DECK, this line should not be entered.
   - For bridge type "EIB", CONC DECK can be entered as "N" and this line can be eliminated from the input.
5. Steel Member Properties
   - All properties are for a steel beam, therefore "G" is entered for G F OR S.
   - Since SYMMETRY is not entered as "Y", member properties for the entire beam must be entered. However, the cross section of the beam is constant throughout its length, therefore only one line of data is required.
   - The SPAN NO is 1.
   - The RANGE is equal to the span length.
   - The SECT TYPE is "W" because the cross section is a wide flange beam W18x35.
   - The WF BEAM M OF I, WF BEAM AREA, FLANGE THICK, FLANGE WIDTH, WF BEAM DEPTH and WEB THICK are entered for the wide flange beam.
   - Since the bottom flange of the encased beam has always been visible, an unshored construction is assumed. COMPOSITE code is entered as "N" to indicate an unshored construction.
   - The yield strength of the beam is assumed to be 33 ksi.
   - For bridge type "EIB", CONC DECK can be entered as "N" and this line can be eliminated from the input.
6. Special Live Loads
   - The permit load consists of a load of five axles and axle spacings as entered.

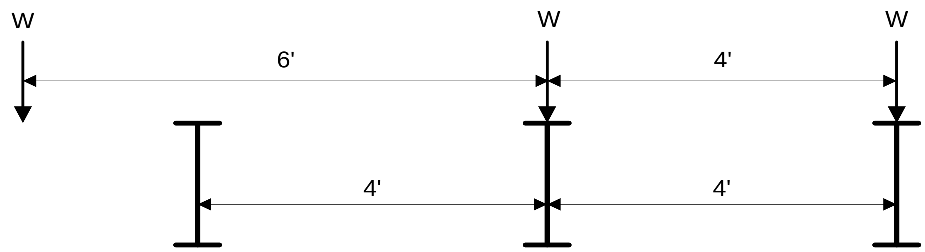


BRIDGE CROSS SECTION

W18 x 35 PROPERTIES
I_x = 510 in^4
A = 10.3 in^2
d = 17.70 in
b_f = 6.0 in
t_f = 0.425 in
t_w = 0.300 in

Figure 7.2.1 Example Problem 2 - Details

DISTRIBUTION FACTOR FOR SHEAR



D. F. = 1 Wheel = $\frac{1}{2}$ **Axles = 0.500**

DISTRIBUTION FACTOR FOR MOMENT

$$\text{D. F.} = \frac{S}{5.5} = \frac{4.0}{5.5}\ \text{Wheels} = \frac{4.0}{(5.5)(2)}\ \text{Axles} = 0.364$$

DISTRIBUTION FACTOR FOR DEFLECTION

$$\text{D. F.} = \frac{(\text{No. Lanes})\,(\text{Reduction Factor})}{\text{No. Beams}} = \frac{(2)\,(1.0)}{9} = 0.222$$

DEAD LOADS - DL1:

$$\left(\frac{8 \times 6}{144}\right)(0.150) = 0.050$$

DEAD LOADS - DL2:

2" Bituminous	$\left(\frac{2}{12}\right)(4.0)(0.150) = 0.100$
Guiderail est. @ 35 #/ft	$(0.035)/4.5 = 0.008$
Steel Channel Curb est. @ 25 #/ft	$(0.025)/4.5 = 0.006$
Total	0.114 **kips/ft**

Figure 7.2.2 Example Problem 2 - Input Calculations

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PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STATE ROUTE	SEGMENT	OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72
=BRRAT	12	1018	0030	0000	ENCASED I-BEAM UNSHORED	EIB	090		1	3	1.10	.	.		Y				.		

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	MOMENT	DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74
.	4.00	.	.	0.500	0.364	0.222	14.00	9.70	0.050	0.114	2.375	15									.	.	

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
S	29.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66
.	.	.	.	.	.	.	.	.	.	.	.	.	.

Figure 7.2.3 Example Problem 2 - Input

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CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs IR	ALLOWABLE Fs OR	ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
S														

STIRRUP DETAILS

STIRRUP AREA	fsy	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING
1	6	8	13	18	23	28	33	38	43	48	53	58	63
		0.0 0											

Figure 7.2.3 Example Problem 2 - Input (cont.)

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STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE WIDTH	TOP PLATE THICK	BOTTOM PLATE WIDTH	BOTTOM PLATE THICK	COMPOSITE	FY	HYBRID FY TOP	HYBRID FY BOT	UNSYMMETRICAL CG TOP	UNSYMMETRICAL CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
G	1	29.00	W	510.00	10.30	0.4250	6.000		17.70	0.3000					N	33.0				

Figure 7.2.3 Example Problem 2 - Input (cont.)

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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								

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.

Figure 7.2.3 Example Problem 2 - Input (cont.)

7.3 EXAMPLE PROBLEM 3

7.3.1 Problem Description

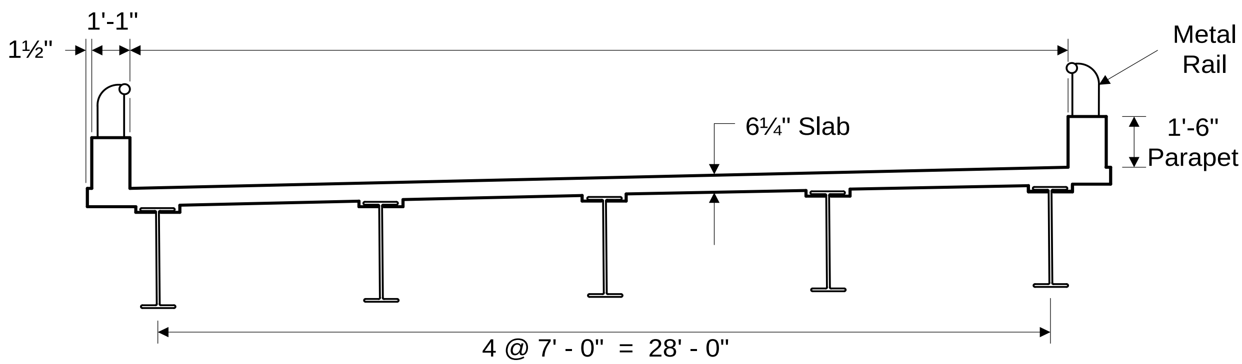
This is an example of a multigirder bridge. A two-span continuous girder bridge with a 6½" concrete deck is analyzed to determine if it could be rated for the HS20 loading. Figure 7.3.1 on page 7-18 shows some of the basic details for this bridge.

7.3.2 Input

The following input lines are entered. Refer to the completed input data sheets (Figure 7.3.3 on page 7-22

1. Project Identification
   - The BRIDGE TYPE is "GGG".
   - The SLC LEVEL is 25% above the allowable stresses **at the** Inventory Rating**, I15**.
   - Analysis is desired for the HS20 loading only, therefore a "B" is coded for LIVE LOAD.
   - A "0" is coded for OUTPUT so that tables of moments, shears, stresses, deflections, axial force and ratings will be printed at various sections of a member.
   - Standard AASHTO IMPACT FACTORs are to be used.
   - **Standard Gage Distance (6 feet) and Passing Distance (2 feet) are to be used.**
   - **FATIGUE = Y.**
   - **CONCRETE DECK = Y.**
2. Bridge Cross Section and Loading
   - Girder SPACING, SLAB THICKness (with ½" of integral wearing surface added) and HAUNCH are taken from plans as shown in Figure 7.3.1on page7-18.
   - DISTRIBUTION FACTORS for SHEAR, MOMENT and DEFLECTion are computed per AASHTO Specifications. Refer to Figure 7.3.2 on page 7-20.
   - DL1 is calculated as shown on Figure 7.3.2 on page 7-20. The weight of the beam and slab will be computed by the program.
   - DL2 consists of the weight of parapets, railing and future paving and was computed as shown in Figure 7.3.2 on page 7-20.
   - F'C of 3.0 ksi and N of 10 are taken from design computations.
   - The bridge is symmetric, so SYMMETRY is entered as "Y".
3. Span Lengths
   - A "C" is entered for CONT. because the girders are continuous.
   - Both span lengths are entered.
4. Concrete Member
   - Fy REINF = 50 ksi

5. Steel Member Properties
   - All properties are for a girder, so "G" is coded for G F OR S.
   - If SYMMETRY is entered as “Y” in the BRIDGS CROSS SECTION AND LOADING line, then the member properties for one-half the entire length of the girder are entered, i.e. only member properties in span 1 needs to be entered.
   - Member properties are entered for SPAN NO. 1.
   - The RANGE for each segment is the distance from the left end of each span to the right end of the segment being described.
   - The SECT TYPE is "W" because the cross section is a wide flange beam W36x135.
   - The WF BEAM M OF I, WF BEAM AREA, FLANGE THICK, FLANGE WIDTH, WF BEAM DEPTH and WEB THICK are entered for the wide flange beam.
   - Each segment is specified either composite or non-composite by entering a "Y" or "N" for COMPOSITE.
   - The last range for the properties is equal to the first span length.
   - Refer to Figure 7.3.1 on page 7-18 for the girder elevation sketch.
6. Lateral Brace Points and stiffener Spacings
   - If SYMMETRY is entered as “Y” in the BRIDGS CROSS SECTION AND LOADING line, then the lateral brace points and stiffener spacings for one-half the entire length of the girder shall be entered, i.e. only the lateral brace points and stiffener spacings in span 1 needs to be entered.
7. Fatigue Data
   - The bridge was built in 1956.
   - The ADTT data for the last two counts are known, so the program will calculate the past growth factor for ADTT.
   - Future growth factor is assumed to be 5%.
   - The structure is redundant.
   - One Lane Distribution Factor is taken as girder spacing divided by 14 per AASHTO Specifications Table 3.23.1.
8. Girder Fatigue Detail
   - Fatigue prone details are described by entering the horizontal and vertical distances of their locations and their AASHTO Categories.
   - Detail locations and categories entered for this example problem are for illustration purpose only. These details may not exist in this bridge.
   - If SYMMETRY is entered as “Y” in the BRIDGS CROSS SECTION AND LOADING line, then the last section entered here must be the center of the bridge even through there is no fatigue detail.



CROSS SECTION

DESIGN DATA

Specifications - A.A.S.H.O.

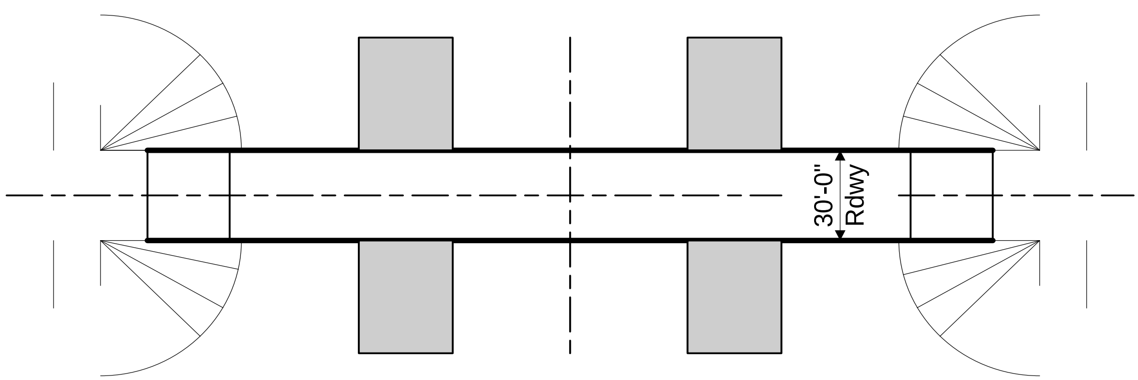
Loading HS 15-44

Future Paving Allowance 18 lbs./ft^2

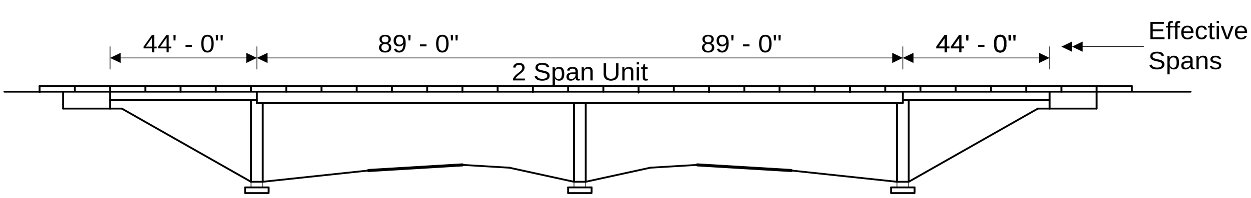
MATERIALS

Structural Steel A-36 or A-572 Grade 50

Concrete f_c' = 3000 psi



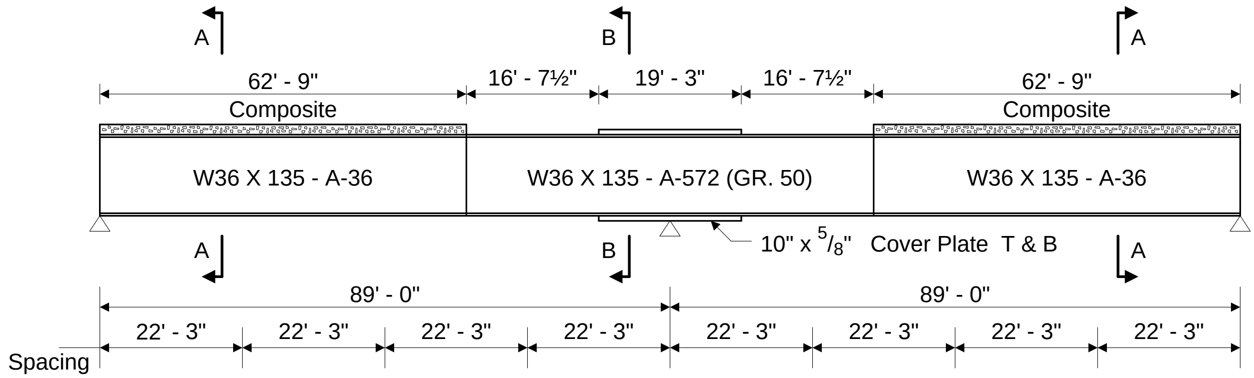
PLAN



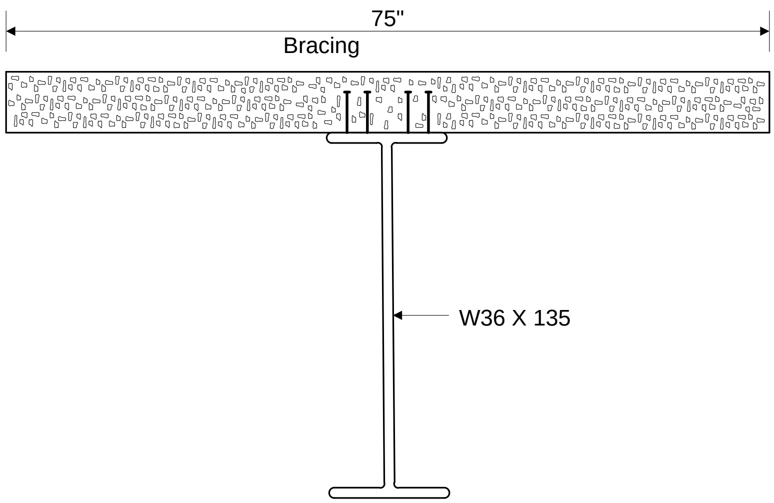
ELEVATION

Figure 7.3.1 Example Problem 3 - Details

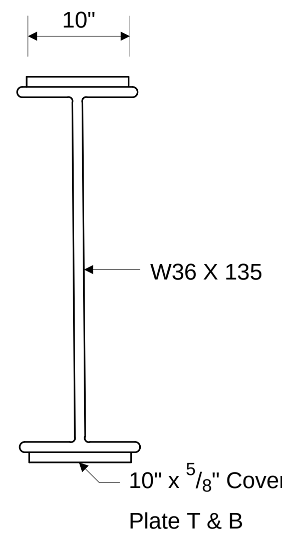
UNSHORED CONSTRUCTION



LONGITUDINAL SECTION



SECTION A-A



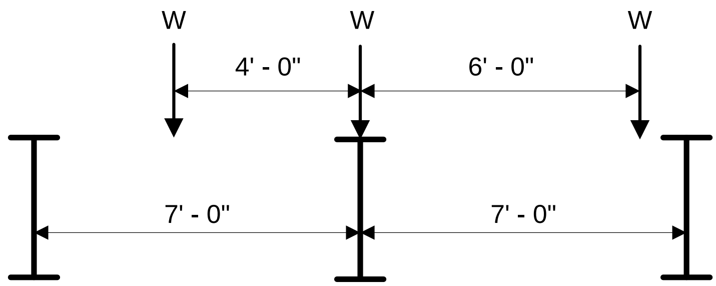
SECTION B-B

FATIGUE DATA

Light Traffic - 100,000 cycles

Figure 7.3.1 Example Problem 3 - Details (cont.)

DISTRIBUTION FACTOR FOR SHEAR



$$D.F. = 1 + \frac{(7.0 - 4.0)}{7.0} + \frac{(7.0 - 6.0)}{7.0} \text{ Wheels } = \frac{1.571}{2} \text{ Axles } = 0.785$$

DISTRIBUTION FACTOR FOR MOMENT

$$\mathbf{D.\ F.} = \frac{S}{5.5} = \frac{7.0}{5.5} \textbf{ Wheels } = \frac{7.0}{(5.5)(2)} \textbf{ Axles } = \mathbf{0.636}$$

DISTRIBUTION FACTOR FOR DEFLECTION

$$\mathbf{D.\ F.} = \frac{(\text{No. Lanes})(\text{Reduction Factor})}{\text{No. Beams}} = \frac{(2)(1.0)}{5} = 0.400$$

Figure 7.3.2 Example Problem 3 - Input Calculations

DEAD LOADS - DL1:

Coping estimated at 11 #/ft	=	**0.011**
Bracing & misc.	=	**0.020**
Total		**0.031 kips/ft**

DEAD LOADS - DL2:

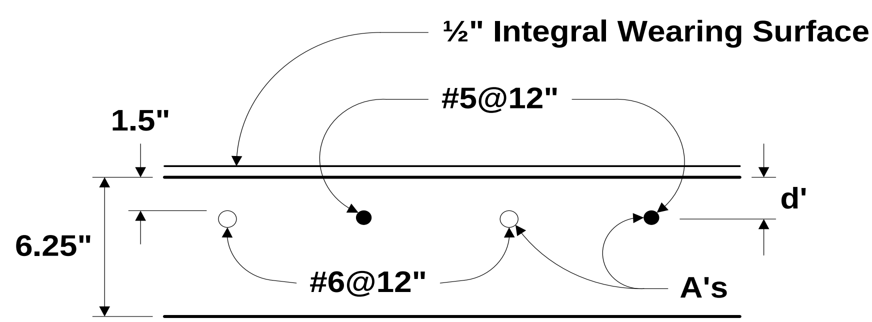
Parapet $(1.08)(1.5)(0.150)(2)(1/5) = 0.097$

Rail est. @ 22 #/ft $(0.022)(2)(1/5) = 0.009$

Future Paving $(30)(0.018)(1/5) = 0.109$

Total 0.215 **kips/ft**

CONCRETE MEMBER PROPERTIES



$$A_s' = 0.31 + 0.44 = 0.71\,in^2$$

$$d' = 1.5 + 0.75/2 = 0.875\ in$$

Figure 7.3.2 Example Problem 3 - Input Calculations (cont.)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BAR7
BRIDGE ANALYSIS AND RATING

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PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STATE ROUTE	SEGMENT	OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB	SKEW CORRECTION FACTOR	PONY TRUSS	PDF	COMPACT
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72		77	78	79
=BRRAT	12	1234	1234	1234	2-SPAN WIDE FLANGE BEAM	GGG	I25		B	0	.	.	.	Y	Y				.			.			

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	MOMENT	DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC	GUSSET	PATCH	UNSYM PIER
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74	77	78	79
.	7.00	.	.	0.785	0.636	0.400	6.75	0.00	0.031	0.215	3.000	10	Y								.	.				

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
C	89.00	89.00	.	.	.	.	.	.	.	.	.	.	.	.	.

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66
.	.	.	.	.	.	.	.	.	.	.	.	.	.

Figure 7.3.3 Example Problem 3 - Input

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

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CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs IR	ALLOWABLE Fs OR	ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
S					1.88	0.71	50							

STIRRUP DETAILS

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

Figure 7.3.3 Example Problem 3 - Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

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STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE WIDTH	TOP PLATE THICK	BOTTOM PLATE WIDTH	BOTTOM PLATE THICK	COMPOSITE	FY	HYBRID FY TOP	HYBRID FY BOT	UNSYMMETRICAL CG TOP	UNSYMMETRICAL CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
G	1	62.75	W	78200.0	39.80	0.7940	11.945		35.55	0.5980					Y	36.0				
G	1	79.38		78200.0	39.80	0.7940	11.945		35.55	0.5980					N	50.0				
G	1	89.00		78200.0	39.80	0.7940	11.945		35.55	0.5980	10.00	0.6250	10.00	0.6250	N	50.0				

Figure 7.3.3 Example Problem 3 - Input (cont.)

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BAR7
BRIDGE ANALYSIS AND RATING

LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO.	BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
		CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47	52	53	55	60	61	63
BG	1	C	1	89.00	B	4	22.25			.			.			.			.			.			.
				.			.			.			.			.			.			.			.
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Figure 7.3.3 Example Problem 3 - Input (cont.)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BAR7
BRIDGE ANALYSIS AND RATING

Form 8 of 9

FATIGUE DATA

YEAR BUILT	PREVIOUS COUNT		RECENT COUNT		FUTURE COUNT		R OR N	ONE LANE DISTR FACTOR	NO OF GVWD
	YEAR OR GF	ADTT	YEAR	ADTT	YEAR OR GF	ADTT			
1	5	9	13	17	21	25	29	30	34
1956	1980	600	1988	820	0500		R	0.500	

GIRDER FATIGUE DETAIL

SPAN NO	DIST FROM CL BRG	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY
1	2	7	12	14	19	21	26	28	33
1	62.75	0.00	B	34.98	C				
1	79.38	0.63	E	36.18	E				
1	89.00								

GROSS VEHICLE WEIGHT DISTRIBUTION

GROSS VEHICLE WEIGHT		NO OF SINGLE UNIT TRUCKS			NO OF SINGLE UNIT TRUCKS		
MIN	MAX	2 AXLE	3 AXLE	4 AXLE	3 AXLE	4 AXLE	5 OR > AXLE
1	6	11	15	19	23	27	31

Figure 7.3.3 Example Problem 3 - Input (cont.)

7.4 EXAMPLE PROBLEM 4

7.4.1 Problem Description

This is an example of a girder-floorbeam-stringer type **(GFS)** bridge. The main girder is a six-span symmetrical plate girder with a parabolic haunch and two in-span hinges. The floorbeams have a wide flange section between main girders and a straight haunch section in the overhang portion of the deck. The bridge has some fatigue-prone details. The main girder and stringers are assumed to act as composite sections both in the positive and negative moment regions. All structural steel conforms to ASTM-A36-62T steel. Figure 7.4.1 on page 7-30 shows the details of the bridge.

7.4.2 Input

The following input lines are entered. Refer to the completed input data sheets shown in Figure 7.4.3 on page 7-34.

1. Project Identification
   - The BRIDGE TYPE is "GFS".
   - The SLC LEVEL is left blank since the Safe Load Capacity Ratings are not desired.
   - "D" is entered for LANES indicating that the ratings are desired based on one lane loaded as described later.
   - The bridge is to be analyzed for the HS20 loading, therefore a "B" is coded for LIVE LOAD.
   - OUTPUT option equal to 0 is used so that all computed values will be printed.
   - Impact factor will be calculated by the program as per AASHTO Specifications.
   - Fatigue analysis of certain details is requested.
   - The bridge has a concrete deck**, CONC DECK = "Y"**.
2. Bridge Cross Section and Loading
   - Bridge cross section dimensions are taken from plans.
   - DISTRIBUTION FACTORS for stringer are computed as shown in Figure 7.4.2 on page 7-32.
   - SLAB THICKness varies from 8 inches to 8.5 inches across the deck. Total thickness of 9 inches is entered to get 8.5 inches effective thickness.
   - DL1 is the dead load due to the weight of stiffeners and other **hardware attached to the girder**.
   - DL2 is the dead load due to the weight of curb, parapet, railing, etc. as calculated and shown in Figure 7.4.2 on page 7-32.
   - F'C of 3.5 ksi and N of 8 are taken from design computations.
   - The girder is symmetric about the centerline of pier 3, so a "Y" is coded for SYMMETRY.
   - **STRINGER DL1 is blank assuming there is no DL1 for stringers.**
   - **FLOORBEAM DL1 is blank assuming there is no DL1 for floorbeams.**

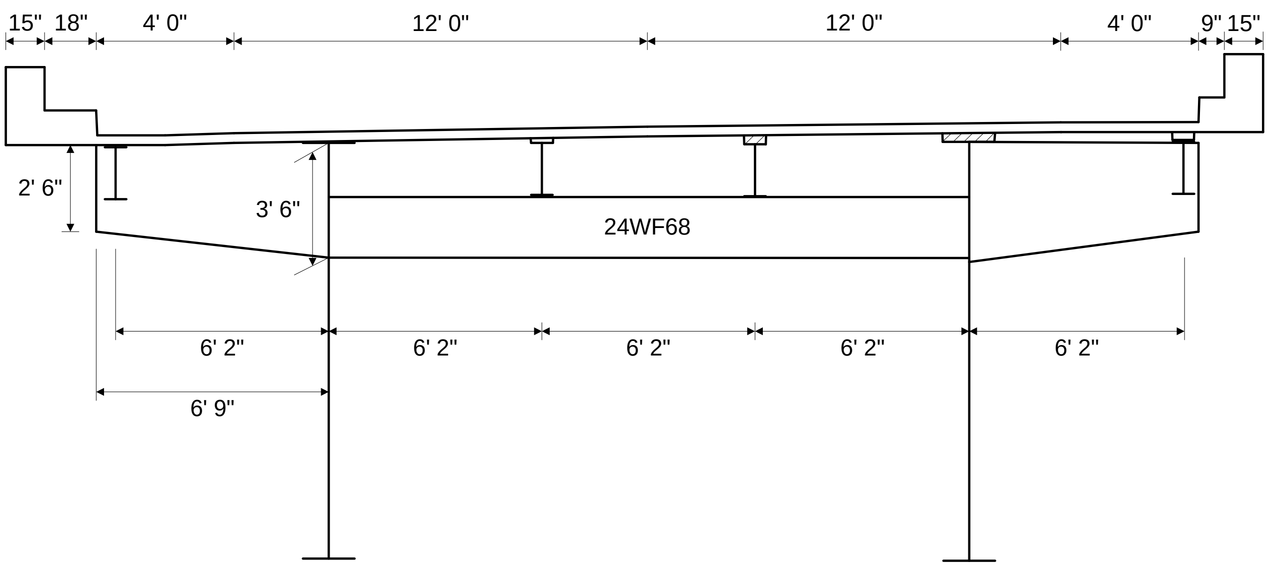
3. Span Lengths
   - "H" is entered for CONT. because the girder has in-span hinges. The girder span lengths are taken from the plans.
4. Hinge Locations
   - The distance of hinges in spans 2 and 5 are measured from the left bearing in span 1.
5. Traffic Lane Locations
   - A 16.0 feet wide lane at the left is considered if the ratings are desired for loaded lanes. Since "D" is entered for LANES, the program will not calculate ratings based on the loaded lanes. This line is entered because it is required for this type of bridge.
6. Stringer Span Lengths
   - The first two floorbeams near the left abutment are to be analyzed. Spacings of these floorbeams are entered as stringer span lengths. Span length 3 is the spacing between floorbeams 2 and 3. Even though floorbeam 3 is not analyzed, this spacing must be entered. The stringer is assumed to act as a continuous span between the floorbeams, so "C" is entered for CONT.
7. Stringer Locations
   - Since the main girder is also supporting the deck along with the stringers, the location of the main girder must also be entered as a stringer location.
8. Concrete Member Properties
   - The deck is a concrete slab; therefore an "S" is entered for TYPE.
   - D' and A_s' refer to the longitudinal reinforcement in the deck. These values will be used in calculating the composite section properties for sections subjected to negative moments in the main girder and stringer.
   - Grade 50 bars are used as a deck reinforcement.
9. Steel Member Properties
   - Since the bridge was declared symmetric, only the girder properties up to the point of symmetry are entered.
   - The first set of properties are for a girder, so "G" is coded for G F OR S.
   - Member properties are entered for SPAN NO. 1, 2 and 3.
   - The RANGE for each segment is the distance from the left end of each span to the right end of the segment being described.
   - The SECT TYPE is "P" for the first range because the cross section is a welded plate girder.
   - Certain sections are in a parabolic haunch where web depth varies as a parabola. Flange dimensions and/or web thickness also vary within the haunched segment. Therefore, the haunched segment is further divided into different ranges with each range having constant flange dimensions and web thickness. The web depth at the end of a parabolic haunch

only is to be entered. A "P" for input item VARIES will indicate that this range has a parabolic haunch. The input of WEB PLATE DEPTH and a "P" for a given range will indicate the end of a parabolic haunch. For example, the parabolic haunch in span 1 begins at 81 feet and ends at 122 feet, but the web thickness changes at 103.5 feet. Therefore, the segment between 81 feet and 122 feet is divided into two ranges, one ends at 103.5 feet and the other ends at 122 feet. The web depth is entered for a range of 122 feet since it is the end of a parabolic haunch in span 1. The web depth at 103.5 feet will be calculated by the program by assuming that the web depth varies from 108 inches to 144 inches between 81 feet and 122 feet as a parabola.

- Each segment is specified as composite by entering a "Y" for COMPOSITE.
- The girder has a homogeneous section. Therefore, HYBRID FY's and UNSYMMETRICAL CG's are not entered.
- Floorbeam 1 is a plate girder type section. Since the floorbeam has an overhang, at least two ranges (one at 0.0) must be entered for the overhang portion. The range for the overhang is entered as a negative value.
- Floorbeam 2 has a wide flange section between the main girders. The overhang portion of floorbeam 2 is a plate girder section. Therefore, the entire member has been entered as a plate girder with a SECT TYPE of "P". The wide flange portion has been approximated by entering the flange properties as the TOP and BOTTOM PLATE and subtracting the flange thicknesses from the beam depth to get the WEB PLATE DEPTH.
- The web depths of overhang portions of both the floorbeams vary as a straight haunch. Therefore, an "S" is entered for VARIES for a range equal to -6.75 feet.
- The stringer is a wide flange beam without any cover plates. Therefore, the moment of inertia, area, beam depth and web thickness are entered. It is also entered as a composite section.

10. Lateral Brace Points and Stiffener Spacings
    - The top flange for the entire girder is assumed to be continuously supported.
    - The bottom flange brace points are taken from the plans and are entered for each span up to span 3 only since the girder is symmetrical.
    - The maximum stiffener spacing is 4.5. Therefore, total number of equal spaces closest to the span length are entered with the remainder spaces near the support for each span. The girder has a longitudinal stiffener and transverse stiffeners. "L" is entered for STIFFENER CODE for the entire span.
    - The value for NO. OF SPACES for BRACE POINTS for the overhang portion of the floorbeam is entered as a negative indicating that this spacing is on the overhang portion.
    - Stringers will be assumed unstiffened, top flange continuously braced and bottom flange braced at the floorbeam supports.

11. Fatigue Data
    - The bridge was built in 1966.
    - The past growth factor for ADTT is assumed as 3%.
    - The most recent count for ADTT was taken in 1989 and the ADTT was 600 trucks per day in one direction.
    - The ADTT data for the year 1996 is estimated to be 790. The program will compute the remaining life of the girder based on the future growth factor calculated from this estimate.
    - The bridge has a non-redundant load path.
    - The ONE LANE DISTR FACTOR is calculated to be 0.837 lanes (axles) by placing the HS20 truck with one wheel right over the left main girder and the second wheel 6 feet away to the right.
12. Girder Fatigue Detail
    - Fatigue-prone details are determined from plans and are entered as shown on the input form.



Typical Section

Figure 7.4.1 Example Problem 4 - Details

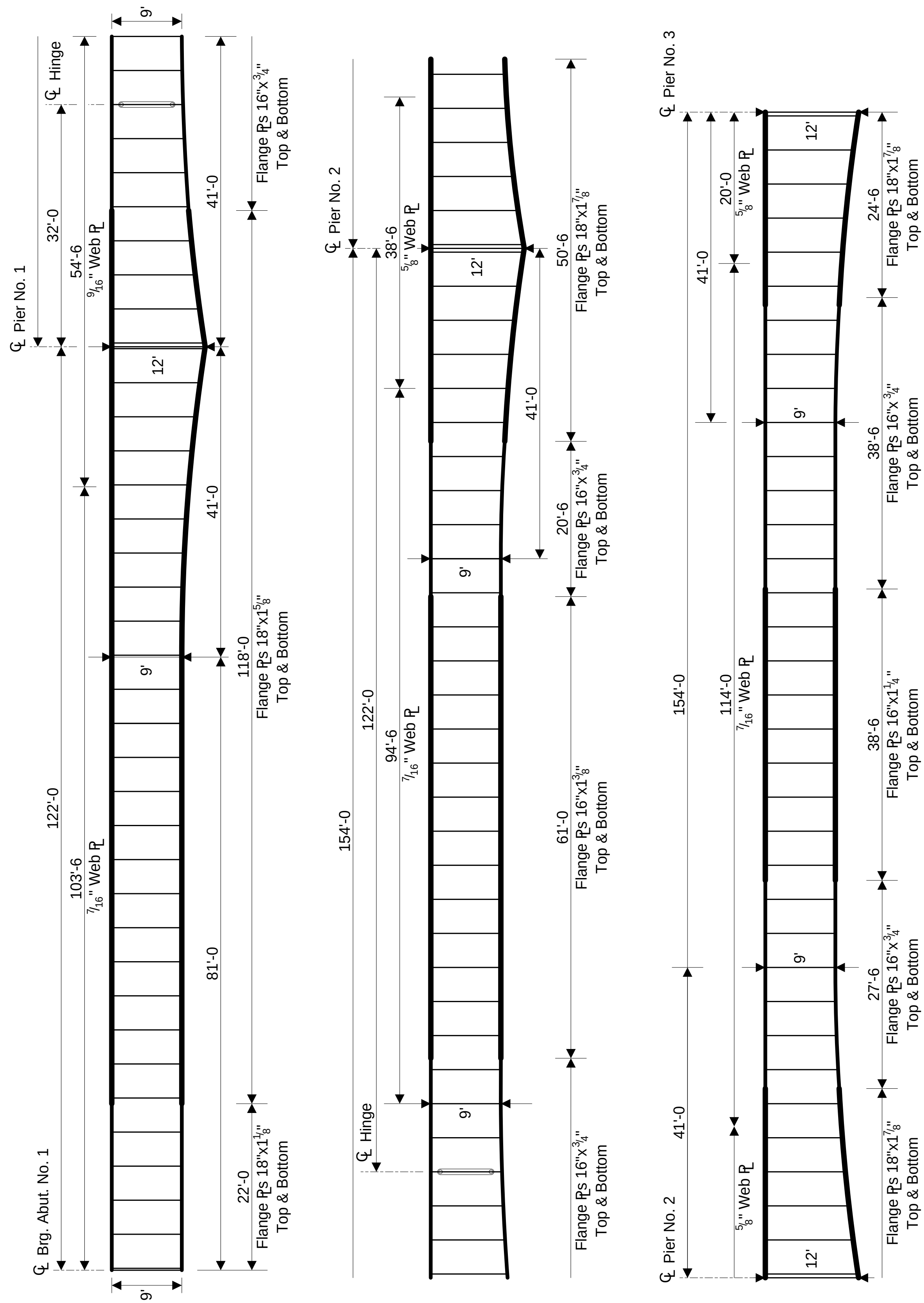
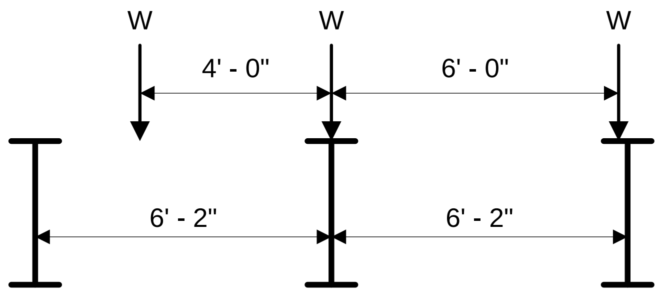


Figure 7.4.1 Example Problem 4 - Details (cont.)

DISTRIBUTION FACTOR FOR SHEAR



$$\text{D.F.} = 1 + \frac{(6.17 - 4.0)}{6.17} + \frac{(6.17 - 6.0)}{6.17}\ \text{Wheels} = \frac{1.38}{2}\ \text{Axles} = 0.690$$

DISTRIBUTION FACTOR FOR MOMENT

$$\textbf{D. F.} = \frac{S}{5.5} = \frac{6.17}{5.5}\ \textbf{Wheels} = \frac{6.17}{(5.5)(2)}\ \textbf{Axles} = \textbf{0.561}$$

DISTRIBUTION FACTOR FOR DEFLECTION

$$\textbf{D. F.} = \frac{(\text{No. Lanes})(\text{Reduction Factor})}{\text{No. Beams}} = \frac{(2)(1.0)}{6} = 0.333$$

Figure 7.4.2 Example Problem 4 - Input Calculations

Dead Loads – DL1:

Cant Brkt Fl	at 10.2 #/ft x 12.2'	= 0.124		
Cant Brkt Web	at 36 #/ft x 6.67'	= 0.240		
Cant Brkt Stiff	at 5.1 #/ft x 5.5'	= 0.028		
Tie Plate (8x⅝)	at 17 #/ft x 4.5'	= 0.077		
Tie Plate (8x½)	at 13.6 #/ft x 1.5'	= 0.020		
Post (18WF45)	at 45 #/ft x 1.5'	= 0.068		
F.B. Brkt (8WF)	at 24 #/ft x 9'	= 0.216		
F.B. Brkt (angles)	at 8.5 #/ft x 10'	= 0.085		
Lat. Brac	at 10.5 #/ft x 25'	= 0.263		
Conn. Plates	say 100 #	= 0.100		
		1.221 kips / 20'	=	0.061 kips/ft
SIP forms	18.75' x 15 #/ft		=	0.280
Stiff (trans)	at 7.7 #/ft x 9' x 2/4.5		=	0.031
Stiff (long)	at 6.4 #/ft		=	0.006
Misc	say ~ 10%		=	0.065
				0.443 kips/ft

Dead Loads – DL2:

Parapet	(0.78)(2.75)(0.150)	=	0.322
	(1.30)(1.25)(0.150)	=	0.244
Railing	say 20 #/ft	=	0.020
			0.586 kips/ft

Deck Thickness

t = 8" orig. deck - ¼" scarification + 1 + ¼" LMC Overlay

t = 9"

Figure 7.4.2 Example Problem 4 - Input Calculations (cont'd)

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BRIDGE ANALYSIS AND RATING

PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STRUCTURE IDENTIFICATION: STATE ROUTE	STRUCTURE IDENTIFICATION: SEGMENT	STRUCTURE IDENTIFICATION: OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72
=BRRAT	46	0422	0030	2212	RT 422 SCHUYLKILL RIVER	GFS		D	B	0	.	.	.	Y	Y				.		

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	DISTRIBUTION FACTORS: MOMENT	DISTRIBUTION FACTORS: DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	BRIDGE DEAD LOADS: DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74
37.50	6.75	-6.75	32.00	0.690	0.561	0.333	9.00	0.00	0.443	0.586	3.500	8	Y								.	.	

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
H	122.00	154.00	154.00	154.00	154.00	122.00	.	.	.	.	.	.	.	.	.

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66
154.0	706.0	.	.	.	.	.	.	.	.	.	.	.	.

Figure 7.4.3 Example Problem 4 - Input

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TRAFFIC LANE LOCATIONS

1			2			3			4			5			6		
DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL
1	5	9	12	16	20	23	27	31	34	38	42	45	49	53	56	60	64
0.00	16.00	100															

STRINGER SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58
C	21.43	21.43	21.43												

STRINGER LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5	9	13	17	21	25	29	33	37	41	45	49	53	57
-6.17	0.00	6.17	12.33	18.50	24.67									

Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

Form 3 of 9

CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs IR	ALLOWABLE Fs OR	ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
S					2.87	0.75	50							

STIRRUP DETAILS

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

Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

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STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE		BOTTOM PLATE		COMPOSITE	FY	HYBRID		UNSYMMETRICAL	
											WIDTH	THICK	WIDTH	THICK			FY TOP	FY BOT	CG TOP	CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
G	1	22.00	P						108.00	0.4375	18.00	1.1250	18.00	1.1250	Y	36.0				
G	1	81.00							108.00	0.4375	18.00	1.6250	18.00	1.6250	Y	36.0				
G	1	103.50						P		0.4375	18.00	1.6250	18.00	1.6250	Y	36.0				
G	1	122.00						P	144.00	0.5625	18.00	1.6250	18.00	1.6250	Y	36.0				
G	2	18.00						P		0.5625	18.00	1.6250	18.00	1.6250	Y	36.0				
G	2	41.00						P	108.00	0.5625	16.00	0.7500	16.00	0.7500	Y	36.0				
G	2	47.00							108.00	0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	2	108.00							108.00	0.4375	16.00	1.3750	16.00	1.3750	Y	36.0				
G	2	113.00							108.00	0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	2	128.50						P		0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	2	135.50						P		0.4375	18.00	1.8750	18.00	1.8750	Y	36.0				
G	2	154.00						P	144.00	0.6250	18.00	1.8750	18.00	1.8750	Y	36.0				
G	3	20.00						P		0.6250	18.00	1.8750	18.00	1.8750	Y	36.0				
G	3	25.00						P		0.4375	18.00	1.8750	18.00	1.8750	Y	36.0				
G	3	41.00						P	108.00	0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	3	52.50							108.00	0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				

Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
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BAR7
BRIDGE ANALYSIS AND RATING

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STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE WIDTH	TOP PLATE THICK	BOTTOM PLATE WIDTH	BOTTOM PLATE THICK	COMPOSITE	FY	HYBRID FY TOP	HYBRID FY BOT	UNSYMMETRICAL CG TOP	UNSYMMETRICAL CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
G	3	91.00							10.800	0.4375	16.00	1.2500	16.00	1.2500	Y	36.0				
G	3	113.00							10.800	0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	3	129.50						P		0.4375	16.00	0.7500	16.00	0.7500	Y	36.0				
G	3	134.00						P		0.4375	18.00	1.8750	18.00	1.8750	Y	36.0				
G	3	154.00						P	14.400	0.6250	18.00	1.8750	18.00	1.8750	Y	36.0				
F	1	0.00	P						4.200	0.3750	10.00	0.4375	10.00	0.4375		36.0				
F	1	-6.75						S	1.500	0.3750	10.00	0.4375	10.00	0.4375		36.0				
F	1	9.25							4.100	0.3750	8.00	0.3750	8.00	1.3750		36.0				
F	2	0.00	P						4.200	0.3750	8.00	0.3750	8.00	0.3750		36.0				
F	2	-6.75						S	2.400	0.3750	8.00	0.3750	8.00	0.3750		36.0				
F	2	9.25							2.256	0.4150	8.97	0.5850	8.97	0.5850		36.0				
S			W	800.00	14.70	0.	7.495		1.799	0.3580					Y	36.0				

Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

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LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO.	BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
		CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47	52	53	55	60	61	63
BG	1	C	1	122.00	B	1	1.50	B	6	19.00	B	1	6.50			.			.			.			.
BG	2	C	1	154.00	B	1	10.92	B	1	19.50	B	1	5.11	B	1	18.86	B	5	18.87	B	1	5.26			.
BG	3	C	1	154.00	B	1	16.17	B	6	21.43	B	1	9.25			.			.			.			.
SG	1	L	1	0.25	L	27	4.50	L	1	0.25			.			.			.			.			.
SG	2	L	1	0.50	L	34	4.50	L	1	0.50			.			.			.			.			.
SG	3	L	1	0.50	L	34	4.50	L	1	0.50			.			.			.			.			.
BF	1	T	-1	6.75	T	2	6.17	B	-1	6.75	B	2	9.25			.			.			.			.
BF	2	T	-1	6.75	T	2	6.17	B	-1	6.75	B	2	9.25			.			.			.			.
SF	1	T	-2	3.08	T	1	1.17	T	1	2.00	T	1	3.00	T	1	6.17			.			.			.
SF	2	T	-2	3.08	T	1	1.17	T	1	2.00	T	1	3.00	T	1	6.17			.			.			.
				.			.			.			.			.			.			.			.
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Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

BAR7
BRIDGE ANALYSIS AND RATING

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FATIGUE DATA

YEAR BUILT	PREVIOUS COUNT		RECENT COUNT		FUTURE COUNT		R OR N	ONE LANE DISTR FACTOR	NO OF GVWD
	YEAR OR GF	ADTT	YEAR	ADTT	YEAR OR GF	ADTT			
1	5	9	13	17	21	25	29	30	34
1966	0300		1989	600	1996	790	N	0.837	0

GIRDER FATIGUE DETAIL

SPAN NO	DIST FROM CL BRG	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY
1	2	7	12	14	19	21	26	28	33
1	21.90	2.12	C	4.12	E	.		.	
1	41.00	2.62	C	4.62	E	.		.	
1	48.80	2.62	C	.		.		.	
1	60.00	2.62	C	4.62	E	.		.	
1	69.90	2.62	C	23.25	E	88.00	E	.	
1	76.00	2.62	C	4.62	E	.		.	
1	85.10	2.62	C	23.30	E	88.33	E	109.00	C
1	122.00	114.63	C	.		.		.	
2	74.80	2.37	C	4.37	E	.		.	
2	77.00	2.37	C	.		.		.	
2	90.60	2.37	C	4.37	E	.		.	
2	103.50	2.37	C	23.00	E	87.75	E	108.38	C
2	109.50	1.75	C	3.75	E	22.37	E	87.13	E
2	126.10	1.75	C	23.12	E	90.24	E	111.61	C
2	133.70	2.87	C	25.40	E	96.00	E	117.64	C

GROSS VEHICLE WEIGHT DISTRIBUTION

GROSS VEHICLE WEIGHT		NO OF SINGLE UNIT TRUCKS			NO OF SINGLE UNIT TRUCKS		
MIN	MAX	2 AXLE	3 AXLE	4 AXLE	3 AXLE	4 AXLE	5 OR > AXLE
1	6	11	15	19	23	27	31

Figure 7.4.3 Example Problem 4 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF INFORMATION SYSTEMS

Form 8 of 9

BAR7
BRIDGE ANALYSIS AND RATING

FATIGUE DATA

YEAR BUILT	PREVIOUS COUNT YEAR OR GF	PREVIOUS COUNT ADTT	RECENT COUNT YEAR	RECENT COUNT ADTT	FUTURE COUNT YEAR OR GF	FUTURE COUNT ADTT	R OR N	ONE LANE DISTR FACTOR	NO OF GVWD
1	5	9	13	17	21	25	29	30	34

GIRDER FATIGUE DETAIL

SPAN NO	DIST FROM CL BRG	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY	DIST FROM BOTTOM	CATEGORY
1	2	7	12	14	19	21	26	28	33
2	154.00	144.88	C						
3	29.00	1.75	C	23.00	E	89.75	E	111.00	C
3	39.10	1.75	C	3.75	E	87.21	E	107.83	C
3	49.00	1.75	C	22.37	E	87.13	E	107.75	C
3	60.50	2.25	C	4.25	E				
3	77.00	2.25	C						
3	78.90	2.25	C	4.25	E				
3	97.60	1.75	C	22.37	E	87.13	E	107.75	C
3	100.40	1.75	C	3.75	E				
3	127.60	1.75	C	23.31	E	91.00	E	112.55	C
3	154.00	144.88	C						

GROSS VEHICLE WEIGHT DISTRIBUTION

GROSS VEHICLE WEIGHT MIN	GROSS VEHICLE WEIGHT MAX	NO OF SINGLE UNIT TRUCKS 2 AXLE	NO OF SINGLE UNIT TRUCKS 3 AXLE	NO OF SINGLE UNIT TRUCKS 4 AXLE	NO OF SINGLE UNIT TRUCKS 3 AXLE	NO OF SINGLE UNIT TRUCKS 4 AXLE	NO OF SINGLE UNIT TRUCKS 5 OR > AXLE
1	6	11	15	19	23	27	31

Figure 7.4.3 Example Problem 4 - Input (cont'd)

7.5 EXAMPLE PROBLEM 5

7.5.1 Problem Description

This is an example of a single span thru truss bridge. The truss has 6 panels and it is symmetric. The center two panels have counters. The timber deck is supported by stringers. The floorbeams are attached at the bottom panel points. Figure 7.5.1 on page 7-45 gives details and shows sketches of the various views of the bridge.

7.5.2 Input

The following input lines are entered. Refer to the completed input data sheets shown in Figure 7.5.3 on page 7-48.

1. Project Identification
   - BRIDGE TYPE is "TFS".
   - The allowable stress for Safe Load Capacity is 25% higher than the Inventory stress.
   - "L" is entered for LANES indicating that the Safe Load Capacity ratings are desired and the traffic lanes described later are the lanes that are in service.
   - Ratings are desired only for the HS20 loading, so a "B" is coded for LIVE LOAD.
   - A "0" is coded for OUTPUT so that tables of moments, shears, stresses, deflections, axial force and ratings will be printed at various sections of a member.
   - IMPACT FACTOR should be in accordance with the AASHTO Specifications. This is the default when this item is left blank.
   - The GAGE DISTANCE of 6 feet as specified in the AASHTO Manual is the default when left blank.
   - The PASSING DISTANCE should be 4 feet to give a 2 foot distance from curb to outside wheel for the single lane as specified in the AASHTO Manual. This is also the default when left blank.
2. Bridge Cross Section and Loading
   - DECK WIDTH, CENTERLINE OF TRUSS TO CURB distance and ROADWAY WIDTH are taken from the sketches.
   - OVERHANG is left blank because the continuity of the floorbeam is not to be considered.
   - DISTRIBUTION FACTORS for SHEAR, MOMENT and DEFLECTion are computed according to AASHTO Specifications as shown in Figure 7.5.2 on page 7-47.
   - SLAB THICKness is zero since there is no concrete deck. The weight of the timber deck will be included under DEAD LOADS.
   - DL1 is left blank since the dead loads acting on a truss are entered separately under TRUSS DEAD LOADS.
   - DL2 is the dead load due to the wood deck as computed in Figure 7.5.2 on page 7-47.

- F'C and N are left blank because there is no concrete in the superstructure.
- Since the truss is symmetric about the joint at the center of the span, "Y" is entered for SYMMETRY.
- The live load is to be applied at the lower joints, so "L" is entered for LL.
- The total NO. OF PANELS is 6.
- Truss members have pinned end connections, so "P" is entered for END COND.
- "S" is entered for CORS because the Secant Formula is to be used in determining the allowable compression in a truss member with end eccentricity.
- For the analysis of this truss, the hinged support (HINGE) is at joint L 0.
- The effect of temperature change is not to be considered for deflection computations, so TEMP CHANGE is left blank.
- "Y" is entered for gusset plate analysis and rating.

3. Span Lengths
   - This is a simple span truss with a span length of 89.1 feet, measured center-to-center of bearing, as shown in Figure 7.5.1 on page 7-45. The length between abutments (84 feet) is not the value to be entered here.
   - "S" is entered for CONT.
4. Traffic Lanes
   - Since "L" is entered for LANES in the PROJECT IDENTIFICATION line, the traffic lanes that are in service must be described here. There is only one traffic lane occupying the entire width of the roadway. This lane is at a DIST of 1.5 feet from the left curb and has a WIDTH of 10 feet. 100 % of the live load is to be applied to this lane (%LL).
5. Stringer Span Lengths
   - Since this is a truss type bridge and stringers are to be analyzed as simple spans over floorbeams, CONT. is equal to "S". Due to symmetry, only the first three STRINGER SPAN LENGTHS need to be entered in order for the program to rate all floorbeams.
6. Stringer Locations
   - Distances of all 8 stringers from the left truss are entered.
7. Truss Geometry
   - Since the truss is declared symmetrical only the geometry of panels 1, 2 and 3 should be described.
   - The first PANEL NUMBER is 1, since there is no vertical member L0U0.
   - All PANEL WIDTHs are equal to 14.85 feet. A check here shows that the sum of six panel widths is 89.1 feet, which equals the truss span length entered earlier.
   - Y is entered for Y OR N since a vertical is present in each panel.
   - The length of the vertical member on the right side of each panel (16.00 feet) is entered for H1.

- The value of H2 is left blank for each panel because there is no joint between the upper and lower joints.
- The values of H3 are also left blank because the elevation of the lower joint on the right-hand side of each panel is at the same elevation as the lower joint on the left hand side of each panel.
- The PANEL TYPE is coded for each panel according to Figure 5.12.2 on page 5-58 in Chapter 5. Note that panel 3 has counters, which corresponds with PANEL TYPE 13.

8. Truss Dead Loads
   - All dead loads acting on the truss were computed from the data available from details (Refer to Figure 7.5.1 on page 7-45).
9. Truss Member Properties
   - All truss member properties were computed from the details given in plans or field notes (See Figure 7.5.1 on page 7-45). The yield strength of all steel used in this old bridge was determined to be 26 ksi.
   - Also note that areas or moments of inertia for some members are less than would be calculated from the plans. Engineering judgment must be used to enter these values so that they reflect the actual deteriorated state of the materials in the field. For example, members L0L1, L1L2 and L2L3 are shown on the sketches to be the same (Two 2" X 3/4" Bars). During inspection of this structure, it was discovered that in both the second and third panels, only one of the bars was acting to support the structure. This is reflected in the coding of the properties for members L1L2 and L2L3.
10. Steel Beam Properties
    - All Member properties for floorbeams 1 (under joint 2), 2 and 3 and an I-beam stringer were obtained from plans. Here again, engineering judgment was used to code these values to reflect the deteriorated state of materials.
11. Gusset Plate Properties
    - All gusset plate properties left to the point of symmetry were entered to show the gusset plate calculations. Please note that these are fake numbers which may not reflect the actual information in the plan.
    - This is a double-sided gusset plate connection and the thickness of gusset plate at each side is 0.625 in. Fy is 33 ksi and Fu is 50 ksi.
    - The shear capacity of all fasteners at the operating level is 35 ksi and the diameter of all fasteners is 1 in.
12. Gusset Plate Member Properties
    - All gusset plate member properties left to the point of symmetry were entered to show the gusset plate calculations for each truss member. Please note that these are fake numbers which may not reflect the actual information in the plan.

FORM NO. 432 Rev.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

Owner State	Maintained By State	Type Thru Truss
By Leg. Act No.	Extent	No. of Spans and Length 1@ 84.0 '
Erected 1902	P.S.C. - P.U.C. Order #	Underclearance 8.25'
By King Bridge Co	Dated	Clear Rdwy. Width 13'
Cost	Plan No.	Skew 90° Rt. -Lt. Ahead

Members	Vert. Clear	Type	Safe Load	Mat'ls and Size	Span C-C Bear. Or Length	Panels or Spacing	C.C. Trusses C.C. Girders	C-C Chords B-B Flags	Connected With
TRUSSES	13.9'	Thru	4 Ton	Steel	84.0'		15.0'	16.0'	Abuts.
		Design							
		Posted	5 T						
GIRDERS									
FLOOR BEAMS		I Beam		Steel					Trusses
				12" x 5"					
STRINGERS		I Beam		Steel		Av. 24"			Floor Beams
		Chan.		60 6" x 3-1/8"					
				20 6" x 2"					
RDY. FLOOR		Lam.		0-0 Width 13.0' Thickness 4"					
SIDEWALKS				Number ____ Side ____ Width ______ Thickness________					
SURF.				Width ______________ Thickness					

SUBSTRUCTURE	MATERIAL	CONDITION	PLAN NO.	FOUNDED ON	ACID PROTECTION
ABUTMENTS	Dry stone	Poor		Gravel	

SKETCH BELOW: (A) Plan includign approaches, length of wings, abutments and piers (B) Side Elevation of Bridge showing outline of strucutre, clear spans, width of abutments and pier tops, underclearances, grades and profile on centerline of roadway including approaches (C) Cross Sections of bridge showing roadway and sidewalk widths, overhead clearance, superelevations, etc. Show location of occupancies on plan, elevation and cross section by dashed lines and solid circles.

See Sheets 2 and 3

Sheet 1 of 3

County Wyoming Leg. Rt 65046
Twp. Forkston Appl. ________
Boro. ____________ Tr. Rt. 234
City ____________ Sta. 589 + 58
Str. or Railroad N. Br. Mehoopany Cr.
Field Book No. 10475/14787 Page 26/67-72
Quad. Wyo. Co. Map N 9.45" E 4.60"
Drain Area 50.0 Mi. Runoff 10900
Str. Slope 2 % Scaled-Surveyed
Opening Ft 693 Ft. Effic. 95 %
Appr. By ____________ Date ______
H.W. 1.0 Above Br. FL. Sf.
H.W. Elev. ____________ Date 1936
Leg. R/W Width _______ Ft. Estab. ____
Leg. Slope Limit Ft. _____ Lt. ____ Rt. ____
Is Bridge Lighted No By ________

OCCUPANCIES

OWNER	LICENSE	APPR.	FEE
	No.		
	No.		
	No.		
	No.		
	No.		

REPAIRS

Date	Character	Cost

PAINTING RECORD

Date	Tons	Area	No. Coats	Cost

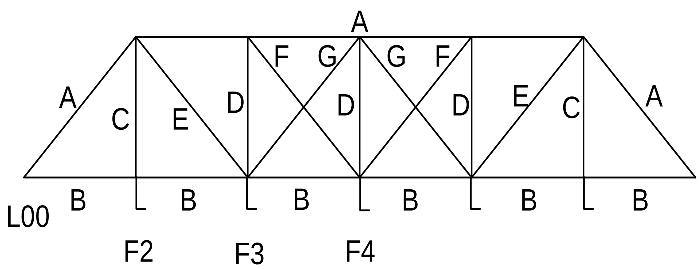
AMT. REQUIRED FOR LAST

No. 1 P.L.	No. 8 S.S.	No. 9 Brab	No. 12 White	Spar Varn.	Al. Baste

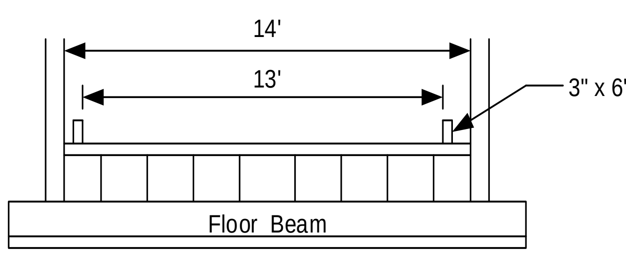
Figure 7.5.1 Example Problem 5 – Details

432-A FORM NO. 433-A	COMMONWELATH OF PENNSYLVANIA DEPARTMENT OF TRANSORTATION SUPPLEMENTARY BRIDGE RECORD	County Wyoming Twp. Forkston Boro. ________ City ________	Sheet 2 of 3 Leg. Rt. 65046 Appl. ________ Tr. Rt. 234 Sta. 589 + 58

SKETCH BELOW: Show makeup and size of member, details f conections, etc. Sketches are not necessary if detailed plans are available.



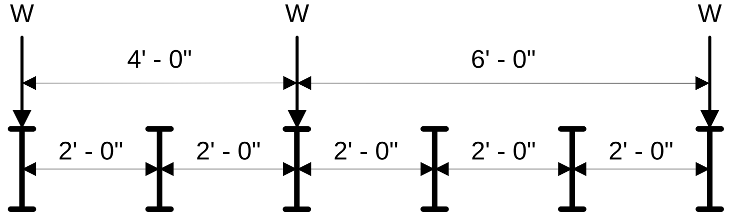
A. 2 *L*'s 5 x 1/4 ' COVER PLATE 12" WIDE.
3/4" HEAD RIVETS
(7) 1/4" PLATE ON BOTTOM
B. 2 BARS 2" x 3/4"
C. 2 BARS 3/4"
D. 2 *L*'s 4" (c.c. 12") SINGLE LACING - 2 SIDES 1-1/4"x 3/16"
E. 2 BARS 2" x 1/2"
F. 1-3/4" ROUND BAR
G. (2) 3/4" FLAT BARS



Note: Only the Details relevent to BAR7 Input are shown here.

Figure 7.5.1 Example Problem 5 - Details (cont'd)

DISTRIBUTION FACTOR FOR SHEAR



$$D.F. = 1 \text{ Wheel} = \frac{1}{2} \text{ Axle} = 0.500$$

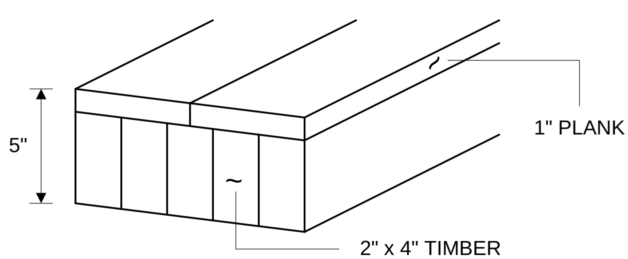
DISTRIBUTION FACTOR FOR MOMENT

$$\textbf{D. F.} = \frac{S}{4.5} = \frac{2}{4.5} = \textbf{0.444 Wheels} = \frac{0.444}{2} \textbf{ Axles} = \textbf{0.222}$$

DISTRIBUTION FACTOR FOR DEFLECTION

$$\textbf{D. F.} = \frac{(\text{No. Lanes})(\text{Reduction Factor})}{\text{No. Beams}} = \frac{(1)(1.0)}{8} = 0.125$$

DEAD LOAD (DL2) CALCULATION - TIMBER DECK



$$\textbf{DL2} = \frac{(0.42)(14.0)(50 \text{ lbs/ft}^2)}{2}$$

$$= 147 \text{ lbs}$$

$$= 0.147 \text{ kips}$$

Figure 7.5.2 Example Problem 5 - Input Calculations

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

Form 1 of 10

BAR7
BRIDGE ANALYSIS AND RATING

PROJECT IDENTIFICATION

PROGRAM IDENT	COUNTY (Structure Identification)	STATE ROUTE (Structure Identification)	SEGMENT (Structure Identification)	OFFSET (Structure Identification)	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB	SKEW CORRECTION FACTOR
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72	73
=BRRAT	65	6504	0104	0605	TRUSS - FLOORBEAM - STRINGER	TFS	I25	L	B	0												

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	SHEAR (Distribution Factors)	MOMENT (Distribution Factors)	DEFLECT (Distribution Factors)	SLAB THICK	HAUNCH	DL1 (Bridge Dead Loads)	DL2 (Bridge Dead Loads)	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC	GUSSET
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74	77
14.00		01.00	13.00	0.500	0.222	0.125				00.147			Y	L	06	P	S	L00		L				Y

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
S	089.10														

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66

Figure 7.5.3 Example Problem 5 - Input

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BRIDGE ANALYSIS AND RATING

Form 2 of 10

TRAFFIC LANE LOCATIONS

1			2			3			4			5			6		
DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL
1	5	9	12	16	20	23	27	31	34	38	42	45	49	53	56	60	64
01.50	10.00	100															

STRINGER SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58
S	14.85	14.85	14.85												

STRINGER LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5	9	13	17	21	25	29	33	37	41	45	49	53	57
00.50	02.50	04.50	06.50	08.50	10.50	12.50	14.50							

Figure 7.5.3 Example Problem 5 - Input (cont'd)

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BRIDGE ANALYSIS AND RATING

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TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST				PANEL TYPE
		Y OR N	H1	H2	H3	
1	3	7	8	12	16	21
1	14.85	Y	16.00	.	.	1
2	14.85	Y	16.00	.	.	6
3	14.85	Y	16.00	.	.	13
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TRUSS DEAD LOADS

LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD
U L	P P		U L	P P		U L	P P		U L	P P	
1	2	4	9	10	12	17	18	20	25	26	28
U	1	1.07	U	2	0.65	U	3	0.65	L	0	1.53
L	1	3.25	L	2	3.25	L	3	3.25			.
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Figure 7.5.3 Example Problem 5 - Input (cont'd)

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BAR7
BRIDGE ANALYSIS AND RATING

Form 5 of 10

TRUSS MEMBER PROPERTIES

MEMBER ID UML	MEMBER ID PP	MEMBER ID UML	MEMBER ID PP	GROSS AREA COMPR	GROSS AREA TENSION	MOMENT OF INERTIA	FY	L	ECCENTRICITY	FLANGE WIDTH	C	CATEGORY	FU	GROSS AREA TENSION	DEPTH	UNSUPP FLANGE LENGTH L	SECTION MODULUS Sxc	MOMENT OF INERTIA Iyc	TORSION INERTIA Jxy
1	2	4	5	7	12	17	23	26	30	33	37	41	43	46	51	54	59	65	71
L	0	L	1	3.00	3.00	1.0	26.0	.	.	.	.		.	.	.	.	.	.	.
L	1	L	2	1.50	1.50	0.5	26.0	.	.	.	.		.	.	.	.	.	.	.
L	2	L	3	1.50	1.50	0.5	26.0	.	.	.	.		.	.	.	.	.	.	.
L	0	U	1	6.90	6.90	26.6	26.0	.	.	.	.		.	.	.	.	.	.	.
L	1	U	1	1.13	1.13	0.1	26.0	.	.	.	.		.	.	.	.	.	.	.
L	2	U	2	3.18	3.18	7.7	26.0	.	.	.	.		.	.	.	.	.	.	.
L	3	U	3	3.18	3.18	7.7	26.0	.	.	.	.		.	.	.	.	.	.	.
U	1	L	2	1.00	1.00	0.4	26.0	.	.	.	.		.	.	.	.	.	.	.
U	2	L	3	0.44	0.44	0 015.5	26.0	.	.	.	.		.	.	.	.	.	.	.
L	2	U	3	1.13	1.13	0.1	26.0	.	.	.	.		.	.	.	.	.	.	.
U	1	U	2	6.90	6.90	26.6	26.0	.	.	.	.		.	.	.	.	.	.	.
U	2	U	3	6.90	6.90	26.6	26.0	.	.	.	.		.	.	.	.	.	.	.
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Figure 7.5.3 Example Problem 5 - Input (cont'd)

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BAR7
BRIDGE ANALYSIS AND RATING

STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE WIDTH	TOP PLATE THICK	BOTTOM PLATE WIDTH	BOTTOM PLATE THICK	COMPOSITE	FY	HYBRID FY TOP	HYBRID FY BOT	UNSYMMETRICAL CG TOP	UNSYMMETRICAL CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
F	1		W	175.50	7.35	0.400	6.500		1.200	0.2500						26.0				
F	2		W	175.50	7.35	0.400	6.500		1.200	0.2500						26.0				
F	3		W	175.50	7.35	0.400	6.500		1.200	0.2500						26.0				
S	1		W	7.70	2.07	0.200	4.000		.600	0.1700						26.0				

Figure 7.5.3 Example Problem 5 - Input (cont'd)

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LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO.	BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
		CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47	52	53	55	60	61	63
BF	1	T	1	0.50	T	4	2.00																		
BF	2	T	1	0.50	T	4	2.00																		
BF	3	T	1	0.50	T	4	2.00																		

Figure 7.5.3 Example Problem 5 - Input (cont'd)

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BRIDGE ANALYSIS AND RATING

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GUSSET PLATE PROPERTIES

GUS CARD	LOC1	LOC2	YIELD STRESS Fy	TENSILE STRESS Fu	THICK	LENGTH Ha	LENGTH Hb	LENGTH Hc	ECCENTRICITY Ea	ECCENTRICITY Eb	ECCENTRICITY Ec	MAX UNSUPPORTED EDGE B	SHEAR CAPACITY OF FASTENER	FASTENER DIAMETER
1	4	5	7	11	15	19	25	31	37	43	49	55	61	66 69
GUS	L	00	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	01	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	02	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	03	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	01	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	02	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	03	33.0	50.00	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000

GUSSET PLATE MEMBER PROPERTIES

GAM CARD	LOC1	LOC2	TRUSS MEMBER						TRUSS MEMBER						TRUSS MEMBER					
			NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT
1	4	5	7	8	13	19	21	23	28	31	32	37	43	45	47	52	55	56	61	67	69	71	76 78
GMB	L	00	2	10.0	10.0	5	6	0.0	30	3	20.0	20.0	10	11	5.0	110							
GMB	L	01	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	4	30.0	30.0	5	6	4.0	30
GMB	L	02	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	L	02	4	20.0	20.0	10	11	6.0	110	5	10.0	10.0	5	6	4.0	30							
GMB	L	03	1	00.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	L	03	4	20.0	20.0	10	11	4.0	110	5	10.0	10.0	5	6	5.0	30							
GMB	U	01	1	10.0	10.0	5	6	0.0	30	3	20.0	20.0	10	11	5.0	110	4	30.0	30.0	5	6	4.0	29
GMB	U	01	5	20.0	20.0	10	11	5.0	110														
GMB	U	02	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	4	30.0	30.0	5	6	4.0	30
GMB	U	02	5	20.0	20.0	10	11	4.0	110														
GMB	U	03	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	U	03	4	20.0	20.0	10	11	5.0	110	5	10.0	10.0	5	6	6.0	30							

Figure 7.5.3 Example Problem 5 - Input (cont'd)

7.6 EXAMPLE PROBLEM 6

7.6.1 Problem Description

This 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 as the data file that was created for Example Problem 5. The special live loadings data file is created using the Input Form 10 Special Live Loadings. For this example problem, it is assumed that the user wants to analyze the bridge described in Example Problem 5 for a set of four special live loadings. The first live loading is the same as the H20 loading except some loading parameters have been modified. The second live loading is like 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 7-57.

7.6.2 Input

The bridge data file is created using the completed input data sheets shown in Figure 7.5.3 on page 7-48. Let the PC file name be BAR7**EX6_TFS_USE_LOADGR1**.DAT.

The special live loading data file is created using the completed input data sheets shown in Figure 7.6.2 on page 7-58. Input Form 9 is filled out for four special live loadings. Let the PC file name of the special live loading data file be **BAR7EX6_TFS_**LOADGR1.DAT. **The** PC data file can be created using any text editor or the Engineering Assistant.

7.6.3 Running BAR7

Once both data files are created, use the following steps to run the program.

For a PC run the prompts should be completed as follow:

BRIDGE ANALYSIS AND RATING (BAR7)
Version 7.15.0.0
Copyright © 1991-201**8**
Commonwealth of Pennsylvania
Department of Transportation

Enter Input File Name: BAR7 **EX6_TFS_USE_LOADGR1**. DAT

Special Live Loads from a Separate File? (Yes or <No>): Yes

Enter Special Live Load File Name: **BAR7EX6_TFS_**LOADGR1.DAT

Review Output on Terminal? (<Yes> or No): Yes

Enter Output File Name <BAR7 **EX6_TFS_USE_LOADGR1**. OUT>:

Alternately, a PC run can be made by using the following command at the DOS prompt.

A: BAR7 BAR7EX5.DAT BAR7EX5.OUT LOADGR1.DAT

Where BAR7 is the executable file, BAR7 **EX6_TFS_USE_LOADGR1**.DAT is the bridge data input file, BAR7 **EX6_TFS_USE_LOADGR1**.OUT is the output file and **BAR7EX6_TFS_**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.

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GUSSET PLATE PROPERTIES

GUS CARD	LOC1	LOC2	YIELD STRESS Fy	TENSILE STRESS Fu	THICK	LENGTH Ha	LENGTH Hb	LENGTH Hc	ECCENTRICITY Ea	ECCENTRICITY Eb	ECCENTRICITY Ec	MAX UNSUPPORTED EDGE B	SHEAR CAPACITY OF FASTENER	FASTENER DIAMETER
1	4	5	7	11	15	19	25	31	37	43	49	55	61	66 69
GUS	L	00	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	01	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	02	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	L	03	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	01	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	02	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
GUS	U	03	33.0	50.0	0.625	31.0	40.0	40.0	7.5	7.50	7.50	30.0	35.0	1.000
			.	.	.	.	.	.	.	.	.	.	.	.

GUSSET PLATE MEMBER PROPERTIES

GAM CARD	LOC1	LOC2	TRUSS MEMBER						TRUSS MEMBER							TRUSS MEMBER						
			NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT
1	4	5	7	8	13	19	21	23	28	31	32	37	43	45	47	52	55	56	61	67	69	71	76 78
GMB	L	00	2	10.0	10.0	5	6	0.0	30	3	20.0	20.0	10	11	5.0	110		.	.			.	
GMB	L	01	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	4	30.0	30.0	5	6	4.0	30
GMB	L	02	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	L	02	4	20.0	20.0	10	11	6.0	110	5	10.0	10.0	5	6	4.0	30		.	.			.	
GMB	L	03	1	00.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	L	03	4	20.0	20.0	10	11	4.0	110	5	10.0	10.0	5	6	5.0	30		.	.			.	
GMB	U	01	1	10.0	10.0	5	6	0.0	30	3	20.0	20.0	10	11	5.0	110	4	30.0	30.0	5	6	4.0	29
GMB	U	01	5	20.0	20.0	10	11	5.0	110		.	.			.			.	.			.	
GMB	U	02	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	4	30.0	30.0	5	6	4.0	30
GMB	U	02	5	20.0	20.0	10	11	4.0	110		.	.			.			.	.			.	
GMB	U	03	1	10.0	10.0	5	6	0.0	30	2	20.0	20.0	10	11	0.0	110	3	30.0	30.0	5	6	4.0	30
GMB	U	03	4	20.0	20.0	10	11	5.0	110	5	10.0	10.0	5	6	6.0	30		.	.			.	

Figure 7.6.1 Example Problem 6 - Special Live Loads

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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	2		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
10.00	14.0	20.00	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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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.

Figure 7.6.2 Example Problem 6 - Input

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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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.

Figure 7.6.2 Example Problem 6 - Input (cont'd)

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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					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
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.

Figure 7.6.2 Example Problem 6 - Input (cont'd)

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SPECIAL LIVE LOADING

LANE LOADING

SP LL NO	NUMBER OF AXLES	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					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
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.

Figure 7.6.2 Example Problem 6 - Input (cont'd)

7.7 EXAMPLE PROBLEM 7

7.7.1 Problem Description

This is an example of how to analyze and rating a pony truss bridge for the following:

1. Gusset plate analysis.
2. Olny truss stability check at floorbeam location 2.
3. Live load = K.
4. Load factor method rating for members with or without eccentricity.

7.7.2 Input

The bridge data file is created in the following input lines. Please note that these may or may not fake numbers which may or may not reflect the actual information in the plan.

1. Project Identification
   - Bridge Type is “TFS”
   - The SLC LEVEL is left blank since the Safe Load Capacity Ratings are not desired.
   - "D" is entered for LANES indicating that the ratings are desired based on one lane loaded as described later.
   - The bridge is to be analyzed for the HS20, ML80, TK527, PA58, and AASHTO Type 3 loadings, and therefore a "K" is coded for LIVE LOAD.
   - OUTPUT option equal to 0 is used so that all computed values will be printed.
   - Impact factor will be calculated by the program as per AASHTO Specifications. This is the default when this item is left blank.
   - The GAGE DISTANCE of 6 feet as specified in the AASHTO Manual is the default when left blank.
   - The PASSING DISTANCE of 4 feet as specified in the AASHTO Manual is the default when left blank. This is to give a 2-foot distance from curb to outside wheel for the single lane and 4-foot distance between the outside wheels of two side-by-side trucks.
   - PONY TRUSS = Y
2. Bridge Cross Section and Loading
   - DECK WIDTH is 34 feet.
   - OVERHANG is left blank because the continuity of the floorbeam is not to be considered.
   - CENTERLINE OF TRUSS TO CURB distance and ROADWAY WIDTH is 2.5 feet
   - ROADWAY WIDTH is 31.08 feet.
   - DISTRIBUTION FACTORS for SHEAR is 0.808, DISTRIBUTION FACTORS for MOMENT is 0.470, and DISTRIBUTION FACTORS for DEFLECTion is 0.286.
   - SLAB THICKness is 8 feet.

- DL1 is left blank since the dead loads acting on a truss are entered separately under TRUSS DEAD LOADS.
- DL2 is 0.410 kips/ft.
- F'C and N are left blank because there is no composite action in the superstructure.
- Since the truss is symmetric about the joint at the center of the span, "Y" is entered for SYMMETRY.
- The live load is to be applied at the lower joints, so "L" is entered for L.
- The total NO. OF PANELS is 7.
- Truss members have riveted end connections, so "R" is entered for END COND.
- "S" is entered for CORS because the Secant Formula is to be used in determining the allowable compression in a truss member with end eccentricity.
- For the analysis of this truss, the hinged support (HINGE) is at joint L 0.
- The effect of temperature change is not to be considered for deflection computations, so TEMP CHANGE is left blank.
- END BRG is “L” because the bearing at the abutment is located at the lower joint.
- STRINGER DL1 is 0.110 kips/ft and FLOORBEAM DL1 is 0.016 kips/ft
- GUSSET ANALYSIS is “Y” is entered for gusset plate analysis and rating.

3. Span Lengths
   - This is a simple span truss with a span length of 112 feet, measured center-to-center of bearing.
   - “S” is entered for CONT.
4. Traffic Lanes
5. Stringer Span Lengths
   - Since this is a truss type bridge and stringers are to be analyzed as simple spans over floorbeams, CONT. is equal to "S". Due to symmetry, only the first four STRINGER SPAN LENGTHS need to be entered for the program to rate all floorbeams.
6. Stringer Locations
   - Distances of all 7 stringers from the centerline of the left truss are entered.
7. Truss Geometry
8. Truss Dead load
9. Truss Member Properties
   - All truss member properties left to the point of symmetry were computed and entered with the following recommended order which is the same as that of output:

     Top chords: U01U02, U02U03, and U03U04

     Bottom chords: L00L01, L01L02, L02L03, and L03L04

     Diagonal chords: L00U01, L02U01, L03U02, L03U04, and L04U03

     Vertical chords: L01U01, L02U02, L03U03, and L04U04

- The yield stress of all truss members was determined to be 30 ksi and the ultimate stress of all truss members was determined to be 60 ksi.
- For pony truss stability check at floorbeam location 2, the Iy = 425 in^4 of the vertical member, L01U01, must be entered.
- For member L00U01, the eccentricity = 1, flange width = 21, and c = 5.7 were entered to trigger the computation of allowable tensile/compressive stress (using working stress method) and axial tension/compression capacity (using load factor method) due to eccentricity.

10. Additional Truss Member Properties for Load Factor Method
    - These additional truss member properties are required for load factor rating and pony truss stability analysis. These member properties shall be computed carefully per the AASHTO Guide Spec for Strength Design of Truss Bridges.
    - All truss member properties left to the point of symmetry were computed and entered with the following recommended order which is the same as that of output:

      Top chords: U01U02, U02U03, and U03U04

      Bottom chords: L00L01, L01L02, L02L03, and L03L04

      Diagonal chords: L00U01, L02U01, L03U02, L03U04, and L04U03

      Vertical chords: L01U01, L02U02, L03U03, and L04U04
11. Steel Beam Properties
    - For pony truss stability check at floorbeam location 2, the steel member properties of floorbeam, F2, must be entered.
12. Gusset Plate properties
    - All gusset plate properties left to the point of symmetry were entered with the following recommended order which is the same as that of output:

      Upper joints: U01, U02, U03, and U04

      Lower joints: L01, L02, L03, and L04
13. Gusset Plate Member Properties
    - All gusset plate member properties left to the point of symmetry were entered with the following recommended order which is the same as that of output:

      Upper joints: U01, U02, U03, and U04

      Lower joints: L01, L02, L03, and L04

7.7.3 Input Forms

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 1 of 12

PROJECT IDENTIFICATION

PROGRAM IDENT	STRUCTURE IDENTIFICATION: COUNTY	STRUCTURE IDENTIFICATION: STATE ROUTE	STRUCTURE IDENTIFICATION: SEGMENT	STRUCTURE IDENTIFICATION: OFFSET	DESCRIPTION	BRIDGE TYPE	SLC LEVEL	LANES	LIVE LOAD	OUTPUT	IMPACT FACTOR	GAGE DISTANCE	PASSING DISTANCE	FATIGUE	CONC DECK	SPEC	REDIST	DIRECT	S OVER FACTOR	END PANEL	HYB	SKEW CORRECTION FACTOR	PONY TRUSS	PDF
1	7	9	13	17	21	45	48	51	52	53	54	57	60	63	64	65	66	67	68	71	72	73	77	78
=BRRAT	52	0006	0250	0036		TFS		D	K	0	.	.	.						.				Y	

BRIDGE CROSS SECTION AND LOADING

DECK WIDTH	OVER-HANG OR SPACING	CL OF GIRDER OR TRUSS TO CURB	ROAD-WAY WIDTH	DISTRIBUTION FACTORS: SHEAR	DISTRIBUTION FACTORS: MOMENT	DISTRIBUTION FACTORS: DEFLECT	SLAB THICK	HAUNCH	BRIDGE DEAD LOADS: DL1	BRIDGE DEAD LOADS: DL2	F'C	N	SYMMETRY	LL LOCAT	NO OF PANELS	END COND	CORS	HINGE AT	TEMP CHANGE	END BRG	STRINGER DL1	FLOOR-BEAM DL1	UNIT WEIGHT DECK CONC	GUSSET	PATCH	UNSYM PIER
1	5	9	13	17	21	25	29	33	37	42	47	51	53	54	55	57	58	59	62	65	66	70	74	77	78	79
34.00	.	02.50	31.08	0.808	0.470	0.286	08.00	.	00.000	00.410	.		Y	L	07	R	S	L00		L	0.110	0.016	150	Y		

Figure 7.7.1 Example Problem 7 - Input

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 2 of 12

SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72
S	112.00														

HINGE LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	11	16	21	26	31	36	41	46	51	56	61	66

TRAFFIC LANE LOCATIONS

1			2			3			4			5			6		
DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL	DIST	WIDTH	% LL
1	5	9	12	16	20	23	27	31	34	38	42	45	49	53	56	60	64

STRINGER SPAN LENGTHS

CONT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58
S	16.00	16.00	16.00	16.00											

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 3 of 12

STRINGER LOCATIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5	9	13	17	21	25	29	33	37	41	45	49	53	57
02.54	07.71	12.88	18.04	23.21	28.38	33.54	.	.	.	.	.	.	.	.

CONCRETE MEMBER PROPERTIES

TYPE	DEPTH	B	D	AS	D'	A'S	FY REINF	ALLOWABLE Fs		ST DET	AV	SPECS	ALPHA	INT WEAR SURFACE
								IR	OR					
1	2	6	10	14	18	22	26	28	31	34	35	39	40	42
	.	.	.	.	.	.		.	.		.			.

STIRRUP DETAILS

STIRRUP AREA	fsy	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING
1	6	8	13	18	23	28	33	38	43	48	53	58	63		
.		.	.	.	.	.	.	.	.	.	.	.	.		

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 4 of 12

TRUSS GEOMETRY

PANEL NUMBER	PANEL WIDTH	VERTICAL POST				PANEL TYPE
		Y OR N	H1	H2	H3	
1	3	7	8	12	16	21
01	16.00	Y	11.25			01
02	16.00	Y	13.83			06
03	16.00	Y	15.00			06
04	16.00	Y	15.00			13

TRUSS DEAD LOADS

LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD	LOCAT		CONC LOAD
U L	P P		U L	P P		U L	P P		U L	P P	
1	2	4	9	10	12	17	18	20	25	26	28
L	00	034.13	L	01	063.79	L	02	064.73	L	03	065.32
L	04	065.32	U	01	003.21	U	02	003.12	U	03	003.11
U	04	003.01									

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

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BAR7
BRIDGE ANALYSIS AND RATING

TRUSS MEMBER PROPERTIES

MEMBER ID U M L (1)	MEMBER ID P P (2)	MEMBER ID U M L (4)	MEMBER ID P P (5)	GROSS AREA COMPR (7)	NET AREA TENSION (12)	MOMENT OF INERTIA Ix (17)	FY (23)	L (26)	ECCENTRICITY (30)	FLANGE WIDTH (33)	C (37)	CATEGORY (41)	FU (43)	GROSS AREA TENSION (46)	DEPTH (51)	UNSUPP FLANGE LENGTH L (54)	SECTION MODULUS Sxc (59)	MOMENT OF INERTIA Iyc (65)	TORSION INERTIA Jxy (71)	MOMENT OF INERTIA Iy (77-80)
U	01	U	02	041.09		01312.0	30.0						60.0		15.6					2145
U	02	U	03	044.03		01381.0	30.0						60.0							2279
U	03	U	04	044.03		01381.0	30.0						60.0							2279
L	00	L	01	029.98	023.67	00802.8	30.0						60.0							
L	01	L	02	029.98	023.67	00802.8	30.0						60.0							
L	02	L	03	042.41	035.05	01048.8	30.0						60.0							
L	03	L	04	042.41	035.05	01048.8	30.0						60.0							
L	00	U	01	038.15		01241.0	30.0	19.55	1.00	21.00	0.570		60.0		15.6		00219.8	00412.0	005.300	2011
L	02	U	01	015.60		00095.8	30.0						60.0							
L	03	U	02	011.75		00044.1	30.0						60.0							
L	03	U	04	008.23		00019.2	30.0						60.0							
L	04	U	03	008.23		00019.2	30.0						60.0							
L	01	U	01	015.60		00096.0	30.0						60.0							0425
L	02	U	02	015.60		00096.0	30.0						60.0							0425
L	03	U	03	015.60		00096.0	30.0						60.0							0425
L	04	U	04	015.60		00096.0	30.0						60.0							0425

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 6 of 12

ADDITIONAL TRUSS MEMBER PROPERTIES FOR LOAD FACTOR METHOD

ATM CARD	MEMBER ID UML	MEMBER ID PP	MEMBER ID UML	MEMBER ID PP	SECTION MODULUS GROSS TENSION	SECTION MODULUS NET TENSION	SECTION MODULUS GROSS COMPR	MU	PLAS SHAPE FAC	EQUI MOM FAC	SHAPE	BOX AREA	BOX S/T	Iy2	MEM HEIGHT
1	4	5	7	8	10	16	22	28	35	38	41	42	47	52	58
ATM	U	01	U	02	00109.6	00109.6	00109.6		1.27	0.85	3				
ATM	U	02	U	03	00117.0	00117.0	00117.0		1.28	0.85	3				
ATM	U	03	U	04	00117.0	00117.0	00117.0		1.28	0.85	3				
ATM	L	00	L	01	00107.6	00107.6	00107.6		1.27	0.85					
ATM	L	01	L	02	00107.6	00107.6	00107.6		1.27	0.85					
ATM	L	02	L	03	00140.4	00140.4	00140.4		1.33	0.85					
ATM	L	03	L	04	00140.4	00140.4	00140.4		1.33	0.85					
ATM	L	00	U	01	00102.3	00102.3	00102.3	003053.2	1.25	0.85	3			01241.0	15.66
ATM	L	02	U	01	00070.6	00070.6	00070.6		1.10	0.85					
ATM	L	03	U	02	00051.5	00051.5	00051.5		1.10	0.85					
ATM	L	03	U	04	00135.6	00135.6	00135.6		1.10	0.85					
ATM	L	04	U	03	00035.6	00035.6	00035.6		1.10	0.85					
ATM	L	01	U	01	00070.6	00070.6	00070.6		1.10	0.85					
ATM	L	02	U	02	00070.6	00070.6	00070.6		1.10	0.85	3				
ATM	L	03	U	03	00070.6	00070.6	00070.6		1.10	0.85	3				
ATM	L	04	U	04	00070.6	00070.6	00070.6		1.10	0.85					

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

STEEL MEMBER PROPERTIES

G F OR S	SPAN NO	RANGE	SECT TYPE	WF BEAM M OF I OR ANGLE VERT LEG	WF BEAM AREA OR ANGLE HORZ LEG	FLANGE OR ANGLE THICK	FLANGE WIDTH	VARIES	WF BEAM OR WEB PLATE DEPTH	WEB THICK	TOP PLATE WIDTH	TOP PLATE THICK	BOTTOM PLATE WIDTH	BOTTOM PLATE THICK	COMPOSITE	FY	HYBRID FY TOP	HYBRID FY BOT	UNSYMMETRICAL CG TOP	UNSYMMETRICAL CG BOT
1	2	3	8	9	16	21	26	31	32	37	42	46	51	55	60	61	64	67	70	75
F	2	018.00	W	11037.90	058.81	1.1500	15.750		03.300	0.7200					N	30.0				
S		000.00	W	00768.60	013.82	0.5500	07.500		01.800	0.3200					N	30.0				

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 8 of 12

LATERAL BRACE POINTS AND STIFFENER SPACINGS

BRACING OR STIFF CODE	SPAN NO.	BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER			BRACE POINT OR STIFFENER		
		CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING	CODE	NO. OF SPACES	SPACING
1	3	4	5	7	12	13	15	20	21	23	28	29	31	36	37	39	44	45	47	52	53	55	60	61	63
BF	2	T	01	002.54	T	03	005.17																		

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

Form 11 of 12

GUSSET PLATE PROPERTIES

GUS CARD	LOC1	LOC2	YIELD STRESS Fy	TENSILE STRESS Fu	THICK	LENGTH Ha	LENGTH Hb	LENGTH Hc	ECCENTRICITY Ea	ECCENTRICITY Eb	ECCENTRICITY Ec	MAX UNSUPPORTED EDGE B	SHEAR CAPACITY OF FASTENER	FASTENER DIAMETER
1	4	5	7	11	15	19	25	31	37	43	49	55	61	66 69
GUS	U	01	030.0	.	0.437	075.000	035.500	035.000	009.880	005.000	005.000	025.500	025.00	0.875
GUS	U	02	030.0	.	0.437	045.750	026.250	025.500	009.780	005.000	005.000	019.500	025.00	0.875
GUS	U	03	030.0	.	0.437	043.000	024.000	023.000	009.750	005.000	005.000	019.500	025.00	0.875
GUS	U	04	030.0	.	0.437	043.000	023.000	024.000	009.750	005.000	005.000	019.500	025.00	0.875
GUS	L	00	030.0	.	0.500	051.500	047.875	047.875	007.500	000.000	006.625	015.000	025.00	0.875
GUS	L	01	030.0	.	0.437	016.000	031.000	031.000	007.500	005.000	005.000	000.000	025.00	0.875
GUS	L	02	030.0	.	0.437	046.000	031.000	031.000	007.500	005.000	005.000	025.000	025.00	0.875
GUS	L	03	030.0	.	0.437	045.000	031.000	031.000	007.500	005.000	005.000	015.500	025.00	0.875
GUS	L	04	030.0	.	0.437	045.000	031.000	031.000	007.500	005.000	005.000	015.000	025.00	0.875
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.
GUS			.	.	.	.	.	.	.	.	.	.	.	.

Figure 7.7.1 Example Problem 7 - Input (cont'd)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF BUSINESS SOLUTIONS AND SERVICES

BAR7
BRIDGE ANALYSIS AND RATING

GUSSET PLATE MEMBER PROPERTIES

GAM CARD	LOC1	LOC2	TRUSS MEMBER							TRUSS MEMBER							TRUSS MEMBER						
			NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT	NO	DISTANCE W	DISTANCE L	NT	NL	LENGTH Lc	NTT
1	4	5	7	8	13	19	21	23	28	31	32	37	43	45	47	52	55	56	61	67	69	71	76 78
GMB	U	01	1	09.000	030.000	04	11		029	3	09.000	019.250	04	07		023	4	06.000	015.000	02	06		011
GMB	U	01	5	06.000	021.000	02	06		011														
GMB	U	02	1	09.000	021.125	04	07		028	2	09.000	016.812	04	06		024	4	06.000	009.000	02	03	02.333	006
GMB	U	02	5	05.500	015.000	02	06		010														
GMB	U	03	1	09.000	018.250	04	07		028	2	09.000	019.000	04	07		028	4	06.000	007.000	02	03		006
GMB	U	03	5	03.500	006.000	02	03		006														
GMB	U	04	2	09.000	018.250	04	07		028	3	03.500	006.000	02	03		006	4	06.000	007.000	02	03		006
GMB	L	00	2	09.000	033.000	04	07		026	3	09.000	027.000	04	10	03.333	036							
GMB	L	01	1	09.000	013.000	04	04		012	2	09.000	013.000	04	04		012	4	06.000	013.000	02	05		010
GMB	L	02	1	09.000	043.000	04	14		036	2	09.000	043.000	04	14		036	4	06.000	013.000	02	05	01.667	010
GMB	L	02	5	06.000	023.000	02	09		015														
GMB	L	03	1	09.000	042.060	04	11		040	2	09.000	042.060	04	11		040	3	03.500	006.000	02	03		006
GMB	L	03	4	06.000	013.000	02	05		010	5	05.500	015.000	02	06		010							
GMB	L	04	1	09.000	042.060	04	11		040	2	09.000	042.060	04	11		040	4	06.000	013.000	02	05		010
GMB	L	04	5	03.500	060.000	02	03		006														
GMB																							
GMB																							
GMB																							
GMB																							
GMB																							

Figure 7.7.1 Example Problem 7 - Input (cont'd)

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. They are also included as a Word template on the disk that has been provided for the program.

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 for the enhancement of the program. Unexpected or incorrect output, rejection of input data, endless program cycling, and program abortion are examples of program malfunctions. Users are requested to review their input data and the program User's Manual before submitting 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 Software Section via mail, fax, or e-mail.

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BAR7
TECHNICAL QUESTIONS

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, LRFD 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 Department of Transportation
Bridge Design and Technology Division
P.O. Box 3560
Harrisburg, PA 17105-3560
PHONE: (717) 787-2881
FAX: (717) 787-2882

FOR DEPARTMENT USE ONLY
RECEIVED BY: ________________ ASSIGNED TO: ___________________DATE: _____________

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BAR7
REVISION REQUEST

This form is to be used to report suspected program malfunctions, or to request revisions to the program or its documentation. Users are requested to review their input data and the program User's Manual before submitting this form.

CONTACT PERSON:____ DATE: ____________________
ORGANIZATION:____ PHONE: ____________________
E-MAIL ADDRESS:____ 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 Business Solutions and Services,
Highway/Engineering Apps Division
Engineering Software Section
P. O. Box 8213
Harrisburg, PA 17105-8213
PHONE: (717) 783-8822
FAX:(717) 705-5529
E-MAIL: penndotbisengineer@state.pa.us

FOR DEPARTMENT USE ONLY
RECEIVED BY: ________________ ASSIGNED TO: ____________________DATE: _____________

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