

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE RATING MANUAL	Section: 9A Effective: April 1, 2002 Supersedes: July 1, 1995
SECTION 9A - PRESTRESSED CONCRETE GIRDER BRIDGES	

9A-1 INTRODUCTION TO RATING PRESTRESSED CONCRETE GIRDER BRIDGES

This section together with section 1, presents the policies and guidelines for rating prestressed concrete girders. Policies are itemized in subsection 9A-2, while supporting guidelines are summarized in subsections 9A-2, 3, 4, and 5.

The types of girders covered by this section include precast pretensioned girders as described below:

- CPG - Concrete Prestressed Girder
- CPGC - Concrete Prestressed Girder Continuous
- CDTPG - Concrete Double-Tee Prestressed Girder
- CBGP - Concrete Box Girder Prestressed
- CBGCP - Concrete Box Girder Continuous Prestressed

9A-2 POLICIES AND GUIDELINES FOR RATING PRESTRESSED CONCRETE GIRDER BRIDGES

I. General

- A. Prestressed concrete girders, either simple span, or simple spans made continuous, shall be rated using the VIRTIS computer program. Refer to subsection 9A-3 for information on this program.
- B. When the LFD method is used for rating girders, unless a more rational methodology like the modified compression field theory in the AASHTO LRFD code is adopted for use, prestressed girders shall not be rated for shear. However, during the design process, all prestressed girders shall be checked for shear using the appropriate AASHTO code.
- C. Double-tee structures without a poured in place composite deck or a full depth diaphragm shall use the live load distribution factor as prescribed in the AASHTO LRFD Specifications. The exterior girder distribution factor shall be calculated using the lever rule.
- D. Double-tee structures with a poured in place composite deck or a full depth rigid diaphragm/bracing system with a rotational stiffness roughly equal to a poured in place deck, the live load distribution factor for Concrete T-Girders as prescribed in Table 3.23.1 of the AASHTO Standard Specifications for Highway Bridges, 16th Edition, shall be used.
- E. When using the AASHTO LRFD Multi-Beam live load distribution factor and load restrictions are required, a rational method may be used for the live load distribution factor calculation, including the use of the LDFAC program.

- F. The rater shall be responsible for determining whether stress-relieved or low-relaxation strands were used in the bridge. If it is not possible to discern what type of strand was used, then the rater shall assume that stress-relieved strands were used prior to December, 1983, and low-relaxation strands thereafter.
- G. Prestressed concrete girder bridges with complex geometric alignment i.e., flared girder bridges or girders with a variable overhang, shall be modeled as simple, straight beams on pin or roller supports. The Virtis program output results can then be supplemented by hand calculations to consider any significant influences, as necessary.
- H. For effective slab widths, the b in the equation $(12t+b)$ shall be the width of the top flange of the girder, not the web.

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, number of prestressing strands, differences in loads or moments, concrete strength, 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. The exterior unit of a multi-beam structure should be rated if it does not have a cast-in-place composite slab. For this case the dead loads due to sidewalks, curbs and railing shall be applied to only the exterior unit.
 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 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. The rater shall also indicate whether stress-relieved or low-relaxation strands were used in the rating calculations.
- B. Dead Loads
1. The final sum of all the individual weight components for dead load calculations may be rounded up to the nearest 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. 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 and diaphragms.

4. Use 5 psf for the unit weight of formwork when it is likely the formwork will remain in place.

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

IV. Simple and Continuous Span Bridges

Simple span prestressed girders shall be rated as simple span members for all loads(i.e. DL1, DL2, LL+I loads). Span length shall be taken as the distance between the centerline of bearing at abutments or supports.

Simple span prestressed girders made continuous for composite dead loads and live load plus impact, shall be rated as continuous members for these loads. Span lengths shall be taken as the distance from centerline of bearing at the abutment to centerline of pier, and centerline of pier to centerline of pier as applicable.

The negative moment analysis at centerline of piers shall be based on the Ultimate Strength (Load Factor) method. The girder's primary negative moment reinforcement and only the top layer of the slab's distribution reinforcement, within the effective slab width, shall be used in the analysis.

Prestressed girder end blocks, if present, shall not be used in the analysis.

Simple span prestressed girders made continuous for composite dead loads and live load plus impact, and if the specified compressive strength of concrete (28 days of age) used in the girders changes from span to span, only the girder with the least compressive strength shall be used to model the entire structure.

V. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. 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 typed on the diskette label. This ensures proper importation of bridge data archive by the Staff Bridge at a later date.

9A-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

The VIRTIS computer program performs the analysis and rating of simple span and multispan prestressed 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 and twelve (12) girder lines can be modeled using the program. 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 due to the girder self weight, deck slab and appurtenances (i.e. rails, median barrier etc.) are calculated automatically by the program. Dead load due to the haunch, wearing surface and stiffener weight (for steel bridges) are defined by the user. For a detailed description of the girder loads, refer to the Opis/Virtis Help Menu index item - dead loads. During modeling a structure, help menu can also be activated by using the F1 key when 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 are equal to their calculated numbers.

For prestressed girder bridges, in addition to using the BRASS LFD engine for analysis, all serviceability checks/rating per Article 6.6.3.3 of the AASHTO Manual For Condition Evaluation Of Bridges shall be performed using the BRASS ASD engine.

All Colorado BT girder 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 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.

9A-4 RATING PRESTRESSED CONCRETE GIRDER BRIDGES DESIGNED BY LOAD FACTOR METHOD

All ratings should be performed in accordance to the AASHTO Manual For Condition Evaluation of Bridges and the appropriate Articles of AASHTO Bridge Design Specifications. The capacity of prestressed concrete members should be evaluated for strength requirements (at both Inventory and Operating level) stated in the AASHTO Design Specifications Article 9.17. At the Inventory level, Serviceability requirements should also be considered. The basic rating equation (6-1a) of the Manual For Condition Evaluation of Bridges may be used if checking the crack serviceability limit state with $A_1=1.0$, $A_2=1.0$, and $C=M^*_{cr}$. Typically, prestressed concrete members used in bridge structures will meet the minimum reinforcement requirements of Article 9.18.2.1 of the AASHTO Design Specifications. While there is no reduction in the flexural strength of the member in the event that these provisions are not satisfied, an owner, as part of the flexural rating may choose to limit live loads to those that preserve the relationship between ϕM_n and M^*_{cr} by adjusting the capacity value "C" in the rating equation (6-1a). Thus when $\phi M_n < 1.2M^*_{cr}$, the adjusted "C" becomes $(k)(\phi)(M_n)$ where $k = (\phi M_n)/(1.2M^*_{cr})$. Non Prestressed Reinforcement may be considered as per AASHTO Specifications Article 9.19.

The following equations regarding Load Factor rating of pretensioned and postensioned concrete members are furnished:

INVENTORY RATING

$$RF = \frac{6\sqrt{F'_C} \pm F_D \pm F_P \pm F_S}{F_{LL+I}} \quad \text{Equation (1) Concrete Tension}$$

$$RF = \frac{.6F'_C \pm F_D \pm F_P \pm F_S}{F_{LL+I}} \quad \text{Equation (2) Concrete Compression}$$

$$RF = \frac{.4F'_C \pm 1/2(F_D \pm F_P \pm F_S)}{F_{LL+I}} \quad \text{Equation (3) Concrete Compression}$$

$$RF = \frac{0.8F_Y^* \pm F_D \pm F_P \pm F_S}{F_{LL+I}} \quad \text{Equation (4) Prestressing Steel Tension}$$

$$RF = \frac{\phi R_n \pm 1.3D \pm 1.0S}{2.17L} \quad \text{Equation (5) Flexural & Shear Strength}$$

OPERATING RATING

$$RF = \frac{\phi R_n \pm 1.3D \pm 1.0S}{1.3L} \quad \text{Equation (6) Flexural \& Shear Strength}$$

$$RF = \frac{0.9F_Y^* \pm F_D \pm F_P \pm F_S}{F_{LL+I}} \quad \text{Equation (7) Prestressing Steel Tension}$$

- RF = Rating Factor
 F'_C = Concrete Compressive Strength
 F_D = Unfactored dead load stresses
 F_P = Unfactored stress due to prestress force after all losses
 F_S = Unfactored stress due to secondary prestress forces
 F_{LL+I} = Unfactored live load stress including impact
 ϕR_n = Nominal strength of section (ϕM_n or ϕV_n) satisfying the ductility limitations of Article 9.18 and Article 9.20 of the AASHTO Standard Specifications. Both moment (ϕM_n) and shear (ϕV_n) should be evaluated.
 D = Unfactored dead load moment or shear
 S = Unfactored prestress secondary moment or shear
 L = Unfactored live load moment or shear including impact
 F_Y^* = Prestressing steel yield stress
 M_{cr}^* = Cracking Moment per AASHTO article 9.18

NOTE:

Equation (7) can control rating when at least one strand is near the extreme tension fiber and the C.G. of the prestressing is near the neutral axis.

9A-5 RATING PRESTRESSED CONCRETE GIRDER BRIDGES WITHOUT PLANS

When there are no plans or other documentation for a particular prestressed concrete structure, its numerical rating shall be determined by a Professional Engineer Registered in the State of Colorado. This rating shall be based on a complete and comprehensive inspection of the structure and directions from the AASHTO MANUAL FOR CONDITION EVALUATION OF BRIDGES 1994, Second Edition. If the structure shows no signs of distress due to load, the Engineer can assign it a maximum inventory rating of 36 tons, and operating rating of 40 tons. For all structures in the State Highway System and designed after January 1994, with the exception of LRFD designed bridges, a no distress condition shall have a minimum Inventory rating of 45 tons and an Operating rating of 75 tons. For LRFD designed bridges, i.e., structures designed after January 1998, a no distress condition shall have a minimum permit vehicle operating rating of 105 tons.

When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and ratings proportionally less shall be given to the prestressed concrete structure.

For bridges owned or maintained by the Colorado Department of Transportation, the Staff Bridge Engineer will approve this type of rating. For bridges owned or maintained by a city or county, a recommended rating shall be approved by the City and County Engineer and shown on the Rating Summary Sheet.

The processes and responsibilities of the Rater and Checker will still follow those described in Section 1 with the following two additions. First, as just described, the Staff Bridge Engineer shall, or appropriate city/county official should, review the recommended rating. Secondly, the rating summary sheet shall state that the structure was rated by inspection.

9A-6 PRESTRESSED CONCRETE GIRDER BRIDGE RATING EXAMPLES

Three examples are presented in this section. First, Structure I-09-Q is a simple span composite concrete prestressed girder bridge with a skew of 33° degrees. It has seven (7) BT-72 girders. Only the interior girder has been modeled for this structure. The second structure, F-17-IE, is a 3-span composite concrete prestressed girder bridge with a skew of 52° degrees. It has four (4) G-54 girders. For simplicity, only the interior girder has been modeled for this structure. The third structure, L-26-BR, is a simple span prestressed girder bridge with a skew of 0°. It has no poured in place composite deck. Due to limitations on the number of girders that Virtis can analyze, only twelve (12) girders (i.e., 6 Double-tee girder Units) have been used to model the structure. For modeling simplicity, only half of a Double-tee interior girder has been modeled for this structure.

Colorado BT girder shapes included:

Colorado BT girder shapes included:

Slab Rating Program Input, Structure No. I-09-Q

WinSlab Input			
Structure Number:	<input type="text" value="I-09-Q"/>	Rating:	<input type="text" value="MH"/>
Batch ID:	<input type="text"/>	Comments:	<input type="text" value="LFD"/>
Highway Number:	<input type="text" value="135"/>	Load Type:	<input type="text" value="1=Colorado"/>
<hr/>			
Deadload	Bituminous Overlay (in):	<input type="text" value="2"/>	
<hr/>			
Geometry			
Effective Span (ft):	<input type="text" value="4.3"/>	Actual Slab Thickness (in.):	<input type="text" value="8"/>
Reinforcing Steel:			
	Area (sqin)	Distance (in)	For definitions of input values please refer to the CDOT Bridge Rating Manual
Top:	<input type="text" value="0.53"/>	<input type="text" value="5.188"/>	
Bottom:	<input type="text" value="0.53"/>	<input type="text" value="1.31"/>	
Materials Properties			
Concrete f'c (PSI):	<input type="text" value="4500"/>	Steel Fy (PSI):	<input type="text" value="60000"/>
or Inv Fc (Working Stress)		or Inv Fs (Working Stress)	
Modular Ratio (Leave blank for load factor):	<input type="text" value="00"/>		
<input type="button" value="OK"/>	<input type="button" value="Cancel"/>	<input type="button" value="Apply"/>	<input type="button" value="Output to File"/>

Effective Span Length: Per AASHTO Article 3.24.1.2(b)

$$\text{Clear distance between flanges} + 1/2 \text{ flange width} = 30'' + 1/2(43) = 51.5'' = 4.3'$$

Slab Rating Program Output, Structure No. I-09-Q

WinSlab Rating Version 1 Date: 10/12/2001

Structure NO. I-09-Q Rater: MH State HWY NO. = 135
 Batch ID= Description: LFD

LOAD FACTOR RATING-COMP STEEL NOT USED

INPUT DATA

Bituminous Overlay(in)=	2.000	Slab Thickness(in)=	8.000
Eff. Span(ft)=	4.300	Eff. Depth(in) =	5.188
Top Reinf. (sq.in)=	0.53	Bottom Dist.(in)=	1.31
Bottom Area(sq.in)=	0.53	Oper. =	4500
Conc. Strength(PSI) Inv =	4500	Oper. =	60000
Steel Yield (PSI) Inv =	60000		
Modular Ratio =	8		

Dead Load Moment 0.23 K-Ft
 LL+I Moment 3.28 K-Ft
 Gross Weight 36.0 Tons

		Inventory	Operating
Actual Concrete Stress	(PSI)	1384.70	2268.79
Actual Reinf. Steel Stress	(PSI)	26715.30	43772.27
Actual Comp. Steel Stress	(PSI)	3069.34	5029.03
Member Capacity	(K-Ft)	11.55	11.55
Member Capacity (LL+I)	(K-Ft)	11.25	11.25
Rating	(Tons)	57.05	95.09

Virtis Bridge Rating Example, Structure No. I-09-Q

Effective slab width: Per AASHTO Article 9.8.1.1

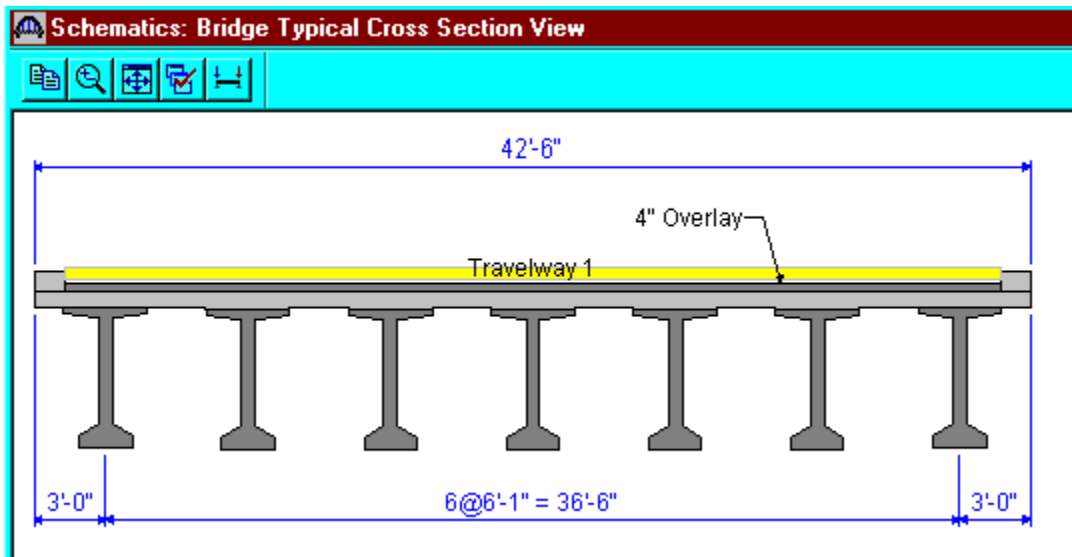
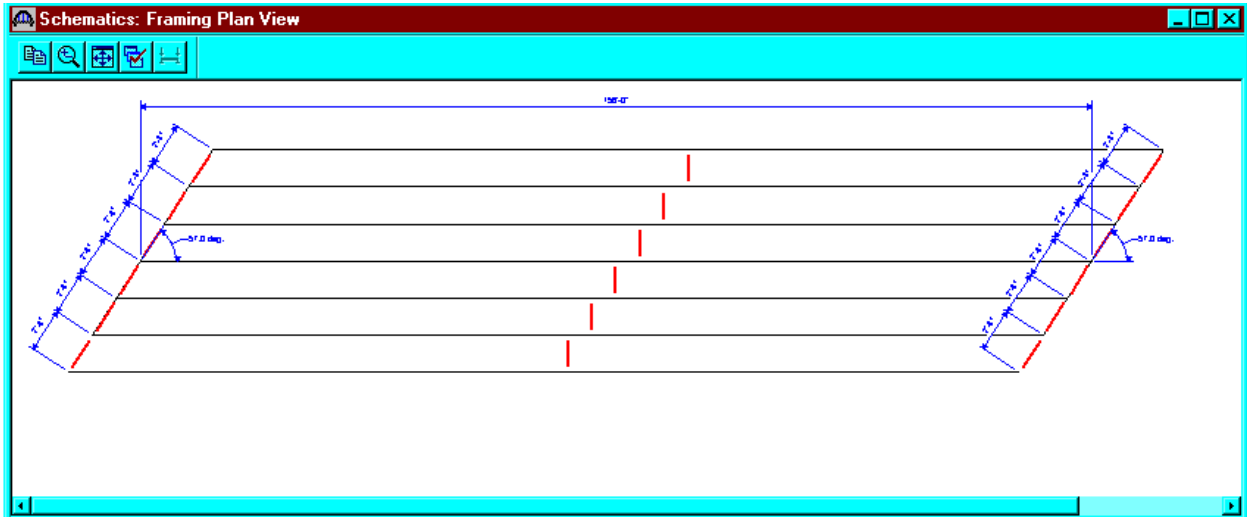
0.25(L) = 0.25(156*12) = 468"
 12t + b = 12*8 + 43 = 139"
 C.L. - C.L. of girder = 6.0833' = 73" Controls

Dead Load:

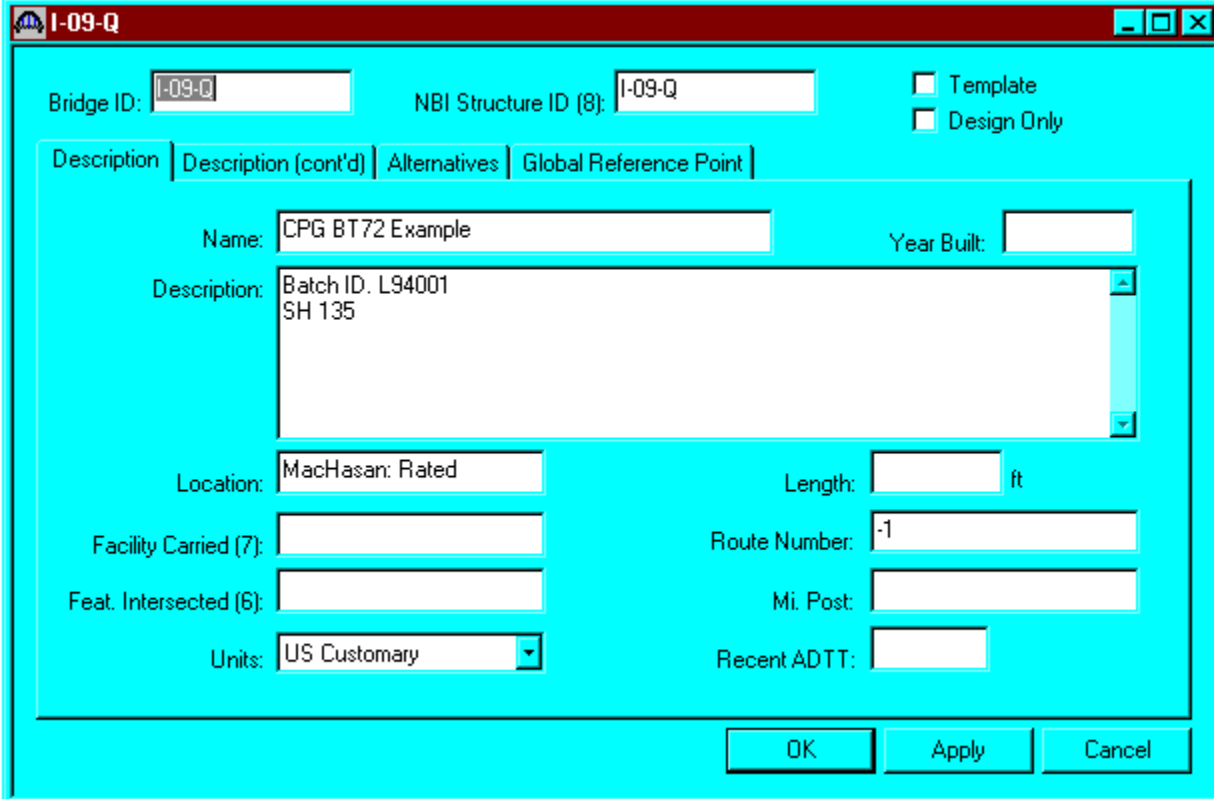
Intermediate Diaphragm = (26/1000)*(73-7)/12 = 0.143 kip
 Use 0.150 kip

Abutment Diaphragm = ((2.67)*(80.5/12)*6.0833*(1/sin57°) - (864/144)*(21/12)*
 (1/sin57°))*(0.150) = 17.6 kips
 Use 18.0 kips

Virtis Bridge Rating Example, Structure No. I-09-Q (contd.)



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



The screenshot shows a software window titled "I-09-Q" with a red title bar. The window contains a form for creating a new bridge structure. At the top, there are two text boxes for "Bridge ID:" and "NBI Structure ID (8):", both containing the value "I-09-Q". To the right of these boxes are two checkboxes: "Template" and "Design Only", both of which are unchecked. Below this is a tabbed interface with four tabs: "Description" (selected), "Description (cont'd)", "Alternatives", and "Global Reference Point". The "Description" tab contains the following fields:

- "Name:" text box containing "CPG BT72 Example".
- "Year Built:" text box.
- "Description:" text area containing "Batch ID. L94001" and "SH 135".
- "Location:" text box containing "MachHasan: Rated".
- "Length:" text box followed by "ft".
- "Facility Carried (7):" text box.
- "Route Number:" text box containing "-1".
- "Feat. Intersected (6):" text box.
- "Mi. Post:" text box.
- "Units:" dropdown menu set to "US Customary".
- "Recent ADTT:" text box.

At the bottom right of the form are three buttons: "OK", "Apply", and "Cancel".

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 concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to save this deck concrete material to memory and close the window.

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 =

Using the same techniques, create a new concrete material to be used for the girder.

Bridge Materials - Concrete

Name: Description:

Compressive strength at 28 days (f'_c) =	<input type="text" value="8.300"/>	ksi
Initial compressive strength (f'_ci) =	<input type="text" value="6.500"/>	ksi
Coefficient of thermal expansion =	<input type="text" value="0.0000060000"/>	1/F
Density (for dead loads) =	<input type="text" value="0.150"/>	kcf
Density (for modulus of elasticity) =	<input type="text" value="0.150"/>	kcf
Modulus of elasticity (E_c) =	<input type="text" value="5523.49"/>	ksi
Initial modulus of elasticity =	<input type="text" value="4888.00"/>	ksi
Poisson's ratio =	<input type="text" value="0.200"/>	
Composition of concrete =	<input type="text" value="Normal"/>	
Modulus of rupture =	<input type="text" value="0.691"/>	ksi
Shear factor =	<input type="text" value="1.000"/>	

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.

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

Bridge Materials - PS Strand

Name: Description:

Strand diameter = in

Strand area = in²

Strand type =

Ultimate tensile strength (Fu) = ksi

Yield strength (Fy) = ksi

Modulus of elasticity (E) = ksi

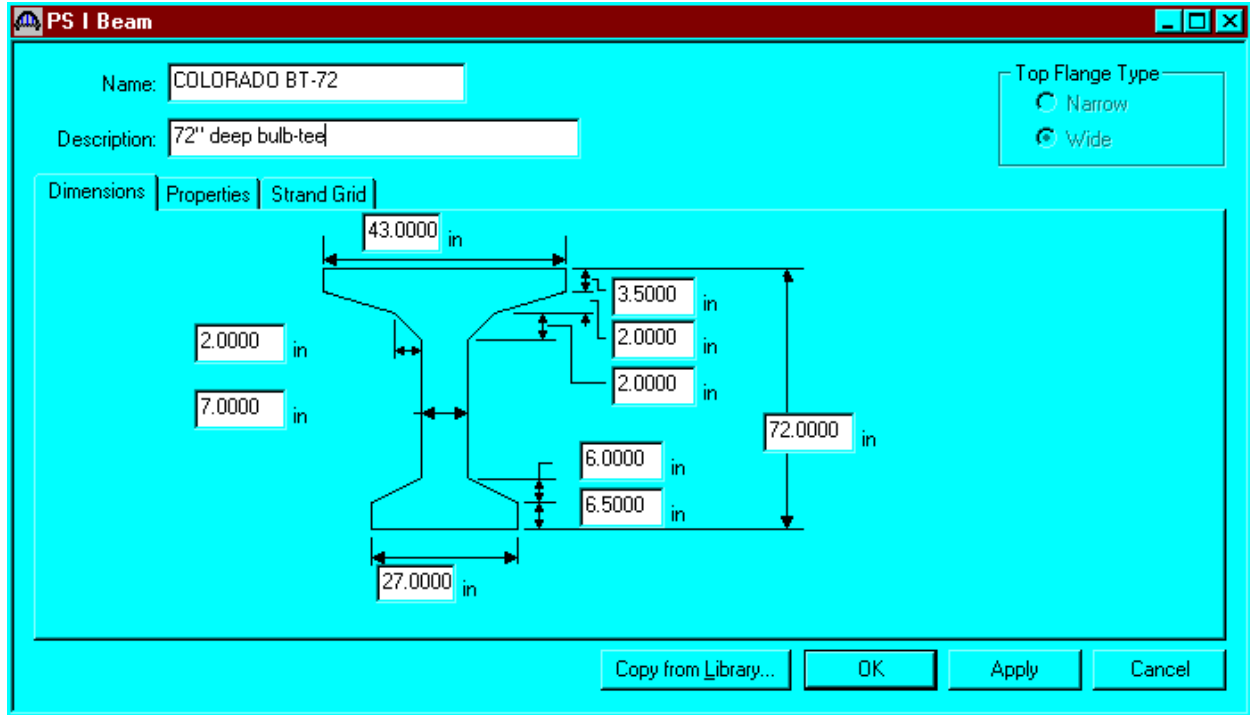
Transfer length (Std) = in

Transfer length (LRFD) = in

Unit weight per length = lb/ft

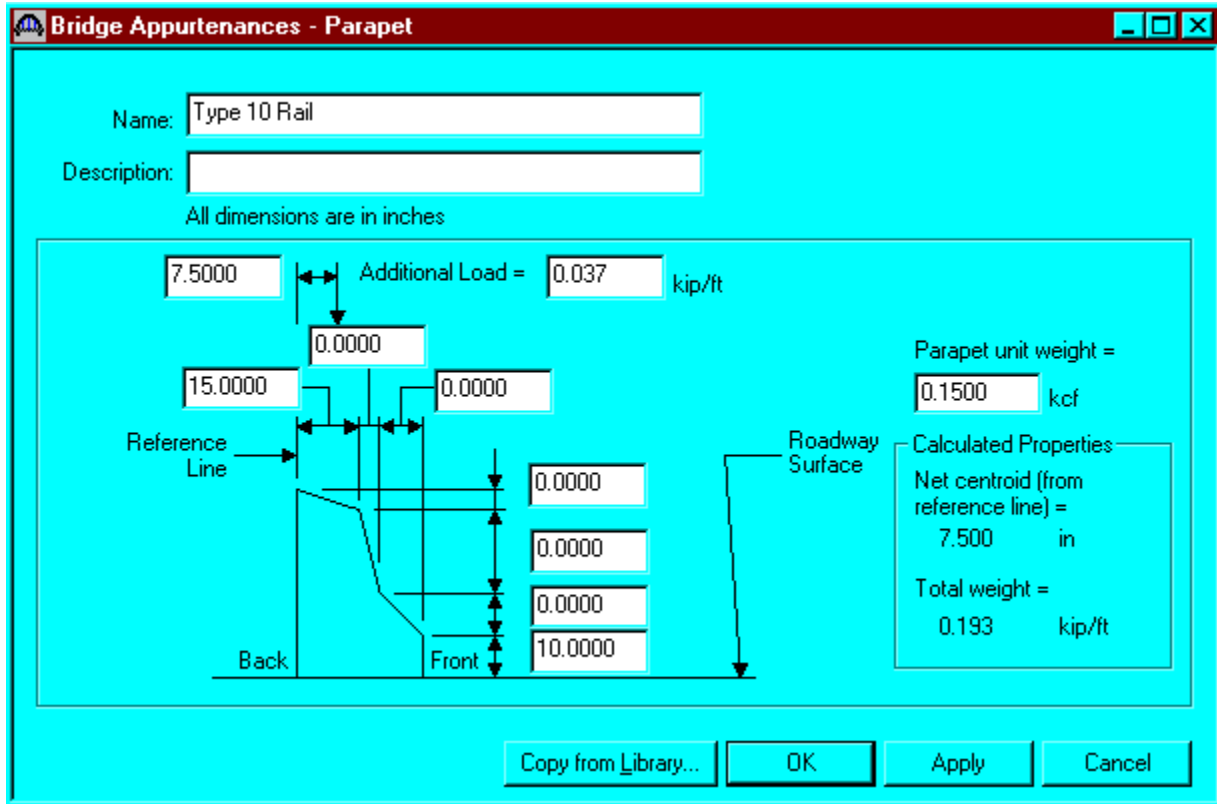
Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Click on the copy from library button or fill in the blanks.



Click OK to save to the memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and click copy from Library button. Select the Jersey Barrier and click OK. The parapet properties are copied to parapet window as shown below. Click OK to save the data to memory and close the window.



The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

Name: 1996 AASHTO Std. Specifications

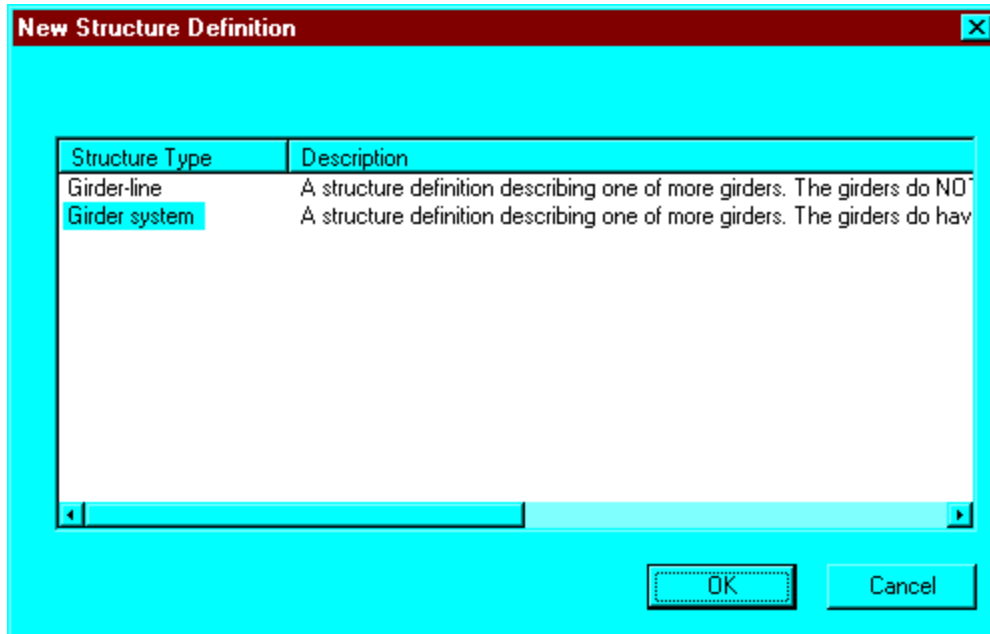
Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Factors | Resistance Factors

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

Copy from Library... OK Apply Cancel

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE 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 Structure Definition

Definition | Analysis | Engine

Name: 7-girder system

Description:

Units: US Customary

Number of spans: 1

Number of girders: 7

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	156.00

For PS only

Average humidity: 60.000 %

Member Alt. Types

Steel

P/S

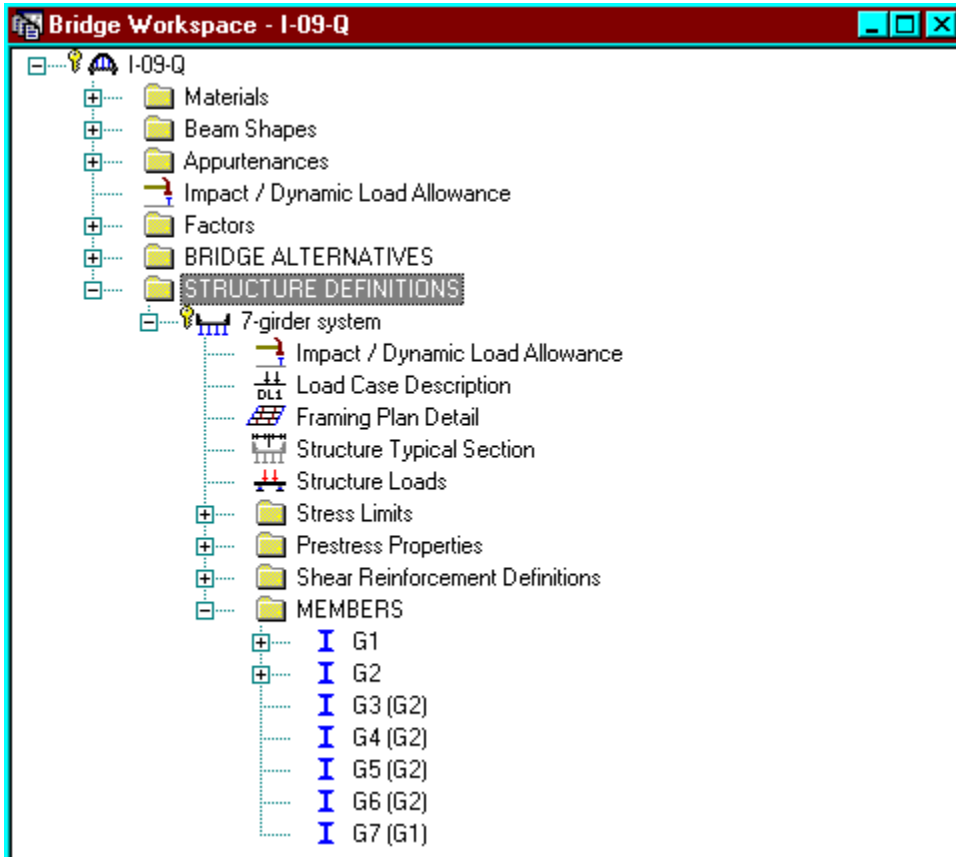
R/C

Timber

OK Apply Cancel

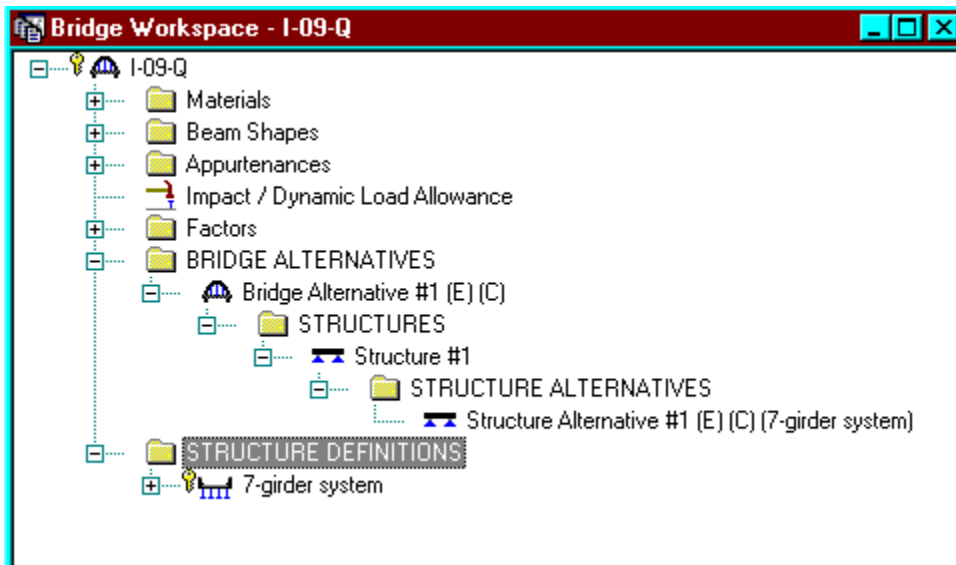
Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:



We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

The partially expanded Bridge Workspace tree is shown below:



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)
parapets		Composite (long term) (Stage 2)	D,DC	
future wearing surface		Composite (long term) (Stage 2)	D,D/W	
Haunch Load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

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	33.0000
2	33.0000

Girder Spacing Orientation

Perpendicular to girder

Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	6.08	6.0
2	6.08	6.0
3	6.08	6.0
4	6.08	6.0
5	6.08	6.0

OK Apply Cancel

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

Structure Framing Plan Details

Number of spans = Number of girders =

Layout: **Diaphragms**

Girder Bay:

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	18.0000
1	0.00	3.95	78.00	1	78.00	78.00	81.95	0.1500
1	156.00	156.00	0.00	1	0.00	156.00	156.00	18.0000

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 structure definition reference line | Distance from right edge of deck to structure definition reference line

Deck thickness

Structure Definition Reference Line

Left overhang | Right overhang

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

Structure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to structure definition reference line =	21.25 ft	21.25 ft
Distance from right edge of deck to structure definition reference line =	21.25 ft	21.25 ft
Left overhang =	3.00 ft	3.00 ft
Computed right overhang =	3.00 ft	3.00 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 structure definition reference line | Distance from right edge of deck to structure definition reference line

Deck thickness

Structure 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.

Structure Typical Section

Back Front

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

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Type 10 Rail	parapets	Back	Left Edge	0.00	0.00	Right
Type 10 Rail	parapets	Back	Right Edge	0.00	0.00	Left

New Duplicate Delete

OK Apply Cancel

Lane Positions:

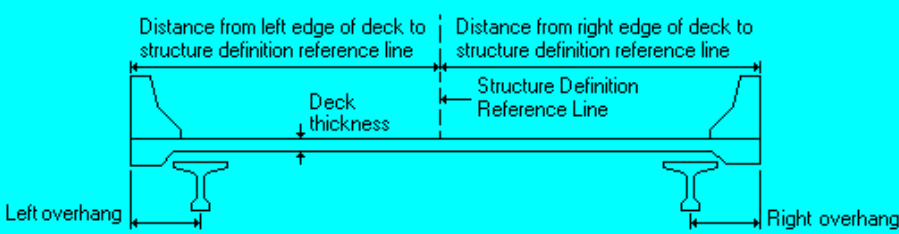
Select the lane position tab and use the Compute... button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.

The screenshot shows a software dialog box titled "Structure Typical Section". At the top, there are standard window controls (minimize, maximize, close). Below the title bar is a diagram of a structure cross-section. A vertical dashed line is labeled "Structure Definition Reference Line". Two travelways, "Travelway 1" and "Travelway 2", are shown on either side. Dimension lines indicate distances: (A) from the left edge of Travelway 1 to the reference line, and (B) from the right edge of Travelway 2 to the reference line. Below the diagram is a tabbed interface with tabs for "Deck", "Deck (Cont'd)", "Parapet", "Median", "Railing", "Generic", "Sidewalk", "Lane Position", and "Wearing Surface". The "Lane Position" tab is active. Below the tabs is a table with the following data:

Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-20.00	20.00	-20.00	20.00

Below the table are several buttons: "Compute...", "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

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



The diagram illustrates a cross-section of a bridge deck. A central horizontal line represents the 'Structure Definition Reference Line'. Above this line, two arrows indicate the 'Distance from left edge of deck to structure definition reference line' and the 'Distance from right edge of deck to structure definition reference line'. Below the line, a vertical arrow indicates the 'Deck thickness'. On the far left and right, arrows indicate the 'Left overhang' and 'Right overhang' respectively. The deck is supported by two I-beam girders.

Structure Typical Section

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

Wearing surface material:

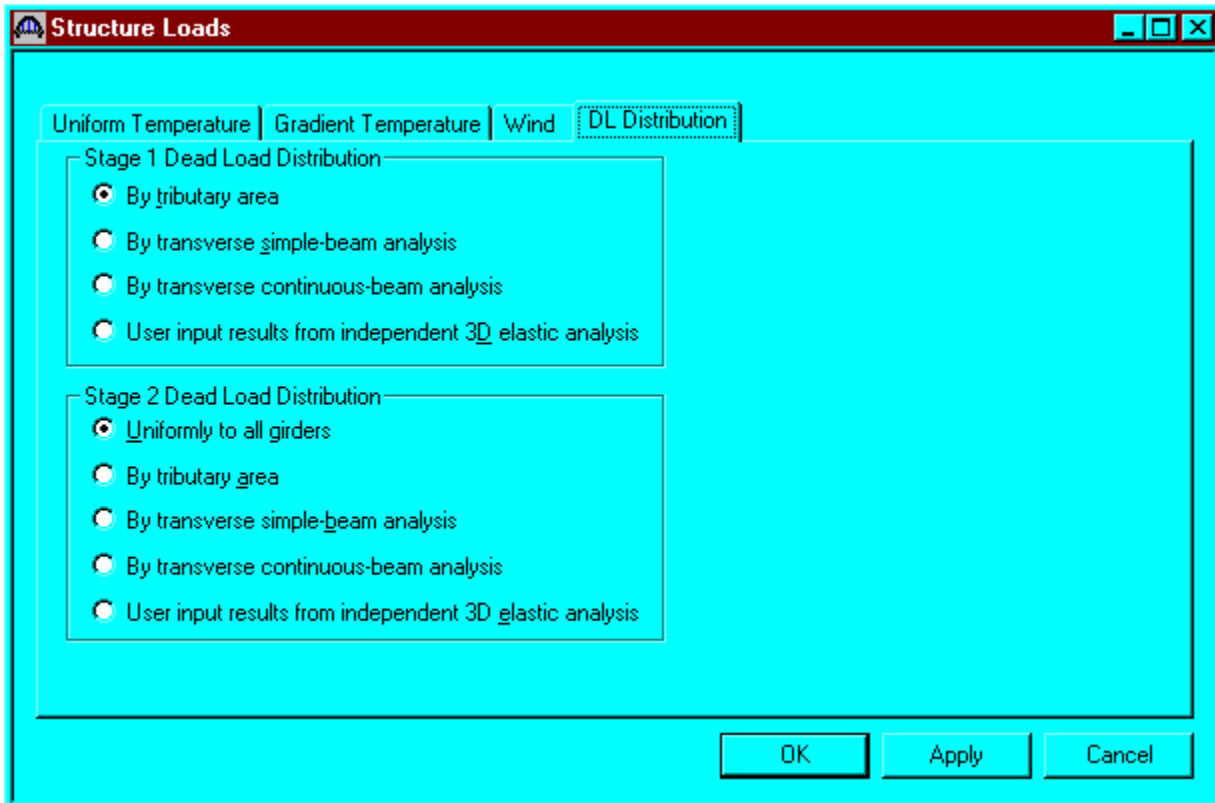
Description:

Wearing surface thickness = in

Wearing surface density = pcf

Load case:

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.



A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the "Beam Concrete" concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.

Stress Limit Sets - Concrete

Name:

Description:

Concrete Material:

	LFD	LRFD
Initial allowable compression:	<input type="text" value="3.900"/> ksi	<input type="text" value="3.900"/> ksi
Initial allowable tension:	<input type="text" value="0.200"/> ksi	<input type="text" value="0.200"/> ksi
Final allowable compression:	<input type="text" value="4.980"/> ksi	<input type="text" value="4.980"/> ksi
Final allowable tension:	<input type="text" value="0.547"/> ksi	<input type="text" value="0.547"/> ksi
Final allowable DL compression:	<input type="text" value="3.320"/> ksi	<input type="text" value="3.735"/> ksi
Final allowable slab compression:	<input type="text" value="2.400"/> ksi	<input type="text"/>
Final allowable compression: (LL + 1/2(Pe + DL))	<input type="text" value="3.320"/> ksi	<input type="text" value="3.320"/> ksi

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the "General P/S Data" tab is required. Click OK to save to memory and close the window.

The screenshot shows a software dialog box titled "Prestress Properties". The "Name" field contains "AASHTO Losses". The "General P/S Data" tab is selected, showing the following settings:

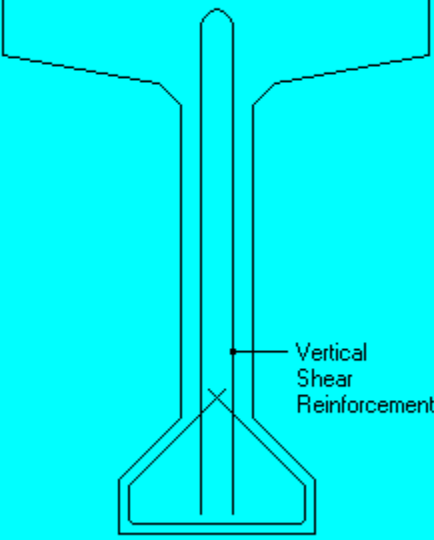
- P/S strand material: 1/2" (7W-270)
- Loss method: AASHTO
- Jacking stress ratio: 0.750
- P/S transfer stress ratio: (empty)
- Transfer time: 24.0 Hours
- Loss Data - AASHTO: Percentage DL: 0.0 %

Buttons for "OK", "Apply", and "Cancel" are located at the bottom right of the dialog.

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.

Shear Reinforcement Definition - Vertical

Name: #4 shear reinf



Material: Grade 60

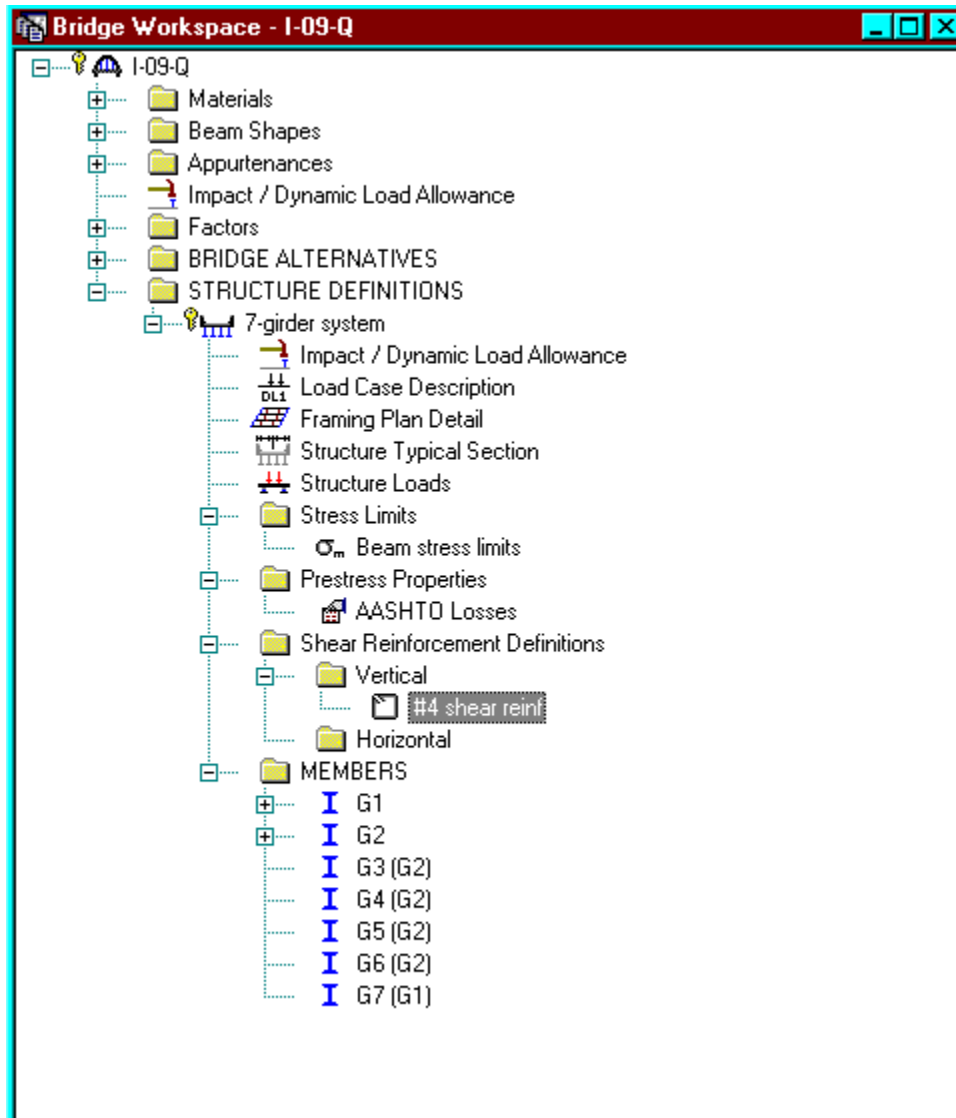
Bar size: 4

Number of legs: 2.00

Inclination (alpha): 90.0 Degrees

OK Apply Cancel

The partially expanded Bridge Workspace tree is shown below:



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: Link with:

Description:

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

Number of spans:

Span No.	Span Length (ft)
1	156.00

Pedestrian load: lb/ft

OK Apply Cancel

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 Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

New Member Alternative

Material Type:

Girder Type:

OK Cancel

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

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.

Member Alternative Description

Member Alternative:

Description | Factors | Engine | Import

Description:

Material Type:

Girder Type:

Member units:

Girder property input method

Schedule based

Cross-section based

Analysis Module

ASD:

LFD:

LRFD:

Additional Self Weight

Additional self weight = kip/ft

Additional self weight = %

Default rating method:

Shear computation method

LRFD:

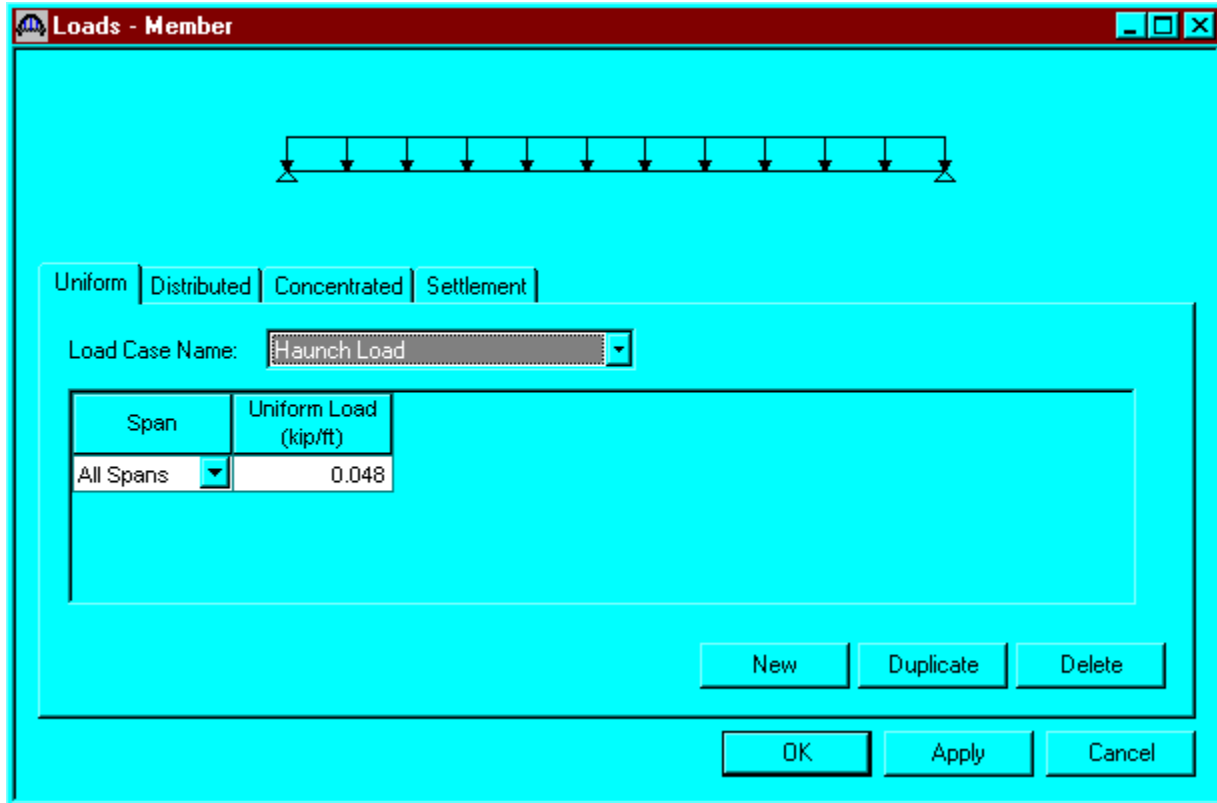
LFD: Ignore shear

Crack control parameter (Z)

Bottom of beam: kip/in

OK Apply Cancel

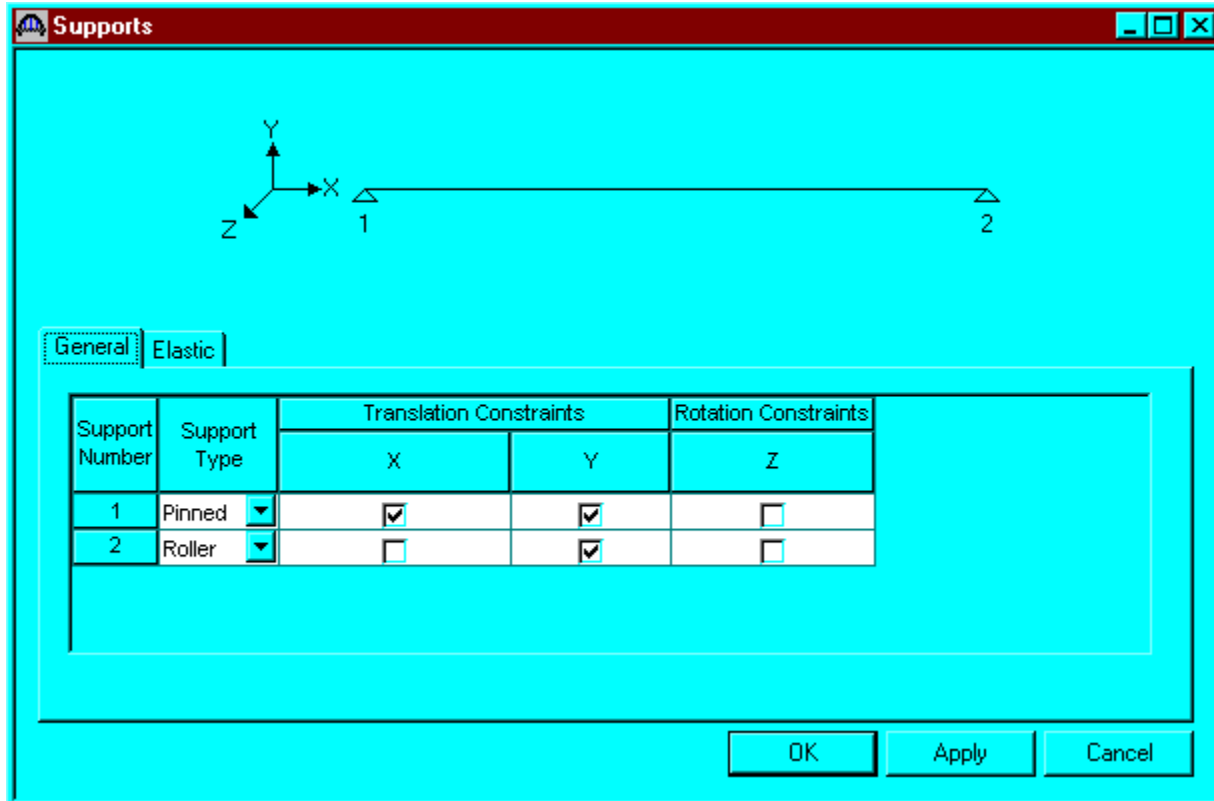
Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.



Calculated average haunch = 2.5"
Haunch used for section properties = 1.43"

Dead Load/Girder = $(2.5-1.43)/12*(43/12)*(0.15) = 0.048$ k/ft

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.

Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	COLORADO BT-72	Beam Concrete	AASHTO Losses	No	5.8000002	5.0000	5.0000

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.

The screenshot shows a software window titled "Beam Details" with three tabs: "Span Detail", "Stress Limit Ranges", and "Slab Interface". The "Stress Limit Ranges" tab is active. It contains a table with the following data:

Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	Beam stress limits	0.00	156.83	156.83

Below the table are three buttons: "New", "Duplicate", and "Delete". At the bottom of the window are three buttons: "OK", "Apply", and "Cancel".

The defaults on the Slab Interface tab are shown below and are acceptable.

The image shows a software dialog box titled "Beam Details" with a red title bar. It contains three tabs: "Span Detail", "Stress Limit Ranges", and "Slab Interface". The "Slab Interface" tab is active. The settings are as follows:

- Interface type: Intentionally Roughened (dropdown menu)
- Default interface width to beam widths:
- Interface width: in
- Cohesion factor: ksi
- Friction factor:

At the bottom right, there are three buttons: "OK", "Apply", and "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 and 3.28. 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	0.869	1.014	0.869	0.286
Multi-Lane	1.106	1.014	1.106	0.857

Compute from Typical Section

OK Apply Cancel

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.

Strand Layout - Span 1

Description Type

P and CGS only Strands in rows

Left harp pt. dist. (X1): ft

Left harp pt. radius: in

Right harp pt. dist. (X2): ft

Right harp pt. radius: in

Force: kip

Left CGS: in

Mid CGS: in


Right CGS: in

Open the Deck Profile window and enter the date describing the structural properties of the deck.

Deck Profile _ □ ×

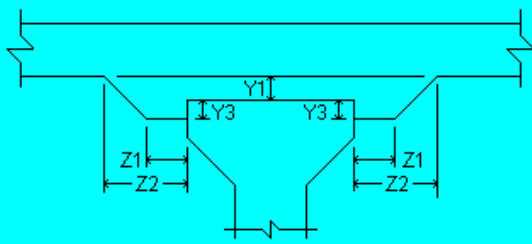
Type:

Deck Concrete | **Reinforcement**

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		0.00	156.00	156.00	8.0000	73.0000		7.600

Double click on Haunch Profile in the tree to define the haunch profile for the girder.

PS Haunch Profile



The diagram shows a cross-section of a haunch profile. It features a central vertical web and two sloped side flanges. Dimension lines indicate: Z1 as the thickness of the side flanges, Z2 as the width of the haunch at the bottom, Y1 as the height of the haunch at the top, and Y3 as the height of the central web.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)	Y3 (in)
1	0.00	156.00	156.00	0.0000	0.0000	1.4300	0.0000

New Duplicate Delete

OK Apply Cancel

Note: Only the haunch thickness to be used in section properties calculation is input here. The program calculates dead load due to this haunch automatically.

The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into the deck.

PS Shear Reinforcement Ranges

Vertical | Horizontal

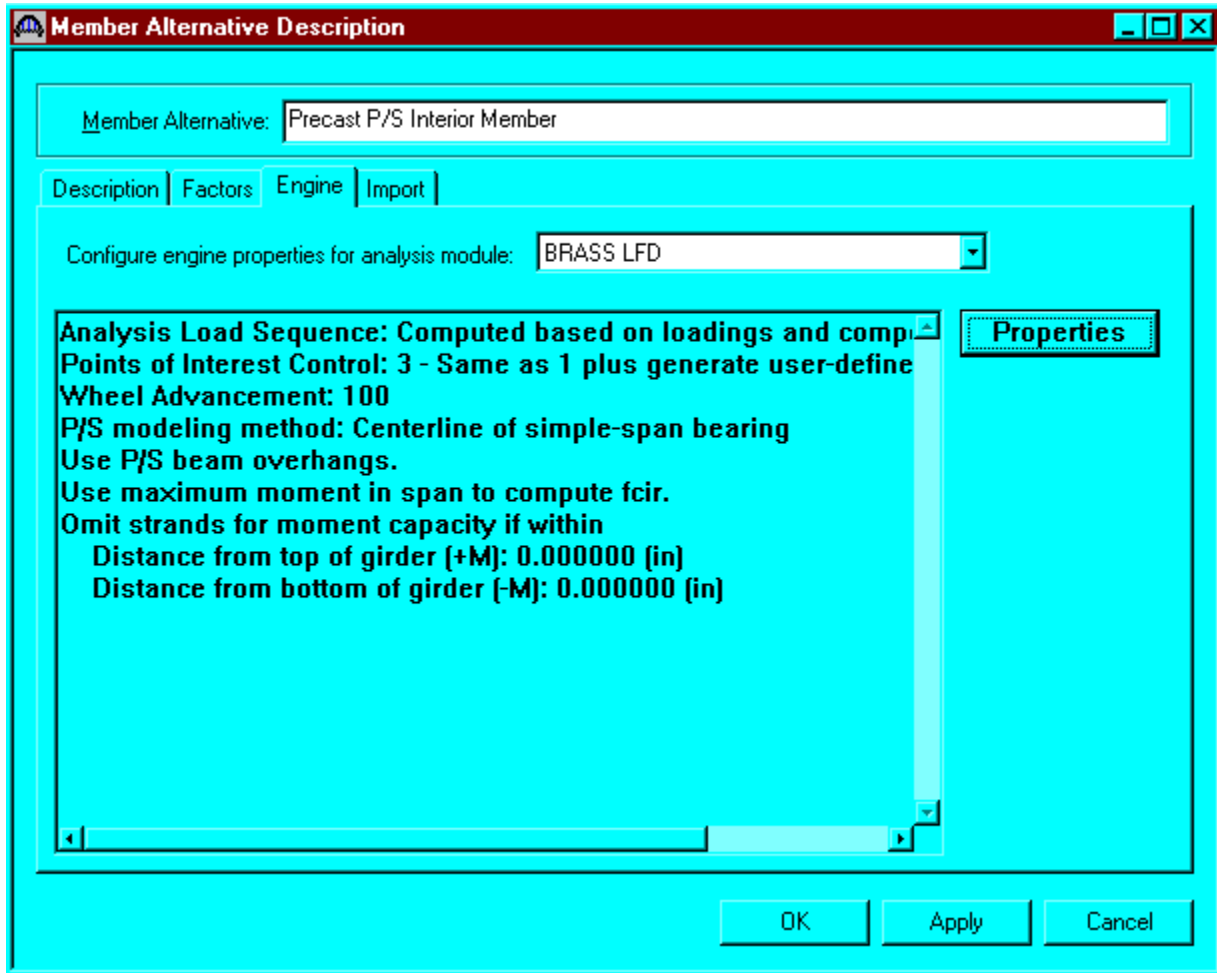
Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#4 shear reinf	<input checked="" type="checkbox"/>	0.17	1	0.0000	0.00	0.17
1	#4 shear reinf	<input checked="" type="checkbox"/>	0.17	6	3.0000	1.50	1.67
1	#4 shear reinf	<input checked="" type="checkbox"/>	1.67	11	4.0000	3.67	5.33
1	#4 shear reinf	<input checked="" type="checkbox"/>	5.33	11	6.0000	5.50	10.83
1	#4 shear reinf	<input checked="" type="checkbox"/>	10.83	11	9.0000	8.25	19.08
1	#4 shear reinf	<input checked="" type="checkbox"/>	19.08	11	12.0000	11.00	30.08
1	#4 shear reinf	<input checked="" type="checkbox"/>	30.08	1	14.0000	1.17	31.25
1	#4 shear reinf	<input checked="" type="checkbox"/>	31.25	63	18.0000	94.50	125.75
1	#4 shear reinf	<input checked="" type="checkbox"/>	125.75	11	12.0000	11.00	136.75
1	#4 shear reinf	<input checked="" type="checkbox"/>	136.75	11	9.0000	8.25	145.00
1	#4 shear reinf	<input checked="" type="checkbox"/>	145.00	11	6.0000	5.50	150.50
1	#4 shear reinf	<input checked="" type="checkbox"/>	150.50	11	4.0000	3.67	154.17
1	#4 shear reinf	<input checked="" type="checkbox"/>	154.17	6	3.0000	1.50	155.67

New Duplicate Delete

OK Apply Cancel

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.



The results of the LFD/ASD rating analysis are as follows:

Analysis Results - Precast P/S Interior Member

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	86.38	144.25	2.399	4.007	93.60	1 - (60.0)	93.60	1 - (60.0)	ULTIMATE MOM	ULTIMATE MOM
HS 20-44	Lane	LFD	82.73	138.16	2.298	3.838	78.00	1 - (50.0)	78.00	1 - (50.0)	ULTIMATE MOM	ULTIMATE MOM
Colorado Permit Vehicle	Axle	LFD		182.97		1.905			62.40	1 - (40.0)		ULTIMATE MOM

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

Analysis Results - Precast P/S Interior Member

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	29.69	35.36	0.825	0.982	93.60	1 - (60.0)	93.60	1 - (60.0)	BOTTOM FLANGE	BOTTOM FLANGE
HS 20-44	Lane	ASD	28.59	34.05	0.794	0.946	93.60	1 - (60.0)	93.60	1 - (60.0)	BOTTOM FLANGE	BOTTOM FLANGE

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

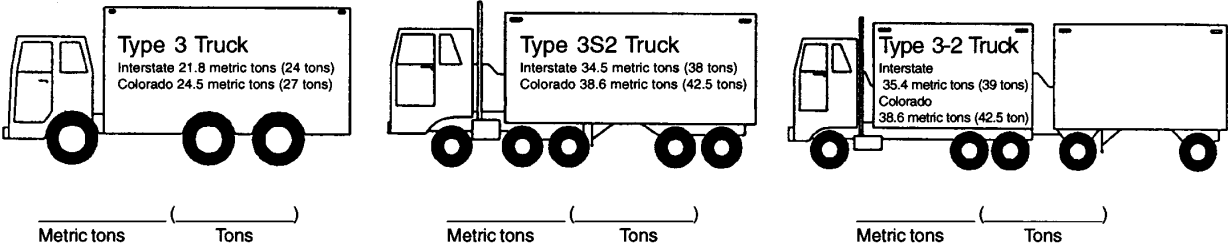
COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure # I-09-Q
	State highway # 135
Rated using Asphalt thickness: 102 mm (4 in.) <input checked="" type="checkbox"/> Colorado legal loads <input type="checkbox"/> Interstate legal loads	Batch I.D.
	Structure type CPG
	Parallel structure #

Structural member	INTERIOR GIRDER BT 72	SLAB	
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Metric tons (Tons)

Inventory	26.4 (29)	51.8 (57)	() ()
Operating	125.4 (138)	86.4 (95)	() ()

Type 3 truck	()	()	() ()
Type 3S2 truck	()	()	() ()
Type 3-2 truck	()	()	() ()
Permit truck	166.4 (183)	()	() ()



Comments

Control Member: Deck; Rated for 2" HBP
 Load Capacity: 95 Tons
 Girder: Only Interior Girder Rated; Haunch included in the section properties calculations;
 BT 72 Girders; Rated for 4" HBP

Color Code: White

Project No: STR(CX) 0135(14)

Rated by	Date	Checked by	Date
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Slab Rating Program Input, Structure No. F-17-IE

WinSlab Input			
Structure Number:	<input type="text" value="F-17-IE"/>	Rater:	<input type="text" value="MH"/>
Batch ID:	<input type="text"/>	Comments:	<input type="text" value="ER SW RAMP"/>
Highway Number:	<input type="text" value="470"/>	Load Type:	<input type="text" value="1=Colorado"/>
<hr/>			
Deadload	Bituminous Overlay (in):	<input type="text" value="4.0"/>	
<hr/>			
Geometry			
Effective Span (ft):	<input type="text" value="9.167"/>	Actual Slab Thickness (in.):	<input type="text" value="8.500"/>
Reinforcing Steel:			
	Area (sqin)	Distance (in)	For definitions of input values please refer to the CDOT Bridge Rating Manual
Top:	<input type="text" value="0.96"/>	<input type="text" value="5.625"/>	
Bottom:	<input type="text" value="0.96"/>	<input type="text" value="1.375"/>	
Materials Properties			
Concrete f _c (PSI):	<input type="text" value="4500"/>	Steel F _y (PSI):	<input type="text" value="40000"/>
or Inv F _c (Working Stress)		or Inv F _s (Working Stress)	
Modular Ratio (Leave blank for load factor):	<input type="text"/>		
OK Cancel Apply Output to File			

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

Clear distance between flanges = $11.5' - 2.333' = 9.167'$

Slab Rating Program Output, Structure No. F-17-IE

WinSlab Rating Version 1 Date: 9/18/2001

Structure NO. F-17-IE Rater: MH State HWY NO. = 470
Batch ID= Description: RAMP A OVER SW RAMP

LOAD FACTOR RATING-COMP STEEL NOT USED

INPUT DATA

Bituminous Overlay(in)=	4.000	Slab Thickness(in)=	8.500
Eff. Span(ft)=	9.167	Eff. Depth(in) =	5.625
Top Reinf. (sq.in)=	0.96	Bottom Dist.(in)=	1.38
Bottom Area(sq.in)=	0.96	Oper. =	4500
Conc. Strength(PSI) Inv =	4500	Oper. =	40000
Steel Yield (PSI) Inv =	40000		
Modular Ratio =	8		

Dead Load Moment 1.30 K-Ft
LL+I Moment 5.81 K-Ft
Gross Weight 36.0 Tons

		Inventory	Operating
Actual Concrete Stress	(PSI)	1220.64	1892.62
Actual Reinf. Steel Stress	(PSI)	19354.22	30008.88
Actual Comp. Steel Stress	(PSI)	5294.17	8208.66
Member Capacity	(K-Ft)	15.00	15.00
Member Capacity (LL+I)	(K-Ft)	13.31	13.31
Rating	(Tons)	38.09	63.48

Virtis Bridge Rating Example, Structure No. F-17-IE**Effective slab width: Per AASHTO Article 9.8.1.1**

0.25(L)= 0.25(52.72*12)= 158.16"
0.25(L)= 0.25(65.00*12)= 195.00"
0.25(L)= 0.25(49.96*12)= 149.88"
12t+ b = 12*8.5+ 28= 130.00" Controls
C.L. - C.L. of girder= 11.5'=138.00"

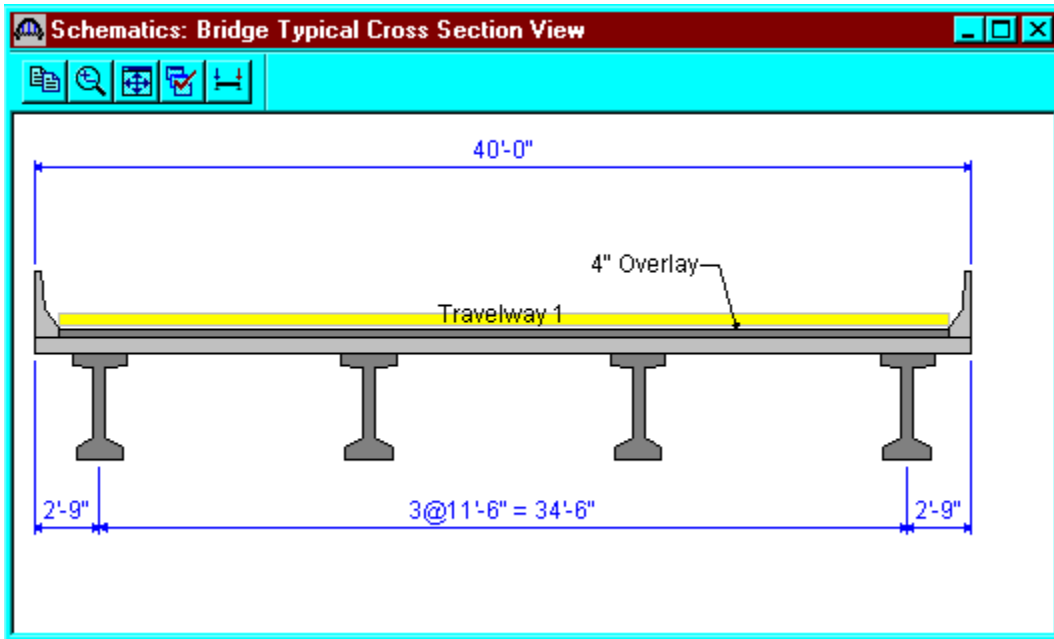
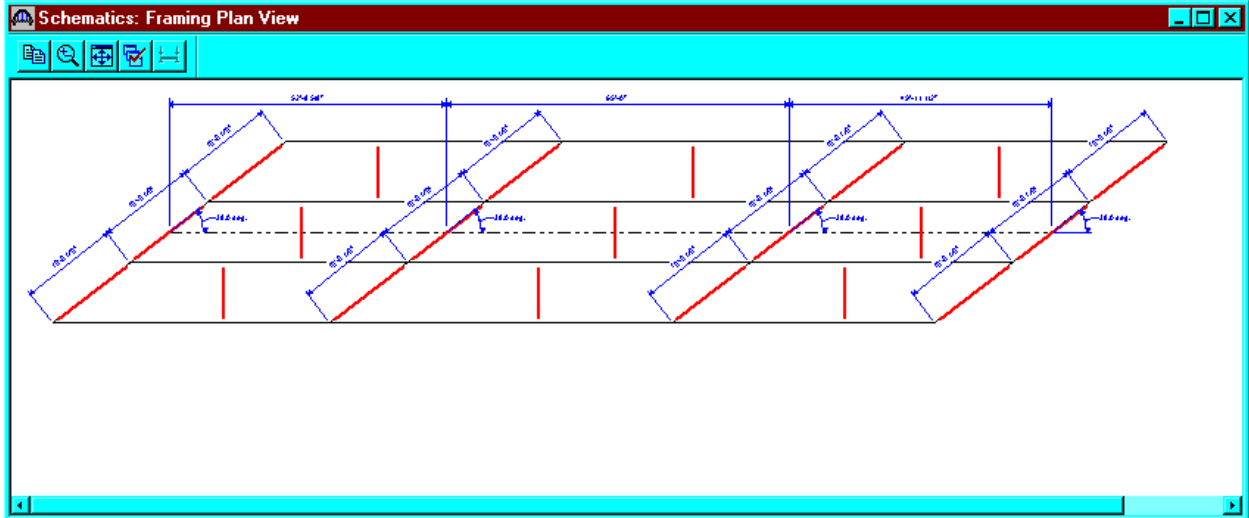
Dead Load:

Intermediate Diaphragm = ((2)*(8/12)*(11.5) - (630/2)*(1/144)*(0.67))*(0.15)
= 2.09 kips Use 2.1 kips

Abutment Diaphragm = ((2.58)*(56.5/12)*(11.5)*(1/sin38°) - (630/144)*(18/12)*
(1/sin38°))*(0.150)= 32.4 kips
Use 32.0 kips

Pier Diaphragm = ((3.50)*(56.5/12)*(11.5)*(1/sin38°) - (630/144)*(29/12)*
(1/sin38°))*(0.150)= 43.6 kips
Use 44.0 kips

Virtis Bridge Rating Example, Structure No. F-17-IE (contd.)



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

The screenshot shows a software window titled "F-17-IE" with a red title bar. The window contains a form for entering bridge information. At the top, there are two text boxes: "Bridge ID:" containing "F-17-IE" and "NBI Structure ID (8):" containing "F-17-IE". To the right of these are two checkboxes: "Template" (unchecked) and "Design Only" (checked). Below this is a tabbed interface with four tabs: "Description" (selected), "Description (cont'd)", "Alternatives", and "Global Reference Point". The "Description" tab contains a "Name:" text box with "CPGC" and a "Year Built:" text box with "1983". Below these is a large "Description:" text area containing "3-Span Concrete Prestressed Girder continuous Bridge". Further down are several other fields: "Location:" (empty), "Length:" (empty) followed by "ft", "Facility Carried (7):" (empty), "Route Number:" containing "-1", "Feat. Intersected (6):" (empty), "Mi. Post:" (empty), "Units:" with a dropdown menu showing "US Customary", and "Recent ADTT:" (empty). At the bottom right of the window are three buttons: "OK", "Apply", and "Cancel".

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 concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to save this deck concrete material to memory and close the window.

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 =

Using the same techniques, create a new concrete material to be used for the girder.

Bridge Materials - Concrete

Name: PS 4.0 ksi Description: fci = 4.0 ksi

Compressive strength at 28 days (f'_c) =	4.000	ksi
Initial compressive strength (f'_{ci}) =	4.000	ksi
Coefficient of thermal expansion =	0.0000060000	1/F
Density (for dead loads) =	0.150	kcf
Density (for modulus of elasticity) =	0.150	kcf
Modulus of elasticity (E_c) =	3834.25	ksi
Initial modulus of elasticity =	3834.25	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.480	ksi
Shear factor =	1.000	

Copy from Library... OK Apply Cancel

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.

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

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

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

Bridge Materials - PS Strand

Name: Description:

Strand diameter = in

Strand area = in²

Strand type =

Ultimate tensile strength (Fu) = ksi

Yield strength (Fy) = ksi

Modulus of elasticity (E) = ksi

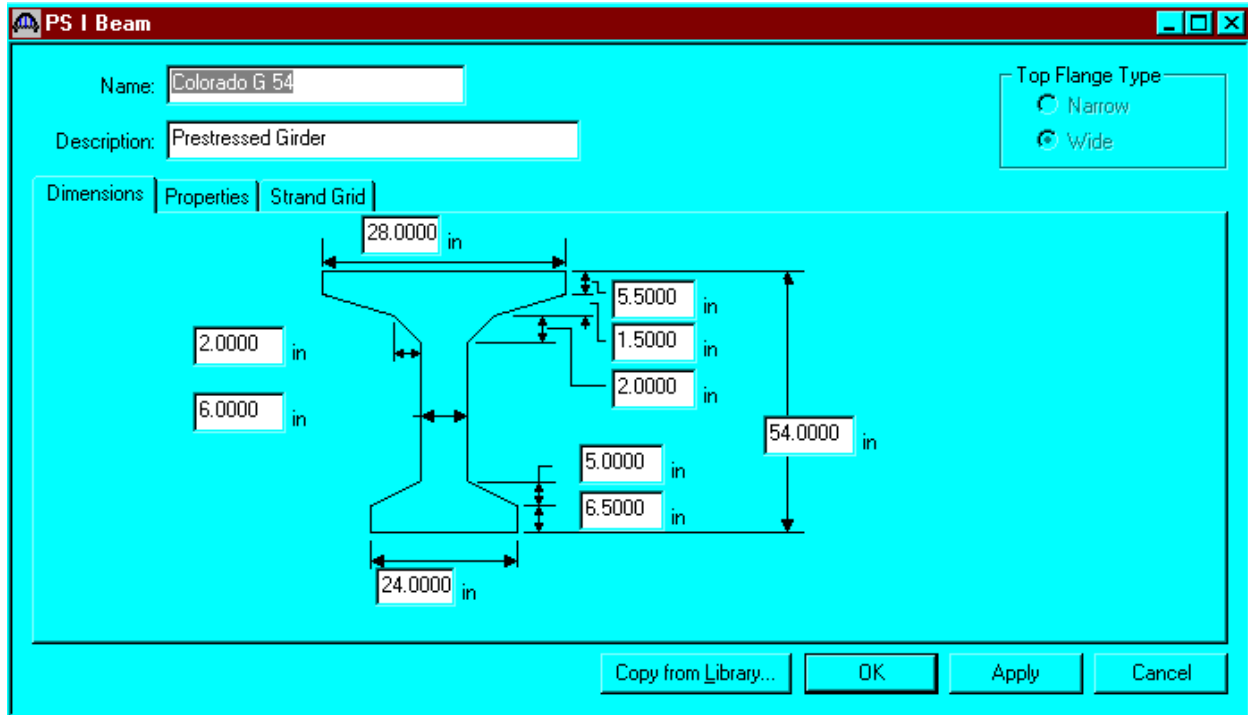
Transfer length (Std) = in

Transfer length (LRFD) = in

Unit weight per length = lb/ft

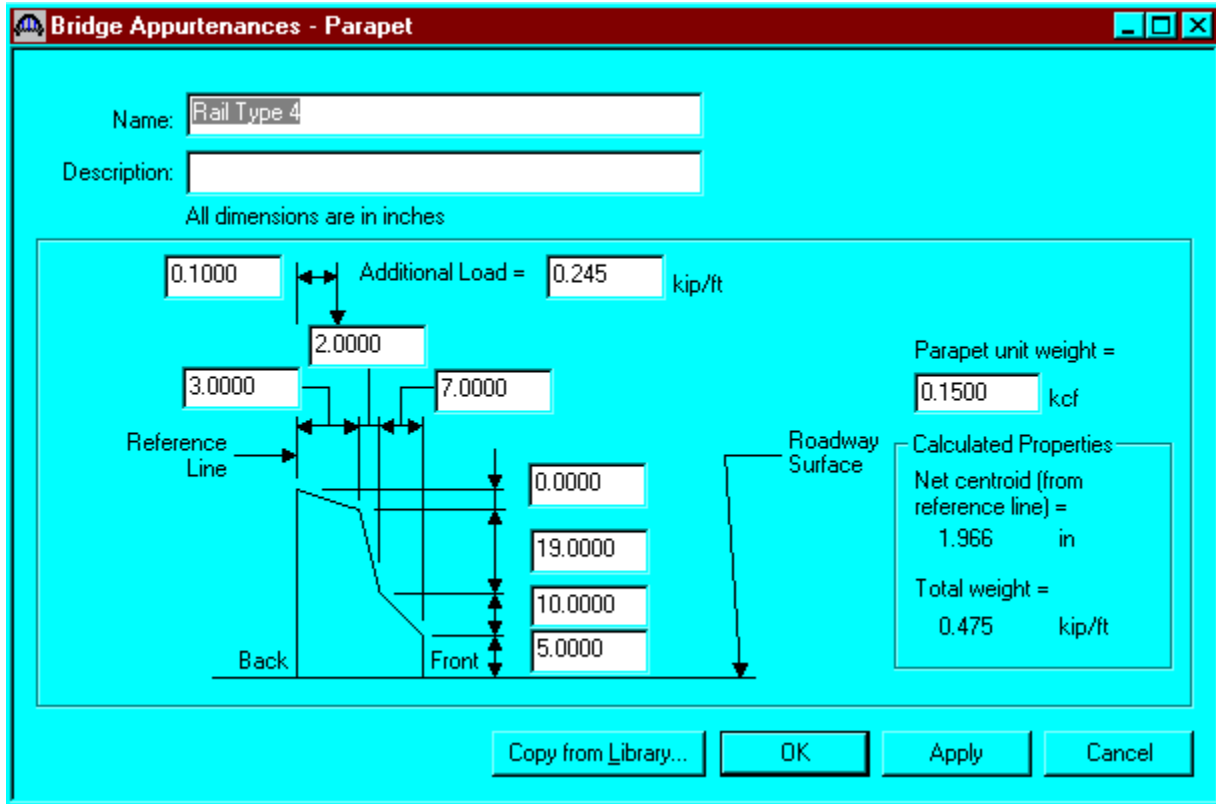
Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Click on the copy from library button or fill in the blanks.



Click OK to save to the memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and click copy from Library button. Select the Jersey Barrier and click OK. The parapet properties are copied to parapet window as shown below. Click OK to save the data to memory and close the window.



The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

Factors - LFD

Name: 1996 AASHTO Std. Specifications

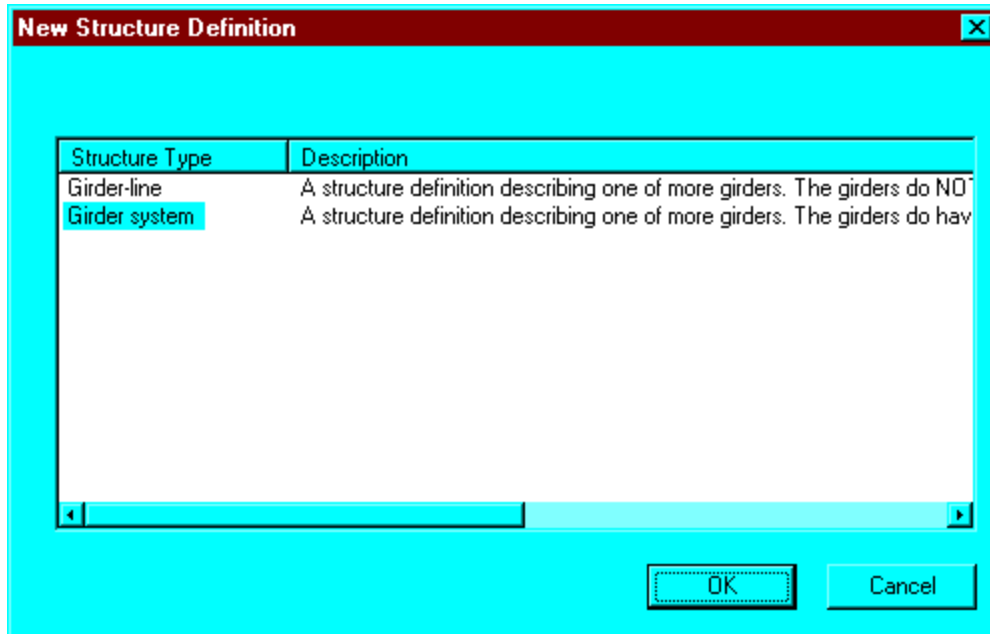
Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Factors | **Resistance Factors**

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

Copy from Library... OK Apply Cancel

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE 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 Structure Definition

Definition | Analysis | Engine

Name: 4 Prestressed Girder System

Description:

Units: US Customary

Number of spans: 3

Number of girders: 4

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	52.72
2	65.00
3	49.96

For PS only

Average humidity: 60.000 %

Member Alt. Types

Steel

P/S

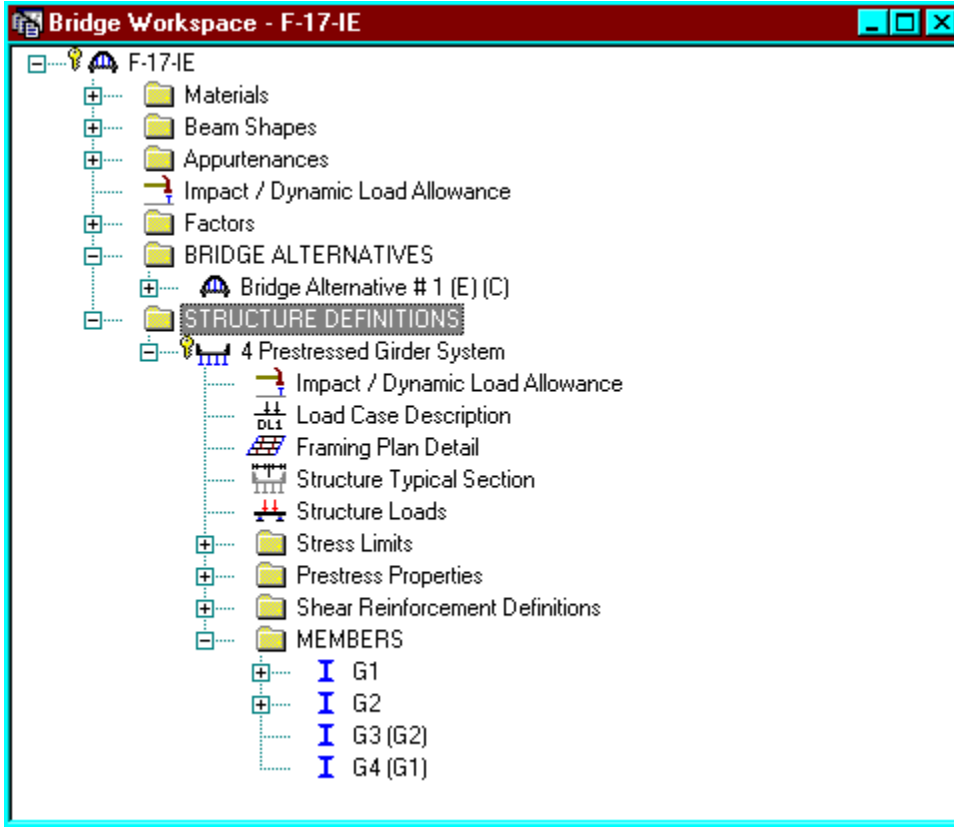
R/C

Timber

OK Apply Cancel

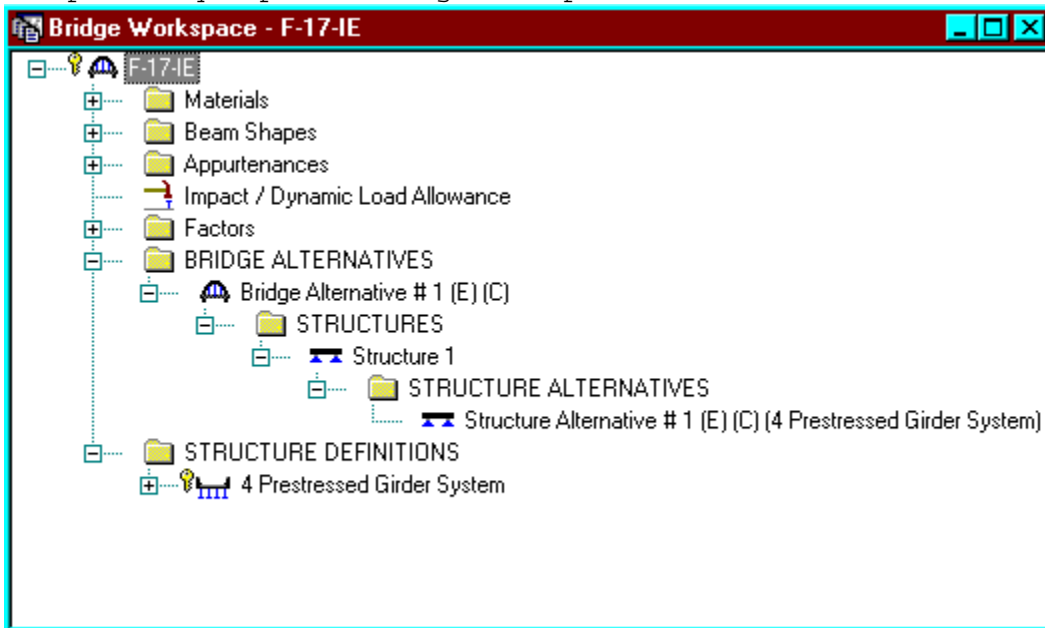
Span lengths for a prestressed girder structure made continuous for live loads shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:



We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

The partially expanded Bridge Workspace tree is shown below:



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		Composite (long term) (Stage 2)	D,DC	
Haunch load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

New Duplicate Delete

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	52.0000
2	52.0000
3	52.0000
4	52.0000

Girder Spacing Orientation

Perpendicular to girder
 Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	11.50	11.50
2	11.50	11.50
3	11.50	11.50

OK Apply Cancel

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

Structure Framing Plan Details

Number of spans = 3 Number of girders = 4

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)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	32.0000
1	17.78	32.50	0.00	1	0.00	17.78	32.50	2.1000
2	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
2	24.78	39.50	0.00	1	0.00	24.78	39.50	2.1000
3	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
3	18.00	32.70	0.00	1	0.00	18.00	32.70	2.1000
3	49.96	49.96	0.00	1	0.00	49.96	49.96	32.0000

New Duplicate Delete

OK Apply Cancel

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 structure definition reference line

Distance from right edge of deck to structure definition reference line

Deck thickness

Structure Definition Reference Line

Left overhang

Right overhang

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

Structure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to structure definition reference line =	20.00 ft	20.00 ft
Distance from right edge of deck to structure definition reference line =	20.00 ft	20.00 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 structure definition reference line

Distance from right edge of deck to structure definition reference line

Deck thickness

Structure Definition Reference Line

Left overhang

Right overhang

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

Deck concrete: Class D(US)

Total deck thickness: 8.5000 in

Deck crack control parameter: kip/in

Sustained modular ratio factor: 2.000

OK Apply Cancel

Parapets:
Add two parapets as shown below.

Structure Typical Section

Back Front

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

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Rail Type 4	Bridge Rail	Back	Left Edge	0.00	0.00	Right
Rail Type 4	Bridge Rail	Back	Right Edge	0.00	0.00	Left

New Duplicate Delete

OK Apply Cancel

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.

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

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

Structure Typical Section

Distance from left edge of deck to structure definition reference line | Distance from right edge of deck to structure definition reference line

Deck thickness | Structure Definition Reference Line

Left overhang | Right overhang

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

Wearing surface material:

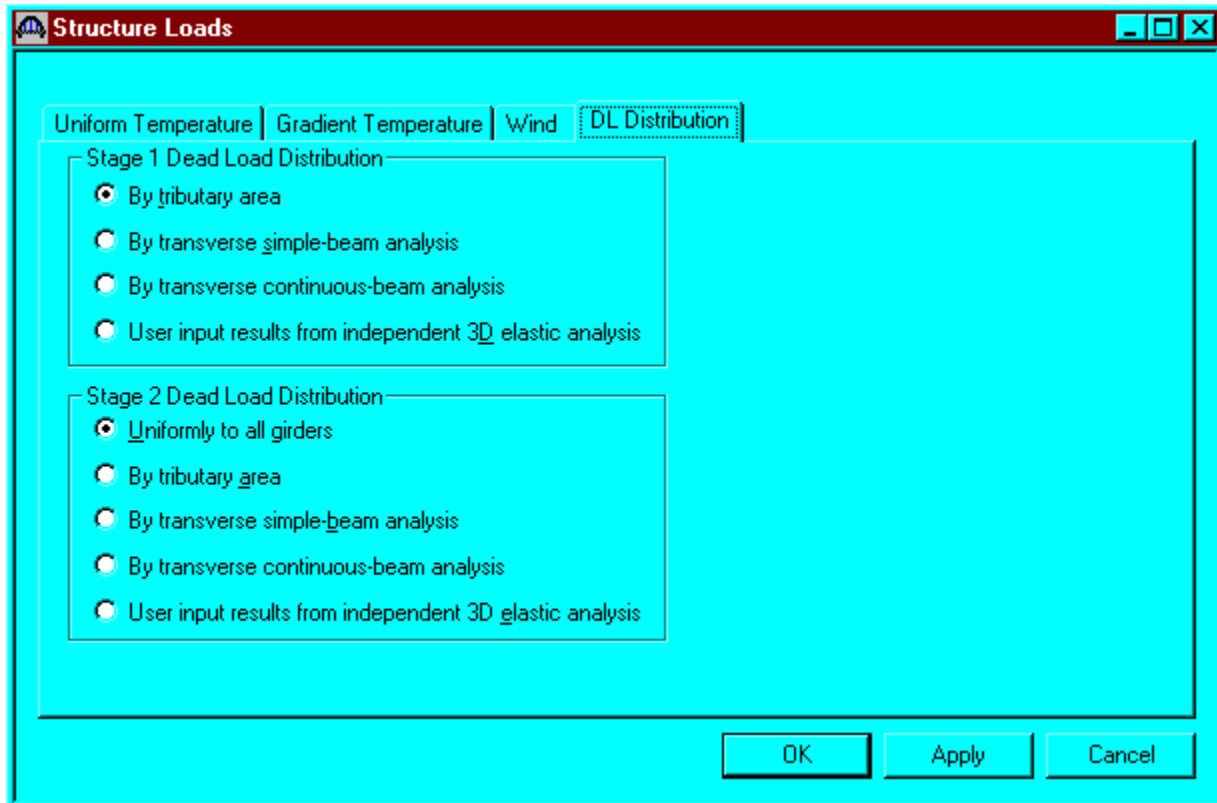
Description:

Wearing surface thickness = in

Wearing surface density = pcf

Load case:

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.



A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the "PS 4.0 ksi" concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.

	LFD	LRFD
Initial allowable compression:	2.400 ksi	2.400 ksi
Initial allowable tension:	0.190 ksi	0.190 ksi
Final allowable compression:	2.400 ksi	2.400 ksi
Final allowable tension:	0.380 ksi	0.380 ksi
Final allowable DL compression:	1.600 ksi	1.800 ksi
Final allowable slab compression:	ksi	ksi
Final allowable compression: (LL + 1/2(Pe + DL))	1.600 ksi	1.600 ksi

Buttons: OK, Apply, Cancel

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the "General P/S Data" tab is required. Click OK to save to memory and close the window.

Prestress Properties

Name: 1/2" SR AASHTO Loss

General P/S Data | Loss Data - Lump Sum | Loss Data - PCI

P/S strand material: 1/2" (7W-270) SR Jacking stress ratio: 0.740

Loss method: AASHTO P/S transfer stress ratio:

Transfer time: 24.0 Hours

Loss Data - AASHTO

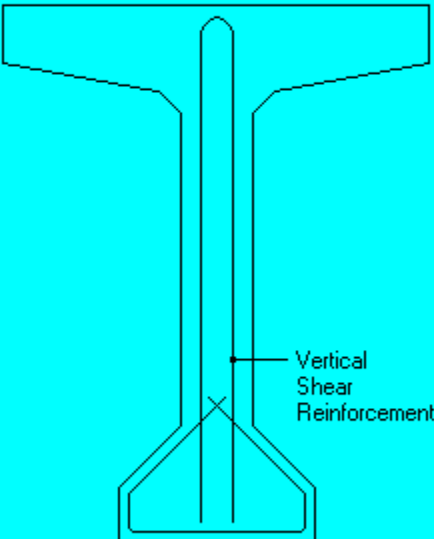
Percentage DL: 0.0 %

OK Apply Cancel

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.

Shear Reinforcement Definition - Vertical

Name: #4 Stirrups



Material: Grade 40

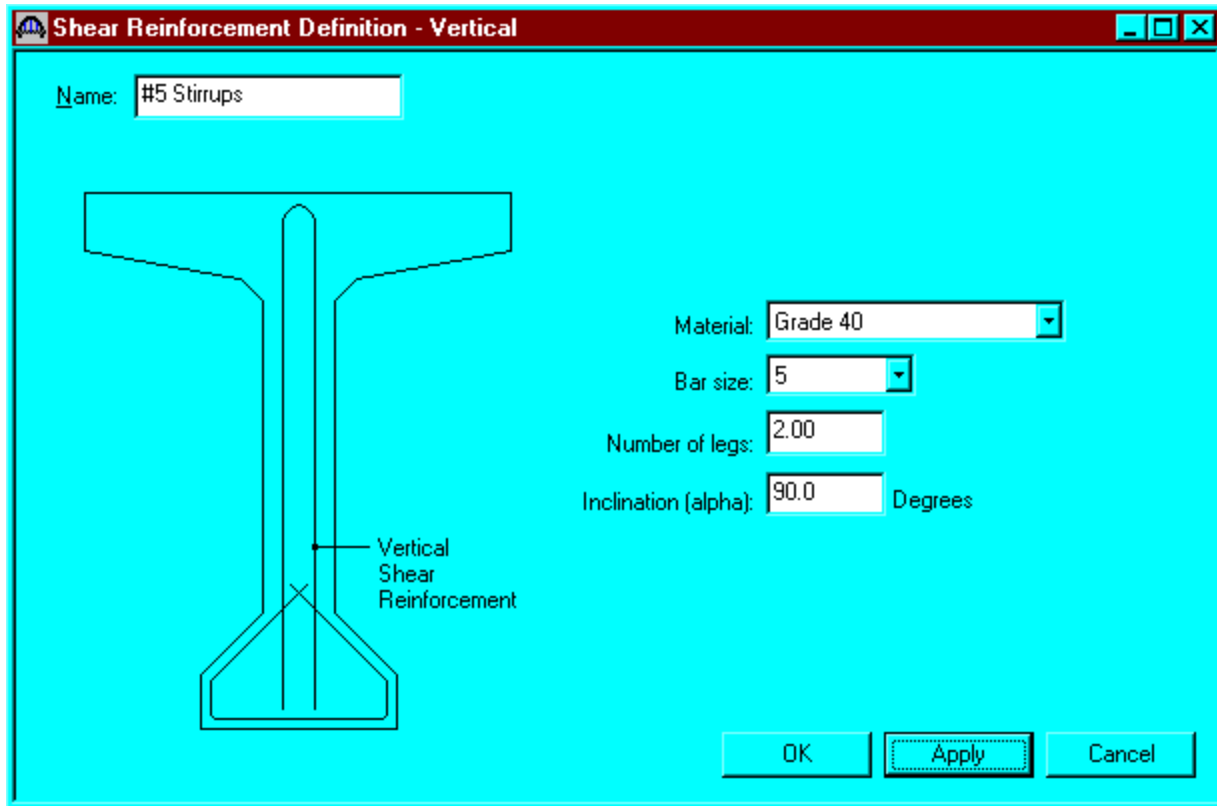
Bar size: 4

Number of legs: 2.00

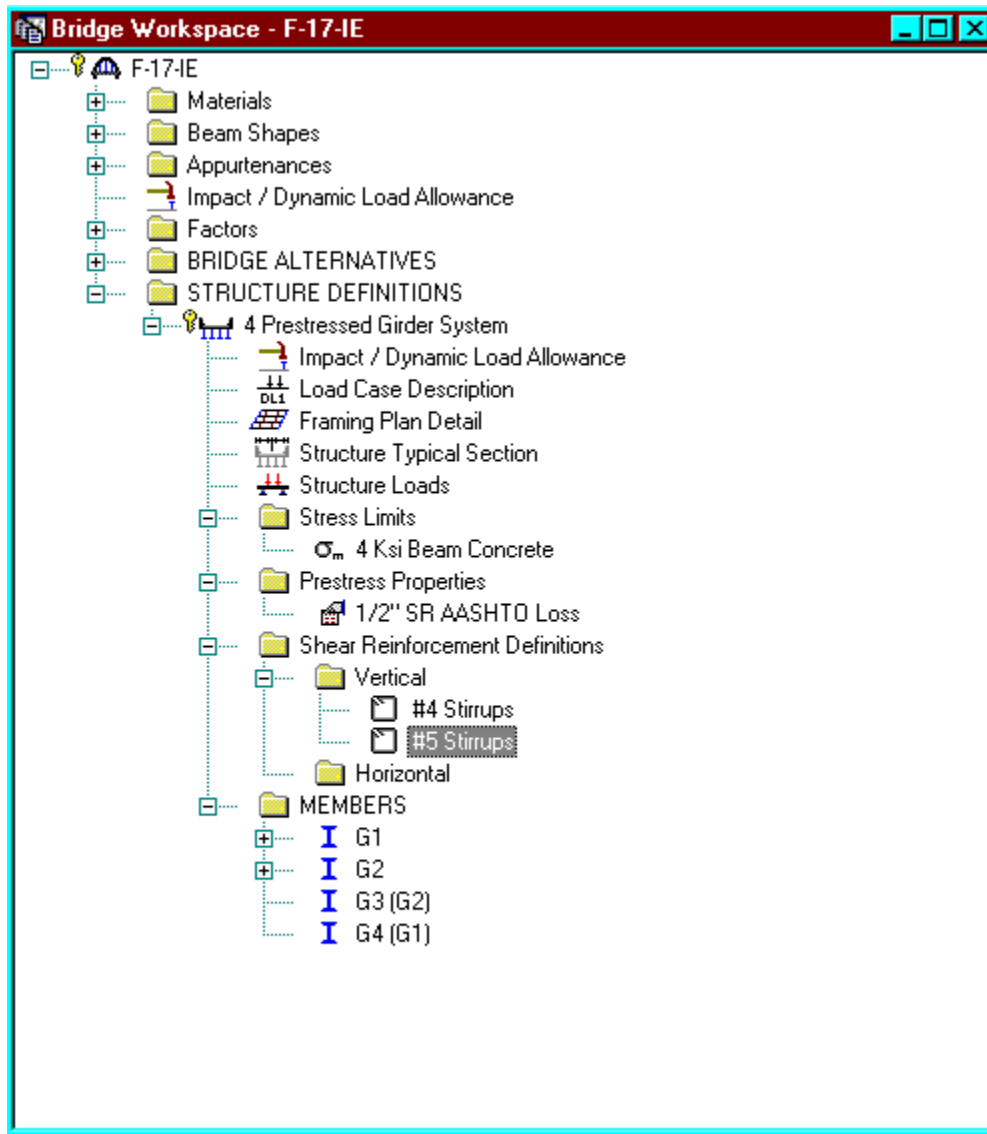
Inclination (alpha): 90.0 Degrees

OK Apply Cancel

Using the same techniques, define another vertical Shear Reinforcement Definition.



The partially expanded Bridge Workspace tree is shown below:



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
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Interior G54 Colorado Gird	

Number of spans: 3 Pedestrian load: 0.000 lb/ft

Span No.	Span Length (ft)
1	52.72
2	65.00
3	49.96

OK Apply Cancel

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 Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

Material Type: Prestressed (Pretension) Girder Type: PS Precast I

OK Cancel

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

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.

Member Alternative Description

Member Alternative: Interior G54 Colorado Girder

Description Factors Engine Import

Description:

Material Type: Prestressed (Pretensioned)

Girder Type: PS Precast I

Member units: US Customary

Girder property input method

Schedule based

Cross-section based

Analysis Module

ASD: BRASS ASD

LFD: BRASS LFD

LRFD: BRASS LRFD

Additional Self Weight

Additional self weight = kip/ft

Additional self weight = %

Default rating method: LFD

Shear computation method

LRFD: General Procedure

LFD: Ignore shear

Crack control parameter (Z)

Bottom of beam: kip/in

OK Apply Cancel

Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.

Span	Uniform Load (kip/ft)
All Spans	0.058

Calculated average haunch = 2.0"
Haunch used for section properties = 0.0"

Dead Load/Girder = $(2.0-0.0)/12*(28/12)*(0.15) = 0.058$ k/ft

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.

Support Number	Support Type	Translation Constraints		Rotation Constraints
		X	Y	Z
1	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	Roller	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	Roller	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	Roller	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.

Beam Details

Span Detail | Continuous Support Detail | Stress Limit Ranges | Slab Interface | Continuity Diaphragm

Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000
2	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000
3	Colorado G 54	PS 4.0 ksi	1/2" SR AASHTO Loss	Yes	7.767	3.0000	3.0000

OK Apply Cancel

The Continuous Support Detail tab is only shown for a multi-span structure. The following data describes the distances from the centerlines of bearing to the centerlines of the piers.

The screenshot shows the 'Beam Details' window with the 'Continuous Support Detail' tab selected. The diagram illustrates a beam with two supports. The centerline of the pier is marked as 'CL of Pier'. The centerlines of the bearings on the left and right are marked as 'CL of Bearing on Left' and 'CL of Bearing on Right' respectively. The distances from the pier centerline to the bearing centerlines are labeled 'SL' and 'SR'. The table below provides the numerical values for these distances.

Support Number	Support Distance on Left, SL (in)	Support Distance on Right, SR (in)
2	10.7500	10.7500
3	10.7500	10.7500

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.

Beam Details

Span Detail | Continuous Support Detail | **Stress Limit Ranges** | Slab Interface | Continuity Diaphragm

Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	4 Ksi Beam Concrete	0.00	52.32	52.32
2	4 Ksi Beam Concrete	0.00	63.71	63.71
3	4 Ksi Beam Concrete	0.00	49.56	49.56

New Duplicate Delete

OK Apply Cancel

The defaults on the Slab Interface tab are shown below and are acceptable.

The image shows a software dialog box titled "Beam Details" with a red title bar. It contains five tabs: "Span Detail", "Continuous Support Detail", "Stress Limit Ranges", "Slab Interface", and "Continuity Diaphragm". The "Slab Interface" tab is selected. The settings are as follows:

- Interface type: Intentionally Roughened (dropdown menu)
- Default interface width to beam widths:
- Interface width: in
- Cohesion factor: ksi
- Friction factor:

At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

The Continuity Diaphragm tab is only displayed for multi-span structures. The data on this tab defines the cast-in-place diaphragms used to make the structure continuous for live load. Press F1 while on this tab to view the continuity diaphragm help topic describing the use of this information.

Beam Details

Span Detail | Continuous Support Detail | Stress Limit Ranges | Slab Interface | **Continuity Diaphragm**

Span Number	Left Support				Right Support			
	Material	Distance (in)	Bar Count	Bar Size	Material	Distance (in)	Bar Count	Bar Size
1					Grade 270	2.0000	3.000	5
2	Grade 270	2.0000	3.000	5	Grade 270	2.0000	3.000	5
3	Grade 270	2.0000	3.000	5				

Ignore positive moment at supports in ratings

New Duplicate Delete

OK Apply Cancel

Now double click on Live Load Distribution in the tree to enter the 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 and 3.28. 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	1.478	1.478	1.478	0.500
Multi-Lane	2.091	2.261	2.091	1.350

Compute from Typical Section

OK Apply Cancel

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.

Strand Layout - Span 1

Description Type

P and CGS only Strands in rows

Left harp pt. dist. (X1): 22 ft

Left harp pt. radius: 0.0001 in

Right harp pt. dist. (X2): 22 ft

Right harp pt. radius: 0.0001 in

Force: 490.00 kip

Left CGS: 17.0000 in

Mid CGS: 2.8400 in

Right CGS: 17.0000 in

OK Apply Cancel

Using the same techniques, define the strand layout for span 2 and span 3.

Strand Layout - Span 2

Description Type
 P and CGS only Strands in rows

Left harp pt. dist. (X1): ft
Left harp pt. radius: in
Right harp pt. dist. (X2): ft
Right harp pt. radius: in
Force: kip
Left CGS: in
Mid CGS: in
Right CGS: in

Strand Layout - Span 3

P and CGS only Strands in rows

Left harp pt. dist. (X1): ft

Left harp pt. radius: in

Right harp pt. dist. (X2): ft

Right harp pt. radius: in

Force: kip

Left CGS: in

Mid CGS: in

Right CGS: in

Open the Deck Profile window and enter the date describing the structural properties of the deck.

Deck Profile [min] [max] [close]

Type:

Deck Concrete Reinforcement

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	167.68	167.68	8.5000	130.0000		7.130

The deck reinforcement in the negative moment regions is described as follows.

Deck Profile

Type:

Deck Concrete Reinforcement

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Bar Count	Bar Size	Distance (in)	Row
Grade 40	1	0.00	167.60	167.60	7.000	5	3.5600	Top of Slab
Grade 60	1	22.72	51.00	73.72	4.000	8	3.7500	Top of Slab
Grade 60	1	30.72	51.00	81.72	4.000	8	3.7500	Top of Slab
Grade 60	2	37.00	51.00	88.00	4.000	8	3.7500	Top of Slab
Grade 60	2	44.00	51.00	95.00	4.000	8	3.7500	Top of Slab

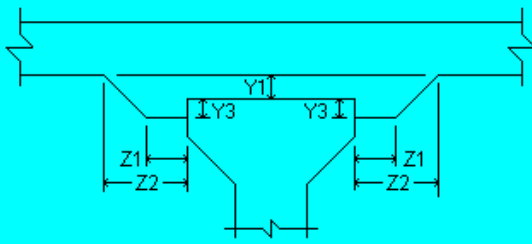
New Duplicate Delete

OK Apply Cancel

Note: Only the top layer of the slab's distribution reinforcement is used in the analysis.

Double click on Haunch Profile in the tree to define the haunch profile for the girder.

PS Haunch Profile



The diagram shows a cross-section of a haunch profile. It features a central vertical web and two sloped side flanges. Dimension Z1 is the thickness of the side flanges, Z2 is the thickness of the bottom flange, Y1 is the height of the side flanges, and Y3 is the height of the central web.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)	Y3 (in)
1	0.00	167.68	167.68	0.0000	0.0000	0.0000	0.0000


New Duplicate Delete

OK Apply Cancel

Note: Only the haunch thickness to be used in section properties calculation is input here. The program calculates dead load due to this haunch automatically.

The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into the deck.

PS Shear Reinforcement Ranges



Vertical | Horizontal

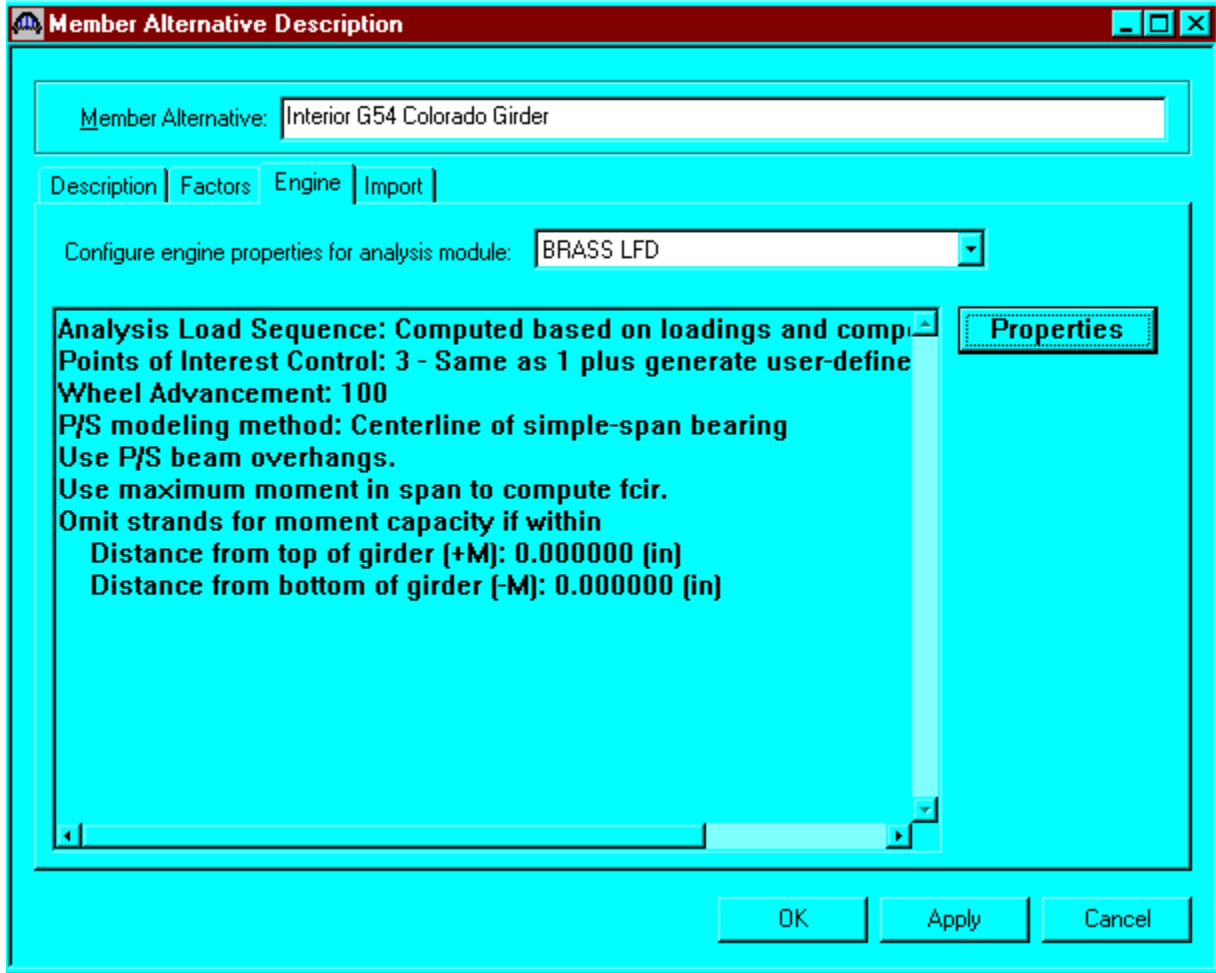
Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#5 Stirrups	<input checked="" type="checkbox"/>	0.16	1	0.0000	0.00	0.16
1	#5 Stirrups	<input checked="" type="checkbox"/>	0.16	6	3.0000	1.50	1.66
1	#4 Stirrups	<input checked="" type="checkbox"/>	1.66	10	9.0000	7.50	9.16
1	#4 Stirrups	<input checked="" type="checkbox"/>	9.16	34	12.0000	34.00	43.16
1	#4 Stirrups	<input checked="" type="checkbox"/>	43.16	10	9.0000	7.50	50.66
1	#4 Stirrups	<input checked="" type="checkbox"/>	50.66	6	3.0000	1.50	52.16
2	#5 Stirrups	<input checked="" type="checkbox"/>	0.16	1	0.0000	0.00	0.16
2	#5 Stirrups	<input checked="" type="checkbox"/>	0.16	6	3.0000	1.50	1.66
2	#4 Stirrups	<input checked="" type="checkbox"/>	1.66	10	9.0000	7.50	9.16
2	#4 Stirrups	<input checked="" type="checkbox"/>	9.16	22	12.0000	22.00	31.16
2	#4 Stirrups	<input checked="" type="checkbox"/>	31.16	1	16.6800	1.39	32.55
2	#4 Stirrups	<input checked="" type="checkbox"/>	32.55	22	12.0000	22.00	54.55
2	#4 Stirrups	<input checked="" type="checkbox"/>	54.55	10	9.0000	7.50	62.05

New Duplicate Delete

OK Apply Cancel

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.



The results of the LFD/ASD rating analysis are as follows:

Analysis Results - Interior G54 Colorado Girder

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	52.01	86.86	1.445	2.413	144.47	3 - (53.5)	144.47	3 - (53.5)	ULTIMATE MOM	ULTIMATE MOM
HS 20-44	Lane	LFD	48.31	80.68	1.342	2.241	51.82	1 - (98.3)	51.82	1 - (98.3)	ULTIMATE MOM	ULTIMATE MOM
Colorado Permit Vehicle	Axle	LFD		105.61		1.100			51.82	1 - (98.3)		ULTIMATE MOM

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

Analysis Results - Interior G54 Colorado Girder

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	45.73	63.12	1.270	1.753	115.03	2 - (95.9)	144.47	3 - (53.5)	TENSION STEEL	BOTTOM FLANGE
HS 20-44	Lane	ASD	37.69	63.96	1.047	1.777	51.82	1 - (98.3)	51.82	1 - (98.3)	TENSION STEEL	TENSION STEEL

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

Note: LFD method controls both the Inventory and the Operating rating.

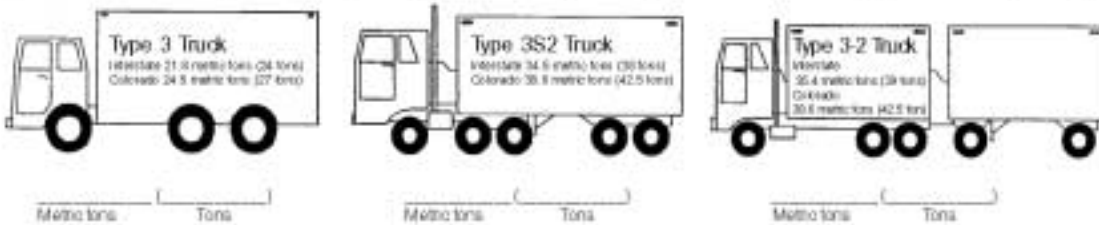
COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure #	P-17-1B
	State highway #	470
Rated using Asphalt thickness: <u>102</u> mm (<u>4</u> in) <input checked="" type="checkbox"/> Colorado legal loads <input type="checkbox"/> Interstate legal loads	Batch ID	
	Structure type	CPGC
	Parent structure #	

Structural member	INTERIOR GIRDER G 54	SLAB		
-------------------	-------------------------	------	--	--

Metric tons (Tons)

Inventory	43.6 (49)	34.5 (39)	()	()
Operating	73.6 (81)	57.3 (63)	()	()

Type 3 truck	()	()	()	()
Type 3S2 truck	()	()	()	()
Type 3-2 truck	()	()	()	()
Permit truck	96.3 (106)	()	()	()



Comments Control Member: Deck: Rated for 4" HBP Load Capacity: 63.0 Tons Girder: Only Interior Girder Rated; Haunch not included in the section properties calculations; G 54 Girders; Rated for 2" HBP Color Code: White Project No: I 25 - 2(153)			
Rated by	Date	Checked by	Date

Virtis Bridge Rating Example, Structure No. L-26-BR

Use average web = 6.0"

Girder flange = $\frac{1}{2}$ (Total flange width) = $\frac{1}{2}$ (86.0) = 43.0"

4x4 ~ W4xW4 WWF, assumed shear reinforcing: #3 single leg bar @ 12" c/c

Dead Load:

Intermediate Diaphragm = 0.150 kip/diaphragm

$\frac{1}{2}$ (diaphragm) = 0.075 kip

Abutment Diaphragm = $((2.50)*(44.5/12)*(3.5833) - (507.5/144)*(20/12))$
 $*(0.150) = 4.1$ kips Use 4.1 kips

Distribution Factors:

- **AASHTO LRFD Table 4.6.2.2.2b-1**

$$K = \sqrt{(1+\mu)*I/J} = \sqrt{(1+0.2)*(90584)/(12345)} = 2.96$$

$$C = K*(W/L) = 2.96*(72/59.5) = 3.58 > K \quad \therefore C = K = 2.96$$

$$NL = 6 \text{ Lanes Assumed} \quad L = 59.5'$$

$$D = 11.5 - NL + 1.4*NL*(1-0.2C)*(1-0.2C)$$

$$= (11.5 - 6) + 1.4*6*(1-0.2*2.96)*(1-0.2*2.96) = 6.898$$

$$S/D = (43/12)/(6.898/2) = 1.039 \text{ Wheel Lines}$$

$$NL = 1 \text{ Lane}$$

$$D = (11.5 - 1) + 1.4*1*(1-0.2*2.96)*(1-0.2*2.96) = 10.733$$

$$S/D = (43/12)/(10.733/2) = 0.668 \text{ Wheel Lines}$$

- **AASHTO Standard Specifications, Table 3.23.1**

Assumed full depth rigid diaphragm.

$$\text{Distribution Factor} = S/6 = (7.167/2)/6 = 0.597 \text{ (Multi Lanes)}$$

$$\text{Distribution Factor} = 0.547 \text{ (Single Lane)}$$

- **LDFAC Program**

Assumed 8" poured in place composite deck.

$$\text{Distribution Factor} = 0.673 \text{ (Multi Lanes)}$$

$$\text{Distribution Factor} = 0.542 \text{ (Single Lane)}$$

LDFAC Version 1.0 (Release Version)

Dbl_Tee

Geometry Data:

Bridge Type		Beam & Slab
Width of Curb	[ft]	0.0000
Element Density		12
Number of Spans		1
Span Length(s)	[ft]	
59.5000		
Skew Angles	[degrees]	
0.0000	0.0000	

Live Load Generator Data

Truck Name		HS20TR
Multiple Presence Factor - 1 Truck		1.00
Multiple Presence Factor - 2 Trucks		1.00
Multiple Presence Factor - 3 Trucks		0.90
Multiple Presence Factor - 4 Trucks		0.75

Point-of-Interest Data

Type	Span #	Span Loc. [ft]	Rel. Span Loc.
Shr	1	0.00	0.00
+Mom	1	30.00	0.50
-Mom	1	60.00	1.00

Beam and Slab Data:

Slab Thickness	[in]	8.0000
Young' Modulus	[ksi]	3823.0000
Poisson's Ratio		0.2000
Exterior Girder Area A	[in^2]	507.50
Exterior Girder Moment I	[in^4]	90584.00
Exterior Girder Moment J	[in^4]	12345.00
Exterior Centroidal Offset	[in]	16.2500
Interior Girder Area A	[in^2]	507.50
Interior Girder Moment I	[in^4]	90584.00
Interior Girder Moment J	[in^4]	12345.00
Interior Centroidal Offset	[in]	16.2500
Girder Modular Ratio n		7.0000
Left Girder Overhang	[in]	21.5000
Right Girder Overhang	[in]	21.5000
Total Number of Girders		20

Girder Spacing Values [in]

43.0000	43.0000	43.0000	43.0000	43.0000	43.0000
43.0000	43.0000	43.0000	43.0000	43.0000	43.0000
43.0000	43.0000	43.0000	43.0000	43.0000	43.0000
43.0000					

LDFAC Version 1.0 - Release Version

Out-of-Limits Results for Formula Are Marked With an Asterisk *

1 - Span Straight Beam & Slab Bridge with HS20TR Load

Multi-Lane Load Distribution Results

Point-of-Interest Data				Analysis Results		Formula Results	
No.	Type	Sp#	Sp%	Interior	Exterior	Interior	Exterior
1	Shr	1	0	0.86074	0.86148	0.97668	0.76099
2	+Mom	1	50	<u>0.67364</u>	0.71775	0.88385	0.88385
3	-Mom	1	100	N/A	N/A	N/A	N/A

LDFAC Version 1.0 - Release Version

Out-of-Limits Results for Formula Are Marked With an Asterisk *

1 - Span Straight Beam & Slab Bridge with HS20TR Load

Single-Lane Load Distribution Results

Point-of-Interest Data				Analysis Results		Formula Results	
No.	Type	Sp#	Sp%	Interior	Exterior	Interior	Exterior
1	Shr	1	0	0.76917	0.86148	0.83889	1.00000
2	+Mom	1	50	<u>0.54238</u>	0.68849	0.57662	1.00000
3	-Mom	1	100	N/A	N/A	N/A	N/A

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

The screenshot shows a software window titled "L-26-BR" with a red title bar. The window contains the following fields and controls:

- Bridge ID:
- NBI Structure ID (8):
- Template
- Design Only
- Tabbed interface with "Description" selected.
- Name:
- Year Built:
- Description:
- Location:
- Length: ft
- Facility Carried (7):
- Route Number:
- Feat. Intersected (6):
- Mi. Post:
- Units:
- Recent ADTT:
- Buttons: OK, Apply, Cancel

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 concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Fill in the data for the beam concrete material as shown below. Click OK to save this beam concrete material to memory and close the window.

Bridge Materials - Concrete

Name: PS 6.0 ksi Description: f'ci = 4.5 ksi

Compressive strength at 28 days (f'c) =	6.000	ksi
Initial compressive strength (f'ci) =	4.500	ksi
Coefficient of thermal expansion =	0.0000060000	1/F
Density (for dead loads) =	0.150	kcf
Density (for modulus of elasticity) =	0.150	kcf
Modulus of elasticity (Ec) =	4695.98	ksi
Initial modulus of elasticity =	4066.84	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.588	ksi
Shear factor =	1.000	

Copy from Library... OK Apply Cancel

Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.

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

Bridge Materials - PS Strand

Name: Description:

Strand diameter = in

Strand area = in²

Strand type =

Ultimate tensile strength (Fu) = ksi

Yield strength (Fy) = ksi

Modulus of elasticity (E) = ksi

Transfer length (Std) = in

Transfer length (LRFD) = in

Unit weight per length = lb/ft

Epoxy coated

Expand the tree labeled Beam Shapes to enter a prestressed beam shape to be used in the analysis. Click on Prestressed Beam Shapes and I Beams in the tree and select File/New from the menu (or right mouse click on I Beam and select New). Fill in the data for the beam (Modeled as a Single-Tee beam). Click the Properties tab, then the compute button and then OK.

The screenshot shows the "PS I Beam" dialog box with the following fields and options:

- Name: Tee Girder
- Description: Dbl tee modeled as a Single tee
- Top Flange Type: Narrow, Wide
- Dimensions tab is active, showing a cross-section diagram of a Tee Girder with the following dimensions:
 - Top flange width: 43.0000 in
 - Web width: 6.0000 in
 - Top flange thickness: 6.5000 in
 - Web height: 44.5000 in
 - Bottom flange thickness: 6.5000 in
 - Bottom flange width: 6.0000 in
 - Other dimensions (all 0.0000 in):
 - Top flange fillet radius
 - Web fillet radius
 - Bottom flange fillet radius
 - Top flange chamfer
 - Web chamfer
 - Bottom flange chamfer

Buttons at the bottom: Copy from Library..., OK, Apply, Cancel.

Click OK to save the data to memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and fill in the data for the Bridge Rail Type 3 (Note: Since the girder is modeled as a single-Tee, use only $\frac{1}{2}$ the curb and rail load). Click OK to save the data to memory and close the window.

Bridge Appurtenances - Parapet

Name: Bridge Rail Type 3

Description: Use only 1/2 Curb and Rail load

All dimensions are in inches

7.5000 Additional Load = 0.051 kip/ft

0.0000

15.0000 0.0000

Reference Line

0.0000

0.0000

0.0000

4.0000

Back Front

Roadway Surface

Parapet unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 7.500 in

Total weight = 0.113 kip/ft

Copy from Library... OK Apply Cancel

The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

This window shows the LFD load factors.

Factors - LFD

Name: 1996 AASHTO Std. Specifications

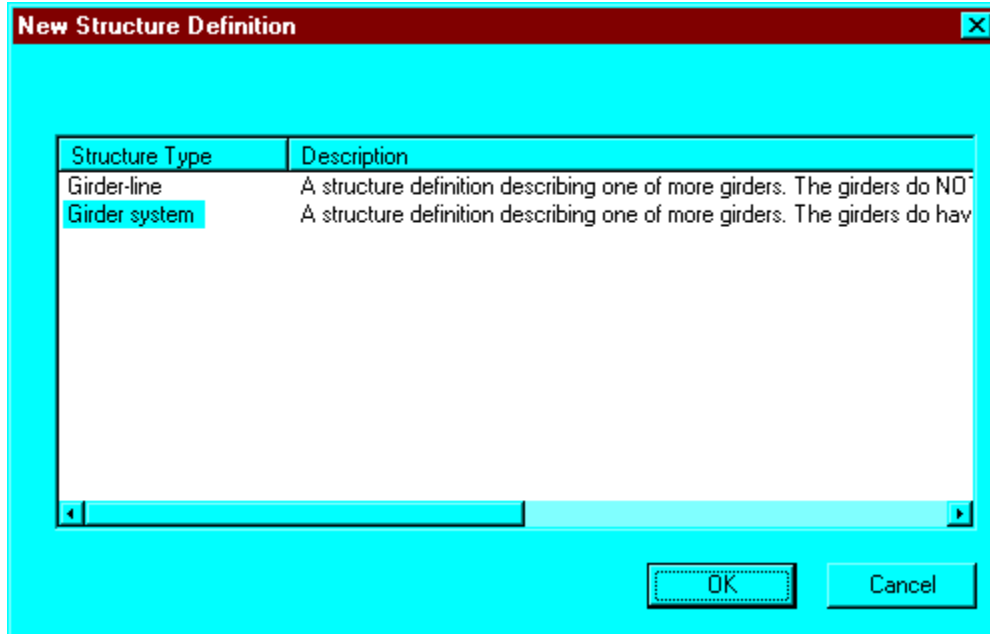
Description: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 including 1997 Interim Specifications

Load Factors | Resistance Factors

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

Copy from Library... OK Apply Cancel

Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE 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 Structure Definition

Definition | Analysis | Engine

Name: Dbl-Tee Girders

Description: Only 12 Girder lines can be analyzed by BRASS. Modeled using 6 dbl-tee units. Note, live load DF to be entered manually.

Units: US Customary

Number of spans: 1

Number of girders: 12

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	59.50

For PS only

Average humidity: 60.000 %

Member Alt. Types

Steel

P/S

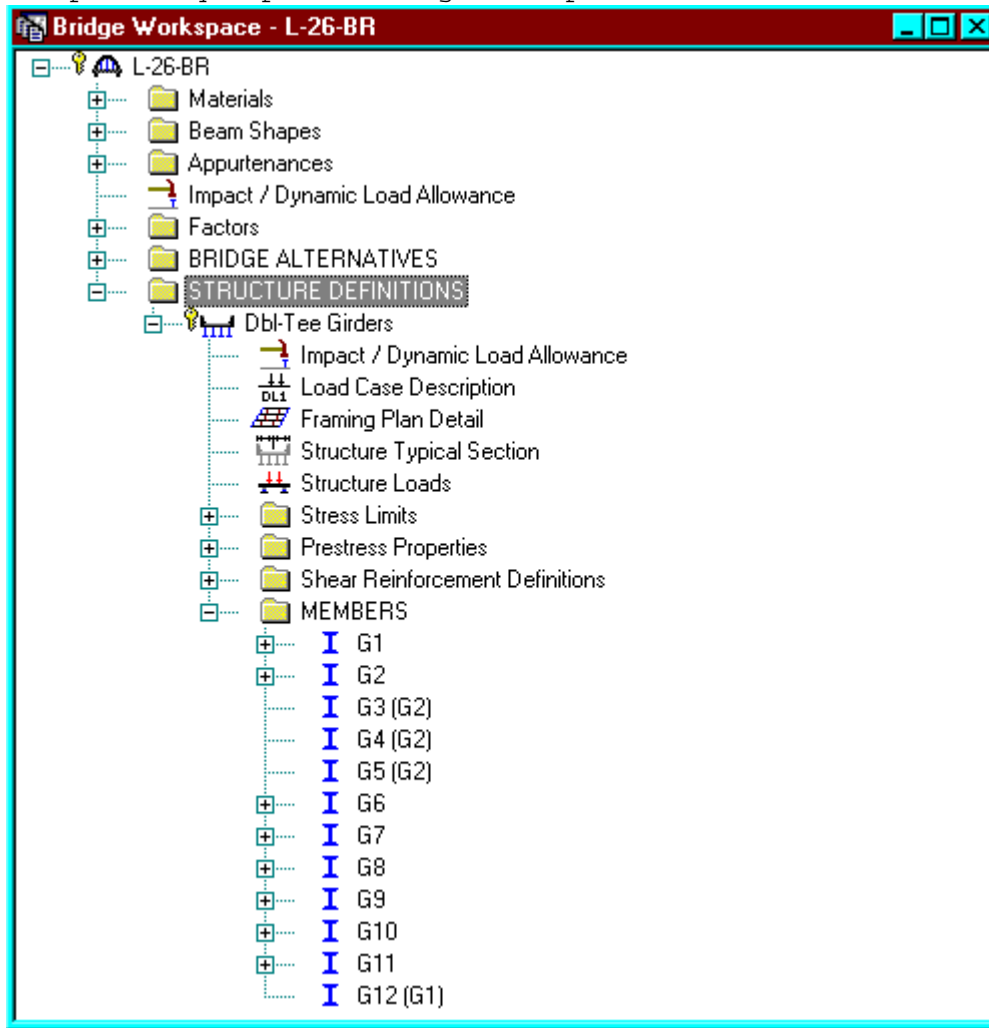
R/C

Timber

OK Apply Cancel

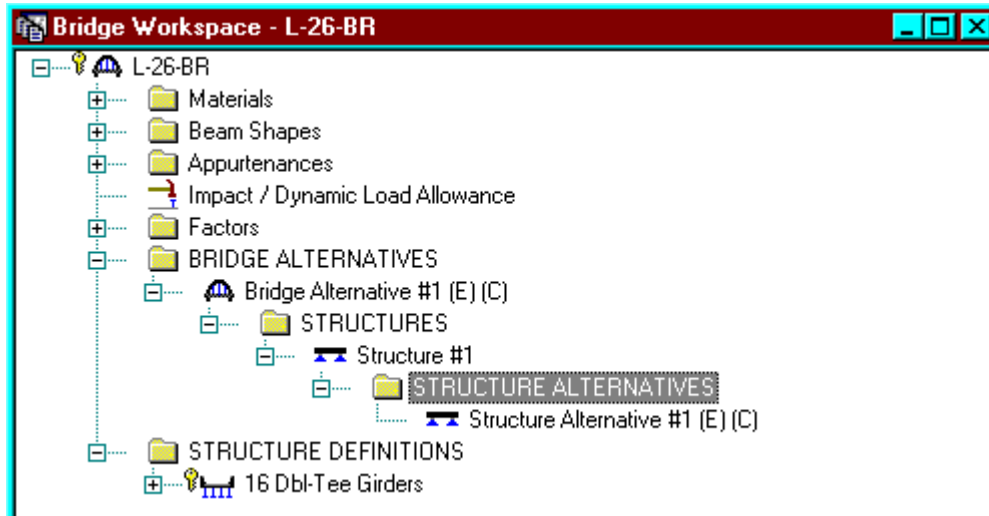
Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:



We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

The partially expanded Bridge Workspace tree is shown below:



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)
Parapets		Non-composite (Stage 1)	D,DC	
Future Wearing Surface		Non-composite (Stage 1)	D,DC	
diaphragm load		Non-composite (Stage 1)	D,DC	

*Prestressed members only

Buttons: 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

Girder Spacing Orientation

Perpendicular to girder

Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	3.58	3.58
2	3.58	3.58
3	3.58	3.58
4	3.58	3.58
5	3.58	3.58
6	3.58	3.58

OK Apply Cancel

If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

Structure Framing Plan Details

Number of spans = Number of girders =

Layout | **Diaphragms**

Girder Bay:

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	4.1000
1	0.00	0.00	29.75	1	29.75	29.75	29.75	0.0700
1	29.75	29.75	29.75	1	29.75	59.50	59.50	4.1000

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 structure definition reference line

Distance from right edge of deck to structure definition reference line

Deck thickness

Structure Definition Reference Line

Left overhang

Right overhang

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

Structure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to structure definition reference line =	21.50 ft	21.50 ft
Distance from right edge of deck to structure definition reference line =	21.50 ft	21.50 ft
Left overhang =	1.79 ft	1.79 ft
Computed right overhang =	1.79 ft	1.79 ft

OK Apply Cancel

The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. This structure does not have a concrete deck, so leave the information on this tab blank.

Parapets:
Add two parapets as shown below.

Structure Typical Section

Back Front

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

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	Parapets	Back	Left Edge	0.00	0.00	Right
Bridge Rail Type 3	Parapets	Back	Right Edge	0.00	0.00	Left

New Duplicate Delete

OK Apply Cancel

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.

Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At End (B) (ft)
1	-20.25	20.25	-20.25	20.25

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

Structure Typical Section

Distance from left edge of deck to structure definition reference line

Distance from right edge of deck to structure definition reference line

Deck thickness

Structure Definition Reference Line

Left overhang

Right overhang

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

Wearing surface material:

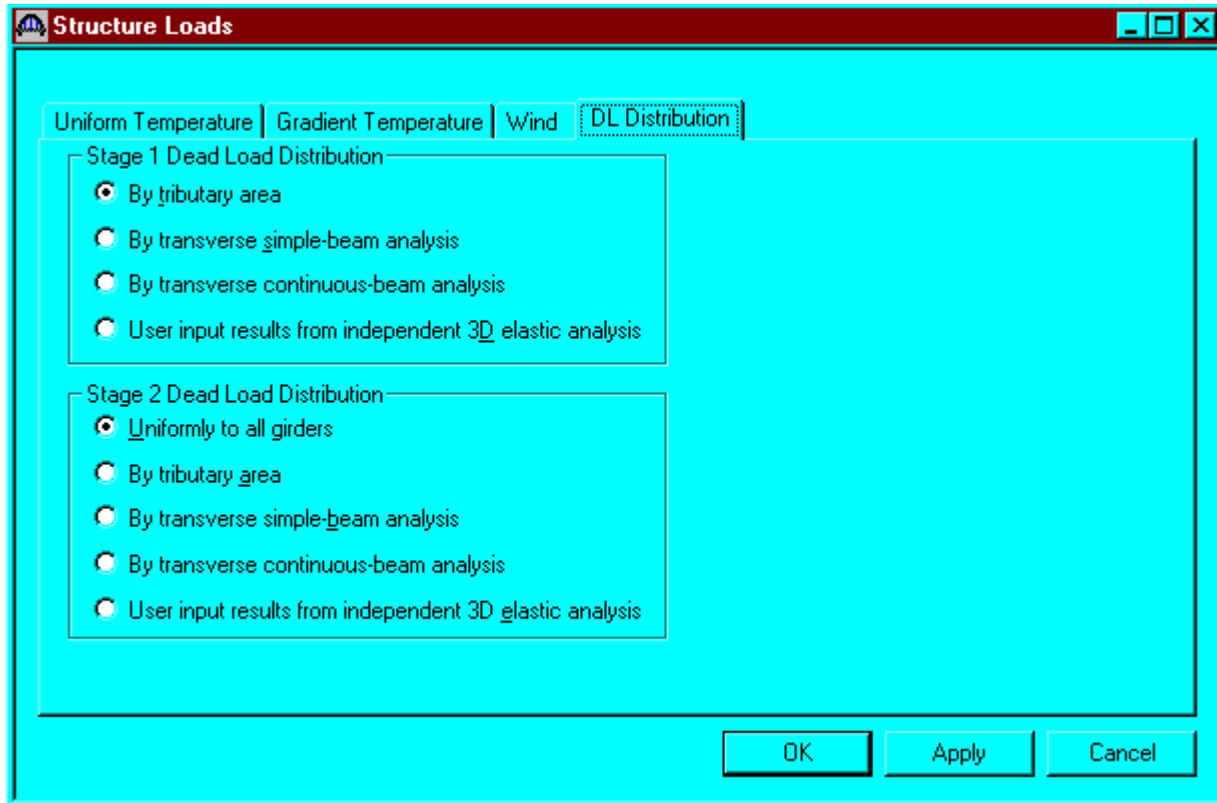
Description:

Wearing surface thickness = in

Wearing surface density = pcf

Load case:

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.



A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the "PS 6.0 ksi" concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.

	LFD	LRFD
Initial allowable compression:	2.700 ksi	2.700 ksi
Initial allowable tension:	0.200 ksi	0.200 ksi
Final allowable compression:	3.600 ksi	3.600 ksi
Final allowable tension:	0.465 ksi	0.465 ksi
Final allowable DL compression:	2.400 ksi	2.700 ksi
Final allowable slab compression:	ksi	ksi
Final allowable compression: (LL + 1/2(Pe + DL))	2.400 ksi	2.400 ksi

Buttons: OK, Apply, Cancel

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the "General P/S Data" tab is required. Click OK to save to memory and close the window.

Prestress Properties

Name:

General P/S Data | Loss Data - Lump Sum | Loss Data - PCI

P/S strand material: Jacking stress ratio:

Loss method: P/S transfer stress ratio:

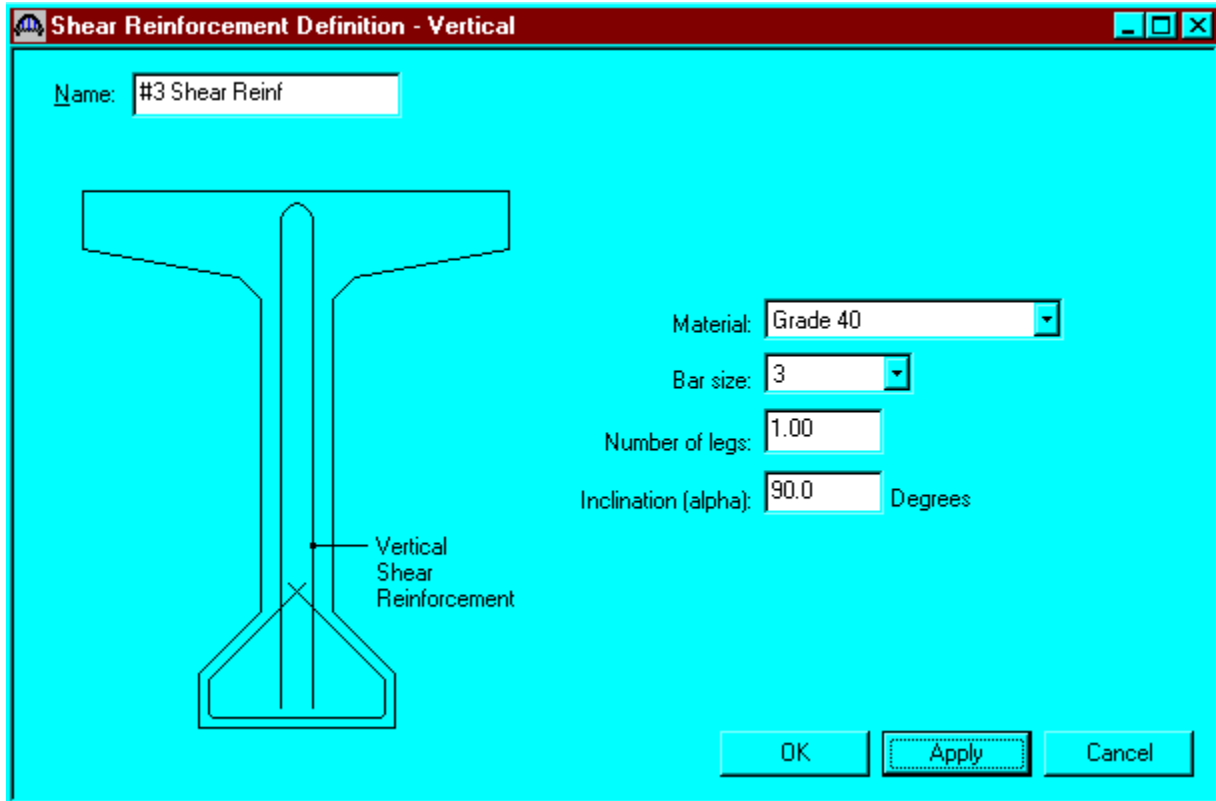
Transfer time: Hours

Loss Data - AASHTO

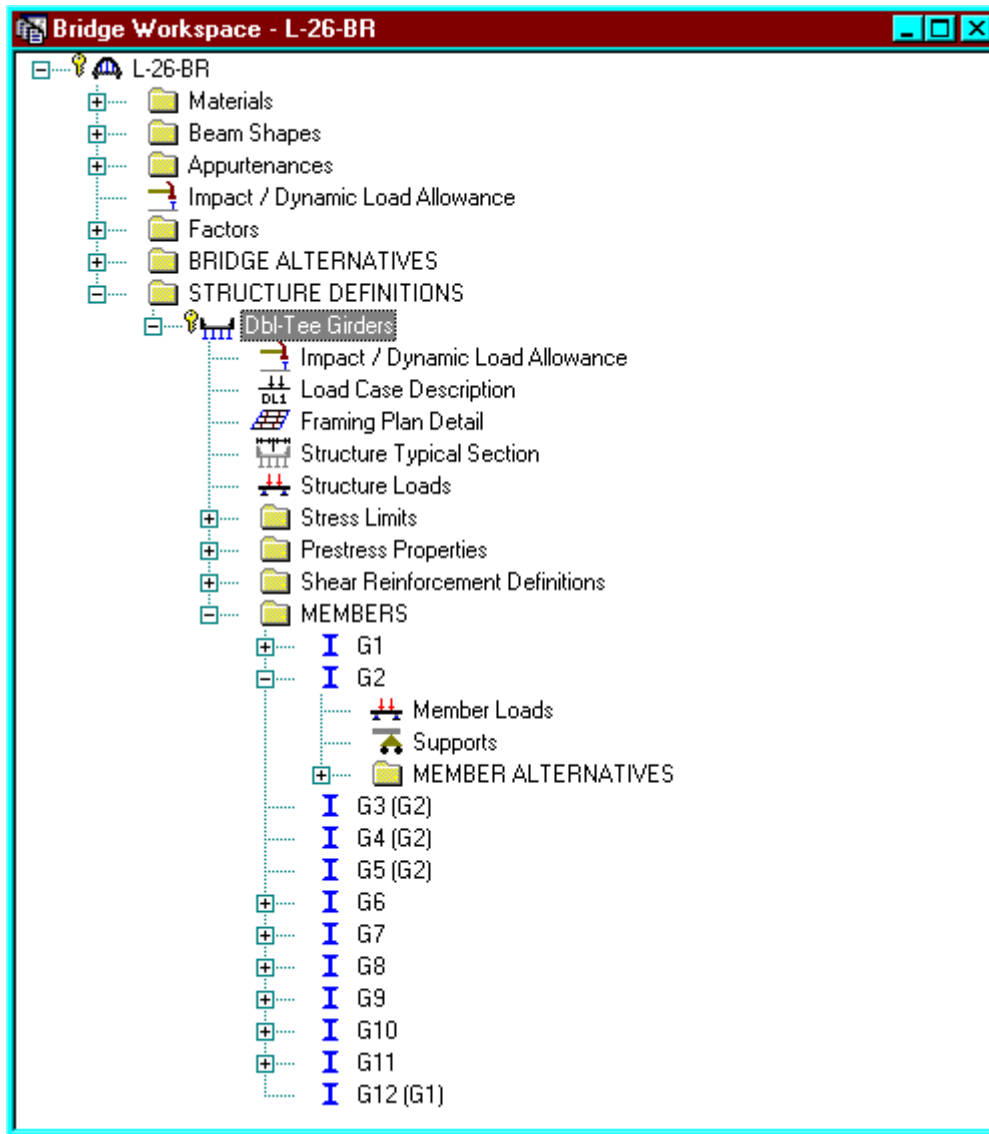
Percentage DL: %

OK Apply Cancel

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



The partially expanded Bridge Workspace tree is shown below:



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
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PS Tee Girder	

Number of spans: 1

Span No.	Span Length (ft)
1	59.50

Pedestrian load: 0.000 lb/ft

OK Apply Cancel

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 Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

Material Type: Prestressed (Pretension) Girder Type: PS Precast I

OK Cancel

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

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.

Member Alternative Description

Member Alternative: PS Tee Girder

Description Factors Engine Import

Description:

Material Type: Prestressed (Pretensioned)

Girder Type: PS Precast I

Member units: US Customary

Girder property input method

Schedule based

Cross-section based

Analysis Module

ASD: BRASS ASD

LFD: BRASS LFD

LRFD: BRASS LRFD

Additional Self Weight

Additional self weight = kip/ft

Additional self weight = %

Default rating method: LFD

Shear computation method

LRFD: General Procedure

LFD: Ignore shear

Crack control parameter (Z)

Bottom of beam: kip/in

OK Apply Cancel

Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to intermediate diaphragm located at centerline of the girder is entered here.

Loads - Member

Uniform | Distributed | Concentrated | Settlement

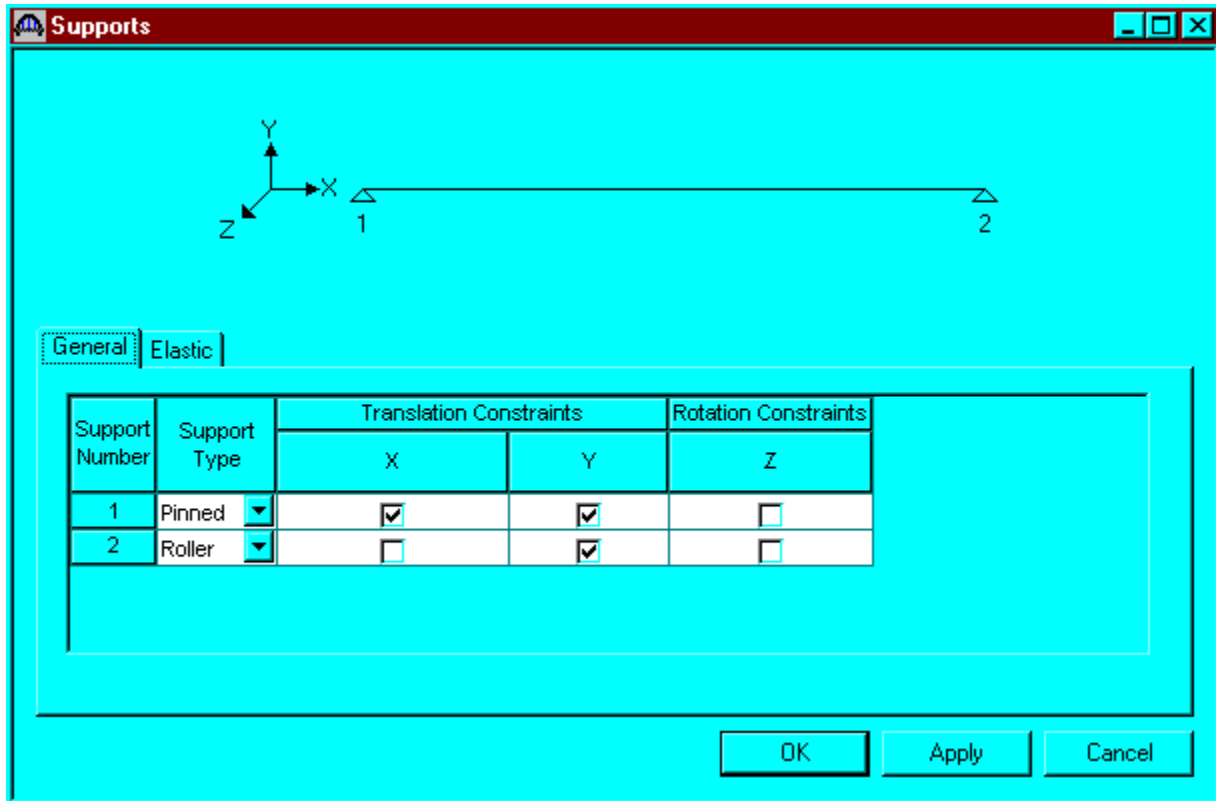
Load Case Name: diaphragm load

Support Number	Distance (ft)	Px (kip)	Py (kip)	M (kip.ft)
1	29.75	0.00	0.07	0.00

New Duplicate Delete

OK Apply Cancel

Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape now in the Beam Details window and then come back to the Live Load Distribution window. Double click on Beam Details in the tree to describe the beam details. Enter the following beam details information.

Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	Tee Girder	PS 6.0 ksi	AASHTO Losses	No	6.069	5.0000	5.0000

Note that the Stress Limit Ranges are defined over the entire length of the precast beam.

Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	Beam Stress Limits	0.00	60.33	60.33

Since we do not have a concrete deck for this structure definition, we do not need to enter any information on the Slab Interface tab.

Click OK to save the Beam Details data to memory and close the window.

Now double click on Live Load Distribution in the tree to enter the following live load distribution factors. Click OK to save data to memory and close the window.

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane			0.547	
Multi-Lane			0.597	

Compute from Typical Section

OK Apply Cancel

Note: The AASHTO live load distribution factor for concrete T-Girder used in the analysis.

Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center of gravity) of the group of strands. Select P and CGS only for the Description Type. Enter the following Strand Layout information for Span 1. Press F1 while on this tab to view the strand layout help topic describing the use of this information.

Strand Layout - Span 1

Description Type

P and CGS only Strands in rows

Left harp pt. dist. (X1): 24 ft

Left harp pt. radius: 0.0001 in

Right harp pt. dist. (X2): 24 ft

Right harp pt. radius: 0.0001 in

Force: 268.26 kip

Left CGS: 22.0000 in

Mid CGS: 4.0000 in

Right CGS: 22.0000 in

OK Apply Cancel

Since this structure does not have a cast in place deck, the Deck Profile and the Haunch Profile information is not required.

The Shear Reinforcement Ranges are entered as described below.

PS Shear Reinforcement Ranges

Vertical | Horizontal

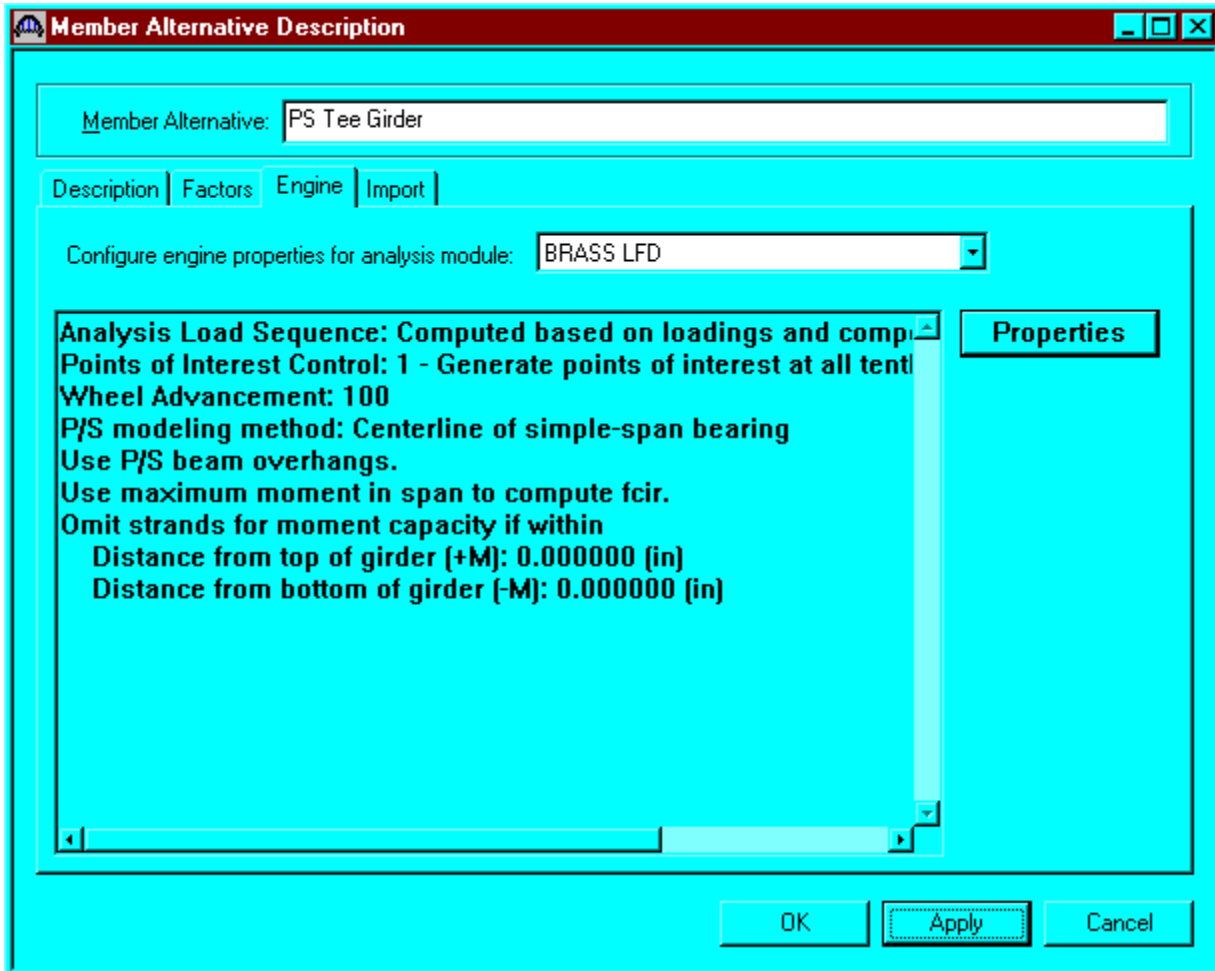
Span Number	Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
1	#3 Shear Reinf	<input type="checkbox"/>	1.67	57	12.0000	57.00	58.66

New Duplicate Delete

OK Apply Cancel

The description of an interior beam for this structure definition is complete.

The BRASS LFD engine data for the member alternative is shown below.



The results of the LFD/ASD rating analysis are as follows:

Analysis Results - PS Tee Girder

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	LFD	30.47	50.88	0.846	1.413	29.75	1 - (50.0)	29.75	1 - (50.0)	ULTIMATE MOM	ULTIMATE MOM
HS 20-44	Lane	LFD	43.96	73.41	1.221	2.039	29.75	1 - (50.0)	29.75	1 - (50.0)	ULTIMATE MOM	ULTIMATE MOM
Colorado Permit Vehicle	Axle	LFD		86.06		0.896			29.75	1 - (50.0)		ULTIMATE MOM

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

Analysis Results - PS Tee Girder

Report Type: Rating Results Summary

Live Load	Live Load Type	Design Method	Inventory Load Rating Ton	Operating Load Rating Ton	Inventory Rating Factor	Operating Rating Factor	Inventory Location ft	Inventory Location Span-(%)	Operating Location ft	Operating Location Span-(%)	Inventory Limit State	Operating Limit State
HS 20-44	Axle	ASD	29.17	31.09	0.810	0.864	29.75	1 - (50.0)	29.75	1 - (50.0)	BOTTOM FLANGE	BOTTOM FLANGE
HS 20-44	Lane	ASD	42.08	44.86	1.169	1.246	29.75	1 - (50.0)	29.75	1 - (50.0)	BOTTOM FLANGE	BOTTOM FLANGE

BRASS-GIRDER - Version 5.08.03 - May. 09, 2001

Close

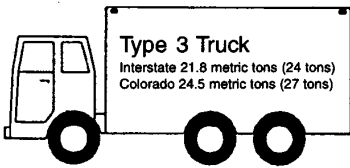
COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure #	L-26-BR	
	State highway #	50	
	Rated using Asphalt thickness: <u>51</u> mm (<u>2</u> in.)	Batch I.D.	
	<input checked="" type="checkbox"/> Colorado legal loads <input type="checkbox"/> Interstate legal loads	Structure type	CDTPG
		Parallel structure #	

Structural member	INTERIOR GIRDER DBL-TEE		
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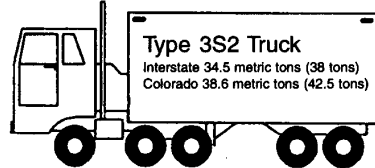
Metric tons (Tons)

Inventory	26.4 (29)	()	()
Operating	46.4 (51)	()	()

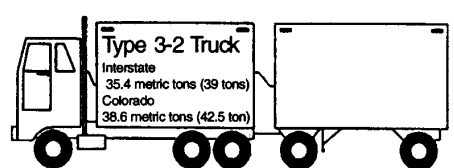
Type 3 truck	()	()	()
Type 3S2 truck	()	()	()
Type 3-2 truck	()	()	()
Permit truck	78.2 (86)	()	()



Metric tons (Tons)



Metric tons (Tons)



Metric tons (Tons)

Comments

Load Capacity: 51 Tons
Girder: Only Interior Girder Rated

Color Code: Orange

Project No: FC 050 - 5(16)

Rated by	Date	Checked by	Date
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