

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE RATING MANUAL	Section: 10 Effective: July 1, 2002 Supersedes: July 1, 1995
SECTION 10 - STEEL BRIDGES	

10-1 INTRODUCTION TO RATING STEEL BRIDGES

This section together with Section 1, presents the policies and guidelines for rating steel girders. Policies are covered in subsection 10-2, while supporting guidelines are presented in subsections 10-2, 3, and 4.

The types of girders covered by this section are:

CI	Concrete on I-Beam
CIC	Concrete on I-Beam Continuous
CIK	Concrete on I-Beam Composite
CICK	Concrete on I-Beam Continuous and Composite
SBG	Steel Box Girder
SBGC	Steel Box Girder Continuous
SDG	Steel Deck Girder
SDGC	Steel Deck Girder Continuous
SSD	Steel Stringer - Concrete Deck
SSE	Steel Stringer - Earth Filled
SSM	Steel Stringer - Metal Plank Floor
SSMC	Steel Stringer Continuous - Metal Plank Floor
SSS	Steel Stringer - Timber Floor
SSSC	Steel Stringer Continuous - Timber Floor
STG	Steel Through Girder
WG	Welded Girder
WGC	Welded Girder Continuous
WGK	Welded Girder Composite
WGCK	Welded Girder Continuous and Composite

10-2 POLICIES AND GUIDELINES FOR RATING STEEL BRIDGES

I. General

- A. All steel girders (except for girders in Truss Bridges) shall be rated by the VIRTIS program or one acceptable to the CDOT Bridge Branch.
- B. Steel girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The VIRTIS output results can then be supplemented with hand calculations to consider any of these significant influences, as necessary. Also, when appropriate, steel girders having or lacking horizontal curvature effects and depending on the type of girder to be analyzed, DESCUS I or DESCUS II may also be used to perform the rating.
- C. All steel bridges shall be rated by the load factor method.
- D. Use the minimum design yield strength value (F_y) and the minimum compressive strength of concrete (F'_c) from plans.

- E. For SSE, SSM and SSS structure types, it is acceptable to disregard AASHTO's allowable stress reduction formula for unsupported compression flanges. If the condition of the girder indicates that full yield strength should not be used, the rating stresses should be reduced as appropriate.
- F. Steel box girder template has not been incorporated in the current version of Virtis 4.0.4. However, steel box girders can be rated using $\frac{1}{2}$ the single-girder parameters in the analysis. The live load distribution factor and the dead load shall be adjusted accordingly.

II. Girders Requiring Rating

- A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, differences in loads or moments, grade of structural steel, etc.
- B. Exterior Girders - An exterior girder shall be rated under the following guidelines.
 - 1. When the section used for an exterior girder is different than the section used for an interior girder.
 - 2. When the overhang is greater than $S/2$.
 - 3. When the plans indicate that the curb and floor slab were poured monolithically, the live load distribution factor for the exterior girder should be calculated and compared to the live load distribution factor (LLDF) for the interior girders. If the LLDF for the exterior girder is equal to or greater than 75% of the LLDF for the interior girders, the exterior girder shall be rated.
 - 4. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

III. Calculations

- A. A set of calculations, separate from computer output shall be prepared and submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating.
- B. Dead Loads
 - 1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.
 - 2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.

3. Use 5 psf for the unit weight of permanent steel bridge deck forms.

4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders, stiffeners, splices and diaphragms. The weight of diaphragms may be treated as point loads or as an equivalent uniform dead load for the span under consideration.

EXAMPLE: For two diaphragms (P) at 1/3 points

$$(PL)/3 = M = (wL \times L)/8$$

Equivalent uniform load . . . $w = (8P)/3L$

5. The method of applying dead loads due to utilities is left to the rater's discretion.

IV. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. Additionally, yield strength (F_y) of structural steel used in the analysis and any variation from the original design assumptions shall be added to the Rating Summary Sheet. The rating package requirements shall be per Section 1-13 of this manual and as amended herein:

Consultant designed projects - Before finalizing the rating package and when VIRTIS is used as the analysis tool, the Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower version of the program shall be rejected. It is required for the CDOT data archive, since the data base management feature inside the program would not work satisfactorily. After the analysis is completed, the rater shall save the data file. When saving is finalized, the rater shall export the data file in *.bbd format (i.e., F-17-IE.bbd format; bbd = BRIDGEWare Bridge Data File) on an IBM-compatible 3.5" PC Disk for delivery with the rating package. Also, the version number used during analysis shall be written on the diskette label. This ensures proper importation of bridge data archive by Staff Bridge at a later date.

10-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

The VIRTIS computer program performs the analysis and rating of simple span and multi-span steel girder bridges. It uses the BRASS ASD or the BRASS LFD engine for analysis. This program was developed in accordance with the AASHTO STANDARD SPECIFICATIONS, 16TH EDITION AND THE AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES.

A maximum of thirteen (13) spans can be modeled using the program. Linear or parabolic girder web depth variation over the length of a defined cross-section can be modeled using Virtis. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

The library explorer can be used to save commonly used items (beam shapes, non standard vehicles, materials, appurtenances etc.) and this eliminates the need for all users to define the same items repeatedly throughout the program. Once a new girder shape is defined or copied from the library, Virtis automatically computes the required section properties and beam constants.

Dead load from the girder self weight, deck slab and appurtenances (i.e. rails, median barrier etc.) are calculated automatically by the program. Dead load from the haunch, wearing surface and stiffener weight (for steel bridges) is defined by the user. For a detailed description of the girder loads, refer to the Opis/Virtis Help Menu index item - dead loads. When a structure is being modeled, the help menu can be activated by using the F1 key if the user requires clarification on a particular item in the GUI window.

In the Live Load Distribution Factor window, when the compute button is used to calculate the DF's automatically by the program, Virtis users shall verify that these numbers are accurate and matches their calculated numbers.

All Colorado BT girder shapes, W-beam shapes, the Colorado permit vehicle, the Colorado posting trucks, and the Interstate posting trucks have been added to the Virtis library explorer and may be copied by the user. The Staff Bridge Rating Coordinator shall be responsible for updating existing information or adding new information (i.e. beam shapes, vehicles, etc.) to the library explorer.

The configuration browser provides access to the configuration features of Virtis. It may be employed to provide specific access privileges, i.e. read, write, delete etc., to the users. This feature is extremely powerful, since Virtis/Opis uses and shares the bridge data from one common source. Therefore, it is required that users of this program create a folder from the bridge explorer window (**EXAMPLE: MY FOLDER OR YOUR LAST NAME**) before creating the model for a new structure.

10-4 RATING STEEL BRIDGES WITHOUT PLANS

It is possible that the only information a rater may have to rate an old steel bridge is field measurements of the members and the directions of the AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES 1994, Second Edition. A convenient source of beam information is the book titled "Historical Record-Dimensions and Properties-Iron and Steel Beams 1873 to 1952", published by the American Institute of Steel Construction (AISC). This book can help the rater determine the approximate year the beams were rolled. The rater can then determine the section properties and the allowable stresses to be used to rate the steel beams.

10-5 STEEL GIRDER BRIDGE RATING EXAMPLE

One example is presented in this section. Structure N-17-BP is a two (2) span continuous composite welded girder bridge with a skew of 0° degrees. Note that the girder web varies linearly near the pier. For simplicity, only the interior girder has been modeled for this structure.

One curved welded girder example using Descus-I will be presented at a later date.

Also, one curved welded box girder example using Descus-II will be presented at a later date.

Slab Rating Program Input, Structure No. N-17-BP

WinSlab Input			
Structure Number:	N-17-BP	Rater:	MH
Batch ID:		Comments:	LFD
Highway Number:	25	Load Type:	2=Interstate
<hr/>			
Deadload	Bituminous Overlay (in):	4	
<hr/>			
Geometry			
Effective Span (ft):	8.25	Actual Slab Thickness (in.):	8.5
Reinforcing Steel:			
	Area (sqin)	Distance (in)	For definitions of input values please refer to the CDOT Bridge Rating Manual
Top:	0.81	5.625	
Bottom:	0.81	1.38	
Materials Properties			
Concrete f'c (PSI):	4500	Steel Fy (PSI):	40000
or Inv Fc (Working Stress)		or Inv Fs (Working Stress)	
Modular Ratio (Leave blank for load factor):	00		
OK		Cancel	Apply
			Output to File

Effective Span Length: Per AASHTO Article 3.24.1.2(b)

Clear distance between flanges + 1/2 flange width = $(105-12)+1/2(12)=93.0"$
 $=8.25'$

Slab Rating Program Output, Structure No. N-17-BP

WinSlab Rating Version 1 Date: 2/20/2002

Structure NO. N-17-BP Rater: MH State HWY NO. = 25
 Batch ID= Description: LFD

LOAD FACTOR RATING-COMP STEEL NOT USED

INPUT DATA

Bituminous Overlay(in)=	4.000	Slab Thickness(in)=	8.500
Eff. Span(ft)=	8.250	Eff. Depth(in) =	5.625
Top Reinf. (sq.in)=	0.81	Bottom Dist.(in)=	1.38
Bottom Area(sq.in)=	0.81	Oper. =	4500
Conc. Strength(PSI) Inv =	4500	Oper. =	40000
Steel Yield (PSI) Inv =	40000		
Modular Ratio =	8		

Dead Load Moment 1.05 K-Ft
 LL+I Moment 5.33 K-Ft
 Gross Weight 36.0 Tons

	Inventory	Operating
Actual Concrete Stress (PSI)	1141.11	1775.74
Actual Reinf. Steel Stress (PSI)	19303.62	30039.23
Actual Comp. Steel Stress (PSI)	4306.93	6702.21
Member Capacity (K-Ft)	12.81	12.81
Member Capacity (LL+I) (K-Ft)	11.45	11.45
Rating (Tons)	35.68	59.47

Virtis Bridge Rating Example, Structure No. N-17-BP**Effective slab width: Per AASHTO Article 10.38.3.1**

$0.25(L) = 0.25(114.167 \times 12) = 342.5''$
 $12 \cdot (t) = (12 \times 8.5) = 102''$ Controls
 C.L. - C.L. of girder = $8.75' = 105''$

Distribution Factor:Interior Girder (Multi-Lane) = $S/5.5 = 8.75/5.5 = 1.591$ Interior Girder (Single-Lane) = $S/7.0 = 8.75/7.0 = 1.250$ Exterior Girder = $[(8.75+0.5)+3.25]/8.75 = 1.428$ **Dead Load:**

HBP = 4"

Curb = $(8/12) \cdot (1.25) \cdot (150) = 125$ lb/ft**Rail:**

Assumed 38 Posts @ 70.55 Lbs each
 Posts = $38 \cdot (70.55) / 228.33 = 11.74$ Lb/ft
 Channel = 40.68 Lb/ft
 3A Rail = 7.81 Lb/ft

 $\Sigma = 60.23$ Lb/ft ~ 0.060 Kip/ft

Interior (D-2 on plan sheet) Diaphragms:

Angles L3x3x5/16 @ 6.1 lb/ft Length = $2(8.75)+2(5.71)=28.92'$
 Weight = $(28.92)*(6.1) = 176.41$ Lbs
 Stiffener Plate 5x5/16x4.5'
 Weight = $2(5.32)(4.5) = 47.88$ Lbs
 $\Sigma = 224.29$ Lbs ~ 0.225 Kips

Pier (D-2 on plan sheet) Diaphragm:

Angles L3x3x5/16 @ 6.1 lb/ft Length = $2(8.75)+2(5.71)=28.92'$
 Weight = $(28.92)*(6.1) = 176.41$ Lbs
 Stiffener Plate 9x1x7.135'
 Weight = $2(30.625)(7.135) = 437.04$ Lbs
 $\Sigma = 613.40$ Lbs ~ 0.614 Kips

End (D-1 on plan sheet) Diaphragms:

Angles L3.5x3.5x5/16 @ 7.2 lb/ft Length = $2(9.839)=19.68'$
 Weight = $(19.68)*(7.2) = 141.70$ Lbs
 Stiffener Plate 6.5x5/8x4.5'
 Weight = $2(13.817)(4.5) = 124.3$ Lbs
 $\Sigma = 266.0$ Lbs ~ 0.266 Kips

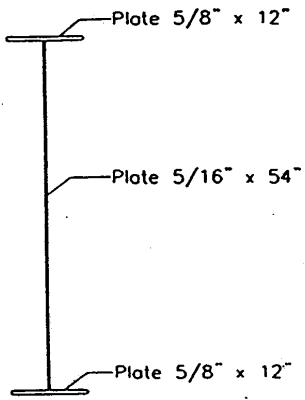
Intermediate Stiffeners:

Assumed length = depth of web = 54"; Neglect longer stiffeners in girder taper
 Stiffener Plate 5x5/16x4.5' @ 5.32Lbs/ft = 23.94 Lbs each
 21 Stiffeners/Span = $21*(23.94)/114.167 = 4.4$ Lbs/ft

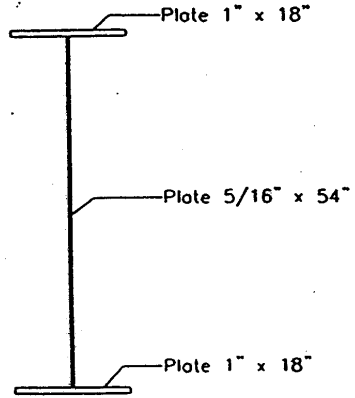
Longitudinal Stiffeners:

Stiffener Plate 4.5x5/16 = 4.79 Lbs/ft
 Stiffener Plate 3.5x5/16 = 3.72 Lbs/ft
 Average Weight = 4.2 Lbs/ft
 Σ Transverse + Longitudinal Stiffeners = $4.4+4.2 = 8.6$ Lbs/ft ~ 0.009 Kip/ft

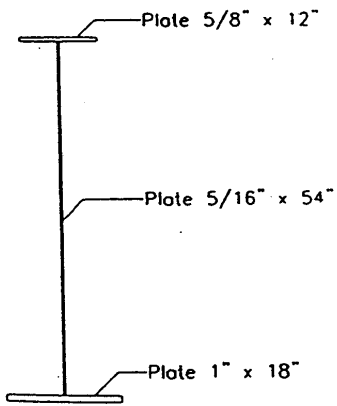
1



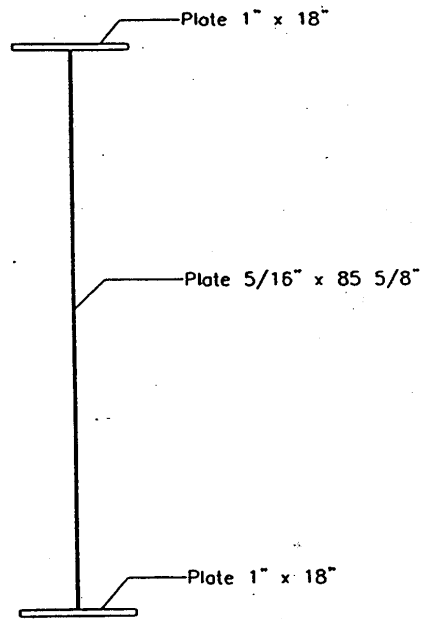
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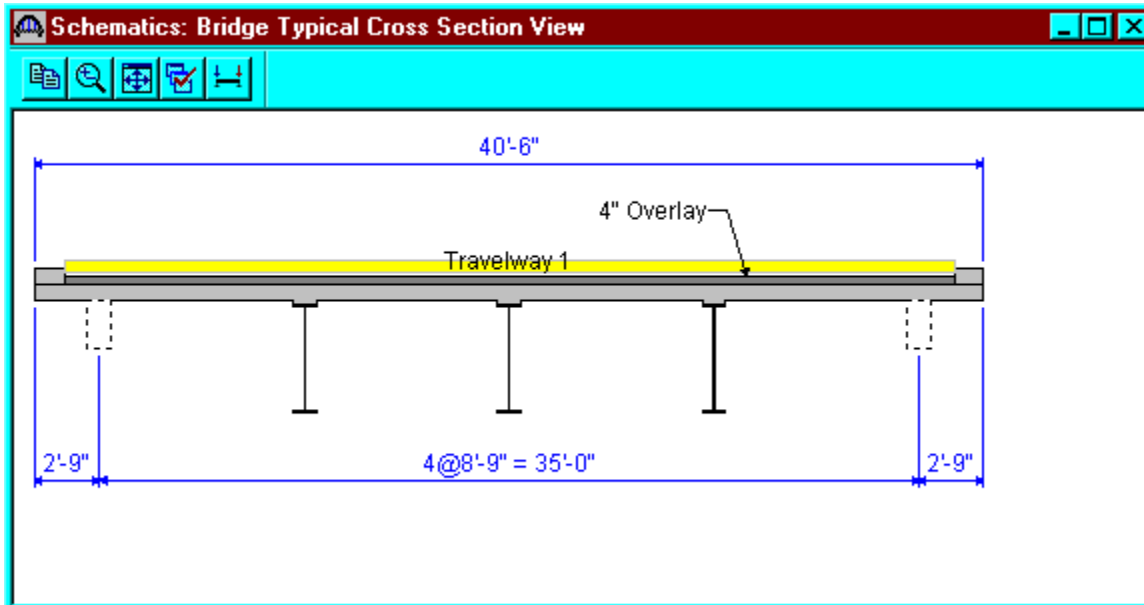
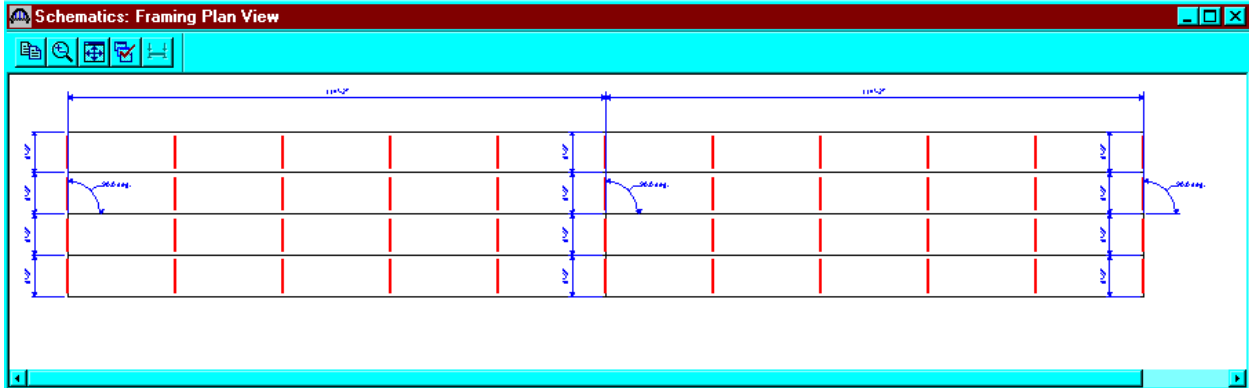
2



4



Virtis Bridge Rating Example, Structure No. N-17-BP (contd.)



From the bridge explorer, create a new bridge and enter the following information.

N-17-BP

Bridge ID: NBI Structure ID (8): Template
 Design Only

Description | Description (cont'd) | Alternatives | Global Reference Point

Name: Year Built:

Description:

Location: Length: ft

Facility Carried (7): Route Number:

Feat. Intersected (6): Mi. Post:

Units: Recent ADTT:

Click OK. This saves the data to memory and closes the window.

NOTE: Since Virtis uses a common/shared database, it is required that users of this program create a folder from the bridge explorer window (**EXAMPLE: MY FOLDER OR YOUR LAST NAME**) before creating the model for a new structure.

To add a new structural steel material, click on Materials, Structural Steel, in the tree and select File/New from the menu (or right click on Structural Steel and select New). Click Copy from Library button and select the appropriate structural steel from the library. Click OK and the following window will open. Click OK to save this structural steel material to memory and close the window.

Bridge Materials - Structural Steel

Name: Description:

Material Properties

Specified minimum yield strength (F_y) = ksi

Specified minimum tensile strength (F_u) = ksi

Coefficient of thermal expansion = 1/F

Density = kcf

Modulus of elasticity (E) = ksi

Using the same techniques, create the following Concrete Materials and Reinforcing Steel Materials. The windows are shown in the following page.

Bridge Materials - Concrete

Name: Description:

Compressive strength at 28 days (f'_c) = ksi

Initial compressive strength (f'_ci) = ksi

Coefficient of thermal expansion = 1/F

Density (for dead loads) = kcf

Density (for modulus of elasticity) = kcf

Modulus of elasticity (E_c) = ksi

Initial modulus of elasticity = ksi

Poisson's ratio =

Composition of concrete =

Modulus of rupture = ksi

Shear factor =

Bridge Materials - Reinforcing Steel

Name: Description:

Material Properties

Specified yield strength (F_y) = ksi

Modulus of elasticity (E_s) = ksi

Ultimate strength (F_u) = ksi

Type

Plain

Epoxy

Galvanized

Other

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.

Bridge Appurtenances - Parapet

Name: Bridge Rail Type 3

Description: 2- Rails

All dimensions are in inches

7.5000 Additional Load = 0.060 kip/ft

0.0000

15.0000 0.0000

Reference Line

0.0000

0.0000

0.0000

8.0000

Back Front

Roadway Surface

Parapet unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 7.500 in

Total weight = 0.185 kip/ft

Copy from Library... OK Apply Cancel

Double click on Impact/Dynamic Load Allowance in the tree. The Bridge Impact window shown below will open. Accept the default values by clicking OK.

Bridge Impact / Dynamic Load Allowance

Standard Impact Factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

Standard AASHTO impact $I = \frac{50}{L + 125}$

Modified impact = [] times AASHTO impact

Constant impact override = [] %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: [15.0] %

All other limit states: [33.0] %

OK Apply Cancel

Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.

Factors - LFD

Name: 1996 AASHTO Std. Specifications

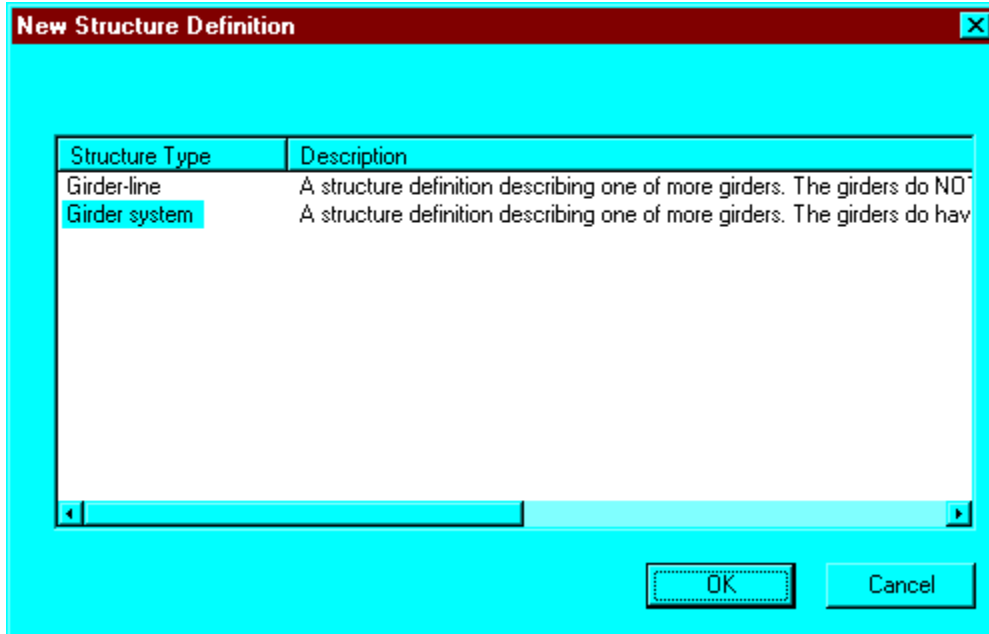
Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Factors | **Resistance Factors**

Load Group	Gamma Factor						
		D	(L+)n	(L+)p	CF	E	B
INV	1.300	1.000	1.670	0.000	1.000	1.000	1.000
OPG	1.300	1.000	1.000	0.000	1.000	1.000	1.000

Copy from Library... OK **Apply** Cancel

Double click on SUPERSTRUCTURE DEFINITION (or click on SUPERSTRUCTURE DEFINITION and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.

Girder System Superstructure Definition

Definition | Analysis

Name: 2 Span - 5 Girder System

Description: Spans 114'-2", 114'-2"

Default Units: US Customary

Number of spans: 2

Number of girders: 5

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	114.17
2	114.17

Frame Structure Simplified Definition

For PS only

Average humidity: %

Member Alt. Types

Steel

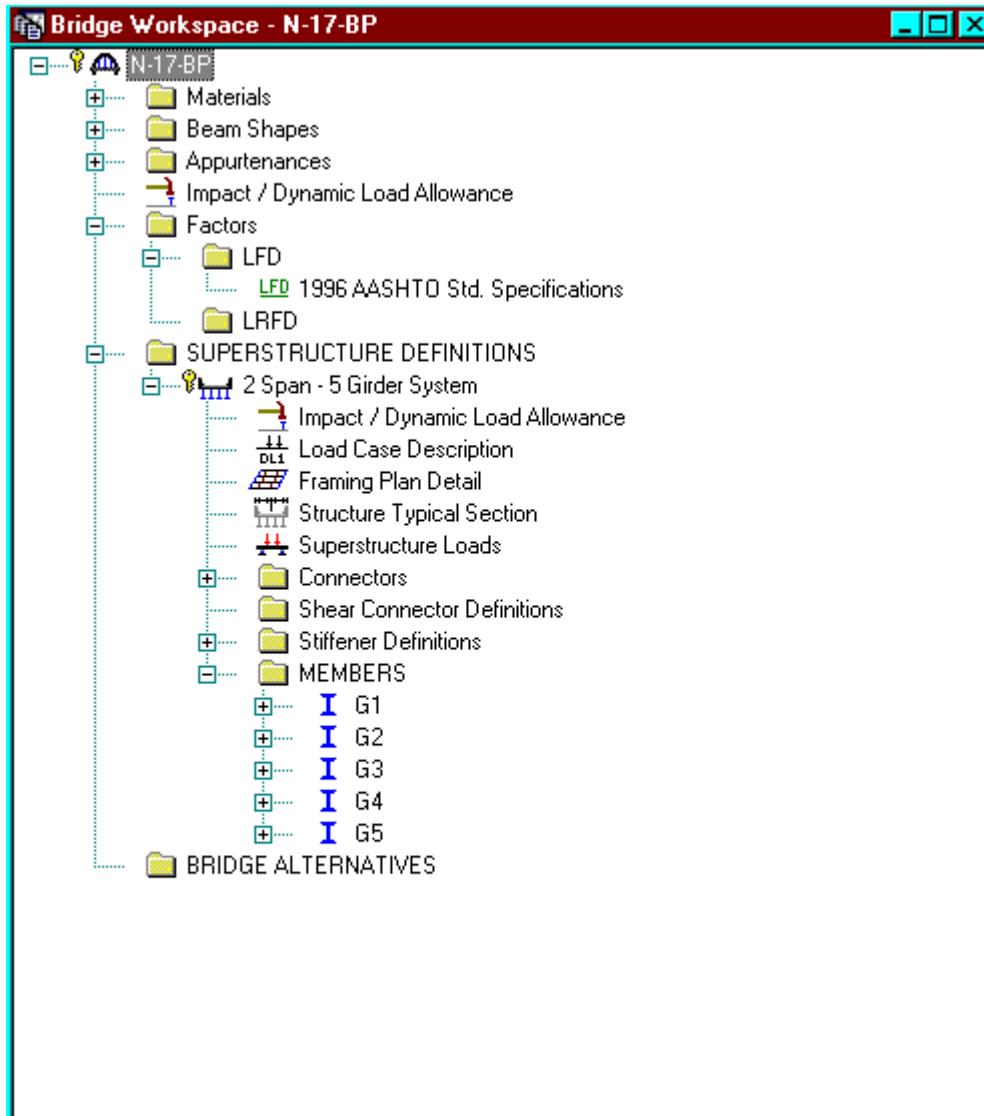
P/S

R/C

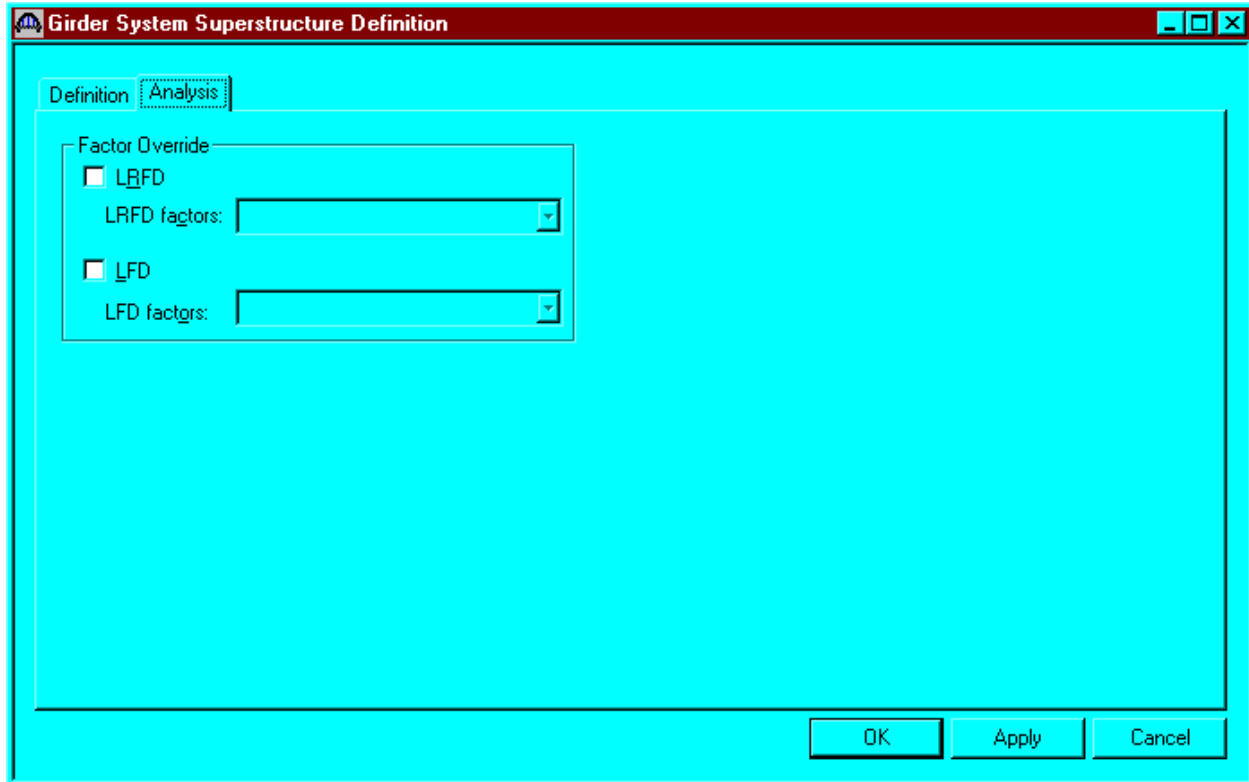
Timber

OK Apply Cancel

The partially expanded Bridge Workspace tree is shown below:



The Analysis tab in the Girder System Superstructure Definition window is used to override system default factors. Since default factors are used here, click OK to save the data to memory and close the window.



The screenshot shows a software window titled "Girder System Superstructure Definition". The window has a red title bar and standard Windows window controls (minimize, maximize, close) in the top right corner. Inside the window, there are two tabs: "Definition" and "Analysis", with "Analysis" being the active tab. Below the tabs is a "Factor Override" section enclosed in a box. This section contains two rows of controls. The first row has a checkbox labeled "LRFD" which is unchecked, followed by a label "LRFD factors:" and a dropdown menu. The second row has a checkbox labeled "LFD" which is unchecked, followed by a label "LFD factors:" and a dropdown menu. At the bottom right of the window, there are three buttons: "OK", "Apply", and "Cancel".

Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed Load Case Description window is shown below.

Load Case Name	Description	Stage	Type	Time* (Days)
HBP		Composite (long term) (Stage 2)	D,DW	
Bridge Rail Type 3		Composite (long term) (Stage 2)	D,DC	

*Prestressed members only

Add Default Load Case Descriptions

New Duplicate Delete

OK Apply Cancel

Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.

Structure Framing Plan Details

Number of spans = Number of girders =

Layout | Diaphragms

Support	Skew (Degrees)
1	0.0000
2	0.0000
3	0.0000

Girder Spacing Orientation

Perpendicular to girder

Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	8.75	8.75
2	8.75	8.75
3	8.75	8.75
4	8.75	8.75

OK Apply Cancel

Switch to the Diaphragms tab to enter diaphragm spacing. Enter the following diaphragms data for Girder Bay 1:

Structure Framing Plan Details

Number of spans = 2 Number of girders = 5

Layout: Diaphragms

Girder Bay: 1 Copy Bay To... Diaphragm Wizard...

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	0.2660
1	0.00	0.00	22.83	4	91.33	91.33	91.33	0.2250
2	0.00	0.00	0.00	1	0.00	0.00	0.00	0.6140
2	0.00	0.00	22.83	4	91.33	91.33	91.33	0.2250
2	91.33	91.33	22.83	1	22.83	114.17	114.17	0.2660

New Duplicate Delete

OK Apply Cancel

Click the Copy Bay To button to copy the diaphragms entered for Bay to the other bays. The following dialog box will appear. Click Apply to copy the diaphragms to girder bay 2. Repeat the same techniques for girder bay 3 and 4.

Copy Diaphragm Bay

Select the new bay: 2

Apply Cancel

Select OK to close Structure Framing Plan Details window.

Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line

Distance from right edge of deck to superstructure definition ref. line

Deck thickness

Superstructure Definition Reference Line

Left overhang

Right overhang

Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | Wearing Surface

Superstructure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to superstructure definition reference line =	20.25 ft	20.25 ft
Distance from right edge of deck to superstructure definition reference line =	20.25 ft	20.25 ft
Left overhang =	2.75 ft	2.75 ft
Computed right overhang =	2.75 ft	2.75 ft

OK Apply Cancel

The Deck (Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line | Distance from right edge of deck to superstructure definition ref. line

Deck thickness | Superstructure Definition Reference Line

Left overhang | Right overhang

Deck | **Deck (Cont'd)** | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | Wearing Surface

Deck concrete:

Total deck thickness: in

Deck crack control parameter: kip/in

Sustained modular ratio factor:

OK Apply Cancel

Parapets:
 Add two parapets as shown below.

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Bridge Rail Type 3	Bridge Rail Type 3	Back	Left Edge	0.00	0.00	Right
Bridge Rail Type 3	Bridge Rail Type 3	Back	Right Edge	0.00	0.00	Left

Lane Positions:

Select the lane position tab and use the Compute... button to compute the lane positions. A dialog showing the results of the computation opens. Click Apply to accept the computed values. The Lane Position tab is populated as shown below.

Structure Typical Section

Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | **Lane Position** | Wearing Surface

Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-19.00	19.00	-19.00	19.00

LRFD Fatigue
 Lanes available to trucks:

Override Truck fraction:

Compute... New Duplicate Delete

OK Apply Cancel

Enter the following wearing surface information on the Wearing Surface tab.

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line

Distance from right edge of deck to superstructure definition ref. line

Deck thickness

Superstructure Definition Reference Line

Left overhang

Right overhang

Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | **Wearing Surface**

Wearing surface material: BituminousPavement

Description:

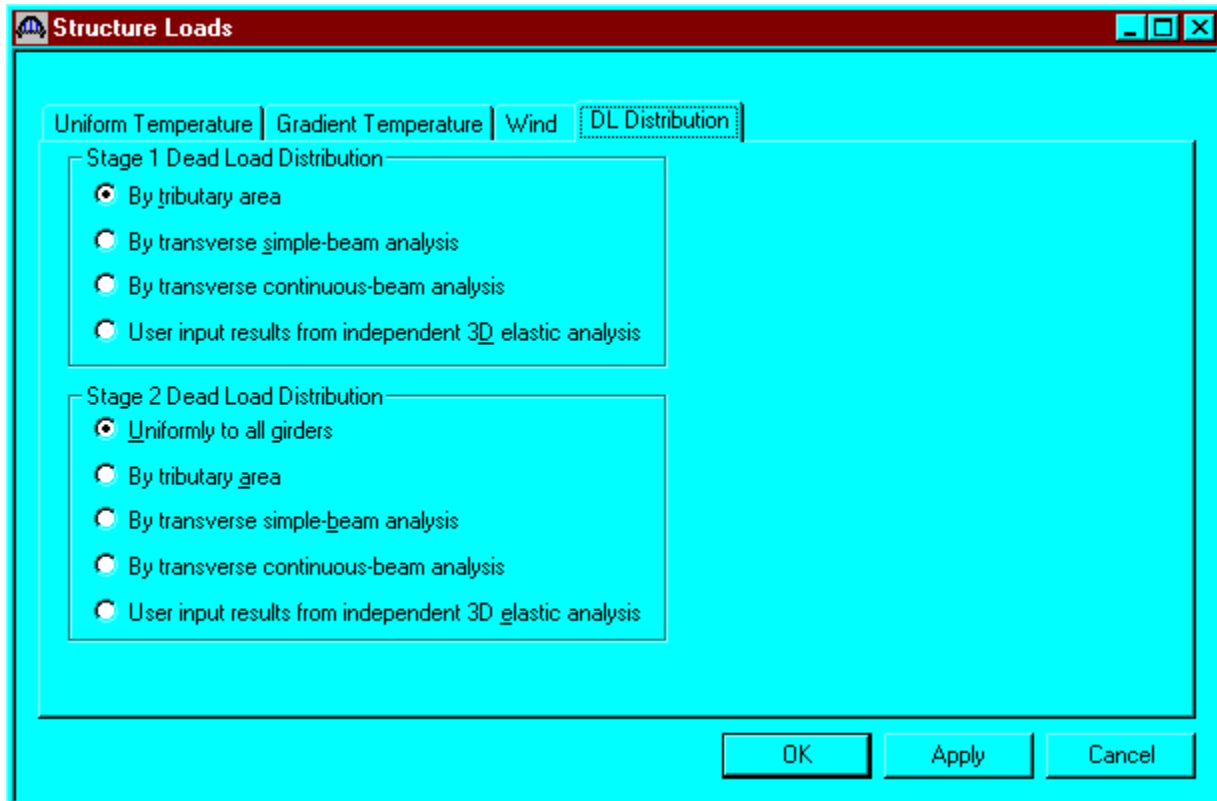
Wearing surface thickness = 4.0000 in

Wearing surface density = 144.000 pcf

Load case: HBP

OK Apply Cancel

Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



Expand the Stiffener Definitions tree item and double click on Transverse. Define the stiffener as shown below. Click OK to save to memory and close the window.

Transverse Stiffener Definition

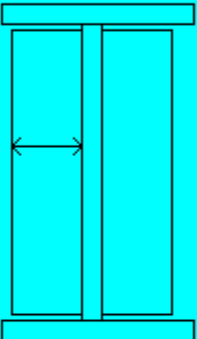
Name:

Stiffener Type
 Single
 Pair

Plate
Thickness: in
Material:

Welds
Top
Web
Bottom

Top Gap: in
 in
Bottom Gap: in



OK Apply Cancel

Transverse Stiffener Definition

Name:

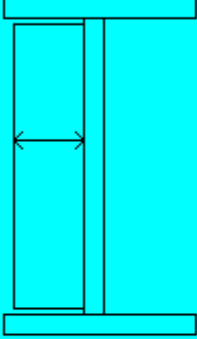
Stiffener Type
 Single
 Pair

Plate
Thickness: in
Material:

Welds
Top:
Web:
Bottom:

Top Gap: in
 in

Bottom Gap: in



OK Apply Cancel

Similarly, define bearing stiffeners by double clicking on Bearing in the tree. Click OK to save to memory and close the window.

Bearing Stiffener Definition

Name: in

Plate

Thickness: in in

Material: in

Welds

Top in

Web in

Bottom in

Bearing Stiffener Definition

Name: in

Plate

Thickness: in in

Material: in

Welds

Top in

Web in

Bottom in

Describing a member:

The member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member.

Member name: G2 Link with: None

Description:

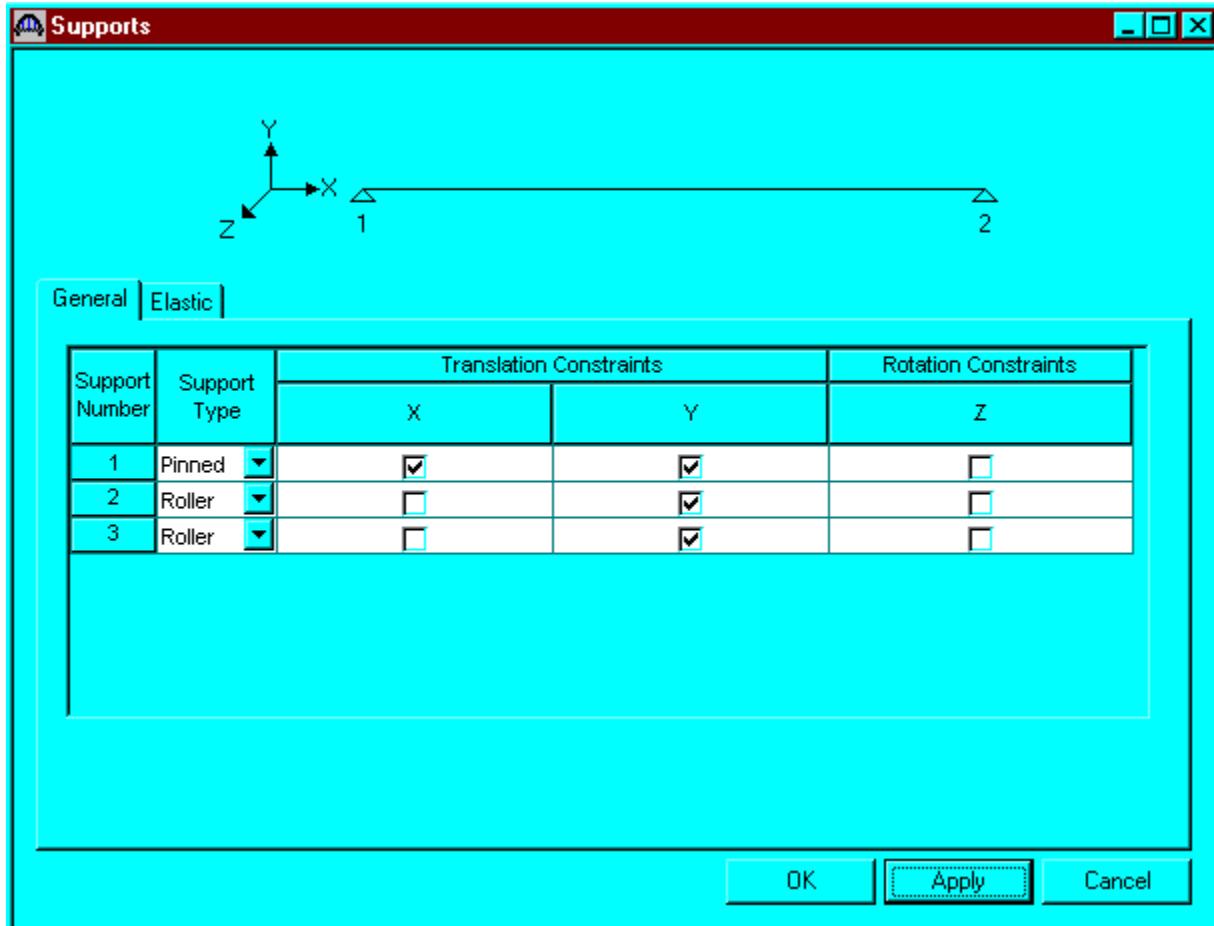
Existing	Current	Member Alternative Name	Description

Number of spans: 2 Pedestrian load: lb/ft

Span No.	Span Length (ft)
1	114.17
2	114.17

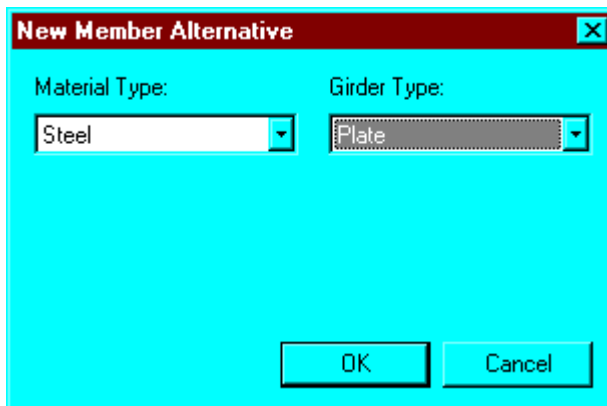
OK Apply Cancel

Double click on Supports to define support constraints for the girder. Support constraints were generated when the structure definition was created and are shown below. Click OK to save data to memory and close the window.



Defining a Member Alternative:

Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select steel for the Material Type and Plate for the Girder Type.



Click OK to close the dialog and create a new member alternative.

Member Alternative Description

Member Alternative:

Description | Factors | Engine | Import

Description:

Material Type:

Girder Type:

Default Units:

Girder property input method:
 Schedule based
 Cross-section based

End bearing locations:
Left: in
Right: in

Analysis Module:
ASD:
LFD:
LRFD:

Additional Self Load:
Additional self load = kip/ft
Additional self load = %

Default rating method:

OK Apply Cancel

Now re-open the Member G2 window, we will see this Member Alternative designated as the existing and current member alternative for this Member.

Member name: G2 Link with: None

Description:

Existing	Current	Member Alternative Name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Plate Girder	

Number of spans: 2 Pedestrian load: lb/ft

Span No.	Span Length (ft)
1	114.17
2	114.17

OK Apply Cancel

Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to memory and close the window.

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.250	1.314	1.250	0.400
Multi-Lane	1.591	1.857	1.591	1.080

Compute from Typical Section

OK Apply Cancel

Double click on Girder Profile in the tree to describe the girder profile. The window is shown below with the data describing the web.

Girder Profile _ □ ×

Type:

Web | Top Flange | Bottom Flange

Begin Depth (in)	Depth Vary	End Depth (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld at Right
54.0000	None	54.0000	0.3125	1	0.00	102.17	102.17	ASTM A588 - <= 4", Fy = 50 ksi	
54.0000	Linear	85.6250	0.3125	1	102.17	12.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi	
85.6250	Linear	54.0000	0.3125	2	0.00	12.00	12.00	ASTM A588 - <= 4", Fy = 50 ksi	
54.0000	None	54.0000	0.3125	2	12.00	102.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi	

Describe the flanges as shown below.

Girder Profile

Type:

Web | **Top Flange** | Bottom Flange

Begin Width (in)	End Width (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
12.00	12.00	0.6250	1	0.00	83.00	83.00	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	1	83.00	31.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	2	0.00	31.17	31.17	ASTM A588 - <= 4", Fy = 50 ksi		
12.00	12.00	0.6250	2	31.17	83.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi		

New Duplicate Delete

OK **Apply** Cancel

Girder Profile

Type:

Web | Top Flange | **Bottom Flange**

Begin Width (in)	End Width (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
12.00	12.00	0.6250	1	0.00	12.00	12.00	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	1	12.00	102.17	114.17	ASTM A588 - <= 4", Fy = 50 ksi		
18.00	18.00	1.0000	2	0.00	102.17	102.17	ASTM A588 - <= 4", Fy = 50 ksi		
12.00	12.00	0.6250	2	102.17	12.00	114.17	ASTM A588 - <= 4", Fy = 50 ksi		

New Duplicate Delete

OK Apply Cancel

Double click on Deck Profile and enter data describing the structural properties of the deck. The deck concrete and reinforcement windows are shown below.

Deck Profile

Type:

Deck Concrete | **Reinforcement** | Shear Connectors

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
Class D(US)	1	0.00	87.75	87.75	8.5000	102.0000	105.0000	
Class D(US)	1	87.75	52.83	140.58	8.5000	102.0000	105.0000	
Class D(US)	2	26.42	87.75	114.17	8.5000	102.0000	105.0000	

New Duplicate Delete

OK Apply Cancel

Deck Profile

Type:

Deck Concrete | **Reinforcement** | Shear Connectors

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Bar Count	Bar Size	Distance (in)	Row
Grade 60	1	68.67	45.50	114.17	7.000	8	3.7500	Top of Slab
Grade 60	1	68.67	45.50	114.17	6.000	5	3.5625	Top of Slab
Grade 60	2	0.00	45.50	45.50	7.000	8	3.7500	Top of Slab
Grade 60	2	0.00	45.50	45.50	6.000	5	3.5625	Top of Slab

New Duplicate Delete

OK Apply Cancel

Composite regions are described using the Shear Connectors tab as shown below.

Deck Profile

Type:

Deck Concrete | Reinforcement | **Shear Connectors**

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Connector ID	Number per Row	Number of Spaces	Transverse Spacing (in)
1	0.00	28.00	28.00	7/8" Dia x 6 in Studs	2	28	9.0000
1	28.00	51.25	79.25	7/8" Dia x 6 in Studs	2	41	9.0000
1	79.25	8.50	87.75	7/8" Dia x 6 in Studs	2	17	9.0000
2	26.42	8.50	34.92	7/8" Dia x 6 in Studs	2	17	9.0000
2	34.92	51.25	86.17	7/8" Dia x 6 in Studs	2	41	9.0000
2	86.17	28.00	114.17	7/8" Dia x 6 in Studs	2	28	9.0000

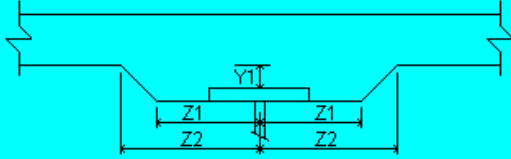
New Duplicate Delete

OK Apply Cancel

Double click on Haunch Profile in the tree to define the haunch profile. Check the box 'embedded flange' if the top flanges of the girder is embedded in the concrete haunch.

Haunch Profile _ □ ×

Haunch Type: Embedded flange

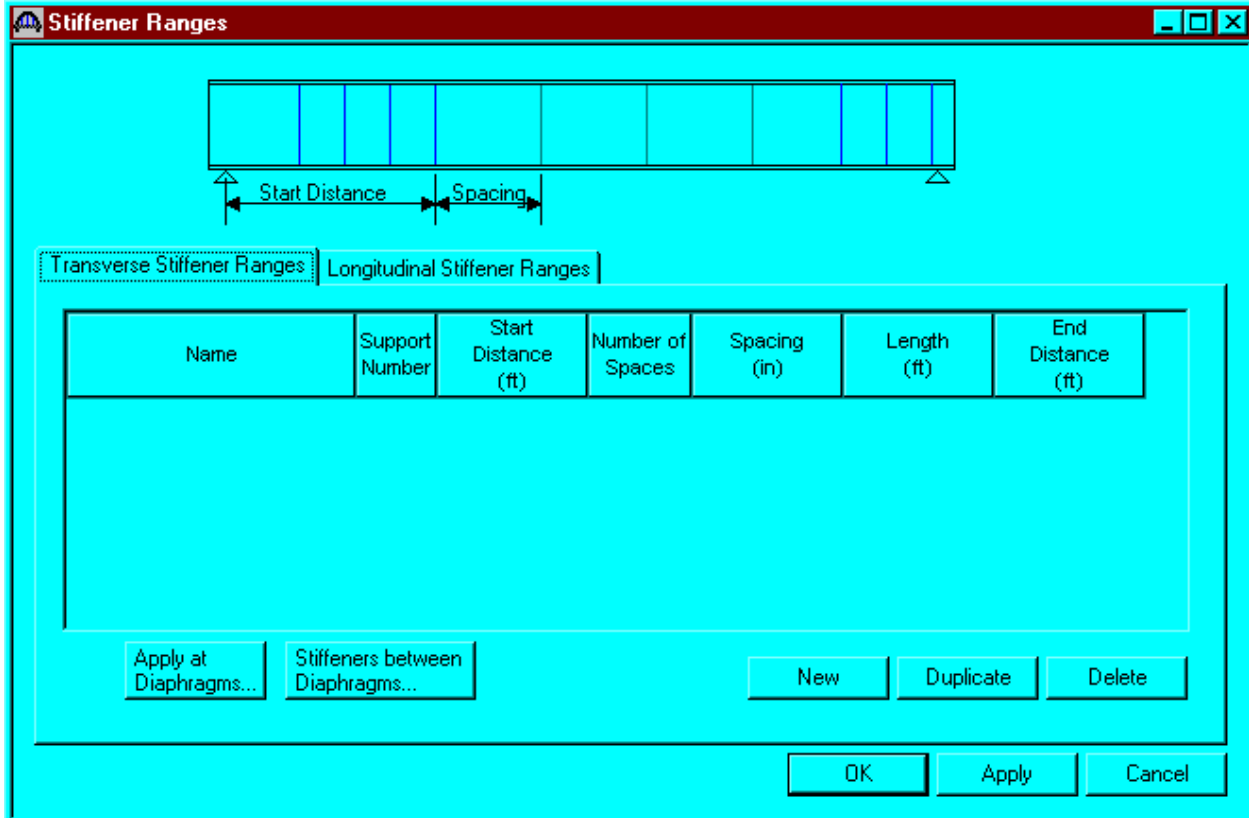


Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)
1	0.00	83.00	83.00	6.0000	6.0000	1.8750
1	83.00	31.17	114.17	6.0000	6.0000	1.5000
2	0.00	31.17	31.17	6.0000	6.0000	1.5000
2	31.17	83.00	114.17	6.0000	6.0000	1.8750

Regions where the hardened concrete deck slab is considered to provide lateral support for the top flange are defined using the Lateral Support window.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
1	0.00	114.17	114.17
2	0.00	114.17	114.17

Define stiffener locations using the Stiffener Ranges window shown below.



Click on the Apply at Diaphragms... to open the following dialog box. Select the Diaphragm connection Plates D2 as the stiffener to be applied at interior diaphragms.

Diaphragm Connection Plates

Apply the following stiffener definitions to the diaphragm locations:

End Diaphragms and Diaphragms At Piers

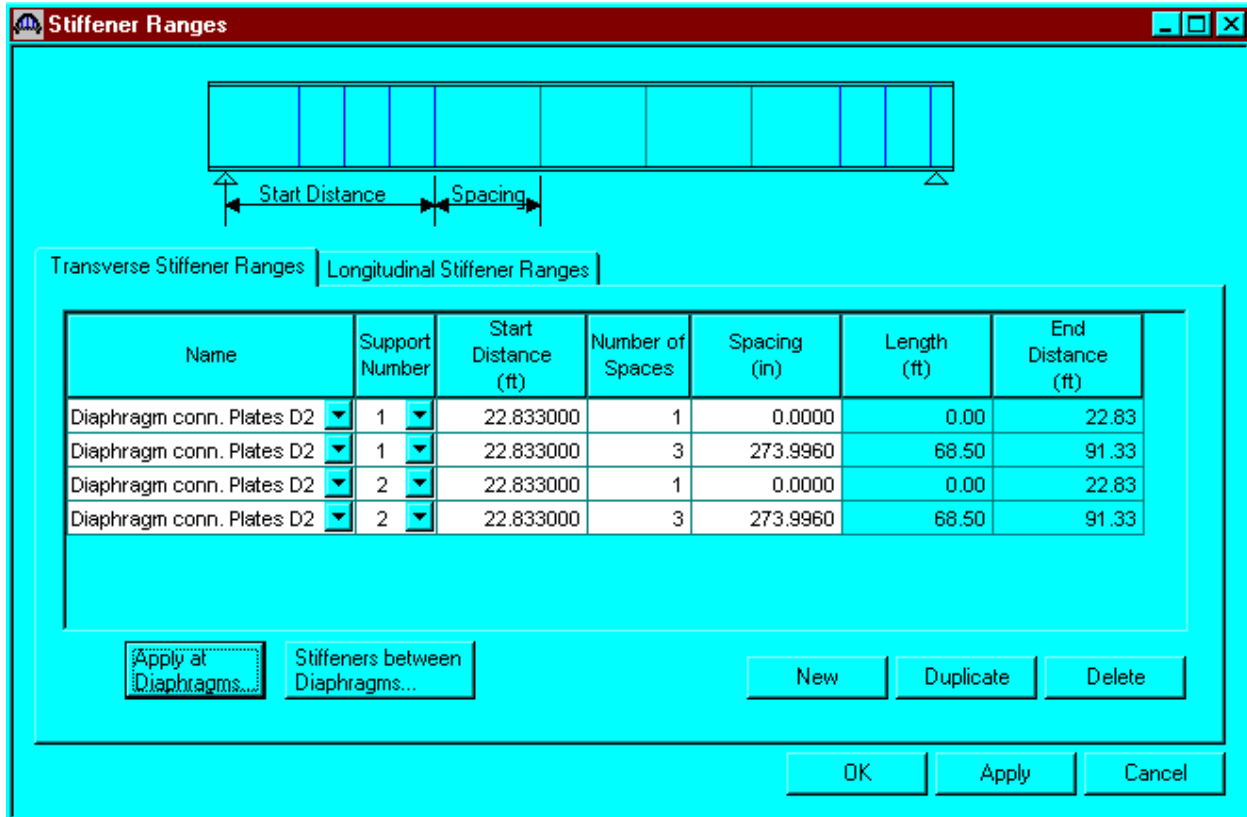
Bearing Stiffener: Bearing Stiffener Abut. D1

Interior Diaphragms

Transverse Stiffener: Diaphragm conn. Plates D2

Apply Cancel

Selecting Apply button will create the following transverse stiffener locations.



This structure has intermediate transverse stiffeners between diaphragms. Click on the Stiffeners between Diaphragms... button to open the following window.

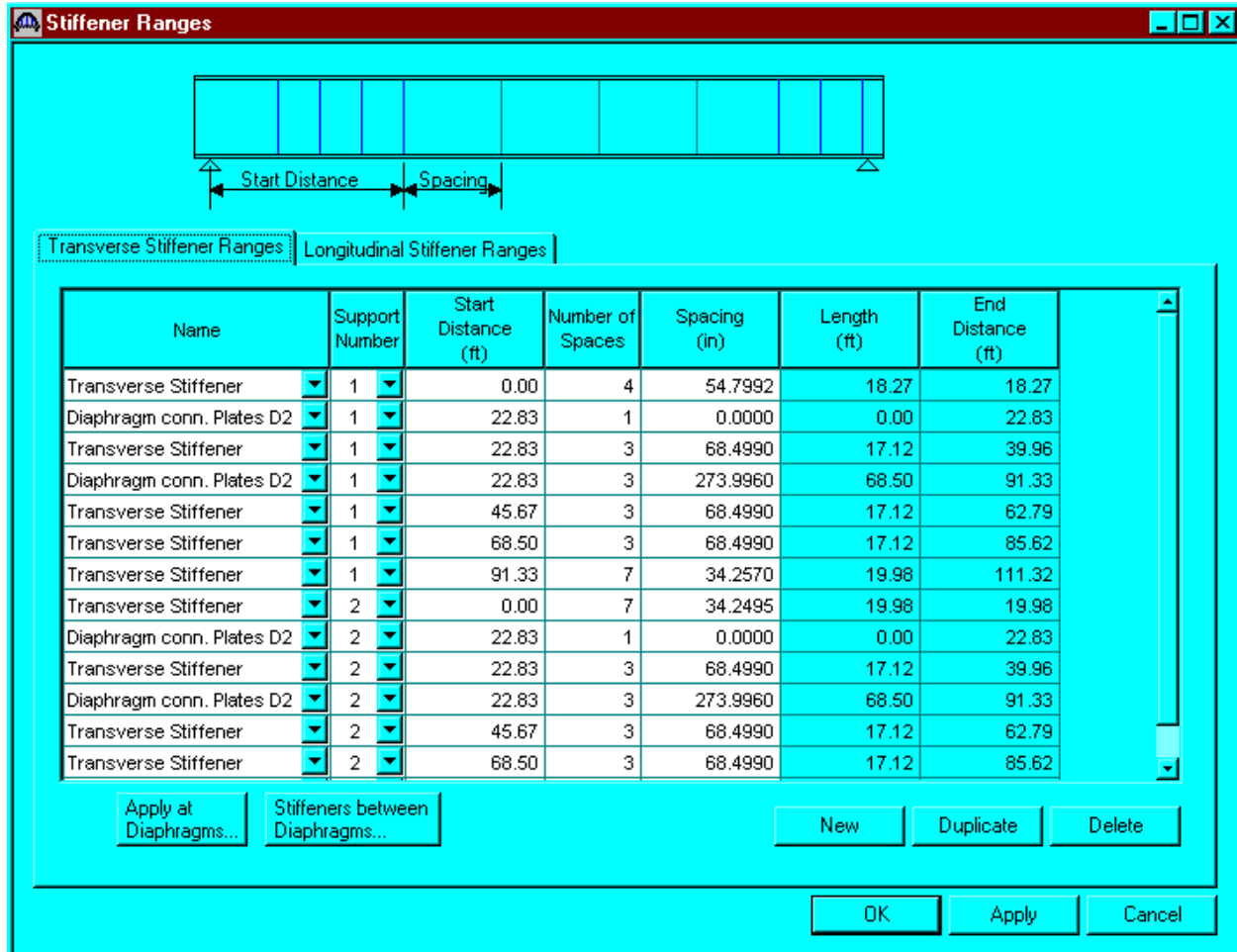
Enter the appropriate stiffener data i.e., the number of equal spaces between diaphragms and the stiffener definition.

Stiffeners between Diaphragms ✕

Diaphragms					Stiffeners	
Girder Bay	Support Number	Start Distance (ft)	Spacing (ft)	End Distance (ft)	Number of Equal Spaces	Stiffener Definition
Both Sides	1 ▾	0.00	22.83	22.83	5	Transverse Stiffener ▾
Both Sides	1 ▾	22.83	22.83	45.67	4	Transverse Stiffener ▾
Both Sides	1 ▾	45.67	22.83	68.50	4	Transverse Stiffener ▾
Both Sides	1 ▾	68.50	22.83	91.33	4	Transverse Stiffener ▾
Both Sides	1 ▾	91.33	22.84	114.17	8	Transverse Stiffener ▾
Both Sides	2 ▾	0.00	22.83	22.83	8	Transverse Stiffener ▾
Both Sides	2 ▾	22.83	22.83	45.67	4	Transverse Stiffener ▾
Both Sides	2 ▾	45.67	22.83	68.50	4	Transverse Stiffener ▾
Both Sides	2 ▾	68.50	22.83	91.33	4	Transverse Stiffener ▾
Both Sides	2 ▾	91.33	22.83	114.17	5	Transverse Stiffener ▾

Click the Apply button.

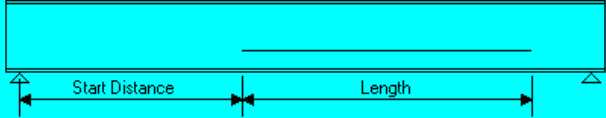
The populated Transverse Stiffener Ranges window is shown below. Click on the Apply button to save the data to memory.



Click on the Longitudinal Stiffener Ranges tab to define the limits of longitudinal stiffeners.

Enter the appropriate stiffener data and click the Apply button to save the data to memory and close the window.

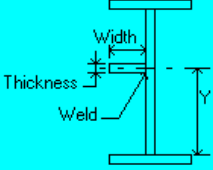
Stiffener Ranges



Start Distance Length

Transverse Stiffener Ranges Longitudinal Stiffener Ranges

Plate Angle

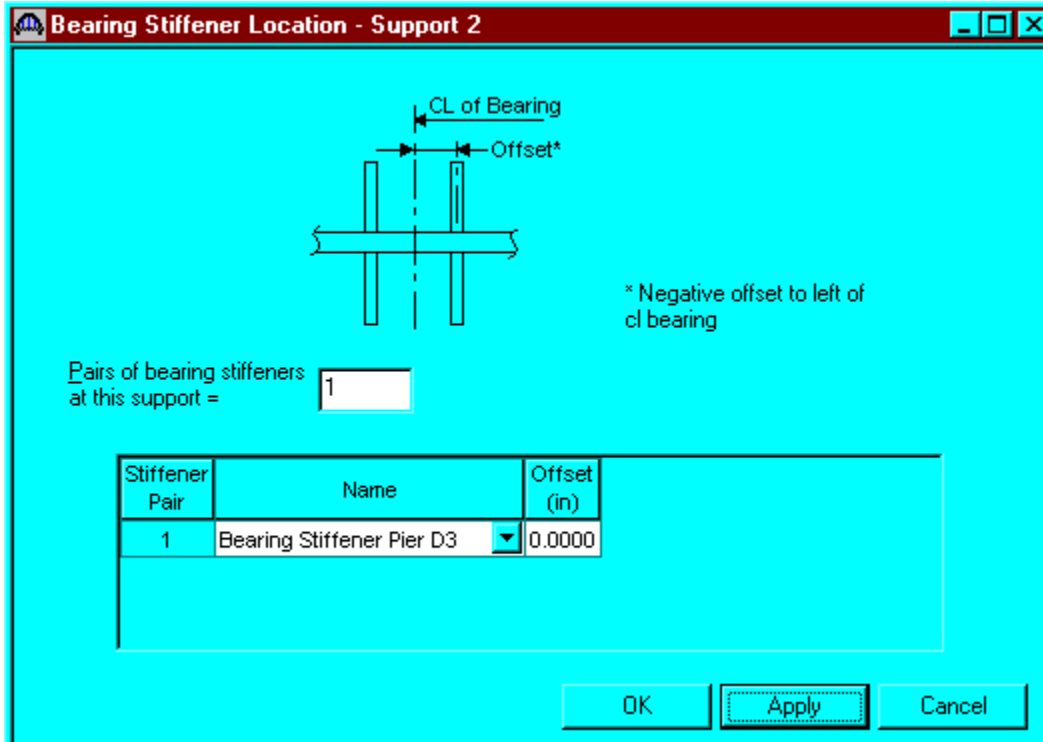
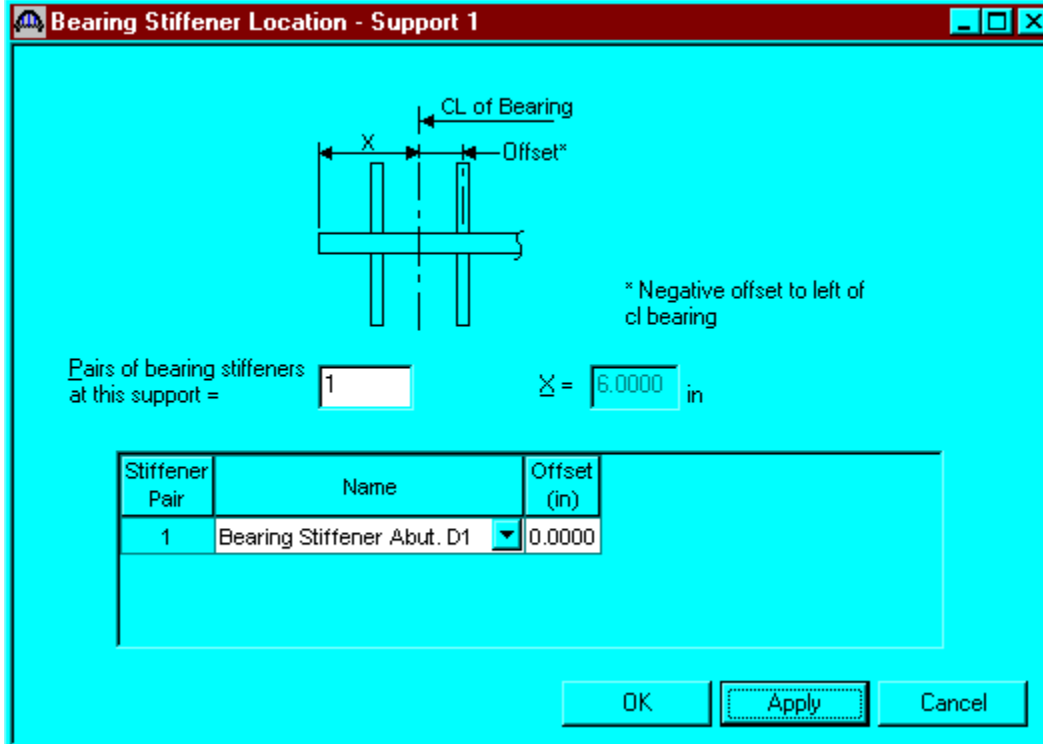


Support Number	Start Distance (ft)	Length (in)	End Distance (ft)	Y (in)	Measured From	Width (in)	Thickness (in)	Material
1	0.00	1080.0000	90.00	11.0000	Top Flange	4.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
1	68.00	410.0000	102.17	11.0000	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
1	102.17	144.0000	114.17	14.2500	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	0.00	144.0000	12.00	14.2500	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	12.00	410.0000	46.17	11.0000	Bottom Flang	3.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi
2	24.17	1080.0000	114.17	11.0000	Top Flange	4.500	0.3125	ASTM A588 - <= 4", Fy = 50 ksi

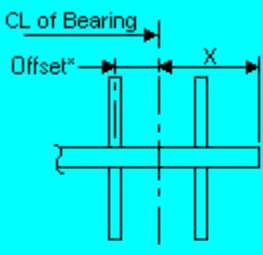
New Duplicate Delete

OK Apply Cancel

Bearing stiffener definitions were assigned to locations when we used the Apply at Diaphragms... button on the Transverse Stiffener Ranges window. Open the window by expanding the Bearing Stiffener Locations branch in the tree and double clicking on each support. The assignment for support 1, 2 and 3 are shown below.



Bearing Stiffener Location - Support 3




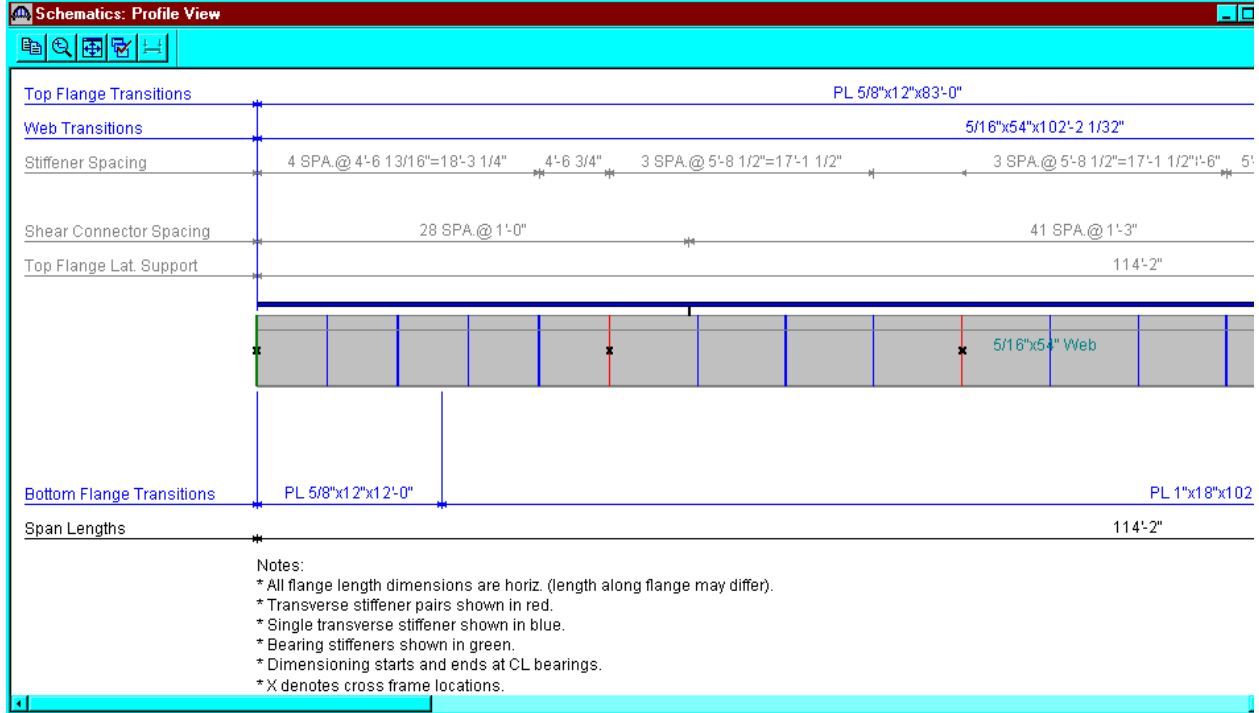
* Negative offset to left of cl bearing

Pairs of bearing stiffeners at this support = Σ = in

Stiffener Pair	Name	Offset (in)
1	Bearing Stiffener Abut. D1	0.0000

OK Apply Cancel

Select Plate Girder (E)(C) in the Bridge Workspace tree; open the schematic for the girder profile by selecting the View Schematic toolbar button  or the Bridge/Schematic from the menu.



The results of the control LFD rating analysis are as follows:

Wyoming Department of Transportation, Bridge Design Division
Date 04/10/2002

Page 144

Member: G2

RATING FACTOR REPORT

ANALYSIS POINT NO. 5: 104.00

LOAD LEVELS

1: 1.30(1.00 * D + 1.67 * L)
2: 1.00(1.00 * D + 1.67 * L)
3: 1.30(1.00 * D + 1.00 * L)
4: 1.00(1.00 * D + 1.00 * L)

TRUCK DESCRIPTION

1. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
2. Truck: AASHTO H 20-S 16 Loading, 1944 Ed
3. Truck: 96 Tons Vehicle
4. SPECIAL-LOAD

----- STRENGTH -----

LOAD LEVEL 1 ----- LOAD LEVEL 2 ----- LOAD LEVEL 3 ----- LOAD LEVEL 4

FLEXURE

	LOAD LEVEL 1	LOAD LEVEL 2	LOAD LEVEL 3	LOAD LEVEL 4
TRUCK 1	01.22	N/A	02.04	N/A
TRUCK 2	01.45	N/A	02.42	N/A
TRUCK 3	00.68	N/A	01.13	N/A
CRITICAL	00.68	N/A	01.13	N/A

$$I = 1.22(36) = 43.9 \text{ TONS}$$

$$O = 2.04(36) = 73.4 \text{ TONS}$$

REINFORCEMENT

	LOAD LEVEL 1	LOAD LEVEL 2	LOAD LEVEL 3	LOAD LEVEL 4
TRUCK 1	N/A	N/A	N/A	N/A
TRUCK 2	N/A	N/A	N/A	N/A
TRUCK 3	N/A	N/A	N/A	N/A
CRITICAL	N/A	N/A	N/A	N/A

$$\text{Permit} = 1.13(96) = 108.5 \text{ TONS}$$

SHEAR

	LOAD LEVEL 1	LOAD LEVEL 2	LOAD LEVEL 3	LOAD LEVEL 4
TRUCK 1	01.58	N/A	02.65	N/A
TRUCK 2	02.00	N/A	03.35	N/A
TRUCK 3	01.12	N/A	01.87	N/A
CRITICAL	01.12	N/A	01.87	N/A

BEARING

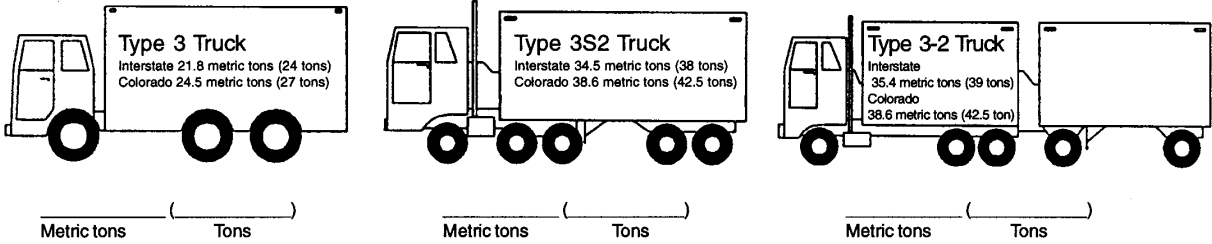
	LOAD LEVEL 1	LOAD LEVEL 2	LOAD LEVEL 3	LOAD LEVEL 4
TRUCK 1	N/A	N/A	N/A	N/A
TRUCK 2	N/A	N/A	N/A	N/A
TRUCK 3	N/A	N/A	N/A	N/A
CRITICAL	N/A	N/A	N/A	N/A

COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure # N-17-BP (N.B.)
	State highway # I-25
Rated using Asphalt thickness: 100 mm (4 in.) <input type="checkbox"/> Colorado legal loads <input checked="" type="checkbox"/> Interstate legal loads	Batch I.D.
	Structure type WGCK
	Parallel structure # N-17-AM (S.B.)

Structural member	INTERIOR GIRDER	SLAB	
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Metric tons (Tons)

Inventory	40.0 (44)	32.7 (36)	()	()
Operating	66.4 (73)	53.6 (59)	()	()
Type 3 truck	()	()	()	()
Type 3S2 truck	()	()	()	()
Type 3-2 truck	()	()	()	()
Permit truck	98.2 (108)	()	()	()



Comments

Control Member: Deck; Rated for 4" HBP
 Load Capacity: 59 Tons
 Girder: Only Interior Girder Rated; Rated for 4" HBP

Color Code: White

Project No: I25-1(88)
 Note: Although Virtis performs the required flexure, shear and bearing capacity check during analysis, shear check has been omitted in the determination of girder load capacity.

Rated by	Date	Checked by	Date
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