

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE RATING MANUAL	Section: 8 Effective: April 1, 2011 Supersedes: April 1, 2002
SECTION 8 - REINFORCED CONCRETE STRUCTURES	

8-1 INTRODUCTION TO RATING REINFORCED CONCRETE BRIDGES

This section covers the rating of reinforced concrete girders and slabs reinforced longitudinally. This section does not cover prestressed concrete members. All reinforced concrete girders and slabs are to be rated using the policies and guidelines in section 1, and subsections 8-2 and 8-3.

The rating of reinforced concrete decks supported by girders is discussed in Section 3.

The following discussion and examples assume the load factor method is being used for rating.

When there are no plans available for the reinforced concrete member being rated, the requirements in subsection 8-4 will govern the rating.

The types of bridges covered by this section are:

- CBG - Concrete Box Girder
- CBGC - Concrete Box Girder Continuous
- CS - Concrete Slab
- CSC - Concrete Slab Continuous
- CSG - Concrete Slab and Girder
- CSGC - Concrete Slab and Girder Continuous

8-2 POLICIES AND GUIDELINES FOR RATING CONCRETE BRIDGES

I. General

- A. All longitudinally reinforced concrete members shall be rated by the Virtis program using the guidelines in subsection 8-3.
- B. Concrete girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The Virtis output results can then be supplemented with hand calculations to consider any of these significant influences, as necessary.
- C. All bridges shall be rated using the Load Factor Method.
- D. When plans are available, use the minimum yield strength values given in the plans; otherwise, values used in Section 1 for the applicable year of construction may be followed. If the condition of the girder indicates that full strength should not be used, the rating should be reduced as appropriate.

- E. All new concrete structures constructed after December 2001 shall be rated for shear at the controlling sections. Except for timber structures, shear rating will not be required for all other structures including rerating of existing structures.
- F. All new concrete structures constructed after December 2001, moment rating shall be performed at standard section locations (i.e. 0.5 point for a simple span structure or the 1.4 point, 2.0 point, 2.5 point, etc. for a three span structure) and any controlling rebar cut-off section location. All other structures including rerating of existing structures shall be performed at standard section locations.
- G. When rating a cast-in-place concrete box girder bridge, separate out the boxes into I shapes and rate a typical interior and exterior girder. Dead loads and live load shall be applied as appropriate.

II. Girders Requiring Rating

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

III. Calculations

- A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.
2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.
3. Use 5 psf for the unit weight of formwork when it is likely the formwork will remain in place. An example is closed cell construction, such as cast-in-place concrete box girders.
4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders, fillets, and diaphragms. The weight of diaphragms may be treated as point loads or as an equivalent uniform dead load for the span.

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

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

$$\text{equivalent uniform load } w = (8P)/3L$$

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

IV. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. 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 Engineer 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., O-18-BY.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.

8-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

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

A maximum of thirteen (13) spans can be modeled using the program. Linear, none or parabolic girder web depth variation over the length of a defined cross-section can be modeled using the Virtis. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

The library explorer can be used to save commonly used items (beam shapes, nonstandard 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) is 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 matches their calculated numbers.

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 Engineer shall be responsible for updating existing information or adding new information (i.e. beam shapes, vehicles etc.) to the library explorer.

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

8-4 RATING CONCRETE BRIDGES WITH UNKNOWN REINFORCING STEEL

It is anticipated that all bridges designed after January 1994 will have as constructed plans.

When there are no plans or other documentation for a particular concrete structure, its numerical rating shall be determined by a Professional Engineer Registered in the State of Colorado. This rating shall be based on its live load history, the condition of the bridge, a complete and comprehensive inspection of the structure and directions from the AASHTO Manual for Bridge Evaluation. If the structure shows no signs of distress due to load, the Engineer can assign it a maximum inventory rating of 36 tons.

When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and an inventory rating less than 36 tons shall be given to the concrete structure. The process is the same for operating rating; only difference is that a maximum rating of 40 tons can be assigned. No distress condition shall have a maximum permit vehicle operating rating of 96 tons. A rating is not required for concrete bridge decks with unknown reinforcing steel where the bridge deck is supported by girders or stringers.

A Rating Summary Sheet is required for these bridges. For bridges owned or maintained by the Colorado Department of Transportation, the Staff Bridge Engineer will approve this type of rating and sign the Rating Summary Sheet.

8-5 CONCRETE GIRDER BRIDGE RATING EXAMPLES

Two examples are presented in this section. First, Structure O-18-BY is a five (5) span concrete-tee girder bridge with a skew of -30° degrees. It has four (4) concrete-tee girders. Since all piers have expansion joints, only the span with the most critical condition as reported in the field inspection report will be modeled in this example. Only the interior girder has been modeled for this structure. The second structure, L-18-AV, is a 4-span continuous concrete-tee girder bridge with a skew of -27.3° degrees. It has seven (7) concrete-tee girders. For simplicity, only the interior girder has been modeled for this structure.

Slab Rating Program Input, Structure No. O-18-BY

WinSlab Input			
Structure Number:	<input type="text" value="O-18-BY"/>	Rater:	<input type="text" value="MH"/>
Batch ID:	<input type="text"/>	Comments:	<input type="text" value="LFD"/>
Highway Number:	<input type="text" value="25"/>	Load Type:	<input type="text" value="2=Interstate"/>
<hr/>			
Deadload	Bituminous Overlay (in):	<input type="text" value="2"/>	
<hr/>			
Geometry			
Effective Span (ft):	<input type="text" value="8.083"/>	Actual Slab Thickness (in.):	<input type="text" value="7.5"/>
Reinforcing Steel:			
	Area (sqin)	Distance (in)	For definitions of input values please refer to the CDOT Bridge Rating Manual
Top:	<input type="text" value="0.83"/>	<input type="text" value="5.688"/>	
Bottom:	<input type="text" value="0.83"/>	<input type="text" value="1.31"/>	
Materials Properties			
Concrete f'c (PSI):	<input type="text" value="3000"/>	Steel Fy (PSI):	<input type="text" value="40000"/>
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(a)

$$(\text{Clear span}) * 1 / \cos 30^\circ = (8.67 - 1.67) * 1 / \cos 30^\circ = 8.083'$$

Slab Rating Program Output, Structure No. O-18-BY

WinSlab Rating Version 1 Date: 12/13/2001

Structure NO. O-18-BY Rater: MH State HWY NO. = 25
Batch ID= Description: LFD

LOAD FACTOR RATING-COMP STEEL NOT USED

INPUT DATA

Bituminous Overlay(in)=	2.000	Slab Thickness(in)=	7.500
Eff. Span(ft)=	8.083	Eff. Depth(in) =	5.688
Top Reinf. (sq.in)=	0.83	Bottom Dist.(in)=	1.31
Bottom Area(sq.in)=	0.83	Oper. =	3000
Conc. Strength(PSI) Inv =	3000	Oper. =	40000
Steel Yield (PSI) Inv =	40000		
Modular Ratio =	9		

Dead Load Moment 0.77 K-Ft
 LL+I Moment 5.24 K-Ft
 Gross Weight 36.0 Tons

		Inventory	Operating
Actual Concrete Stress	(PSI)	997.12	1579.66
Actual Reinf. Steel Stress	(PSI)	18433.86	29203.39
Actual Comp. Steel Stress	(PSI)	5304.24	8403.10
Member Capacity	(K-Ft)	12.81	12.81
Member Capacity (LL+I)	(K-Ft)	11.81	11.81
Rating	(Tons)	37.43	62.39

Virtis Bridge Rating Example, Structure No. O-18-BY**Effective slab width: Per AASHTO Article 8.10.1.1**

$0.25(L) = 0.25(57 \times 12) = 171''$
 $12t + \text{Web Thickness} = (12 \times 7.5) + 20 = 110''$
 C.L. - C.L. of girder = $8.6667' = 104''$ Controls

Dead Load:

Intermediate Diaphragm = $((0.75) \times (3.25) \times (8.67 - 1.83) + 0.5 \times 2 \times 0.33 \times 0.33 \times (8.67 - 1.83)) \times (1/\cos 30^\circ) \times (0.150) = 3.02$ kips
 Use 3.1 kips

Abutment Diaphragm = Weight Varies

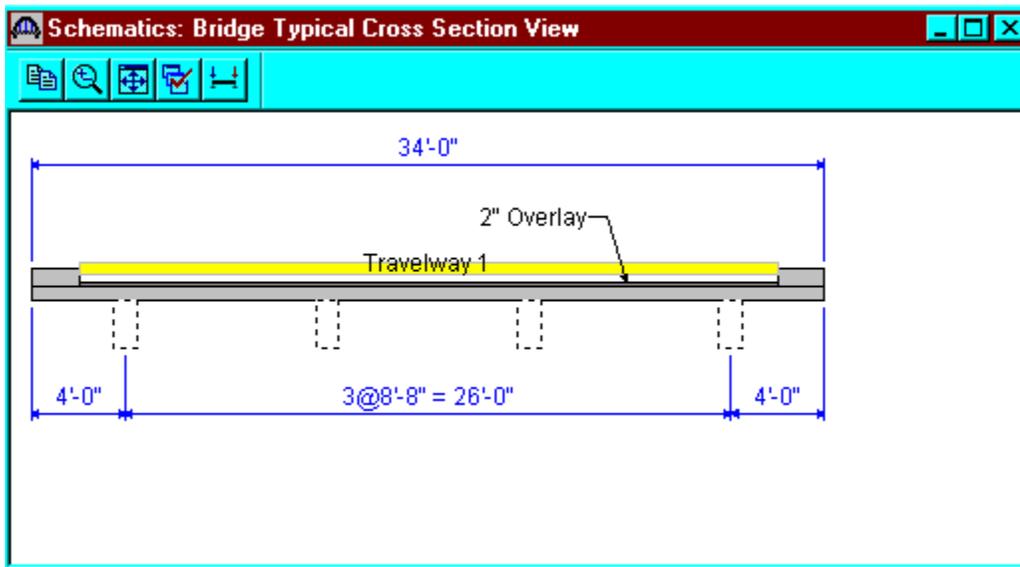
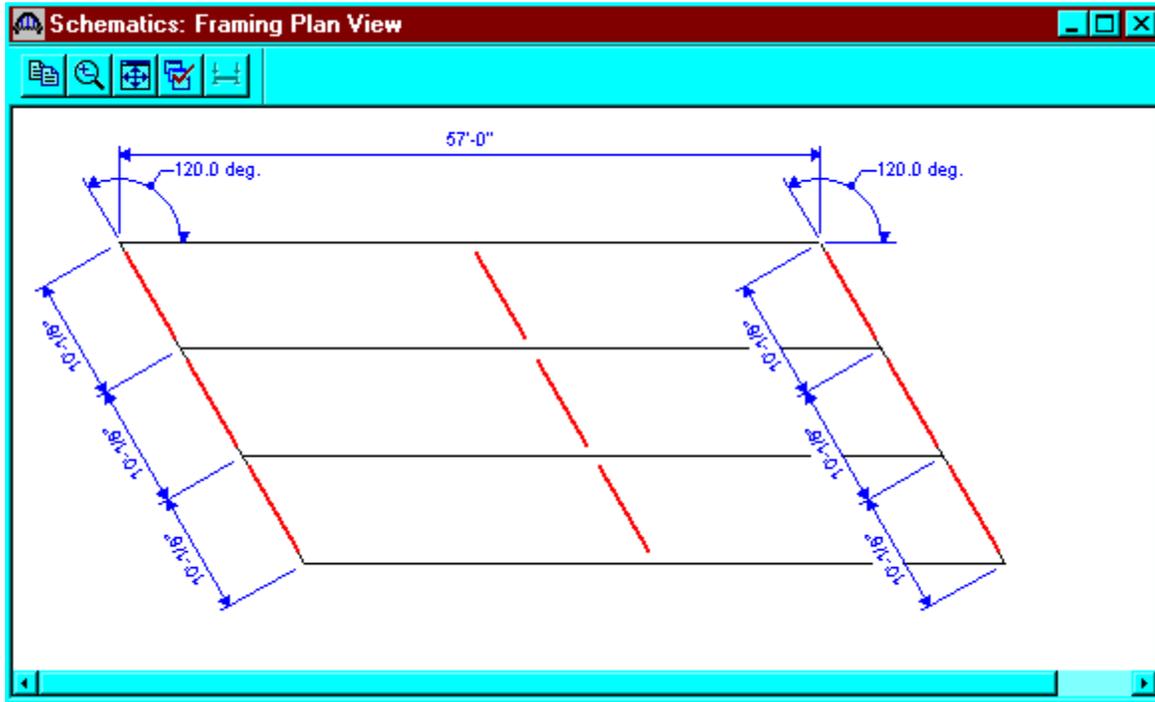
Use 6.2 kips

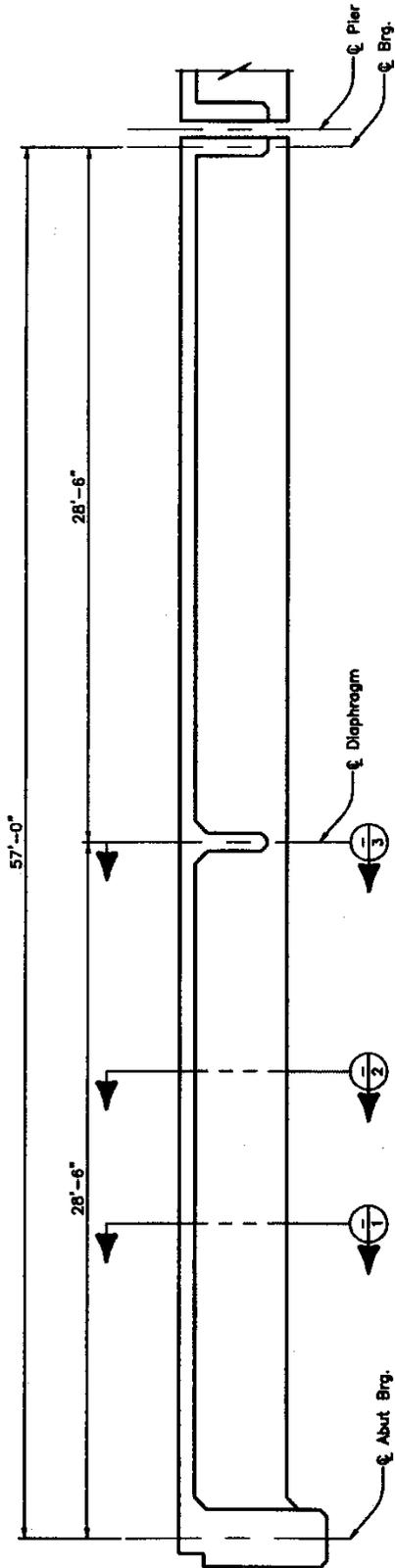
Distribution Factor:

Multi-Lane = $S/6 = 8.667/6 = 1.444$

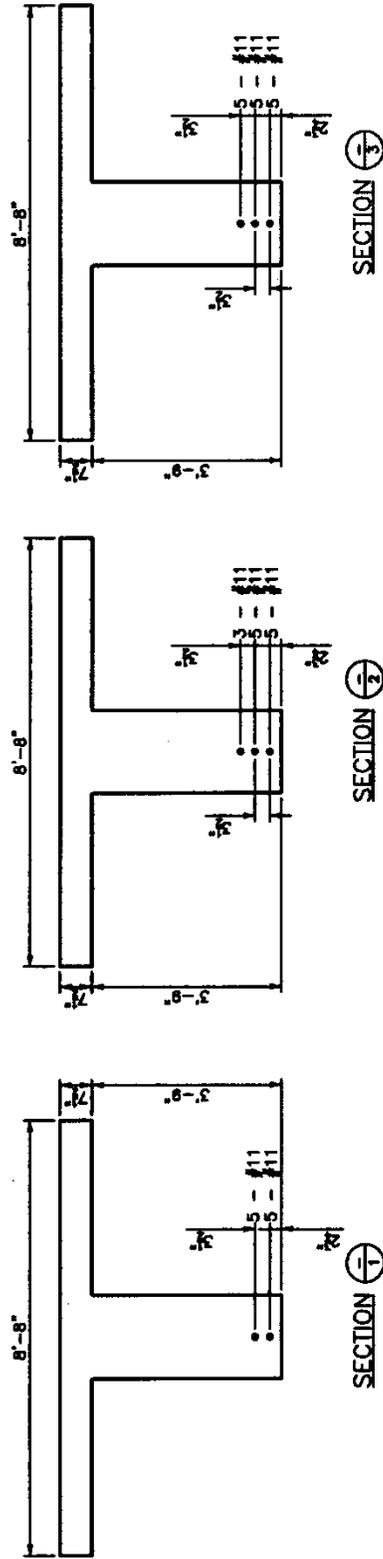
Single Lane = $1 + 2.667/8.667 = 1.308$

Virtis Bridge Rating Example, Structure No. O-18-BY (contd.)





SPAN #1



Project No: I-25-(21)31 Structure No: 0-18-BY

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

Bridge ID: 0-18-BY NBI Structure ID (8): 0-18-BY Template
 Design Only

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

Name: CSG Year Built: 1959

Description: 5-Span Concrete Tee-Beam Structure; Expansion Joint at piers;
Model as 1-Span Concrete Tee-Beam Structure

Location: Length: ft

Facility Carried (7): Route Number: -1

Feat. Intersected (6): Mi. Post:

Units: US Customary Recent ADTT:

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). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save this 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 (Ec) = ksi

Initial modulus of elasticity = ksi

Poisson's ratio =

Composition of concrete = ▼

Modulus of rupture = ksi

Shear factor =

Using the same techniques, create the following Reinforcing Steel Material to be used for the girder.

Bridge Materials - Reinforcing Steel

Name: Description:

Material Properties

Specified yield strength (F_y) = ksi

Modulus of elasticity (E_s) = ksi

Ultimate strength (F_u) = ksi

Type

Plain

Epoxy

Galvanized

Other

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

Bridge Appurtenances - Parapet

Name: Bridge Rail

Description: Curb & side mounted Metal Rail

All dimensions are in inches

0.0100 Additional Load = 0.055 kip/ft

0.0000

24.0000 0.0000

Reference Line

0.0000

0.0000

0.0000

9.0000

Back Front

Roadway Surface

Parapet unit weight = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 9.645 in

Total weight = 0.280 kip/ft

Copy from Library... OK Apply Cancel

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

Bridge Impact / Dynamic Load Allowance

Standard Impact Factor

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

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

Modified impact = [] times AASHTO impact

Constant impact override = [] %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: [15.0] %

All other limit states: [33.0] %

OK Apply Cancel

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

Factors - LFD

Name: 1996 AASHTO Std. Specifications

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

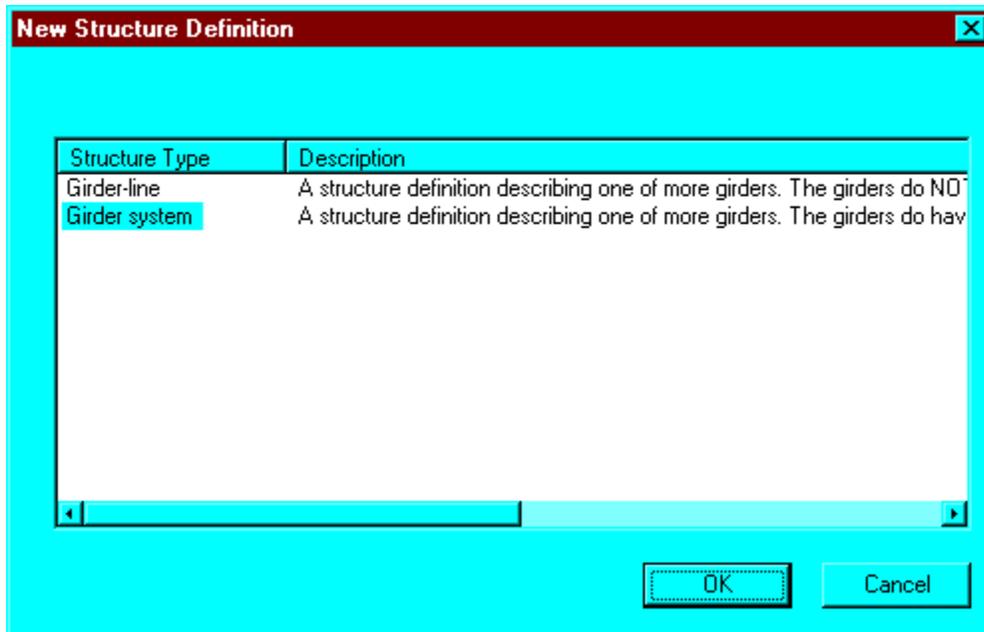
Load Factors | Resistance Factors

Load Group	Gamma Factor	D	(L+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

We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

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-Concrete Tee-Girder System

Description: 5 Span structure; All equal spans

Units: US Customary

Number of spans: 1

Number of girders: 4

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	57.00

For PS only

Average humidity: %

Member Alt. Types

Steel

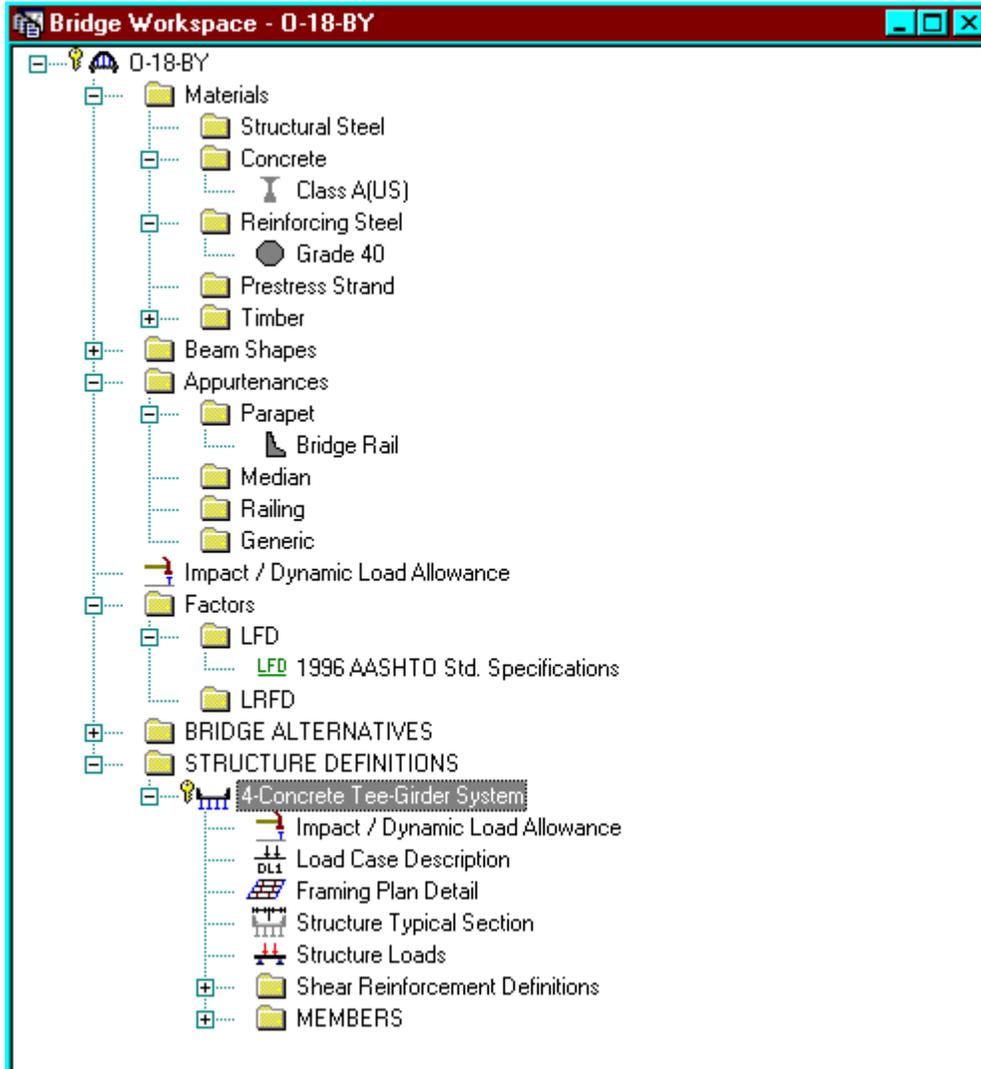
P/S

R/C

Timber

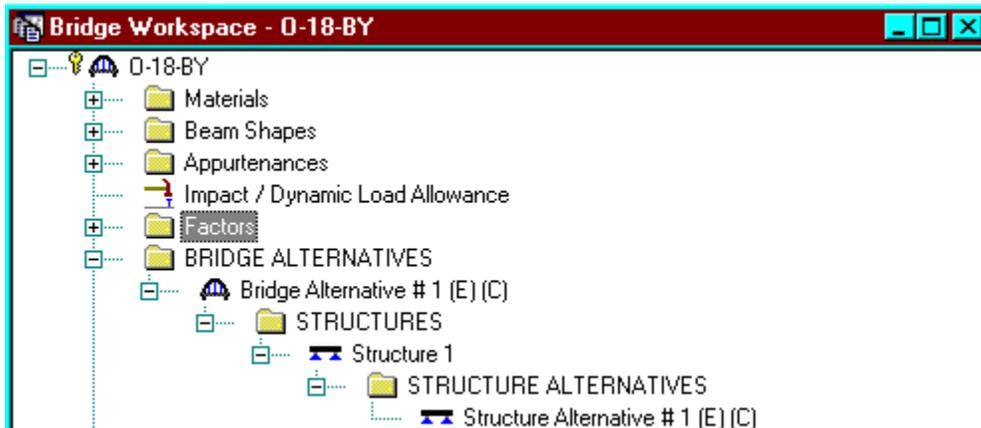
OK Apply Cancel

The partially expanded Bridge Workspace tree is shown below:



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)
Bridge Rail		Composite (long term) (Stage 2)	D,DC	
HBP		Composite (long term) (Stage 2)	D,D/W	

*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	-30.0000
2	-30.0000

Girder Spacing Orientation

Perpendicular to girder

Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	8.67	8.67
2	8.67	8.67
3	8.67	8.67

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: 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	6.2000
1	0.00	0.00	28.50	1	28.50	28.50	28.50	3.1000
1	28.50	28.50	28.50	1	28.50	57.00	57.00	6.2000

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

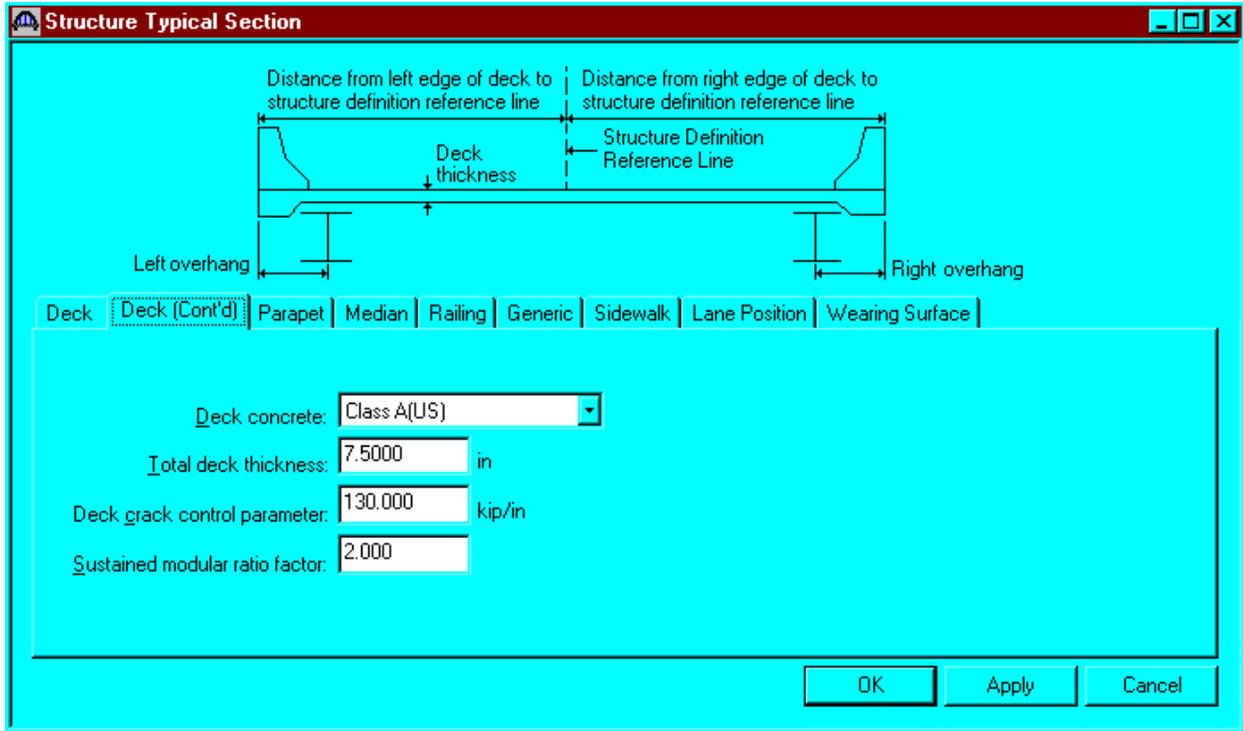
Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | Wearing Surface

Structure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to structure definition reference line =	17.00 ft	17.00 ft
Distance from right edge of deck to structure definition reference line =	17.00 ft	17.00 ft
Left overhang =	4.00 ft	4.00 ft
Computed right overhang =	4.00 ft	4.00 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.



Parapets:
Add two parapets as shown below.

The screenshot shows a software window titled "Structure Typical Section" with a red title bar. Inside the window, there is a diagram of a parapet cross-section. The diagram is a black line drawing on a white background. It shows a vertical line on the left labeled "Back", a vertical line on the right labeled "Front", and a horizontal line at the bottom. The top edge of the parapet is a series of connected line segments: a vertical segment on the left, a short horizontal segment, a diagonal segment sloping down to the right, a short horizontal segment, and a diagonal segment sloping down to the right to meet the "Front" vertical line.

Below the diagram is a tabbed interface with the following tabs: "Deck", "Deck (Cont'd)", "Parapet" (which is selected and has a dotted border), "Median", "Railing", "Generic", "Sidewalk", "Lane Position", and "Wearing Surface".

Under the "Parapet" tab is a table with the following data:

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

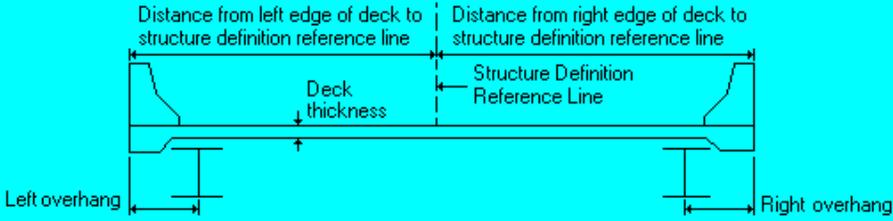
Below the table are three buttons: "New", "Duplicate", and "Delete". At the bottom of the window are three buttons: "OK", "Apply", and "Cancel".

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 apply 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	-15.00	15.00	-15.00	15.00

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 horizontal 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 reference line, a vertical arrow indicates the 'Deck thickness'. On the far left and right, horizontal arrows indicate the 'Left overhang' and 'Right overhang' respectively.

Structure Typical Section

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

Wearing surface material:

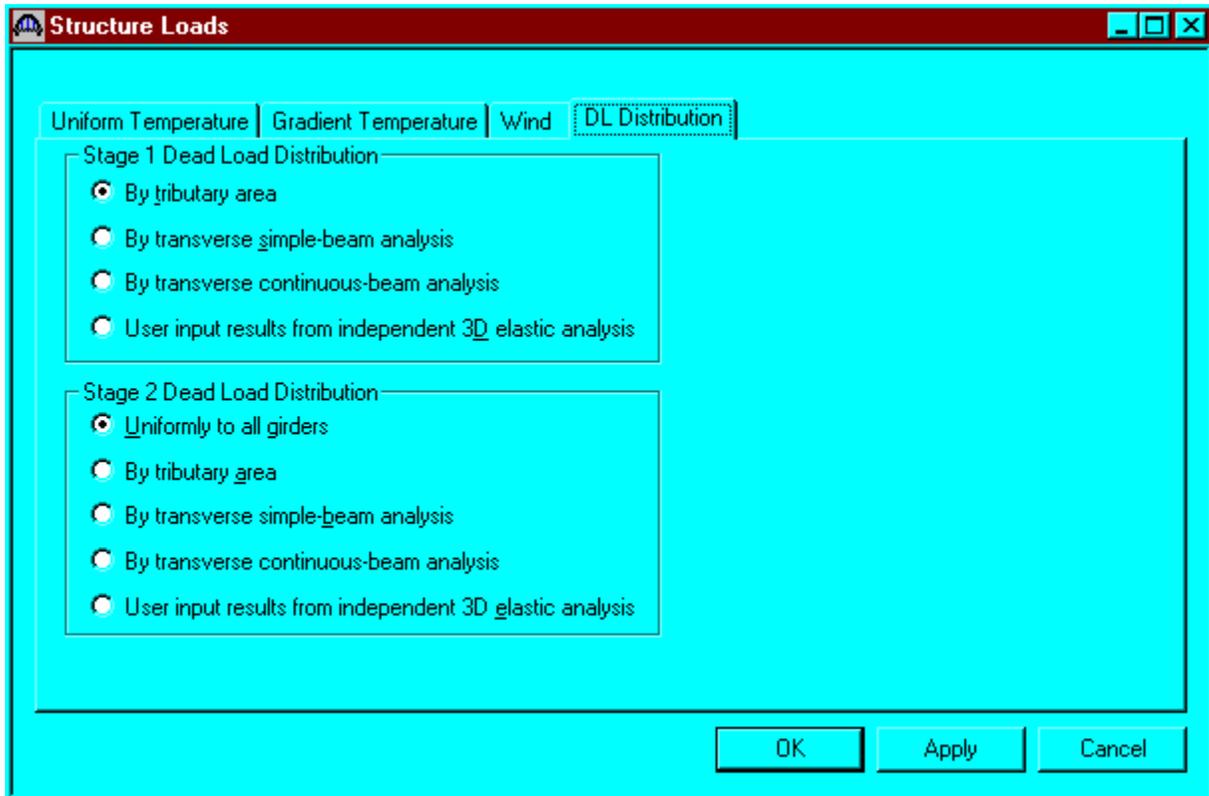
Description:

Wearing surface thickness = in

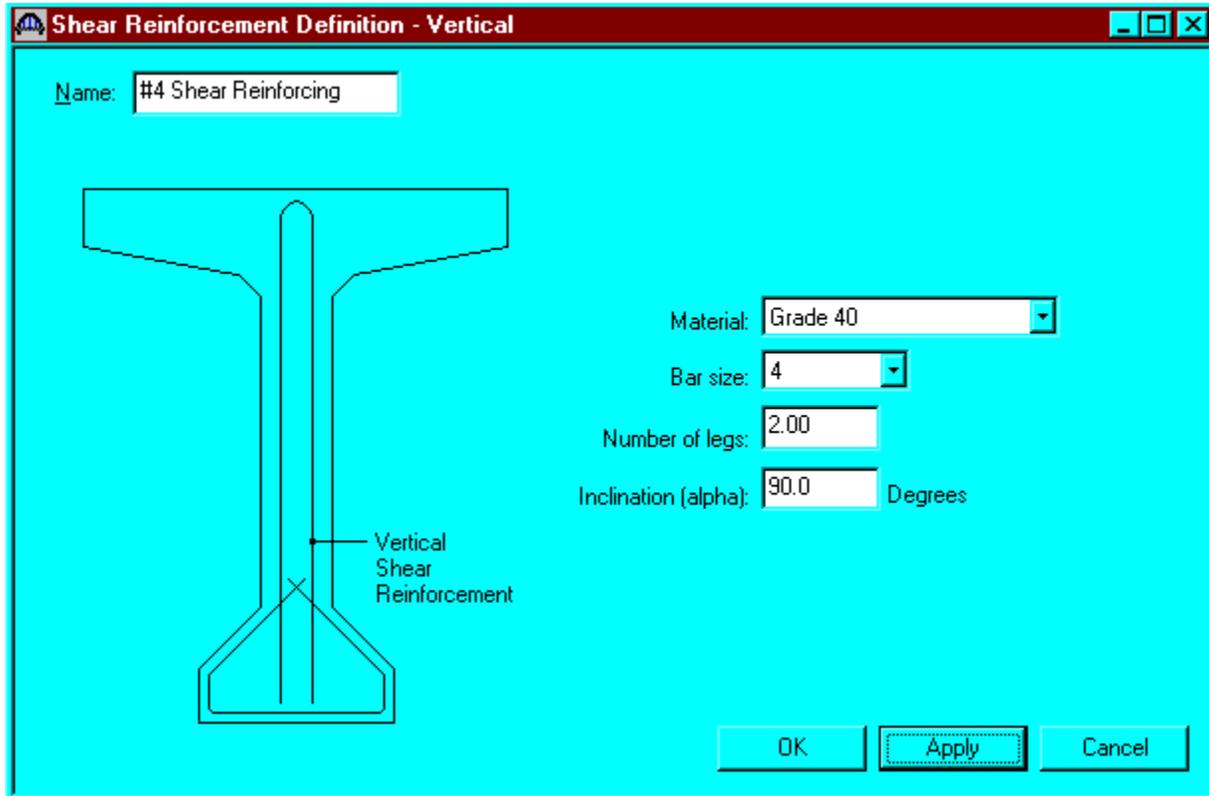
Wearing surface density = pcf

Load case:

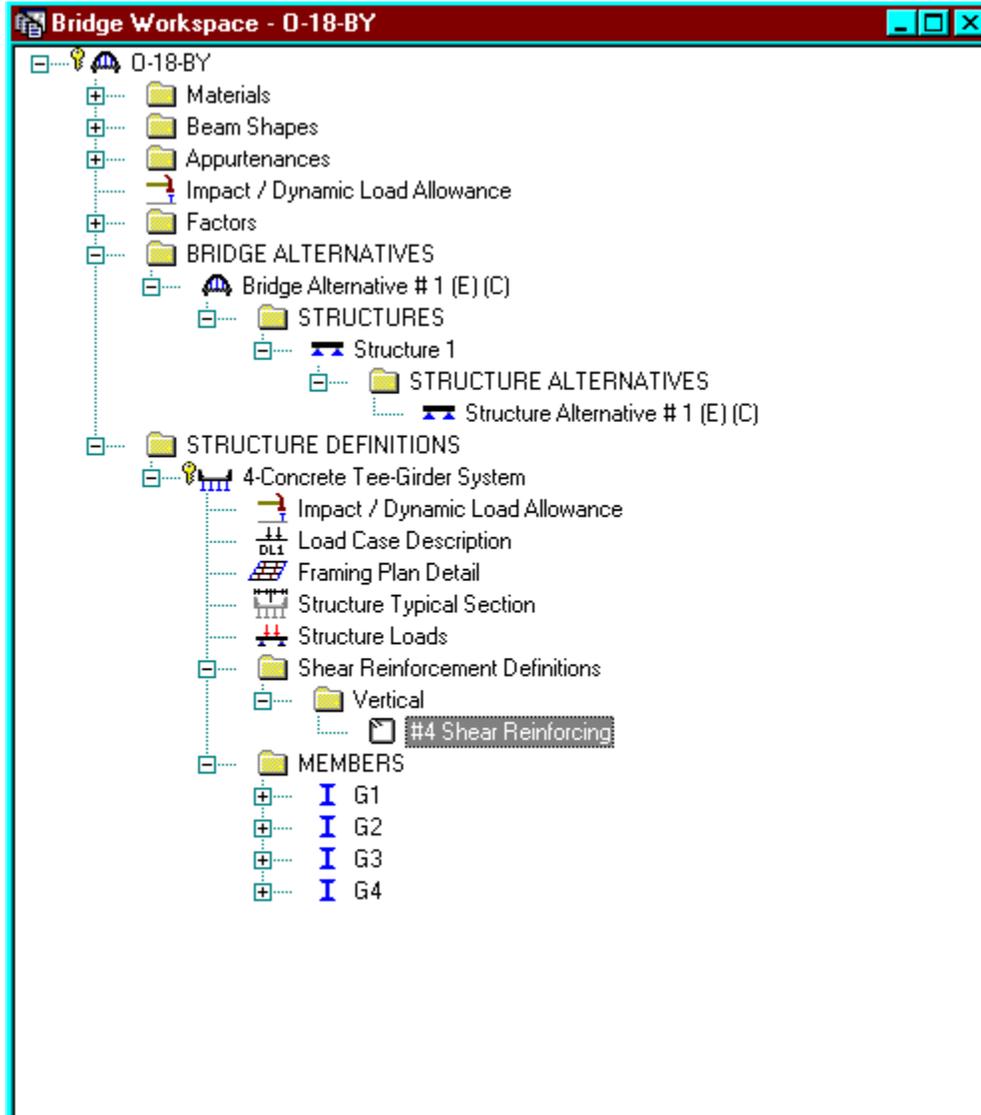
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



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"/>	Interior 52.5" RC Tee Bea	

Number of spans: 1 Pedestrian load: 0 lb/ft

Span No.	Span Length (ft)
1	57.00

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 Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.

New Member Alternative

Material Type: Reinforced Concrete Girder Type: Reinforced Concrete Tee

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.

Member Alternative Description

Member Alternative: Interior 52.5' RC Tee Beam

Description Factors Engine Import

Description:

Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Tee

Member units: US Customary

Girder property input method

Schedule based

Cross-section based

End bearing locations

Left: 7.5000 in

Right: 7.5000 in

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

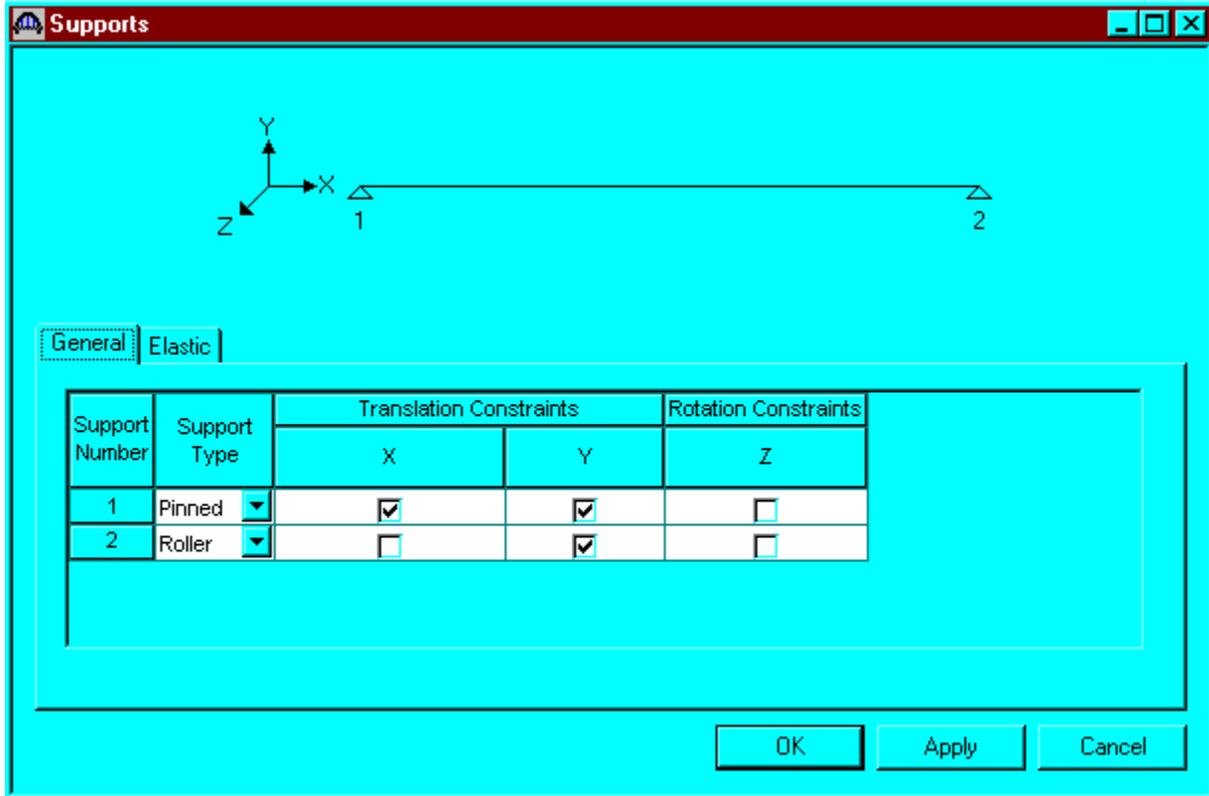
Crack control parameter (Z)

Bottom of beam: kip/in

OK Apply Cancel

Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

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.



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

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.308	1.308	1.308	0.500
Multi-Lane	1.444	1.846	1.444	1.000

Compute from Typical Section

OK Apply Cancel

Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.

Cross Sections

Name: Type:

Dimensions | Reinforcement

Diagram showing a reinforced concrete tee cross-section with dimensions:

- Tributary width: 104.0000 in
- Flange thickness: 7.5000 in
- Web width: 20.0000 in
- Total height: 52.5000 in
- Slope length A = 4.0000 in

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

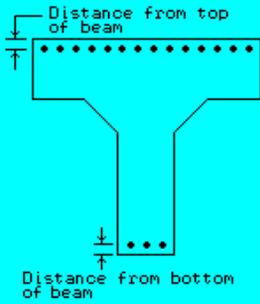
OK Apply Cancel

Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

Cross Sections

Name: Type:

Dimensions Reinforcement



Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40

New Duplicate Delete

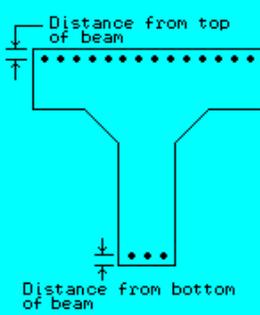
OK Apply Cancel

Using the same techniques, create cross section 2, cross-section 3 and define their associated reinforcement patterns.

Cross Sections

Name: Type:

Dimensions **Reinforcement**



Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40
Bottom of Girder	11	3.000	9.7500	Grade 40

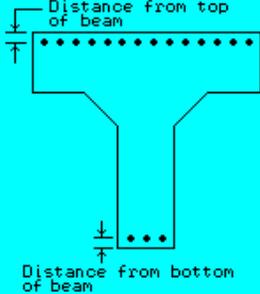
New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions Reinforcement



Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	5.000	2.7500	Grade 40
Bottom of Girder	11	5.000	6.2500	Grade 40
Bottom of Girder	11	5.000	9.7500	Grade 40

New Duplicate Delete

OK Apply Cancel

The Cross Section Ranges window is shown below. Define the ranges over which the cross sections apply.

The diagram shows a horizontal beam with a hatched section in the middle. The hatched section is labeled 'Start Section' and 'End Section'. The distance from the left end of the beam to the start of the hatched section is labeled 'Start Distance'. The length of the hatched section is labeled 'Length'. The distance from the end of the hatched section to the right end of the beam is also labeled 'Length'.

Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Cross Section 1	Cross Section 1	None	1	0.000	12.800	12.800
Cross Section 2	Cross Section 2	None	1	12.800	6.250	19.050
Cross Section 3	Cross Section 3	None	1	19.050	18.900	37.950
Cross Section 2	Cross Section 2	None	1	37.950	6.250	44.200
Cross Section 1	Cross Section 1	None	1	44.200	12.800	57.000

Buttons: New, Duplicate, Delete, OK, Apply, Cancel

Shear reinforcement locations are described using the Shear Reinforcement Ranges window shown below.

RC Shear Reinforcement Ranges

Name	Support Number	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Shear R	1	0.00	1	18.0000	1.50	1.50
#4 Shear R	1	1.50	5	6.0000	2.50	4.00
#4 Shear R	1	4.00	4	9.0000	3.00	7.00
#4 Shear R	1	7.00	4	12.0000	4.00	11.00
#4 Shear R	1	11.00	13	15.0000	16.25	27.25
#4 Shear R	1	27.25	1	30.0000	2.50	29.75
#4 Shear R	1	29.75	13	15.0000	16.25	46.00
#4 Shear R	1	46.00	4	12.0000	4.00	50.00
#4 Shear R	1	50.00	4	9.0000	3.00	53.00
#4 Shear R	1	53.00	6	6.0000	3.00	56.00
#4 Shear R	1	56.00	1	4.0000	0.33	56.33

Define points of interest using the Points of Interest window shown below.

The Point of Interest window enables the user to enter points of interest in addition to those that are automatically generated by the program.

$15 \text{ bar diameter} = 15 \cdot (11/8) = 1.712'$
 $\text{Clear Span}/20 = (57-1.83)/20 = 2.75'$
 $\text{Effective Depth} = 46.25/12 = 3.85' \quad \text{Use } 3.8'$

$\text{First rebar cutoff from left support} = 12.8'$
 $\text{Second rebar cutoff from left support} = 19.05'$

Point of Interest

Distance from leftmost support: ft or Span: Fraction: Side: Left Right

Shear | Engine

Override schedule

	Vertical Shear Reinf.	Horiz. Shear Reinf.
Material:	<input type="text" value="Grade 40"/>	<input type="text"/>
Bar size:	<input type="text"/>	<input type="text"/>
# of legs:	<input type="text"/>	<input type="text"/>
Area:	<input type="text"/>	<input type="text"/>
Inclination:	<input type="text"/>	<input type="text"/>
Spacing:	<input type="text"/>	<input type="text"/>

% Shear:

Shear distance:

LRFD

Computation Method:

Sx:

Beta:

Theta:

LFD

Ignore shear

OK Apply Cancel

Point of Interest

Distance from leftmost support: ft or Span: Fraction: Side: Left Right

Shear | Engine

Override schedule

	Vertical Shear Reinf.	Horiz. Shear Reinf.
Material:	<input type="text" value="Grade 40"/>	<input type="text"/>
Bar size:	<input type="text"/>	<input type="text"/>
# of legs:	<input type="text"/>	<input type="text"/>
Area:	<input type="text"/>	<input type="text"/>
Inclination:	<input type="text"/>	<input type="text"/>
Spacing:	<input type="text"/>	<input type="text"/>

% Shear:

Shear distance:

LRFD

Computation Method:

Sx:

Beta:

Theta:

LFD

Ignore shear

OK Apply Cancel

Shear Check: $d = 52.5'' - 6.25'' = 46.25'' = 3.85'$

Shear at a distance 'd' from the free edge of the left support + 1.167' =
 $3.85' + 1.167' = 5.02'$

Point of Interest

Distance from leftmost support: ft or Span: Fraction: Side: Left Right

Shear | Engine

Override schedule

	Vertical Shear Reinf.	Horiz. Shear Reinf.
Material:	<input type="text" value="Grade 40"/>	<input type="text"/>
Bar size:	<input type="text"/>	<input type="text"/>
# of legs:	<input type="text"/>	<input type="text"/>
Area:	<input type="text"/>	<input type="text"/>
Inclination:	<input type="text"/>	<input type="text"/>
Spacing:	<input type="text"/>	<input type="text"/>

% Shear:

Shear distance:

LRFD

Computation Method:

Sx:

Beta:

Theta:

LFD

Ignore shear

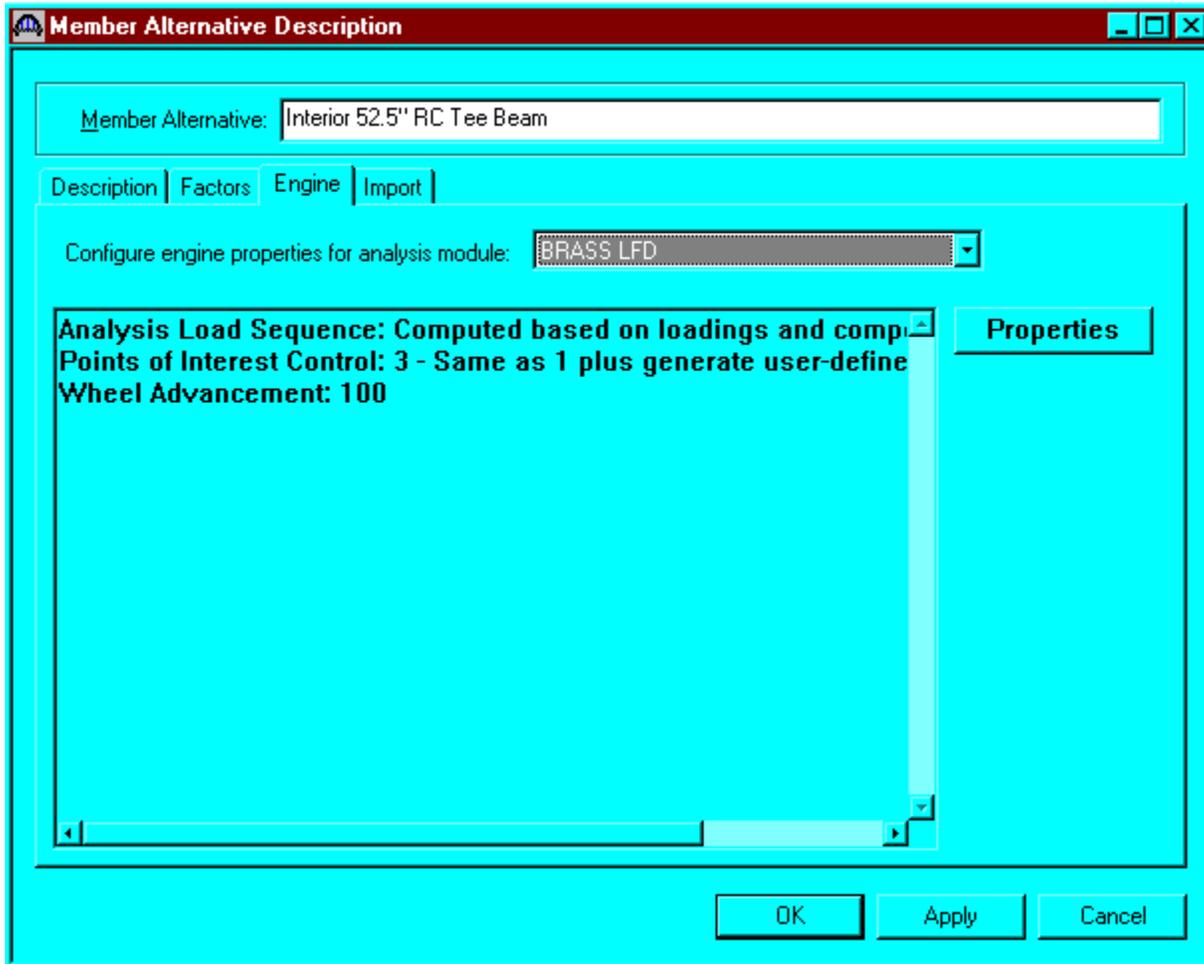
OK Apply Cancel

Shear Check: $d = 52.5'' - 6.25'' = 46.25'' = 3.85'$

Shear at a distance 'd' from the free edge of the right support + 0.167' = $3.85' + 0.167' = 4.02'$

Therefore, Distance from the left support = $57.0' - 4.04' = 52.98'$

Open the Member Alternative Description window and click the Engine tab as shown below.



Click the Properties button to edit the engine properties for BRASS LFD.

BRASS-Standard Member Alternative Properties [X]

Analysis

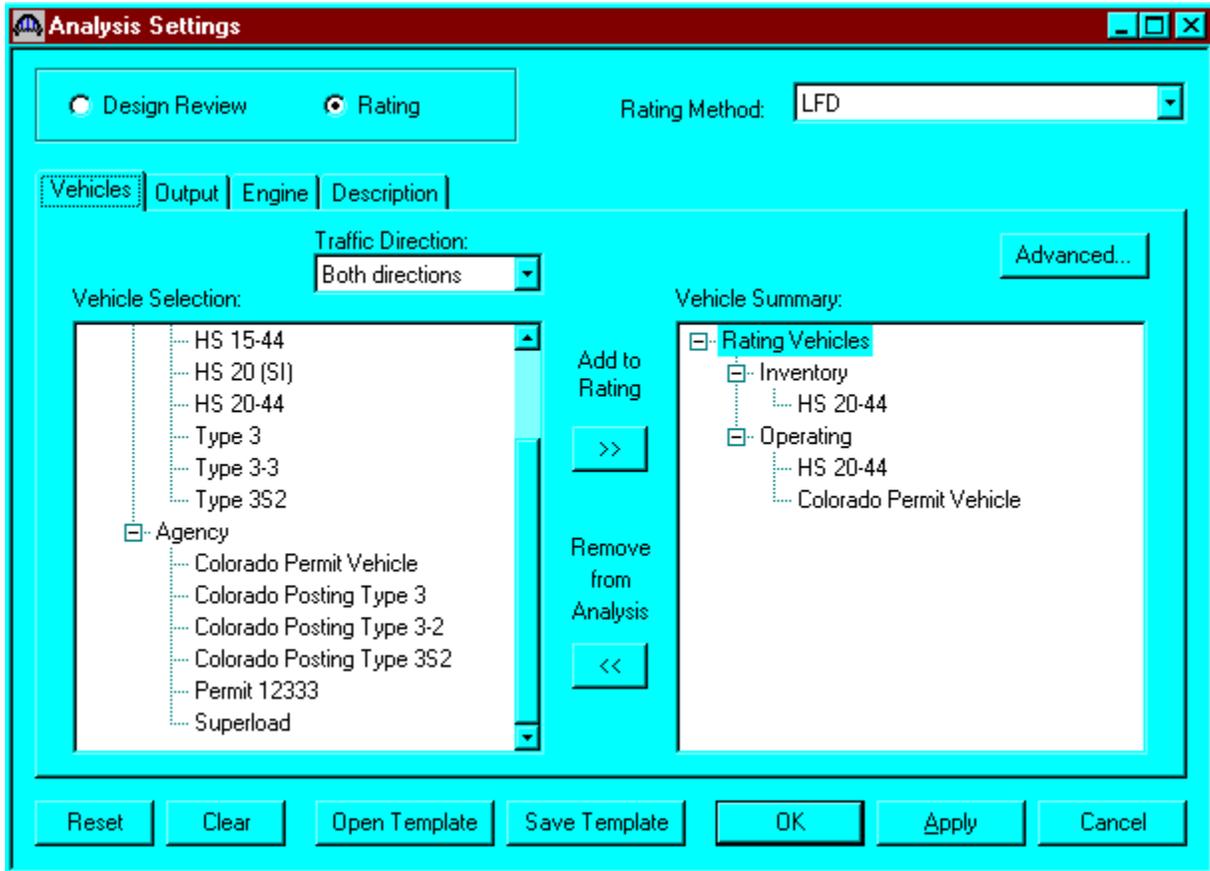
Load Sequence:
Computed based on loadings and composite regions.

POI Control:
1 - Generate points of interest at all tenth points along TOP spans

Wheel advancement denominator: 100

OK
Cancel

To perform a rating, select the View Analysis Settings button on the toolbar to open the window shown below. Select the required vehicles to be used in the rating and click OK.



The results of the LFD rating analysis are as follows.

Analysis Results - Interior 52.5" RC Tee Beam

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	Oper Limit :
HS 20-44	Axle	LFD	48.57	81.11	1.349	2.253	28.50	1 - (50.0)	28.50	1 - (50.0)	ULTIMATE MOMENT CAPACIT	ULTIMATE MON
HS 20-44	Lane	LFD	70.55	117.82	1.960	3.273	28.50	1 - (50.0)	28.50	1 - (50.0)	ULTIMATE MOMENT CAPACIT	ULTIMATE MON
Colorado Permit Vehicle	Axle	LFD		139.40		1.451			28.50	1 - (50.0)		ULTIMATE MON

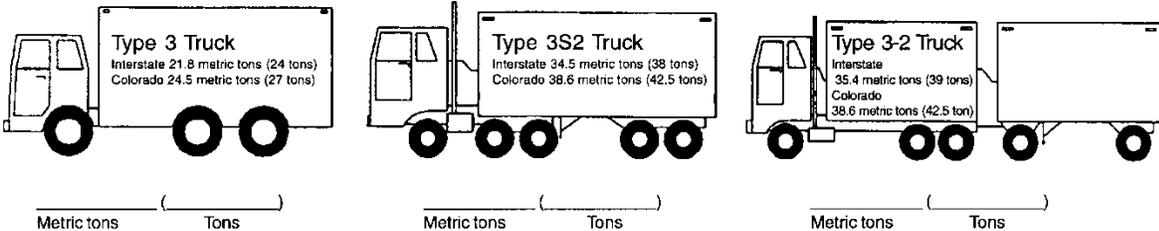
BRASS-GIRDER - Version 5.08.03 - May, 09, 2001

Close

COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure # O-18-BY (S.B.)
	State highway # I-25
Rated using Asphalt thickness: 50 mm (2 in.) <input type="checkbox"/> Colorado legal loads <input checked="" type="checkbox"/> Interstate legal loads	Batch I.D.
	Structure type CSG
	Parallel structure # O-18-CD (N.B.)

Structural member	INTERIOR GIRDER	SLAB	
-------------------	-----------------	------	--

	Metric tons (Tons)			
Inventory	43.6 (48)	33.6 (37)	()	()
Operating	73.6 (81)	56.4 (62)	()	()
Type 3 truck	()	()	()	()
Type 3S2 truck	()	()	()	()
Type 3-2 truck	()	()	()	()
Permit truck	126.3 (139)	()	()	()



Comments Control Member: Deck; Rated for 2" HBP Load Capacity: 62 Tons Girder: Only Interior Girder Rated; Rated for 2" HBP Color Code: White Project No: I-25-1(21)31			
Rated by	Date	Checked by	Date

Slab Rating Program Input, Structure No. L-18-AV

WinSlab Input			
Structure Number:	L-18-AV	Rater:	MH
Batch ID:		Comments:	
Highway Number:	25	Load Type:	1=Colorado
<hr/>			
Deadload	Bituminous Overlay (in):	2	
<hr/>			
Geometry			
Effective Span (ft):	8.44	Actual Slab Thickness (in.):	6.5
Reinforcing Steel:			
	Area (sqin)	Distance (in)	For definitions of input values please refer to the CDOT Bridge Rating Manual
Top:	0.75	5.156	
Bottom:	0.75	1.34	
Materials Properties			
Concrete f'c (PSI):	3000	Steel Fy (PSI):	40000
or Inv Fc (Working Stress)		or Inv Fs (Working Stress)	
Modular Ratio (Leave blank for load factor):	00		
OK		Cancel	Apply
			Output to File

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

$$(\text{Clear span}) * 1 / \cos 27.3^\circ = (9.00 - 1.50) * 1 / \cos 27.3^\circ = 8.440'$$

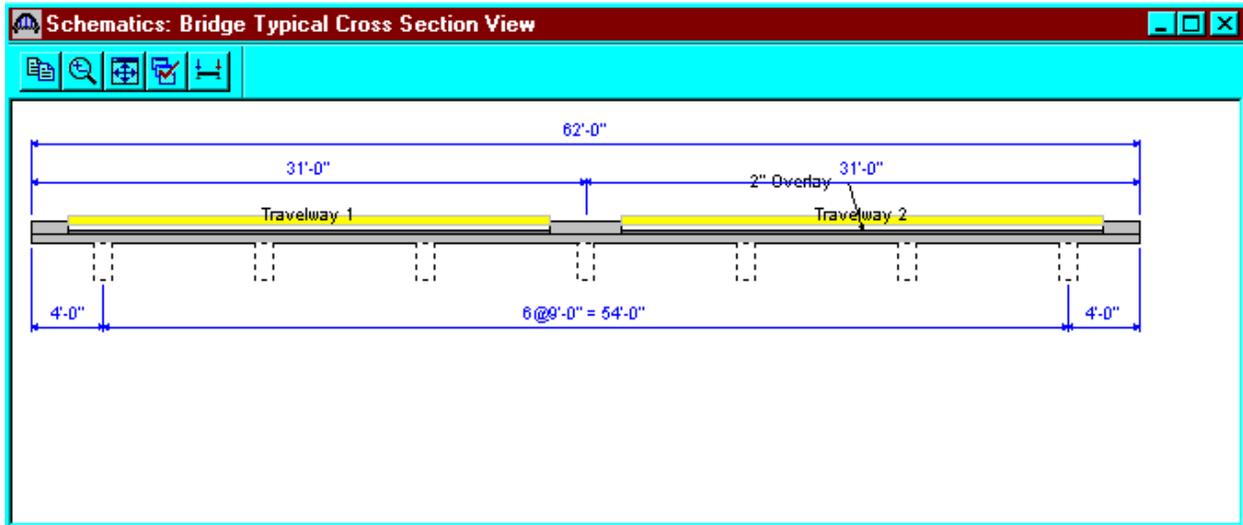
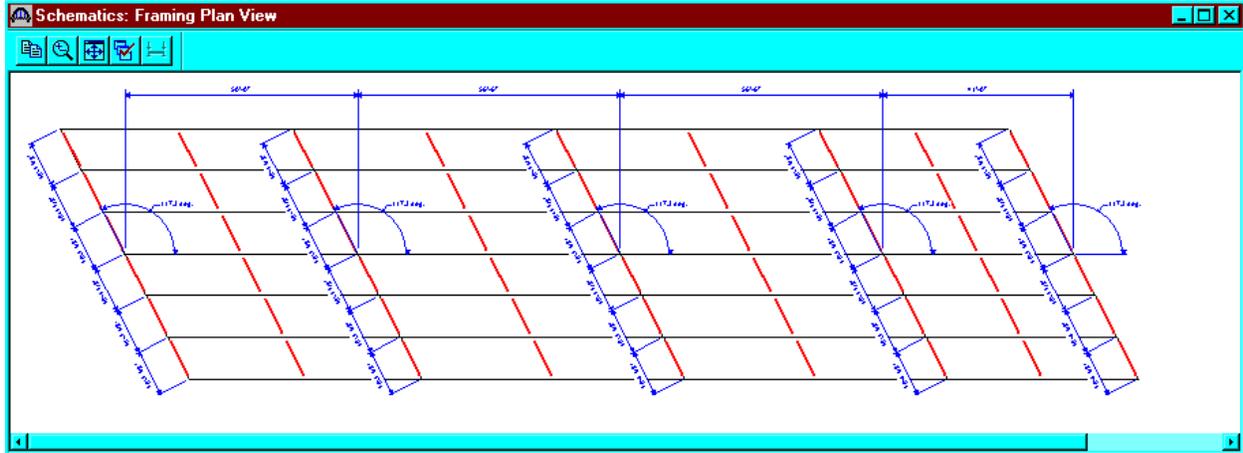
$$\text{Distance to Top Steel} = 5.156''$$

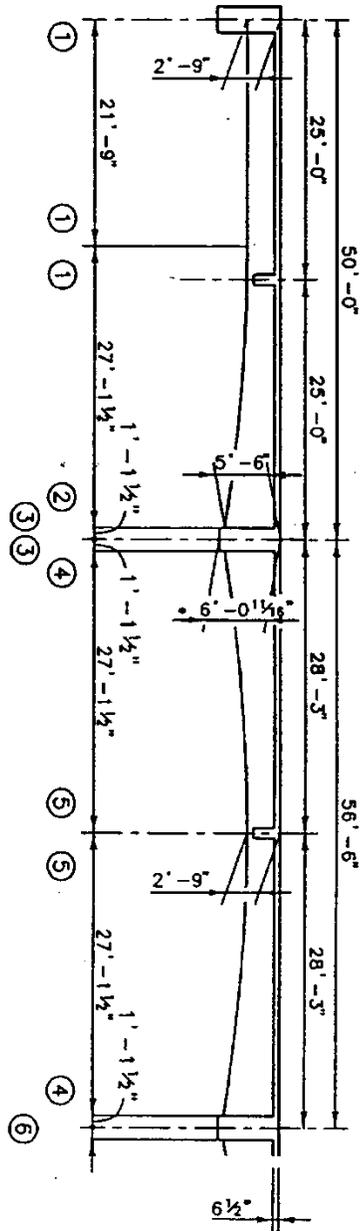
$$\text{Distance to Bottom Steel} = 1.344''$$

Top Steel Area: #6 @ 12 = 0.440
 #5 @ 12 = 0.310
 $\Sigma = 0.750 \text{ in}^2$

Bott. Steel Area: #6 @ 12 = 0.440
 #5 @ 12 = 0.310
 $\Sigma = 0.750 \text{ in}^2$

Virtis Bridge Rating Example, Structure No. L-18-AV (contd.)

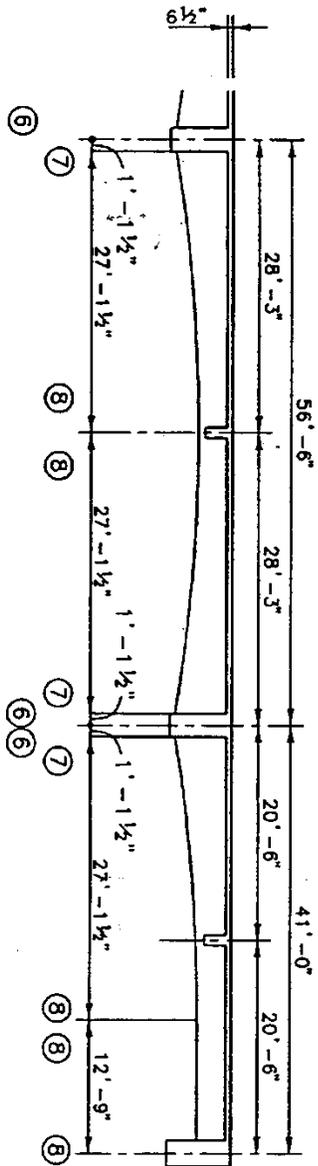




SPAN 1

SPAN 2

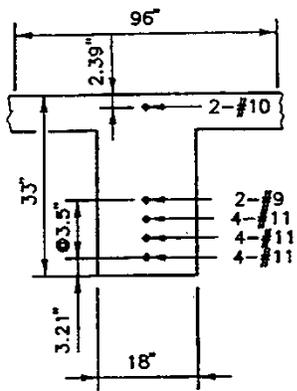
* Varies, Min. 6'-0 1/8" @ G-6



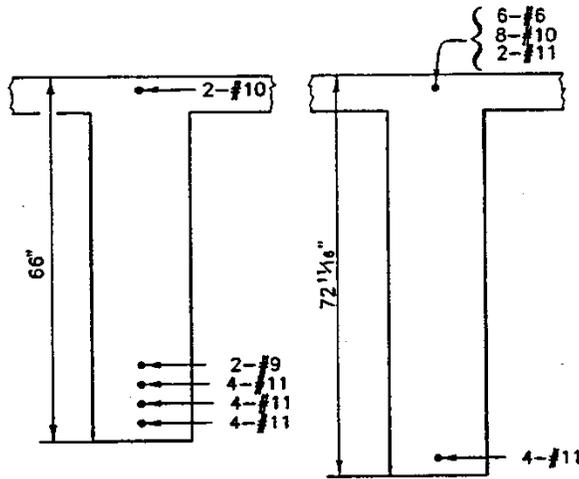
SPAN 3

SPAN 4

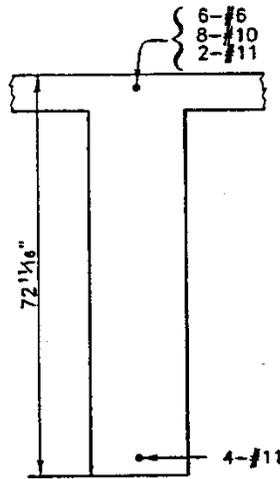
ELEVATION ~ G-6



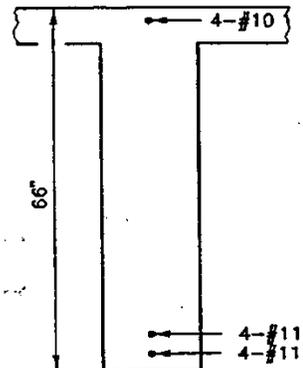
①



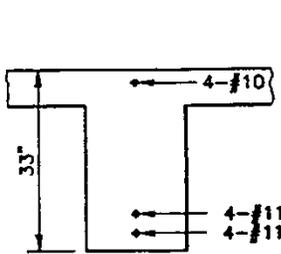
②



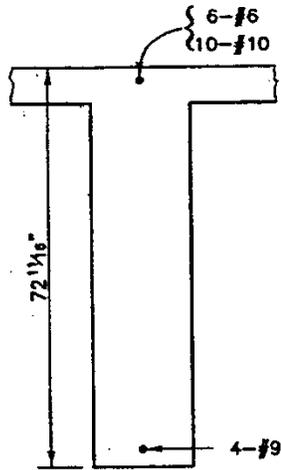
③



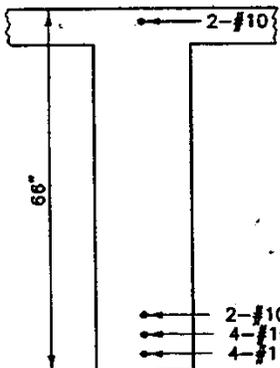
④



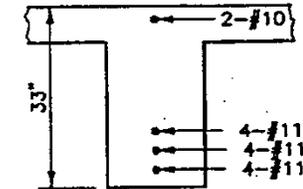
⑤



⑥



⑦



⑧

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

The screenshot shows a software window titled "L-18-AV" with the following fields and controls:

- Bridge ID:
- NBI Structure ID (8):
- Template
- Design Only
- Tabbed interface: Description | Description (cont'd) | Alternatives | Global Reference Point
- Name:
- Year Built:
- Description:
- Location:
- Length: ft
- Facility Carried (7):
- Route Number:
- Feat. Intersected (6):
- Mi. Post:
- Units:
- Recent ADTT:
- 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). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save this 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 the following Reinforcing Steel Material to be used for the girder.

Bridge Materials - Reinforcing Steel

Name: Description:

Material Properties

Specified yield strength (F_y) = ksi

Modulus of elasticity (E_s) = ksi

Ultimate strength (F_u) = ksi

Type

Plain
 Epoxy
 Galvanized
 Other

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

Bridge Appurtenances - Parapet

Name:

Description:

All dimensions are in inches

The diagram shows a cross-section of a parapet. A vertical reference line is on the left. The total width of the parapet is 15.5000 inches. An additional load of 0.033 kip/ft is applied to the top surface. The parapet has a top width of 24.0000 inches. The height of the parapet is 9.0000 inches. The diagram is divided into 'Back' and 'Front' sections. The 'Back' section has a height of 0.0000 inches. The 'Front' section has a height of 0.0000 inches. The 'Roadway Surface' is indicated at the bottom right.

Additional Load = kip/ft

Reference Line

Back

Front

Roadway Surface

Parapet unit weight = kcf

Calculated Properties

Net centroid (from reference line) = 12.448 in

Total weight = 0.258 kip/ft

Right mouse click on Median in the tree, and select New. Fill in the median properties as required. Click OK to save the data to memory and close the window.

Bridge Appurtenances - Median

Name:

Description:

All dimensions are in inches

The diagram shows a cross-section of a raised median. A vertical line on the left is labeled "Reference Line". The top width of the median is 0.0000 inches. The top width of the raised portion is 12.0000 inches. The top width of the sloped portion is 6.0000 inches. The top width of the base is 12.0000 inches. The height of the raised portion is 0.0000 inches. The height of the sloped portion is 0.0000 inches. The height of the base is 9.0000 inches. The "Back" and "Front" labels are at the bottom. The "Roadway Surface" is indicated by a horizontal line on the right. An "Additional Load" of 0.0000 kip/ft is applied to the top surface.

Additional Load = kip/ft

Median unit weight = kcf

Calculated Properties

Net centroid (from reference line) = in

Total weight = kip/ft

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

Bridge Impact / Dynamic Load Allowance

Standard Impact Factor

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

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

Modified impact = times AASHTO impact

Constant impact override = %

LRFD Dynamic Load Allowance

Fatigue and fracture limit states: %

All other limit states: %

OK Apply Cancel

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

Factors - LFD

Name: 1996 AASHTO Std. Specifications

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

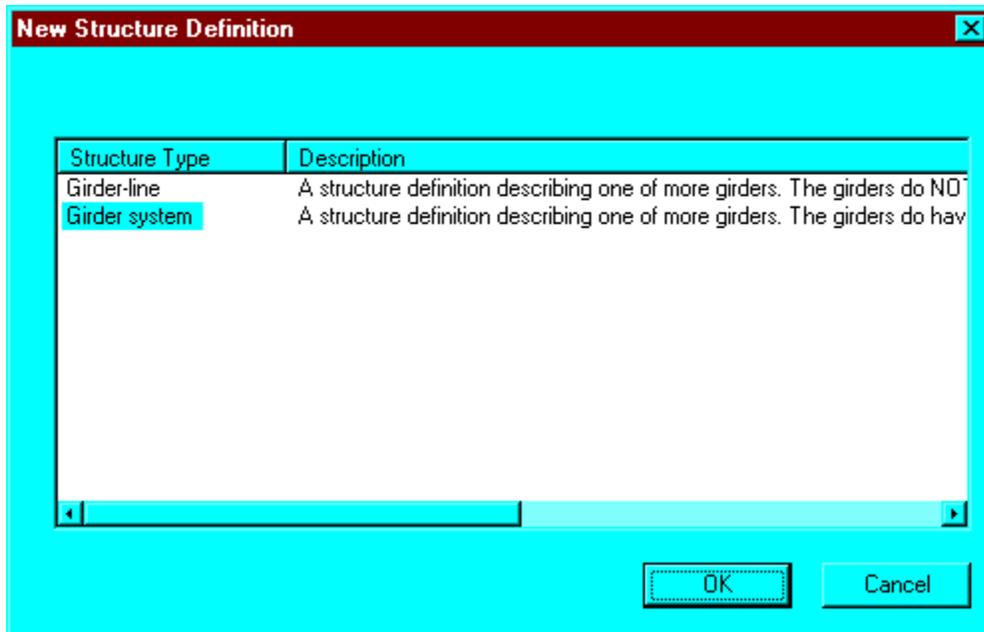
Load Factors | Resistance Factors

Load Group	Gamma Factor	D	(L+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

We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

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-Concrete Tee-Girder System

Description: 4-Span Structure

Units: US Customary

Number of spans: 4

Number of girders: 7

Deck type: Concrete

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	50.00
2	56.50
3	56.50
4	41.00

For PS only

Average humidity: %

Member Alt. Types

Steel

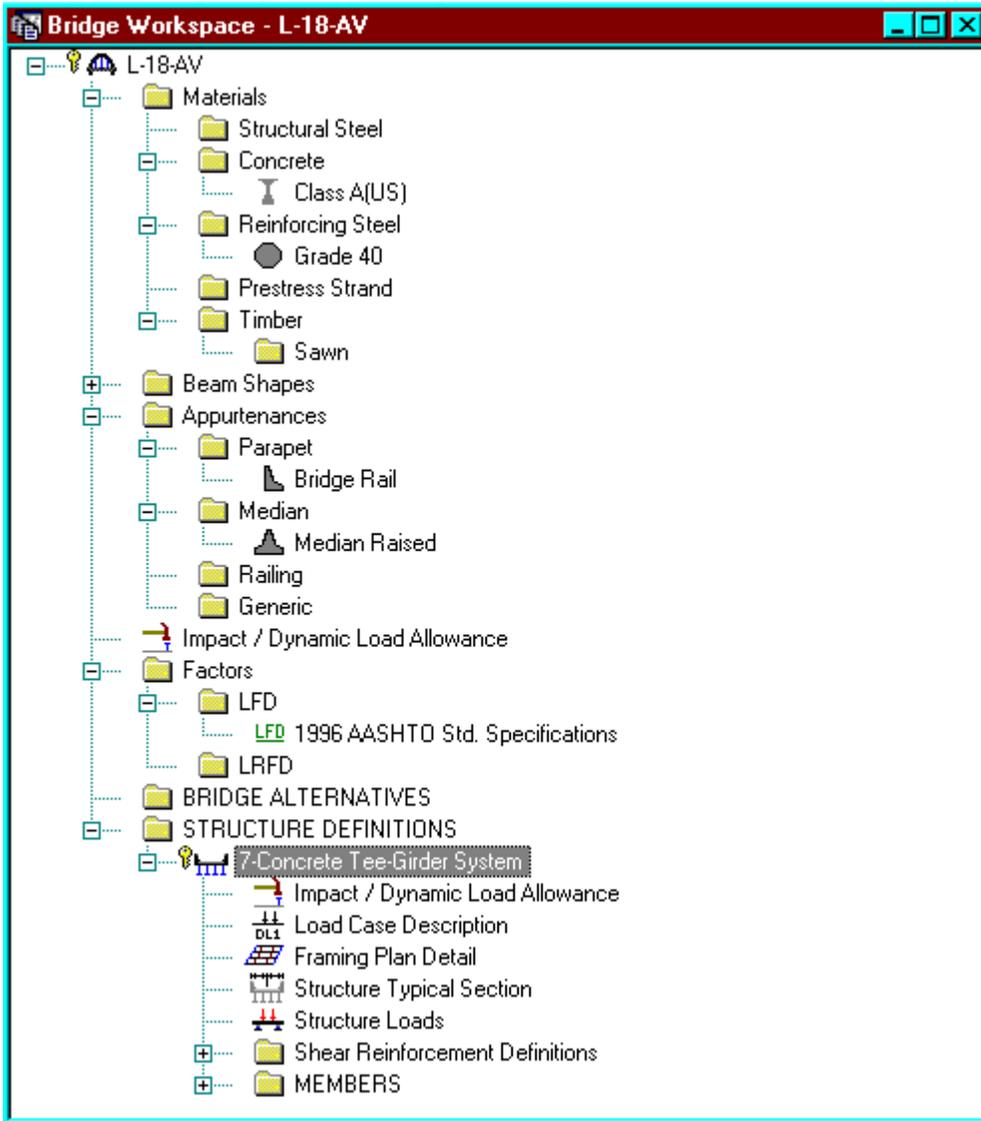
P/S

R/C

Timber

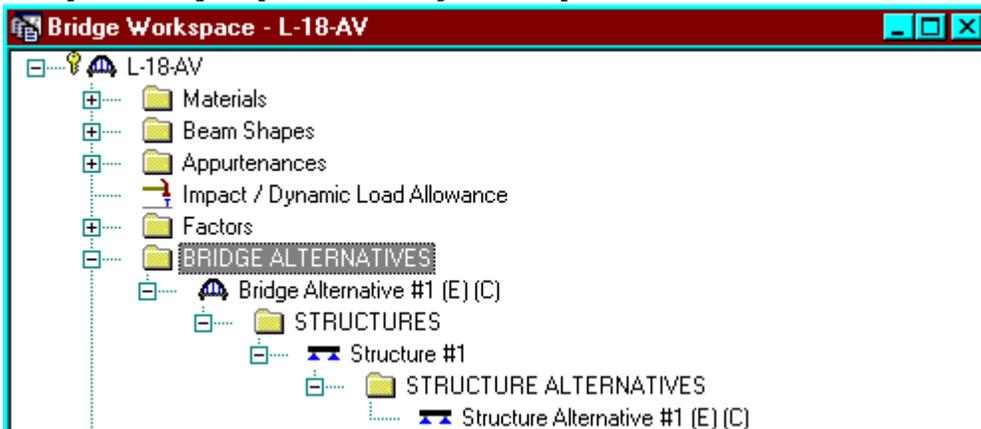
OK Apply Cancel

The partially expanded Bridge Workspace tree is shown below:



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)
Bridge Rail		Composite (long term) (Stage 2)	D,DW	
HBP		Composite (long term) (Stage 2)	D,DW	
Median Raised		Composite (long term) (Stage 2)	D,DW	

*Prestressed members only

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	-27.3000
2	-27.3000
3	-27.3000
4	-27.3000
5	-27.3000

Girder Spacing Orientation

Perpendicular to girder

Along support

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	9.00	9.00
2	9.00	9.00
3	9.00	9.00
4	9.00	9.00
5	9.00	9.00
6	9.00	9.00

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	9.0000
1	0.00	0.00	25.00	1	25.00	25.00	25.00	1.7000
1	25.00	25.00	25.00	1	25.00	50.00	50.00	8.2500
2	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
2	0.00	0.00	28.25	1	28.25	28.25	28.25	1.7000
2	28.25	28.25	28.25	1	28.25	56.50	56.50	8.2500
3	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
3	0.00	0.00	28.25	1	28.25	28.25	28.25	1.7000
3	28.25	28.25	28.25	1	28.25	56.50	56.50	8.2500
4	0.00	0.00	0.00	1	0.00	0.00	0.00	8.2500
4	0.00	0.00	20.50	1	20.50	20.50	20.50	1.7000
4	20.50	20.50	20.50	1	20.50	41.00	41.00	9.0000

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 =	31.00 ft	31.00 ft
Distance from right edge of deck to structure definition reference line =	31.00 ft	31.00 ft
Left overhang =	4.00 ft	4.00 ft
Computed right overhang =	4.00 ft	4.00 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: Class A(US)

Total deck thickness: 6.5000 in

Deck crack control parameter: 130.000 kip/in

Sustained modular ratio factor: 2.000

OK Apply Cancel

Parapets:

Add two parapets as shown below.

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

Median:

Add one median as shown below.

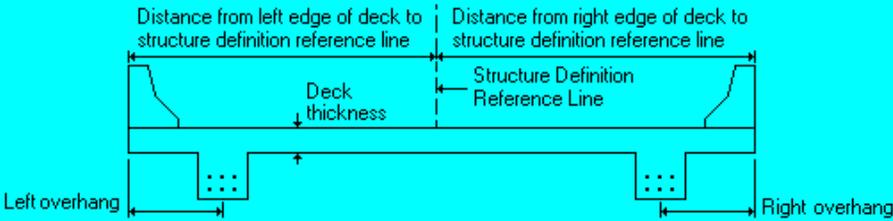
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Median Raised	Median Raised	Back	Left Edge	29.00	29.00	Right

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 apply 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	-29.00	-2.00	-29.00	-2.00
2	2.00	29.00	2.00	29.00

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

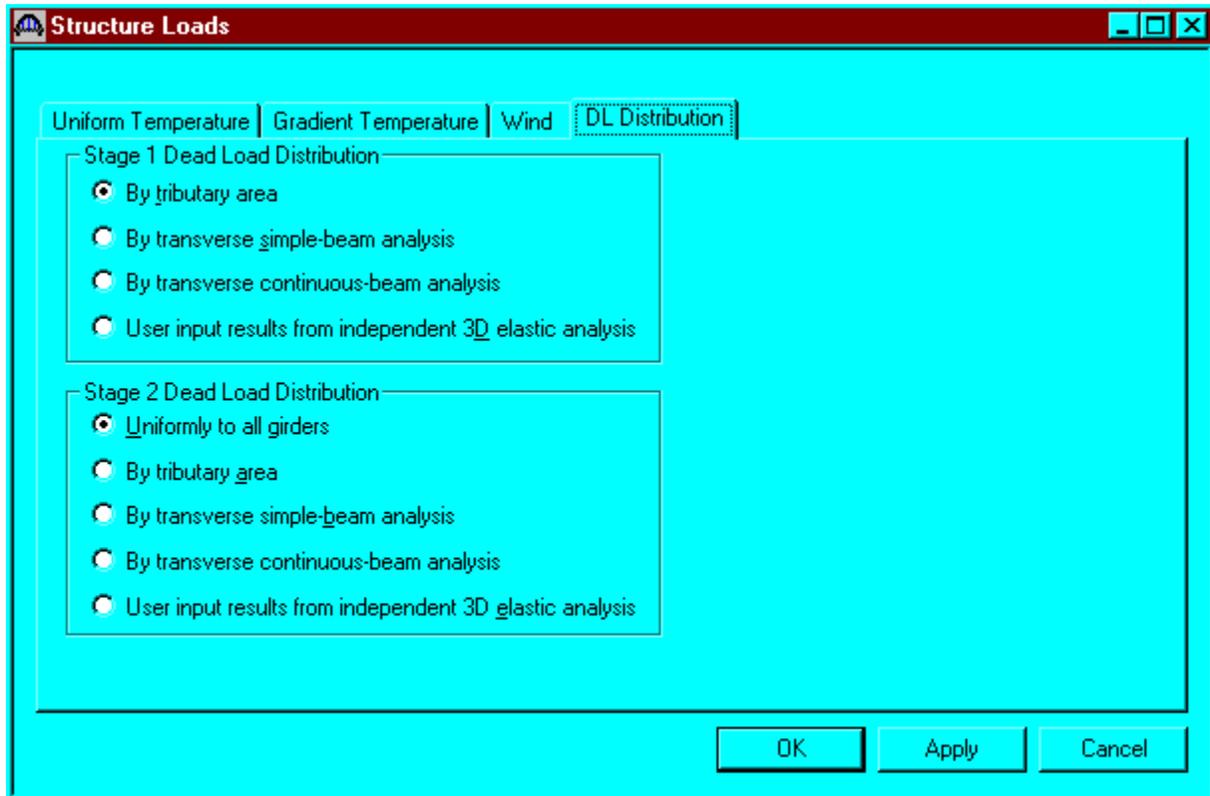


The diagram illustrates a cross-section of a bridge deck. A central horizontal line is labeled "Structure Definition Reference Line". Above this line, two horizontal arrows indicate the "Distance from left edge of deck to structure definition reference line" and the "Distance from right edge of deck to structure definition reference line". The vertical distance between the top surface of the deck and the reference line is labeled "Deck thickness". Below the reference line, the deck is shown with "Left overhang" and "Right overhang" sections, each containing a series of vertical lines representing reinforcement. Below the diagram is a tabbed interface with the following settings:

Deck	Deck (Cont'd)	Parapet	Median	Railing	Generic	Sidewalk	Lane Position	Wearing Surface
Wearing surface material: <input type="text" value="HBP"/>								
Description: <input type="text" value="Hot Bituminous Material"/>								
Wearing surface thickness = <input type="text" value="2.0000"/> in								
Wearing surface density = <input type="text" value="144.000"/> pcf								
Load case: <input type="text" value="HBP"/>								
<input type="button" value="Copy from Library..."/>								

At the bottom of the window are three buttons: , , and .

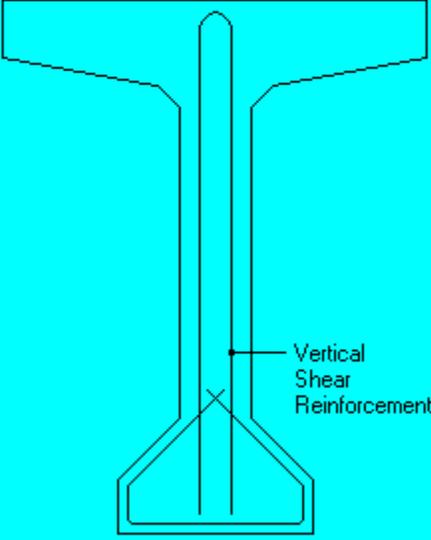
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



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 Reinforcing



Material: Grade 40

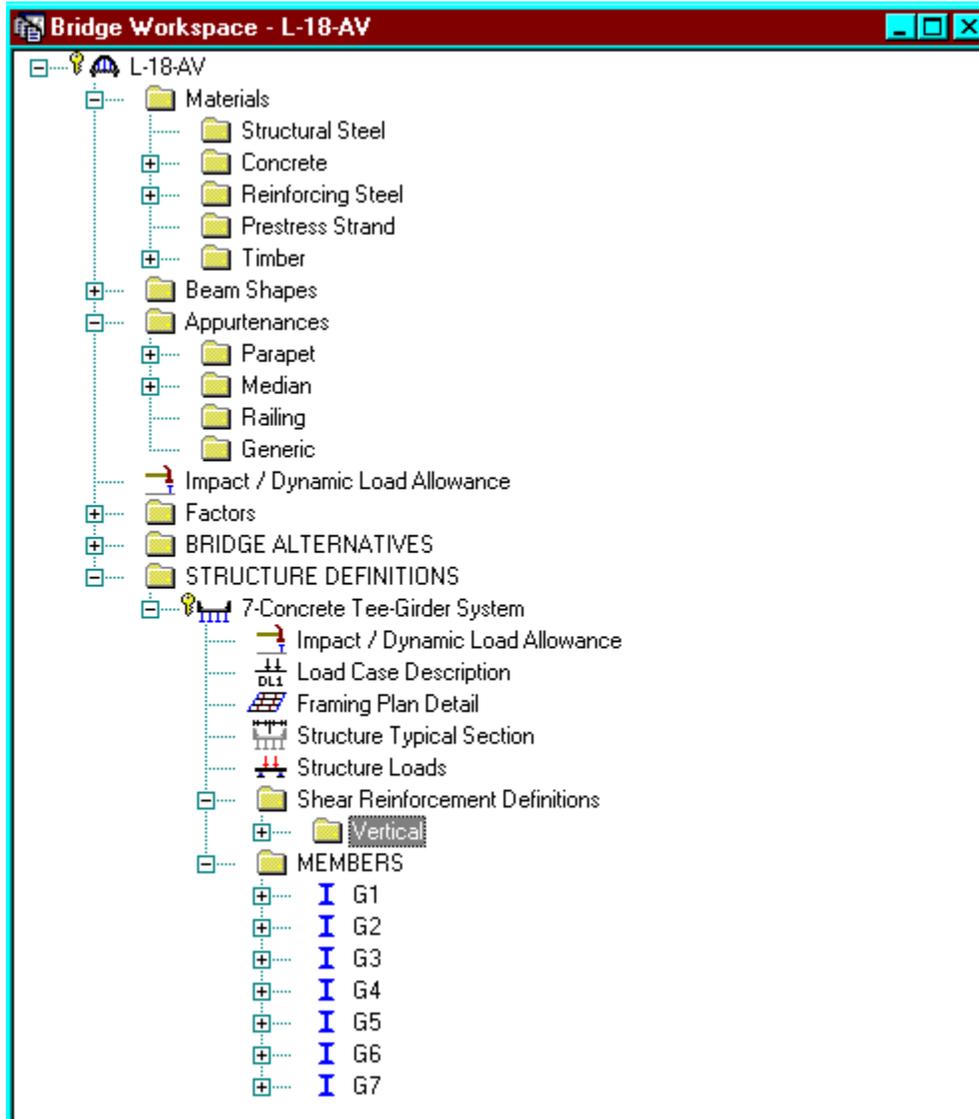
Bar size: 4

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: G2 Link with: None

Description:

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

Number of spans: 4

Span No.	Span Length (ft)
1	50.00
2	56.50
3	56.50
4	41.00

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 Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.

Material Type: Girder Type:

Reinforced Concrete Reinforced Concrete Tee

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.

Member Alternative Description

Member Alternative: Interior Variable Depth RC Tee Beam

Description | Factors | Engine | Import

Description:

Material Type: Reinforced Concrete

Girder Type: Reinforced Concrete Tee

Member units: US Customary

Girder property input method

Schedule based

Cross-section based

End bearing locations

Left: 13.5000 in

Right: 13.5000 in

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

Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

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"/>
5	Roller	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.333	1.333	1.333	0.286
Multi-Lane	1.500	1.889	1.500	0.857

Compute from Typical Section

OK Apply Cancel

Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.

Cross Sections _ _ X

Name: Type:

Dimensions | Reinforcement

Tributary width: in

in

in

in

in

A = in

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

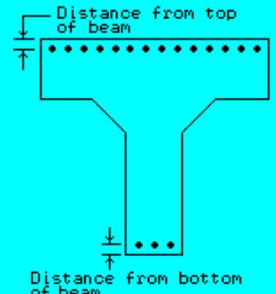
Material:

Modular Ratio:

Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

Name:
Type:

Dimensions
Reinforcement



Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	9	2.000	13.7100	Grade 40
Bottom of Girder	10	2.000	30.6100	Grade 40

Using the same techniques, create cross sections 2 thru 8, and define their associated reinforcement patterns.

Cross Sections

Name: Type:

Dimensions | Reinforcement

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	9	2.000	13.7100	Grade 40
Bottom of Girder	10	2.000	63.6100	Grade 40

New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Tributary width: in
 in
 in
 in
 in
 A = in

Top Flange
 Material:
 Modular Ratio:
 Eff. width (Std): in
 Eff. width (LRFD): in
 Eff. thickness: in

Other Parts
 Material:
 Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	2.000	70.2975	Grade 40
Bottom of Girder	10	8.000	70.2975	Grade 40
Bottom of Girder	6	6.000	70.2975	Grade 40

New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	10	4.000	63.6100	Grade 40

New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Tributary width: in
 in
 in
 in
 in
 A = in

Top Flange
 Material:
 Modular Ratio:
 Eff. width (Std): in
 Eff. width (LRFD): in
 Eff. thickness: in

Other Parts
 Material:
 Modular Ratio:

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	10	4.000	30.6100	Grade 40

Cross Sections

Name: Type:

Dimensions | Reinforcement

Tributary width: in

in

in

in

in

in

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Distance from top of beam

Distance from bottom of beam

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	9	4.000	3.2100	Grade 40
Bottom of Girder	10	10.000	70.2975	Grade 40
Bottom of Girder	6	6.000	70.2975	Grade 40

New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	10	4.000	6.7100	Grade 40
Bottom of Girder	10	2.000	10.2100	Grade 40
Bottom of Girder	10	2.000	63.6100	Grade 40

New Duplicate Delete

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Top Flange

Material:

Modular Ratio:

Eff. width (Std): in

Eff. width (LRFD): in

Eff. thickness: in

Other Parts

Material:

Modular Ratio:

OK Apply Cancel

Cross Sections

Name: Type:

Dimensions | Reinforcement

Row	Bar Size	Bar Count	Distance (in)	Material
Bottom of Girder	11	4.000	3.2100	Grade 40
Bottom of Girder	11	4.000	6.7100	Grade 40
Bottom of Girder	11	4.000	10.2100	Grade 40
Bottom of Girder	10	2.000	30.6100	Grade 40

New Duplicate Delete

OK Apply Cancel

The Cross Section Ranges window is shown below. Define the ranges over which the cross sections apply.

Cross Section Ranges
_ □ ×

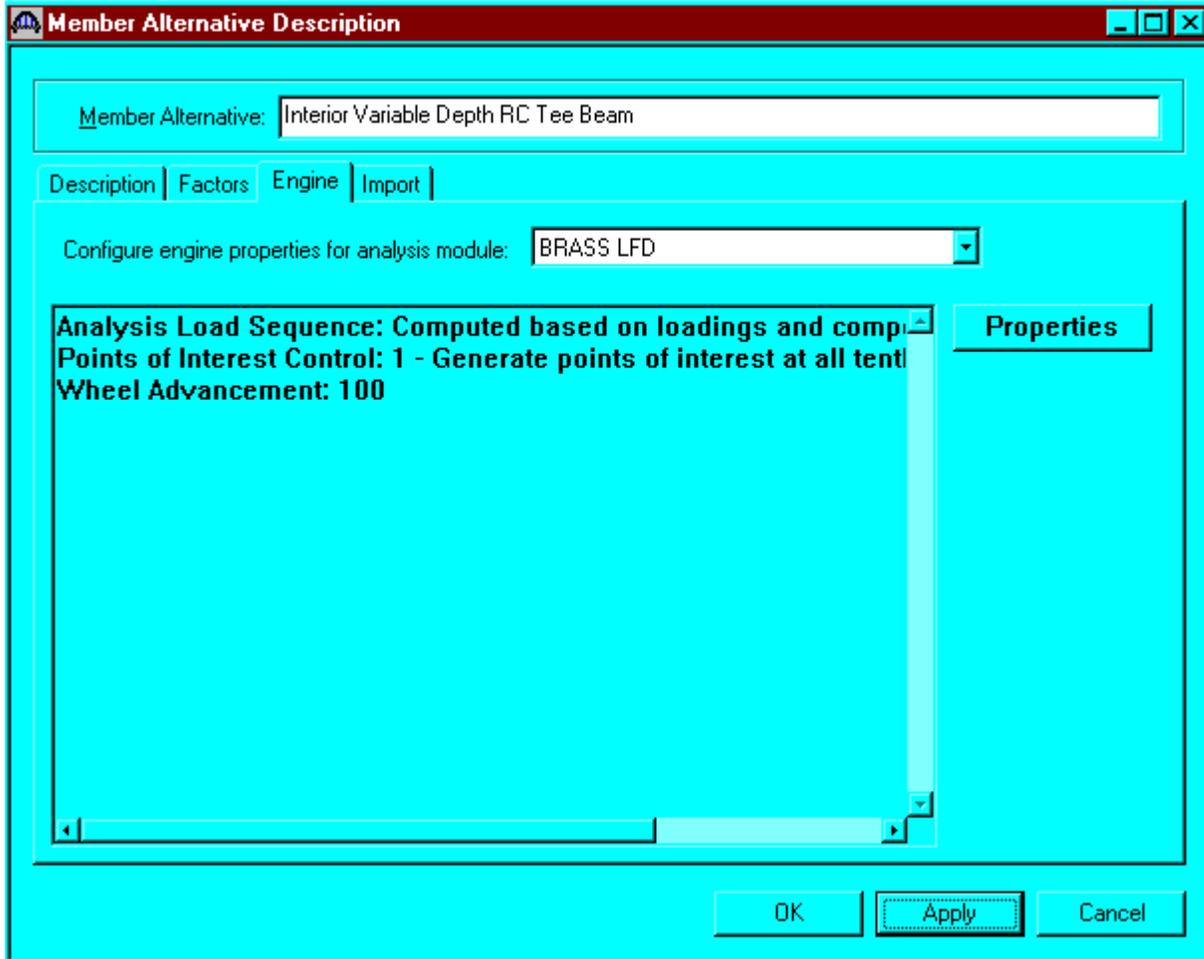
The diagram shows a horizontal beam with a hatched section in the middle. A dimension line labeled 'Start Distance' spans from the left end to the start of the hatched section. A dimension line labeled 'Length' spans the width of the hatched section. Below the beam, two vertical lines mark the 'Start Section' and 'End Section' boundaries of the hatched area.

Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Cross Section 1	Cross Section 1	None	1	0.000	21.750	21.750
Cross Section 1	Cross Section 2	Parabolic	1	21.750	27.125	48.875
Cross Section 2	Cross Section 3	Linear	1	48.875	1.125	50.000
Cross Section 3	Cross Section 4	Linear	2	0.000	1.125	1.125
Cross Section 4	Cross Section 5	Parabolic	2	1.125	27.125	28.250
Cross Section 5	Cross Section 4	Parabolic	2	28.250	27.125	55.375
Cross Section 4	Cross Section 6	Linear	2	55.375	1.125	56.500
Cross Section 6	Cross Section 7	Linear	3	0.000	1.125	1.125
Cross Section 7	Cross Section 8	Parabolic	3	1.125	27.125	28.250
Cross Section 8	Cross Section 7	Parabolic	3	28.250	27.125	55.375
Cross Section 7	Cross Section 6	Linear	3	55.375	1.125	56.500
Cross Section 6	Cross Section 7	Linear	4	0.000	1.125	1.125
Cross Section 7	Cross Section 8	Parabolic	4	1.125	27.125	28.250
Cross Section 8	Cross Section 8	None	4	28.250	12.750	41.000

New
Duplicate
Delete

OK
Apply
Cancel

Open the Member Alternative Description window and click the Engine tab as shown below.



Click the Properties button to edit the engine properties for BRASS LFD.

BRASS-Standard Member Alternative Properties [X]

Analysis

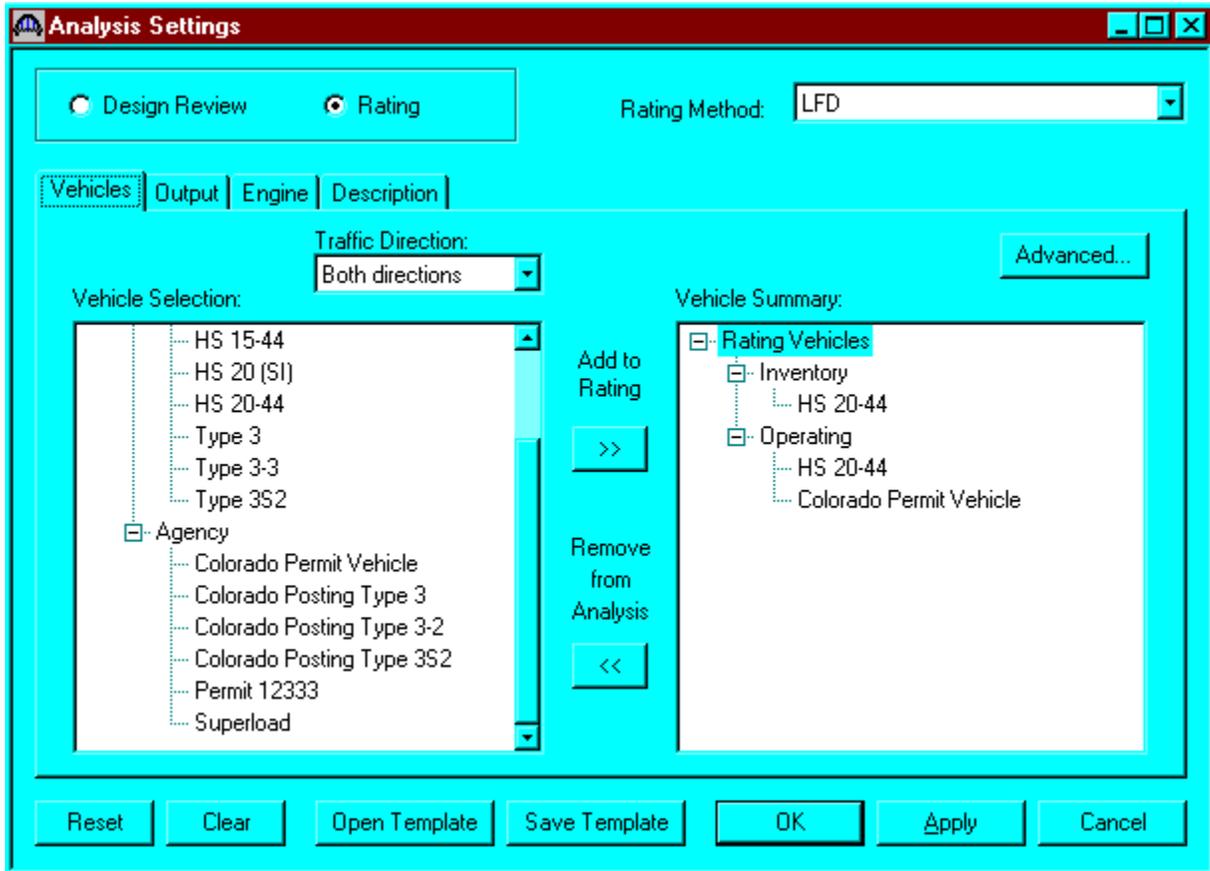
Load Sequence:
Computed based on loadings and composite regions.

POI Control:
1 - Generate points of interest at all tenth points along TOP spans

Wheel advancement denominator: 100

OK
Cancel

To perform a rating, select the View Analysis Settings button on the toolbar to open the window shown below. Select the required vehicles to be used in the rating and click OK.



The results of the LFD rating analysis are as follows.

Member: G2

RATING FACTOR REPORT

ANALYSIS POINT NO. 17: 205.00

LOAD LEVELS

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

TRUCK DESCRIPTION

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

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

	LOAD LEVEL 1	LOAD LEVEL 2	LOAD LEVEL 3	LOAD LEVEL 4
POS. MOMENT				
TRUCK 1	01.23	44.28 ^T	02.05	73.8 ^T
TRUCK 2	01.67		02.80	
TRUCK 3	01.09		01.83	
CRITICAL	01.09		01.83	175.7 ^T
NEG. MOMENT				
TRUCK 1	01.79		02.99	
TRUCK 2	01.49		02.50	
TRUCK 3	01.17		01.96	
CRITICAL	01.17		01.96	
POS. SHEAR				
TRUCK 1	N/A		N/A	
TRUCK 2	N/A		N/A	
TRUCK 3	N/A		N/A	
CRITICAL	N/A		N/A	
NEG. SHEAR				
TRUCK 1	N/A		N/A	
TRUCK 2	N/A		N/A	
TRUCK 3	N/A		N/A	
CRITICAL	N/A		N/A	

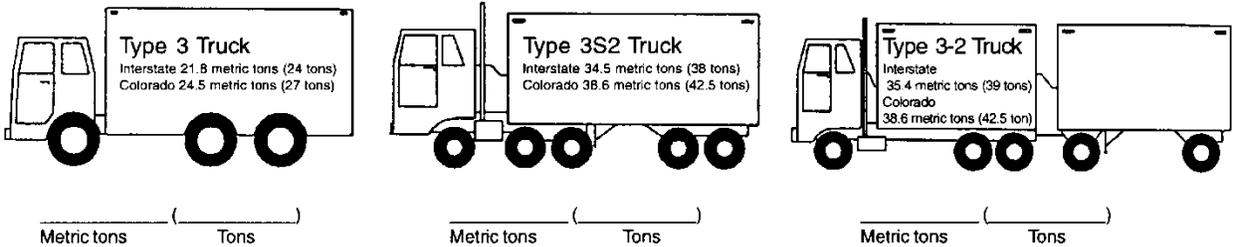
COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure # L-18-AV
	State highway # I25 Overpass
Rated using Asphalt thickness: 50 mm (2 in.) <input checked="" type="checkbox"/> Colorado legal loads <input type="checkbox"/> Interstate legal loads	Batch I.D.
	Structure type CSGC
	Parallel structure #

Structural member	INTERIOR GIRDER @ 2.5 PT	SLAB	
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Metric tons (Tons)

Inventory	40.0 (44)	26.4 (29)	() ()
Operating	67.3 (74)	44.5 (49)	() ()

Type 3 truck	()	()	() ()
Type 3S2 truck	()	()	() ()
Type 3-2 truck	()	()	() ()
Permit truck	160.0 (176)	()	() ()



Comments

Control Member: Deck; Rated for 2" HBP
 Load Capacity: 49 Tons
 Girder: Only Interior Girder Rated; Rated for 2" HBP

Color Code: White

Project No: I 002-3(20) Eldorado Street over I-25
 IM 0251-141 Rehab/Rail repair

Rated by	Date	Checked by	Date
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