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

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

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

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.

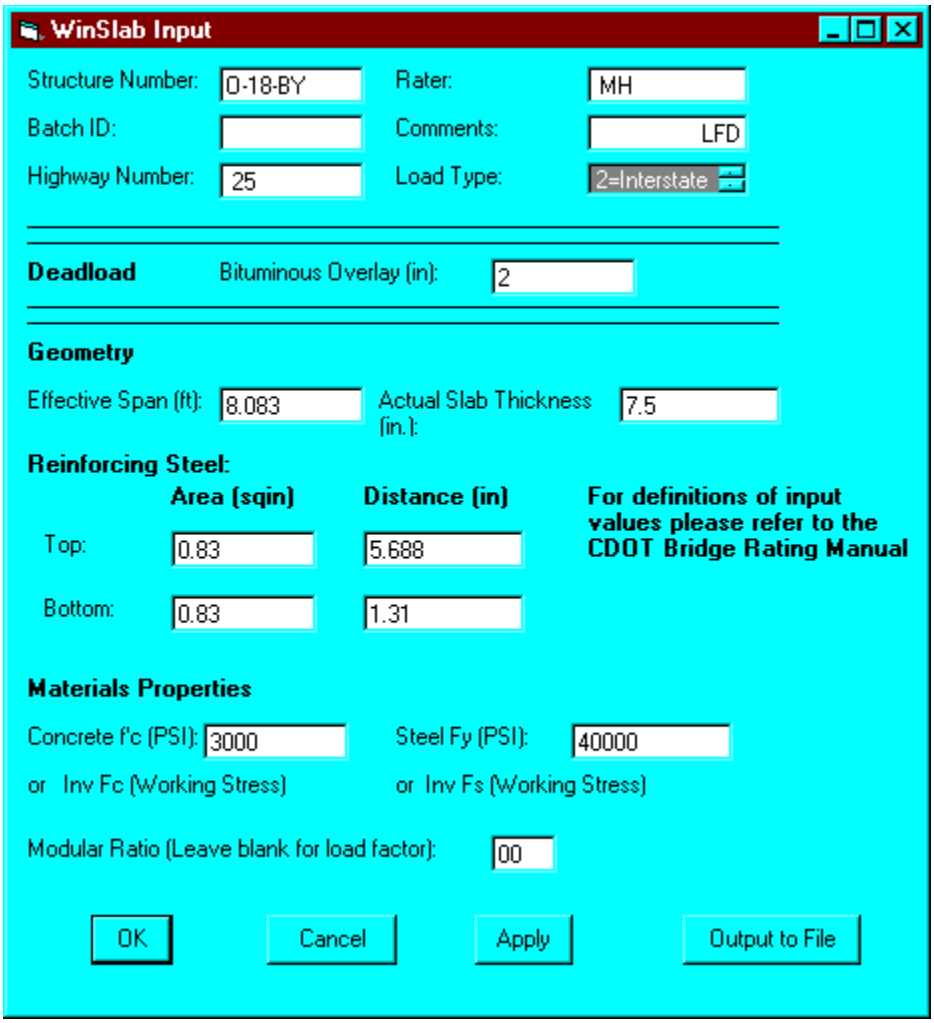
When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and an inventory rating less than 36 tons shall be given to the concrete structure. The process is the same for operating rating; only difference is that a maximum rating of 40 tons can be assigned. 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



Effective Span Length: Per AASHTO Article 3.24.1.2(a)

(Clear span)*1/cos30° = (8.67-1.67)*1/cos30° = 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
       Eff. Span(ft)=             8.083          Slab Thickness(in)= 7.500
       Top Reinf. (sq.in)=         0.83          Eff. Depth(in) =    5.688
       Bottom Area(sq.in)=         0.83          Bottom Dist.(in)=   1.31
       Conc. Strength(PSI) Inv =   3000          Oper. =             3000
       Steel Yield (PSI)   Inv =  40000          Oper. =             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*12)= 171”
12t+ Web Thickness = (12*7.5)+ 20 = 110”
C.L. - C.L. of girder= 8.6667’= 104” Controls

Dead Load:

Intermediate Diaphragm = ((0.75)*(3.25)*(8.67-1.83) + 0.5*2*0.33*0.33*
(8.67-1.83))*(1/Cos30°)*(0.150)= 3.02 kips
Use 3.1 kips

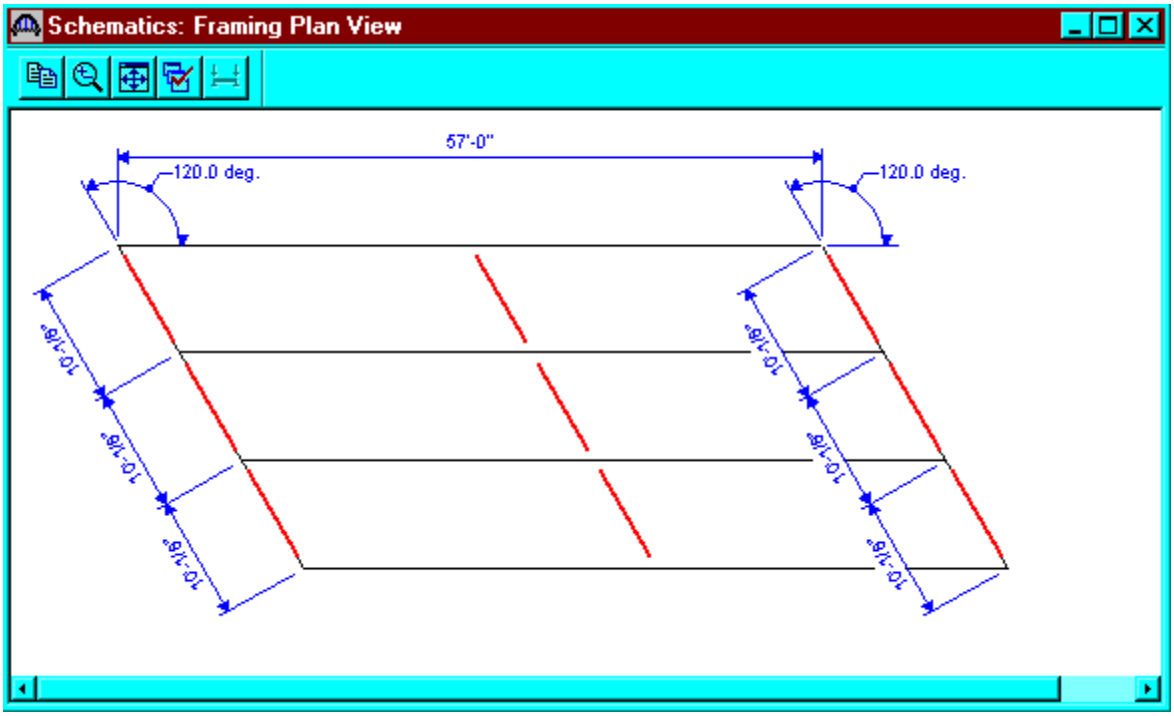
Abutment Diaphragm = Weight Varies
Use 6.2 kips

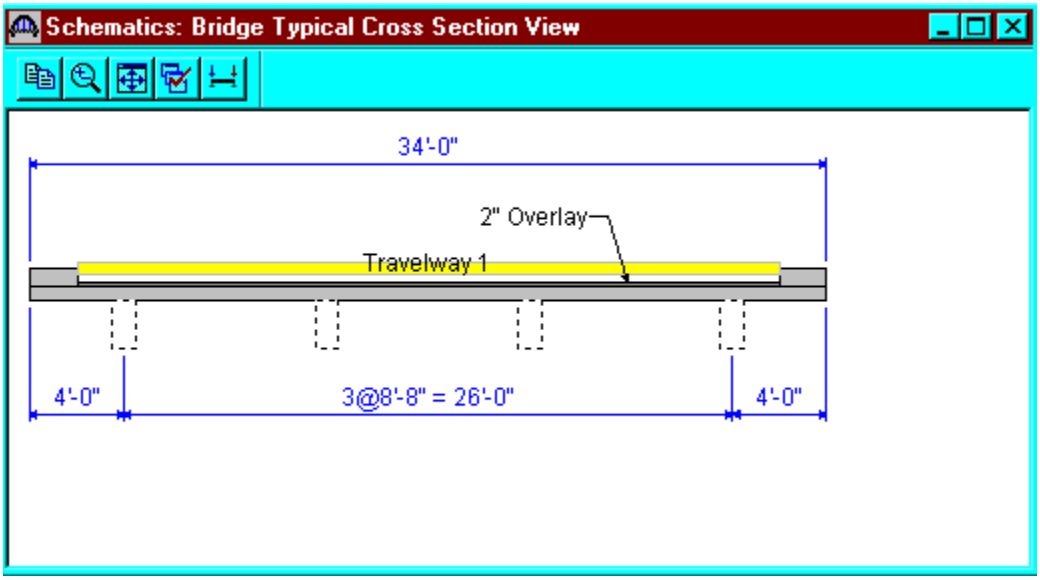
Distribution Factor:

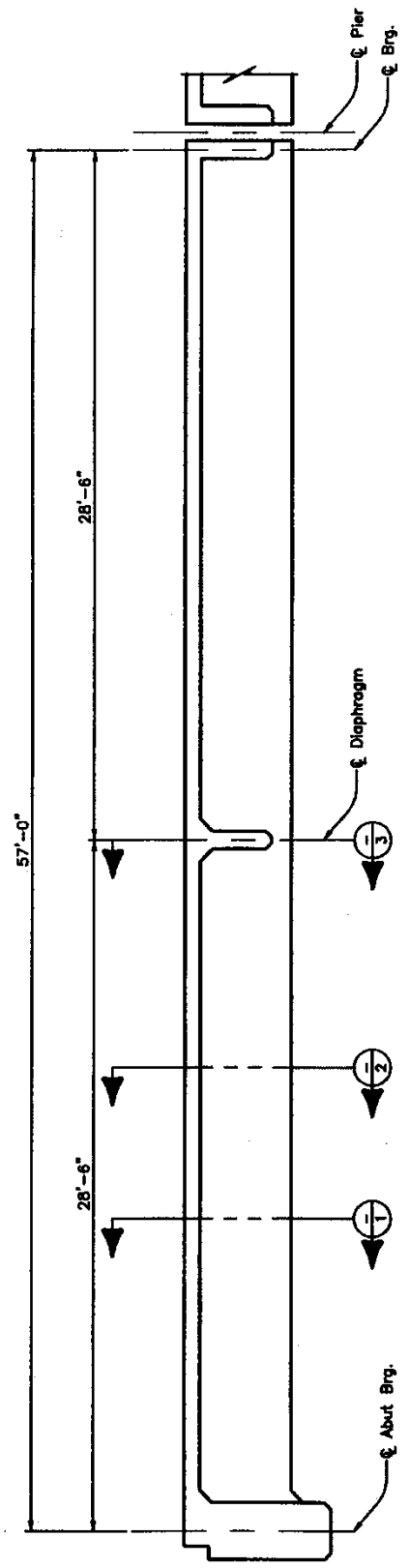
Multi-Lane = S/6 = 8.667/6 = 1.444

Single Lane = 1+ 2.667/8.667 = 1.308

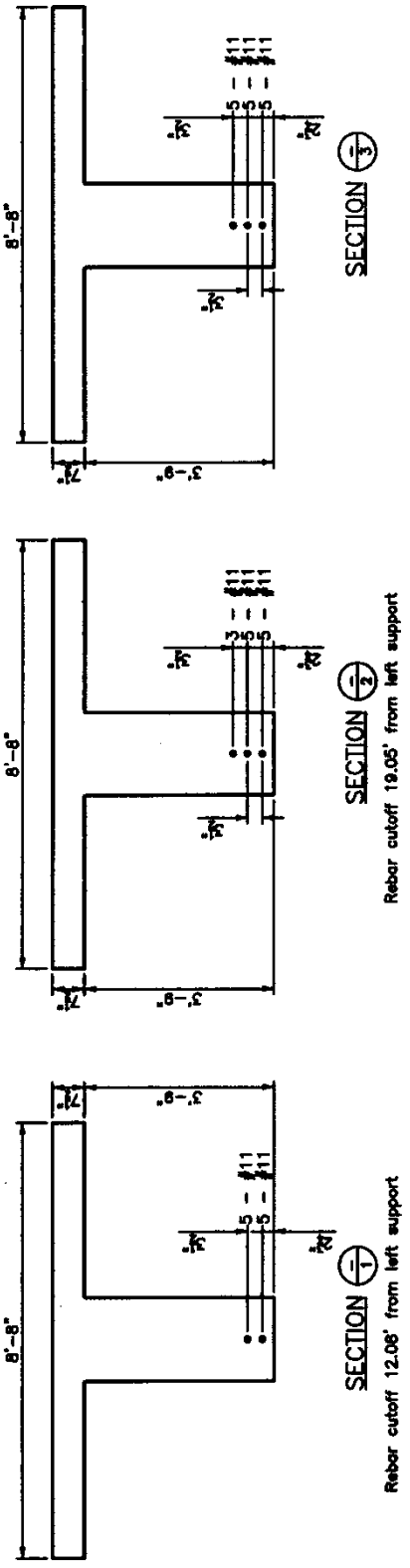
Virtis Bridge Rating Example, Structure No. O-18-BY (contd.)





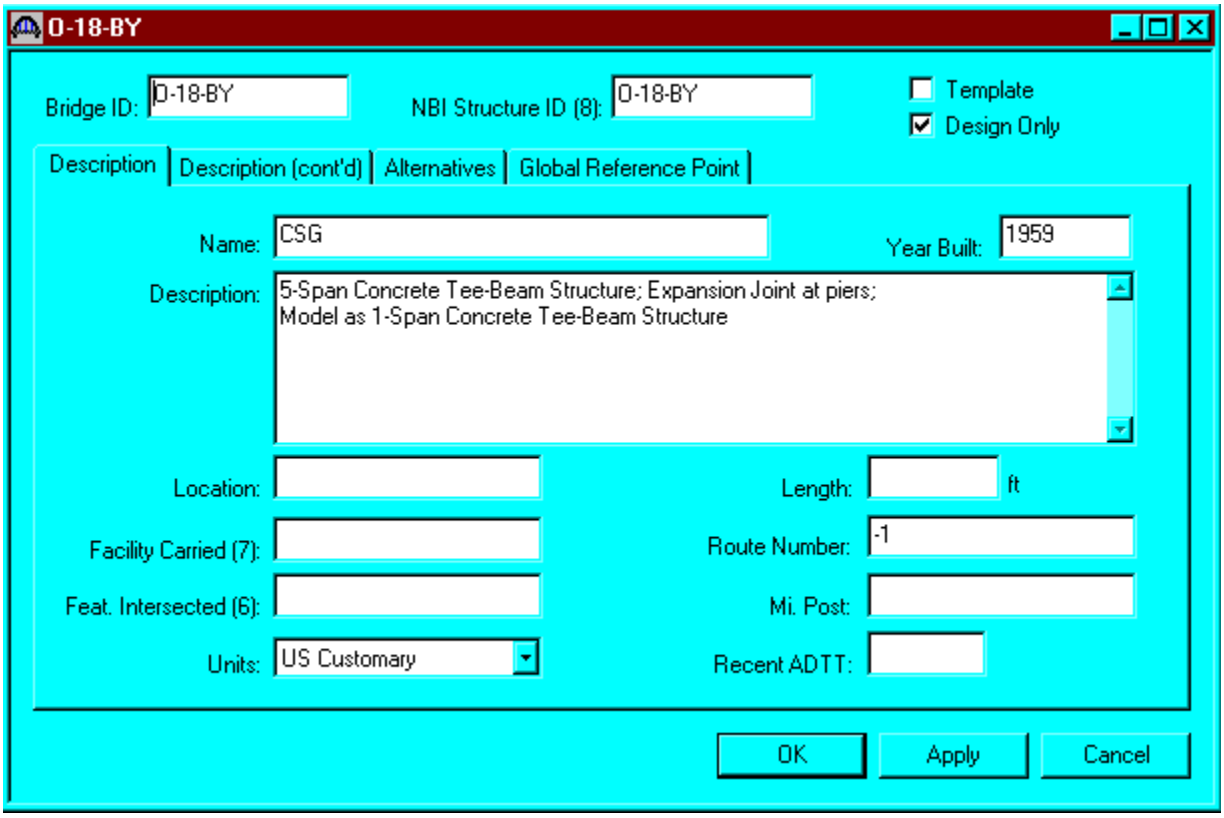


SPAN #1



Project No: I-25-1(21)31 Structure No: 0-18-BY

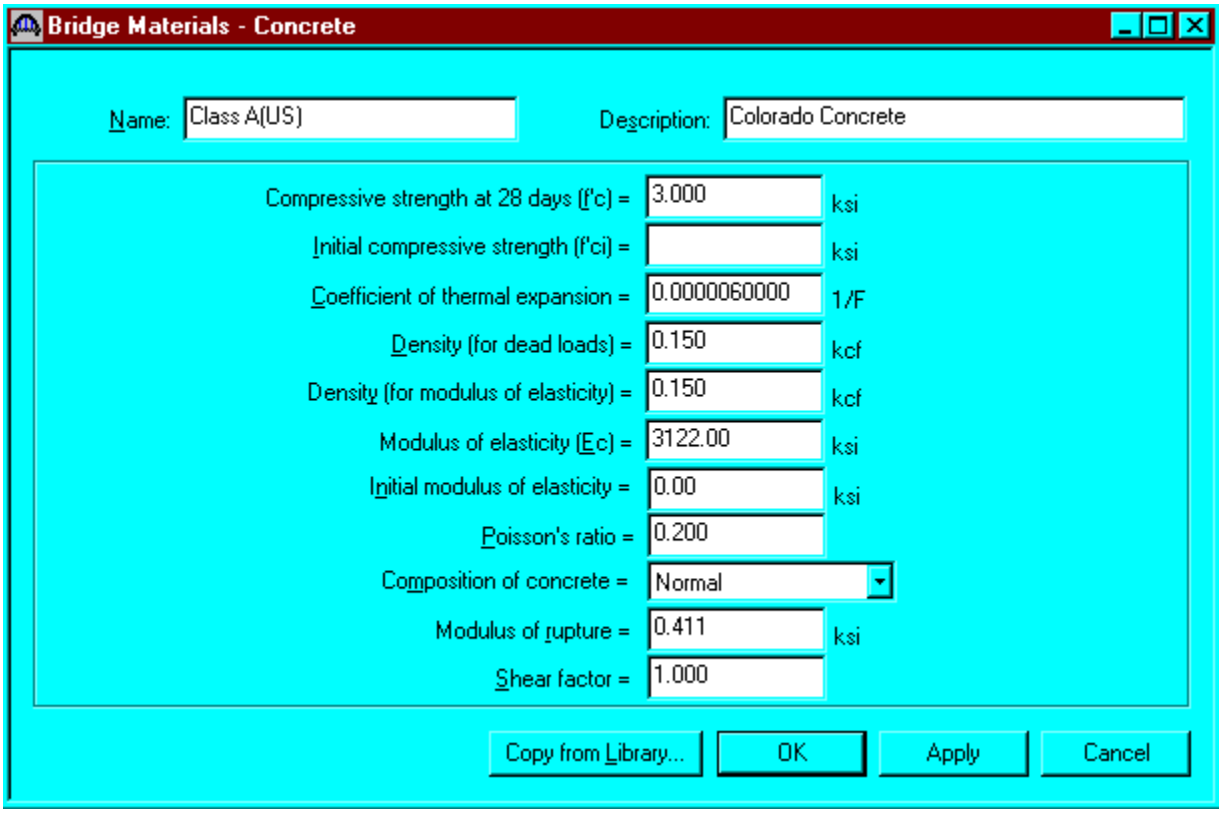
From the bridge explorer, create a new bridge and enter the following information.



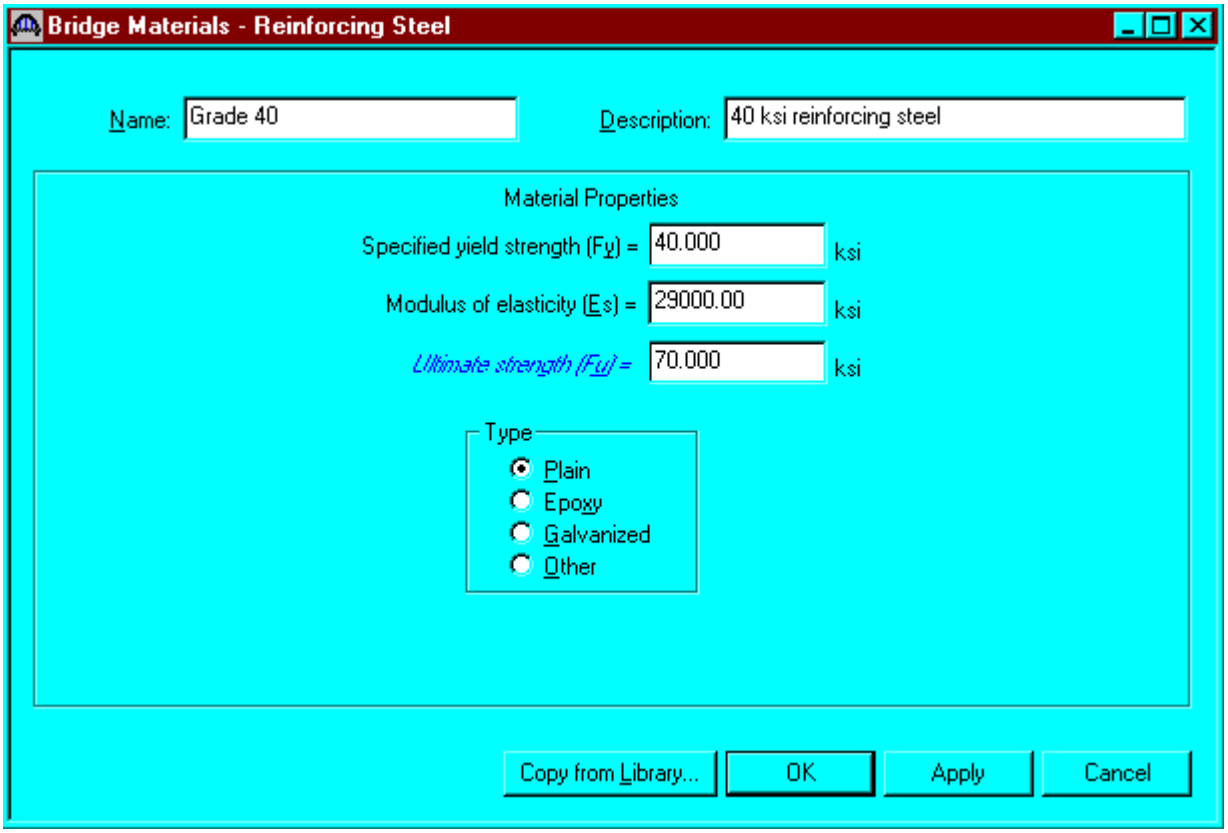
Click OK. This saves the data to memory and closes the window.

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.

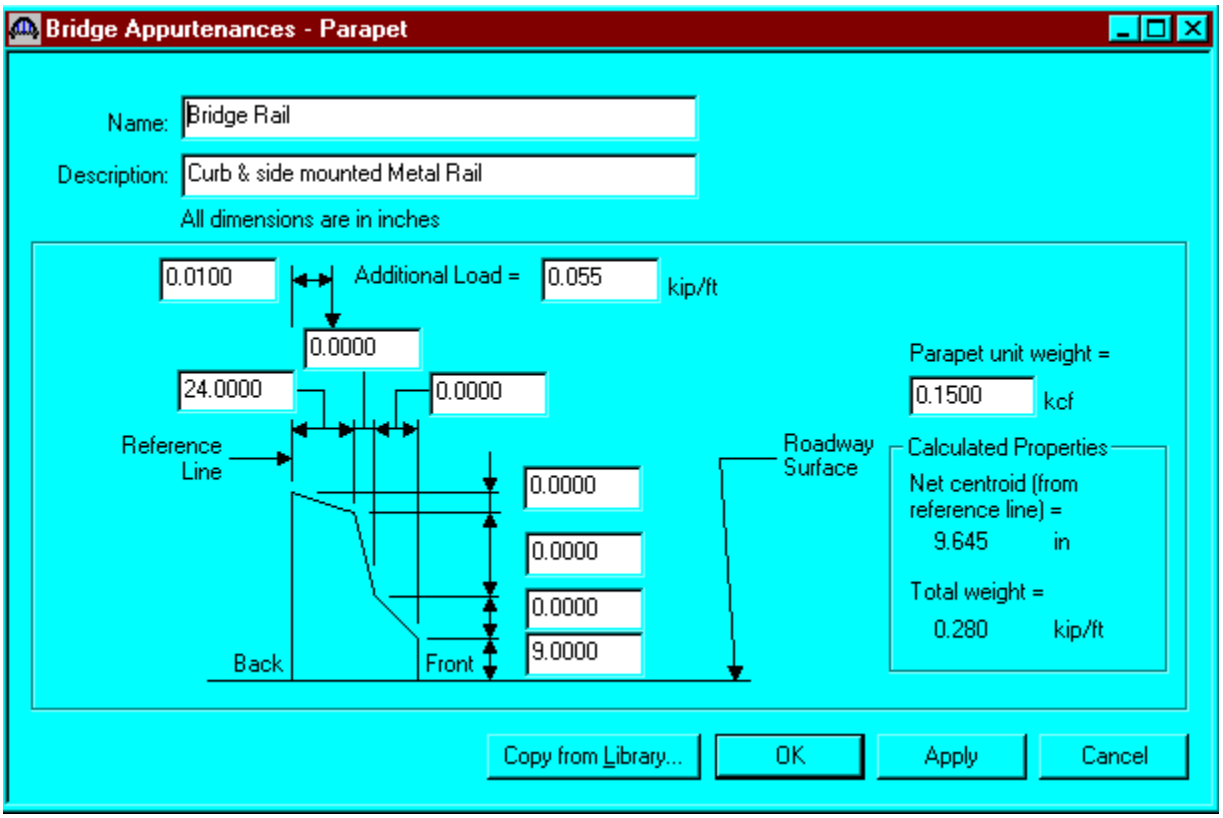
To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save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



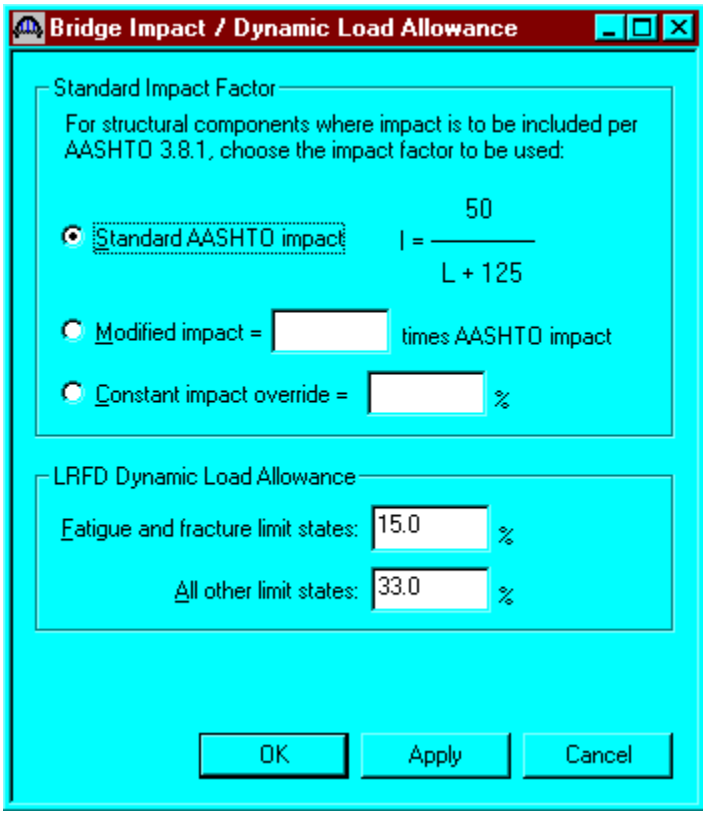
Using the same techniques, create the following Reinforcing Steel Material to be used for the girder.



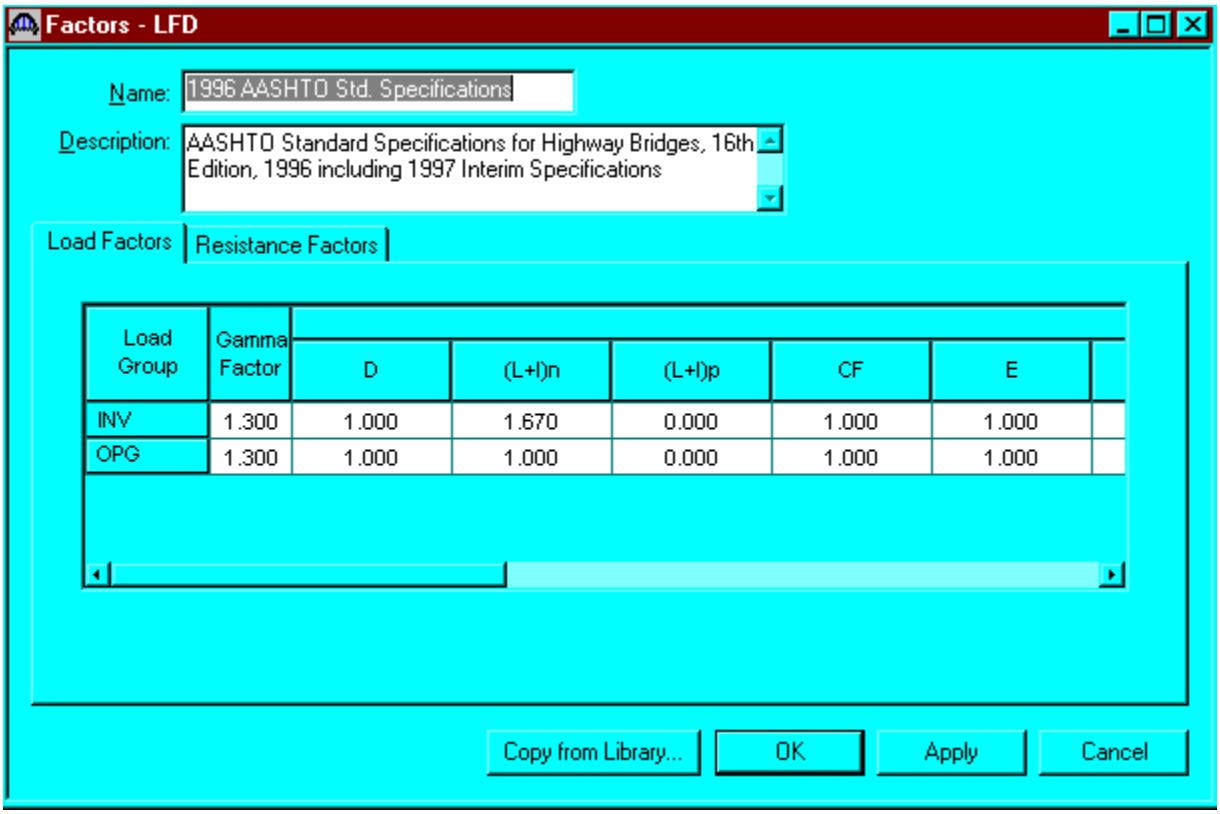
To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.



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.

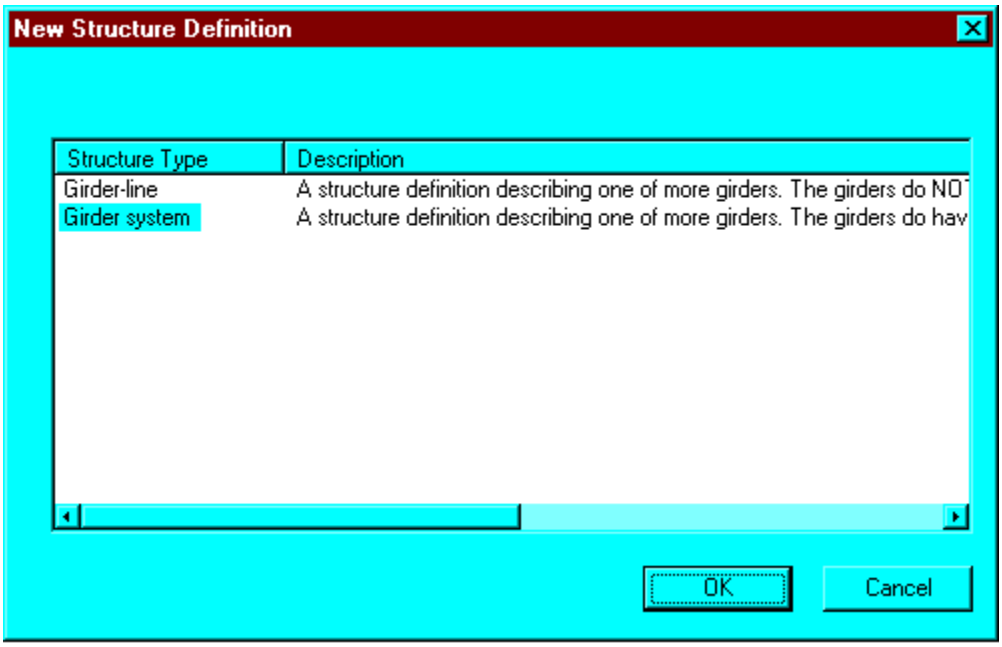


Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.

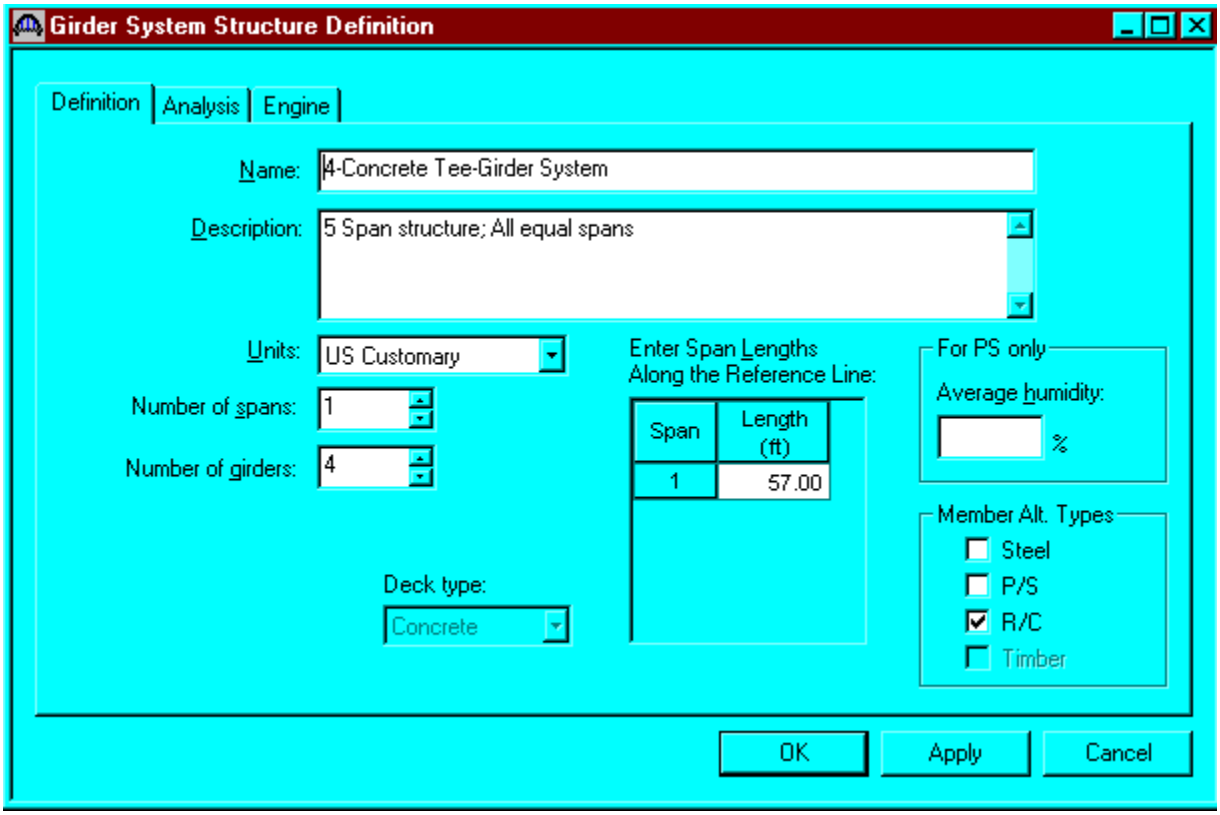


We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

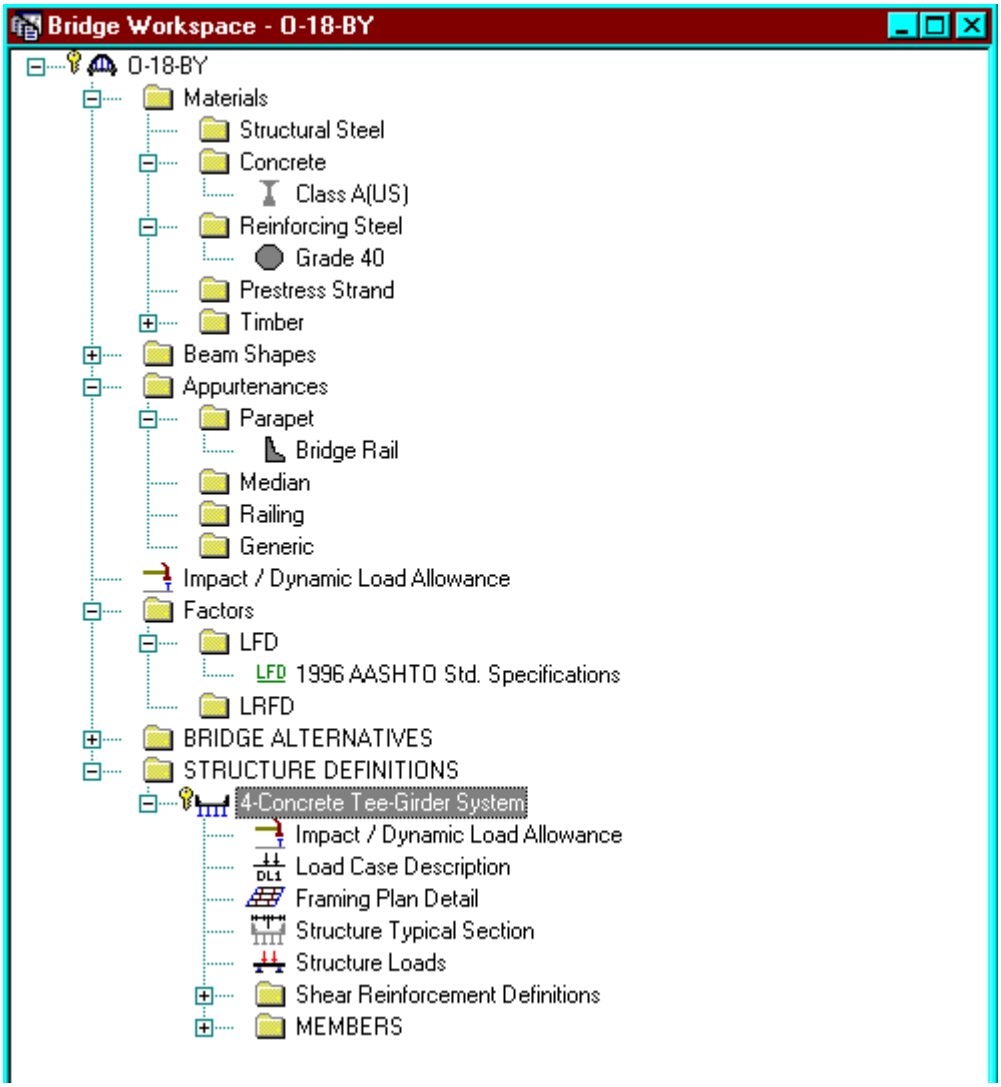
Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



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.

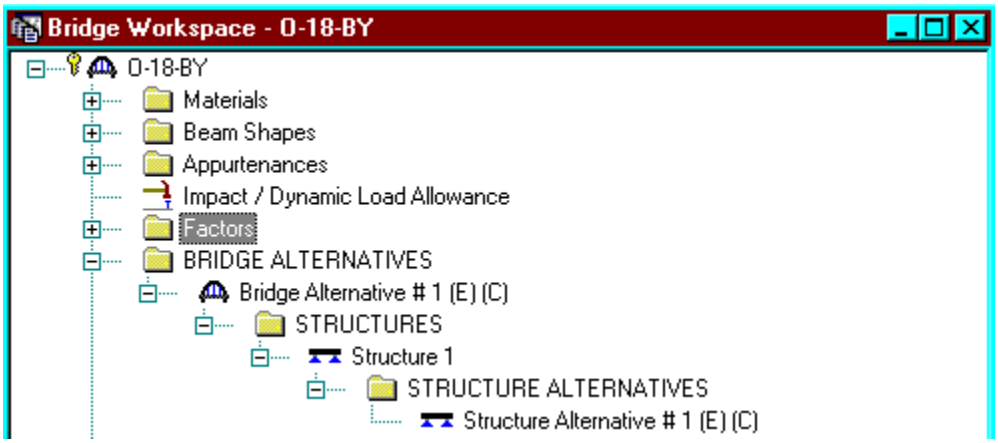


The partially expanded Bridge Workspace tree is shown below:

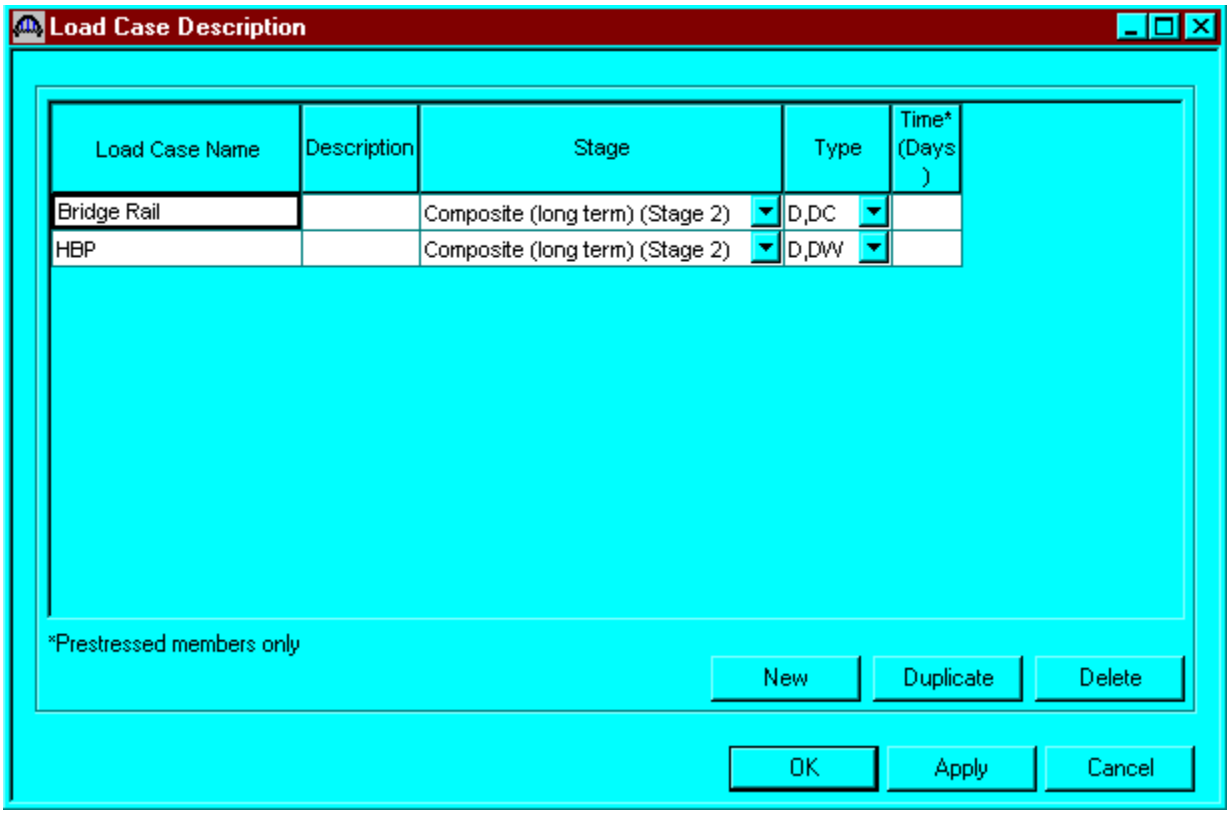


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

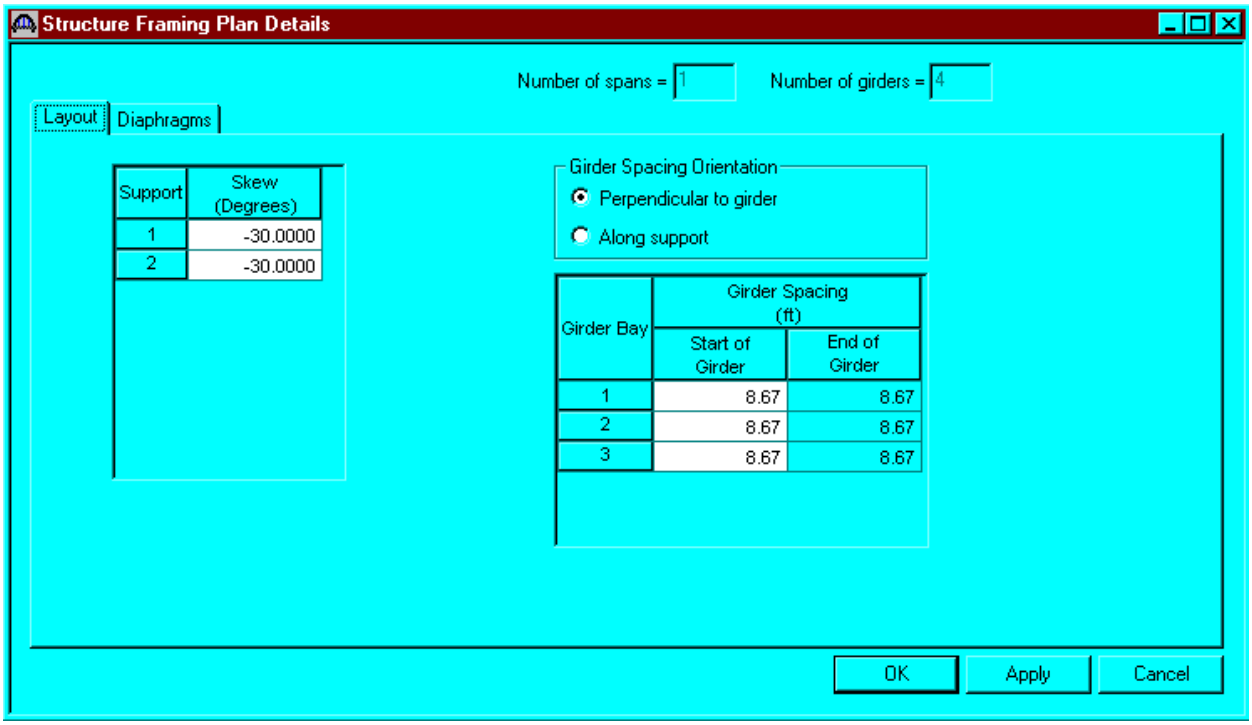
The partially expanded Bridge Workspace tree is shown below:



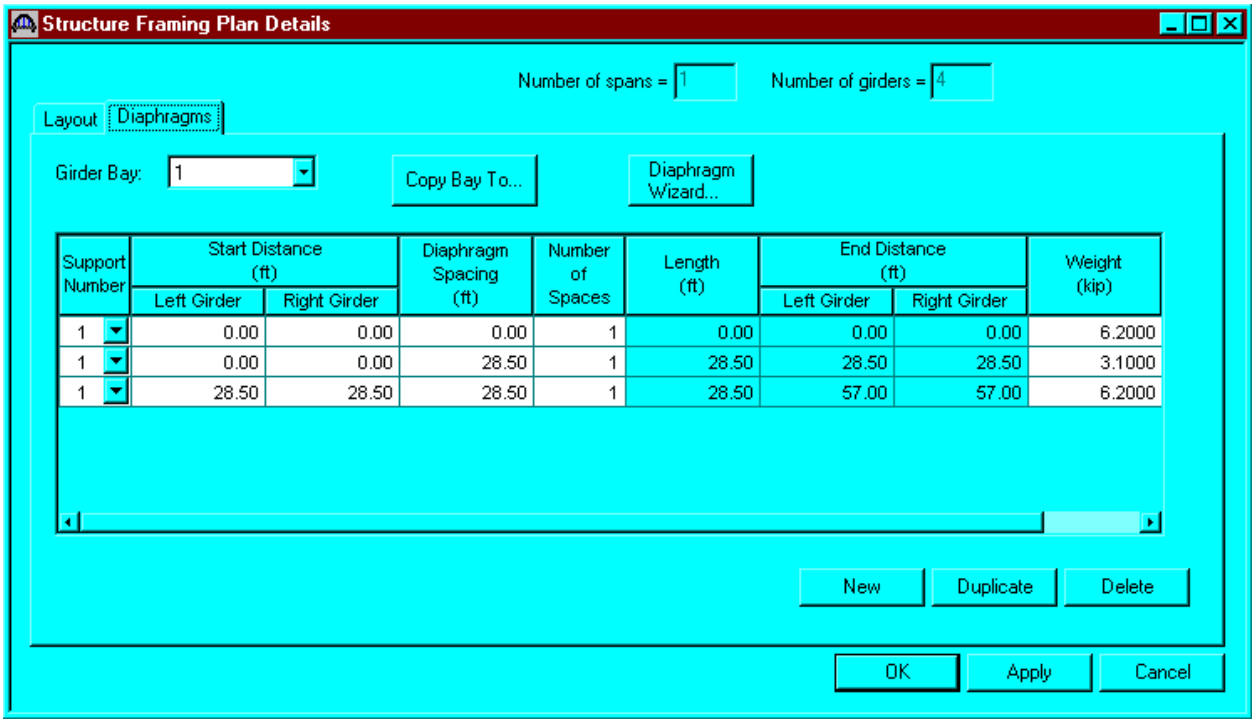
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed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



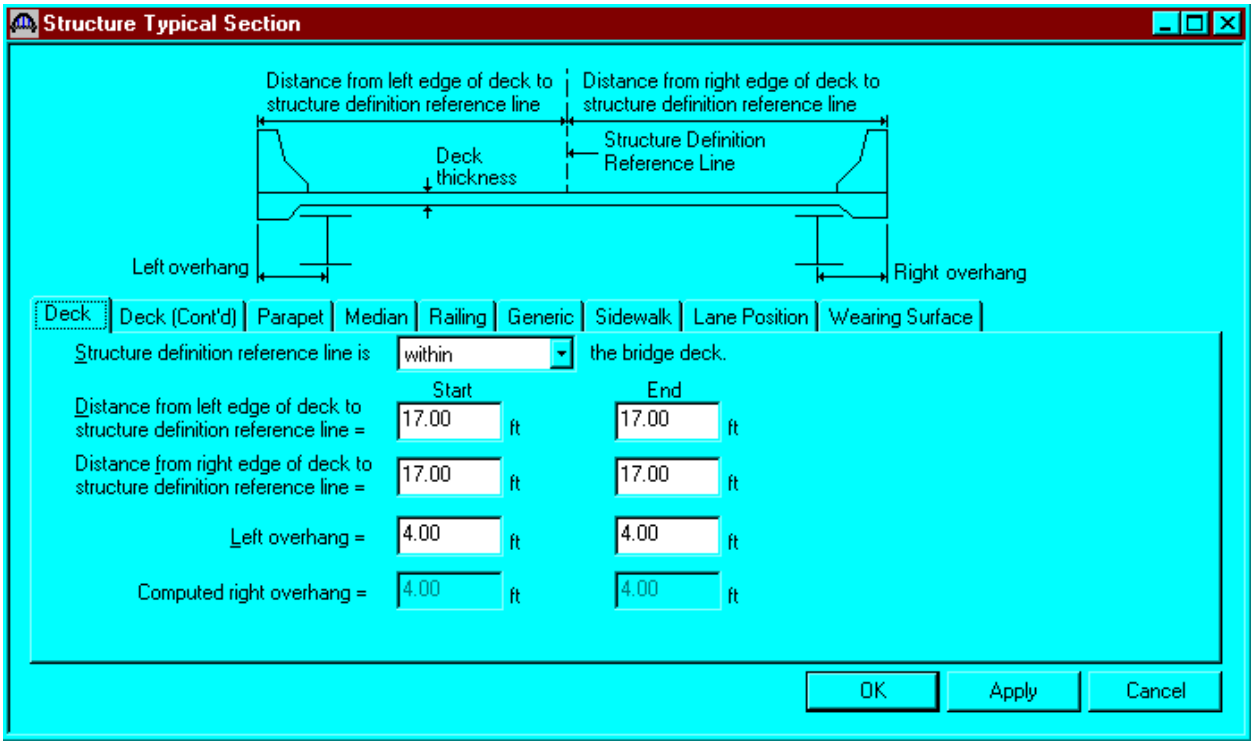
Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



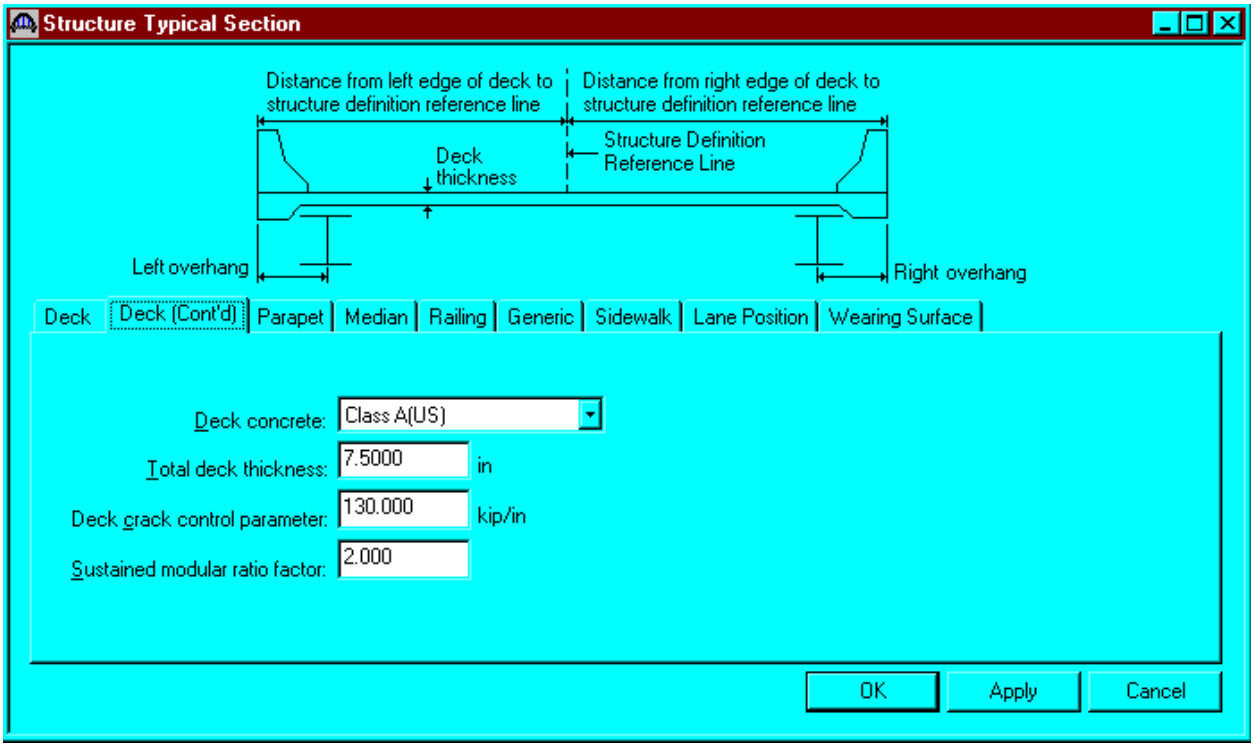
If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



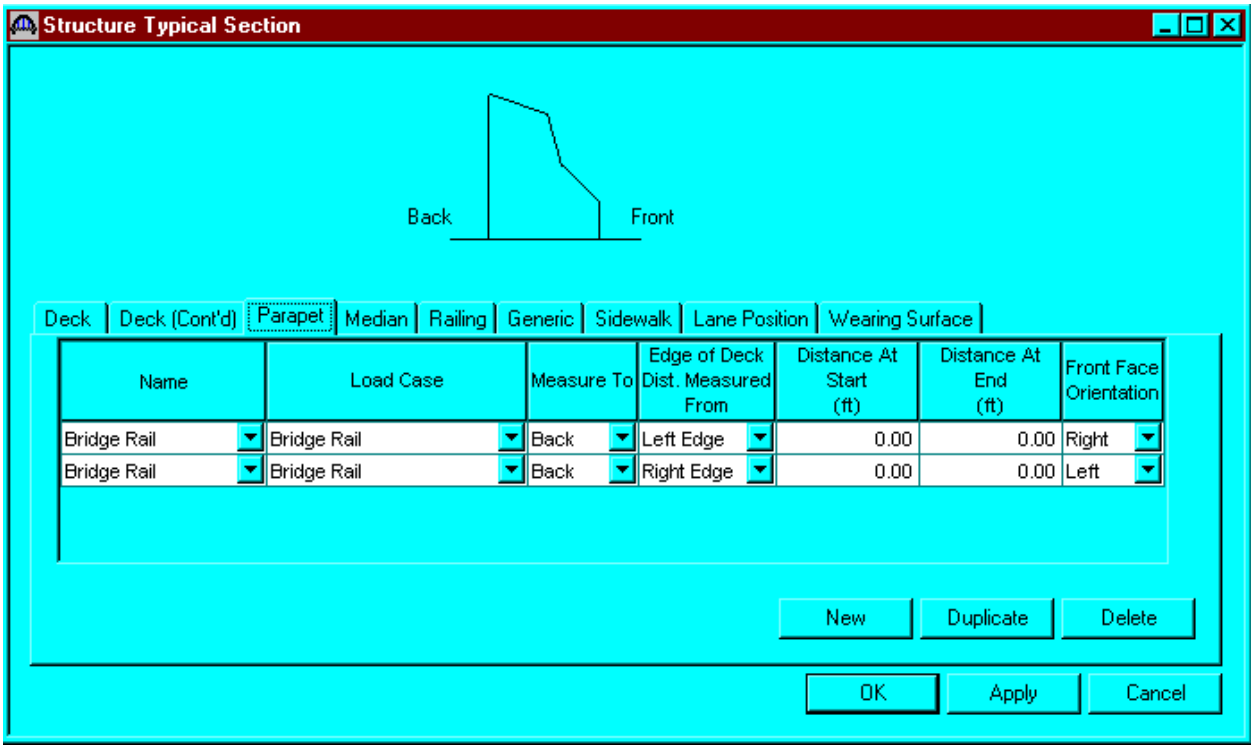
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



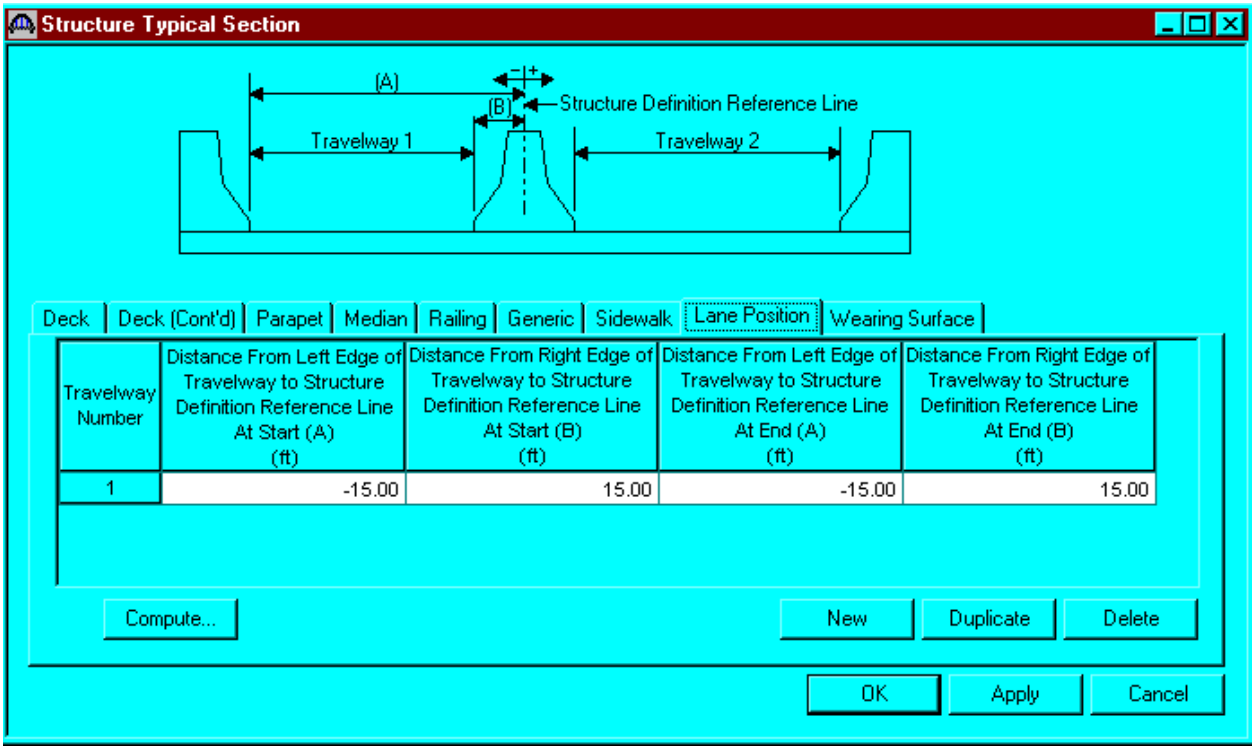
The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



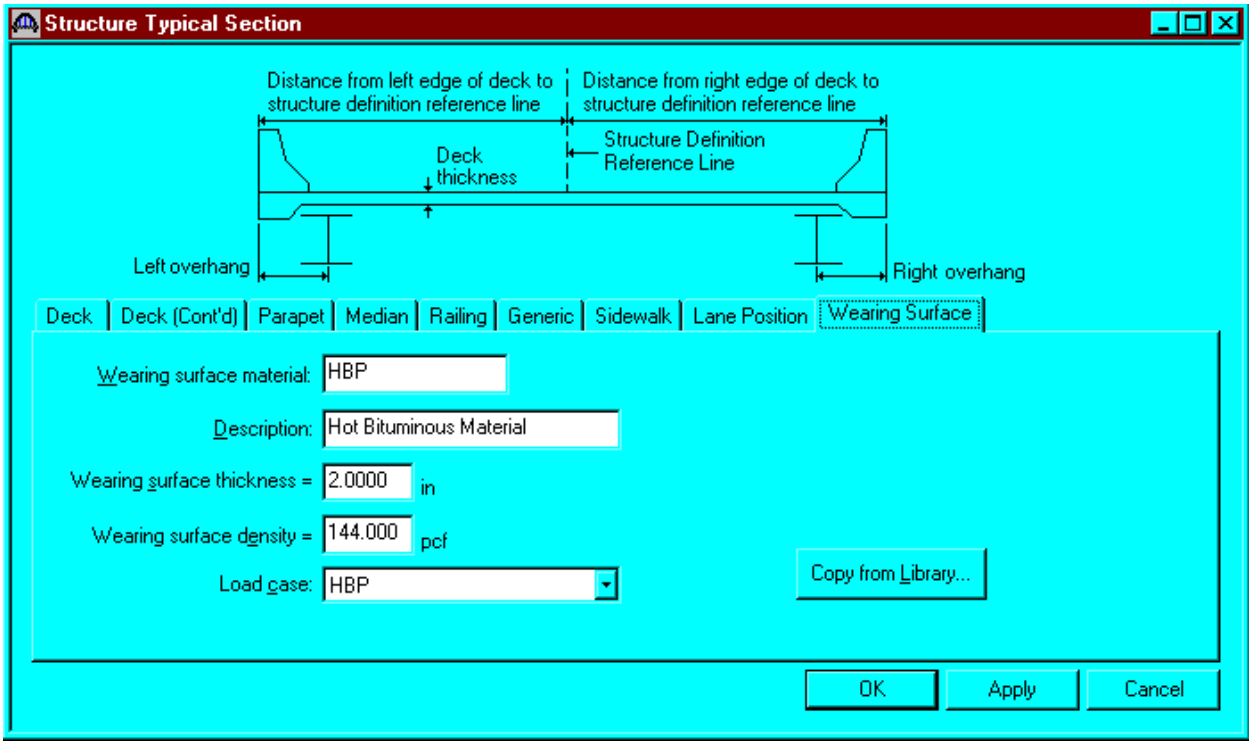
Parapets:
Add two parapets as shown below.



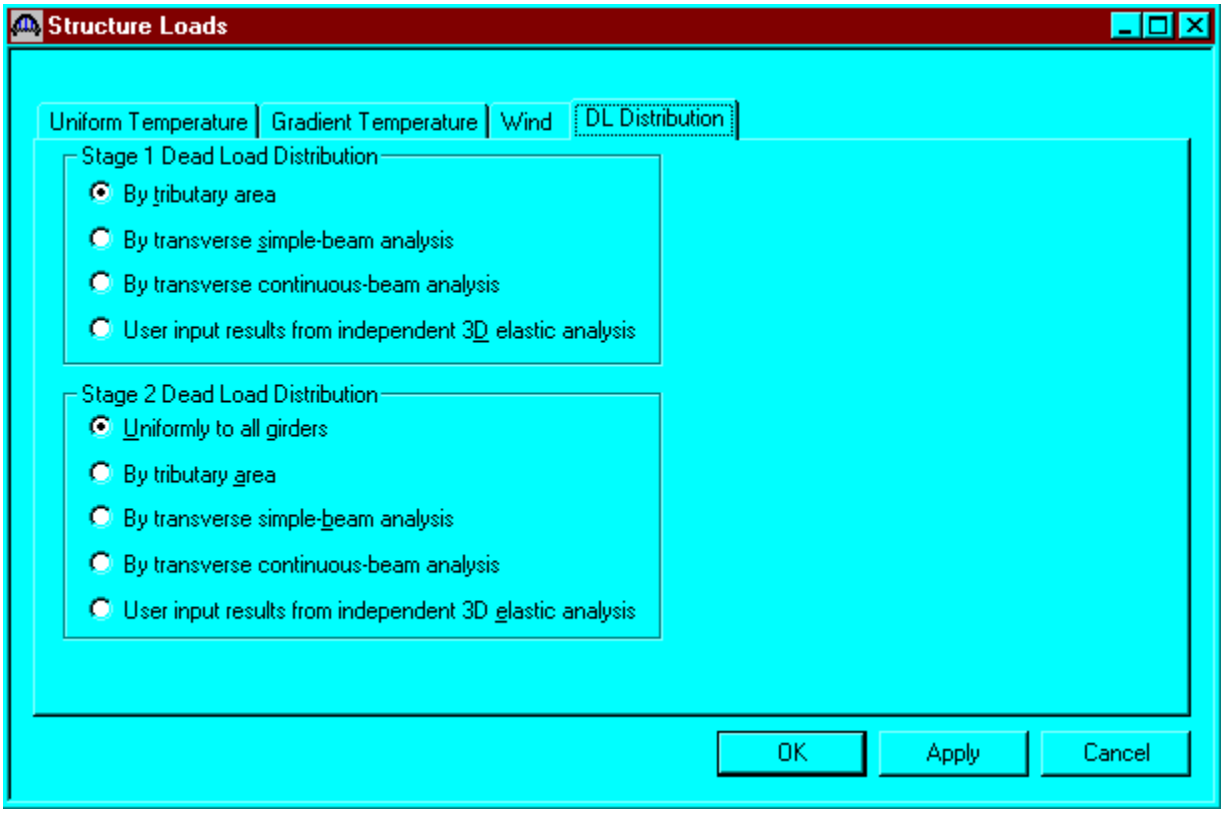
Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to apply the computed values. The Lane Position tab is populated as shown below.



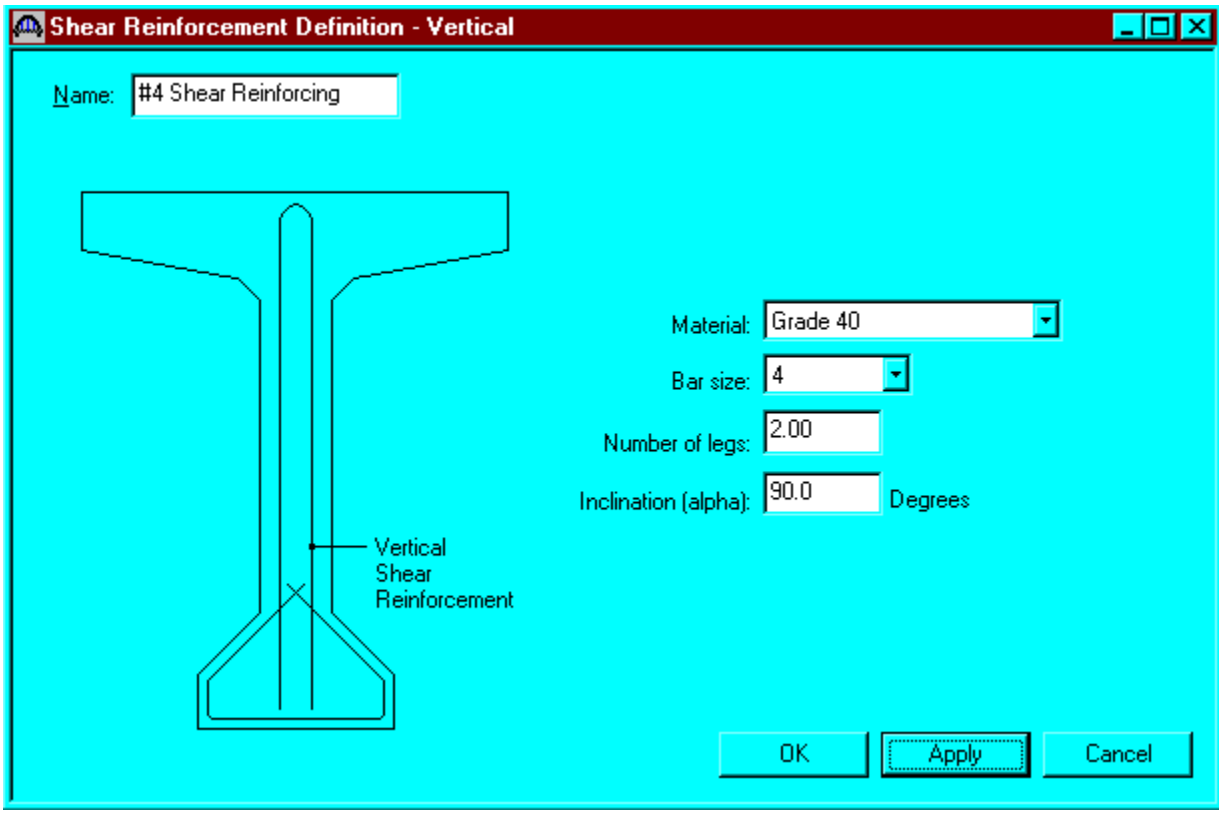
Enter the following wearing surface information on the Wearing Surface tab.



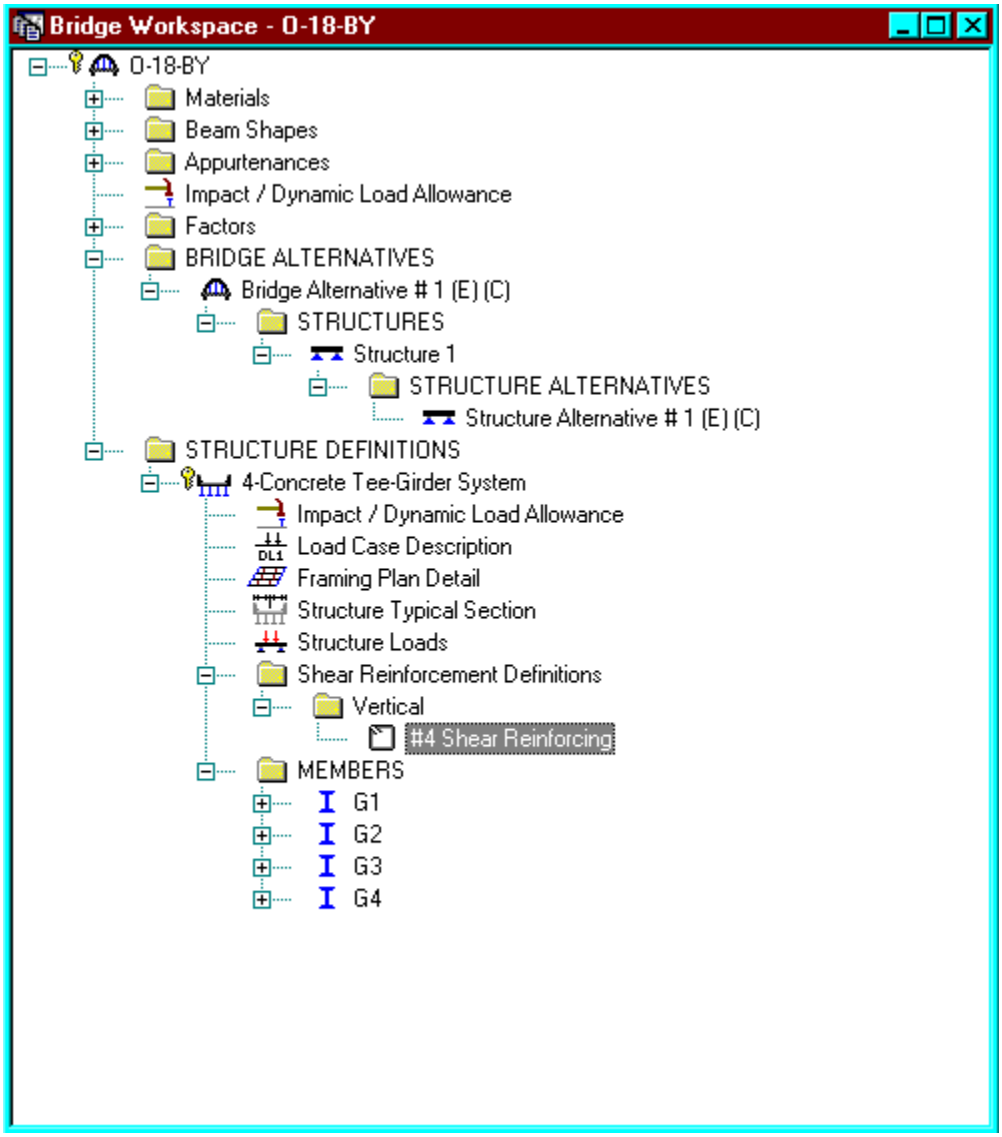
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



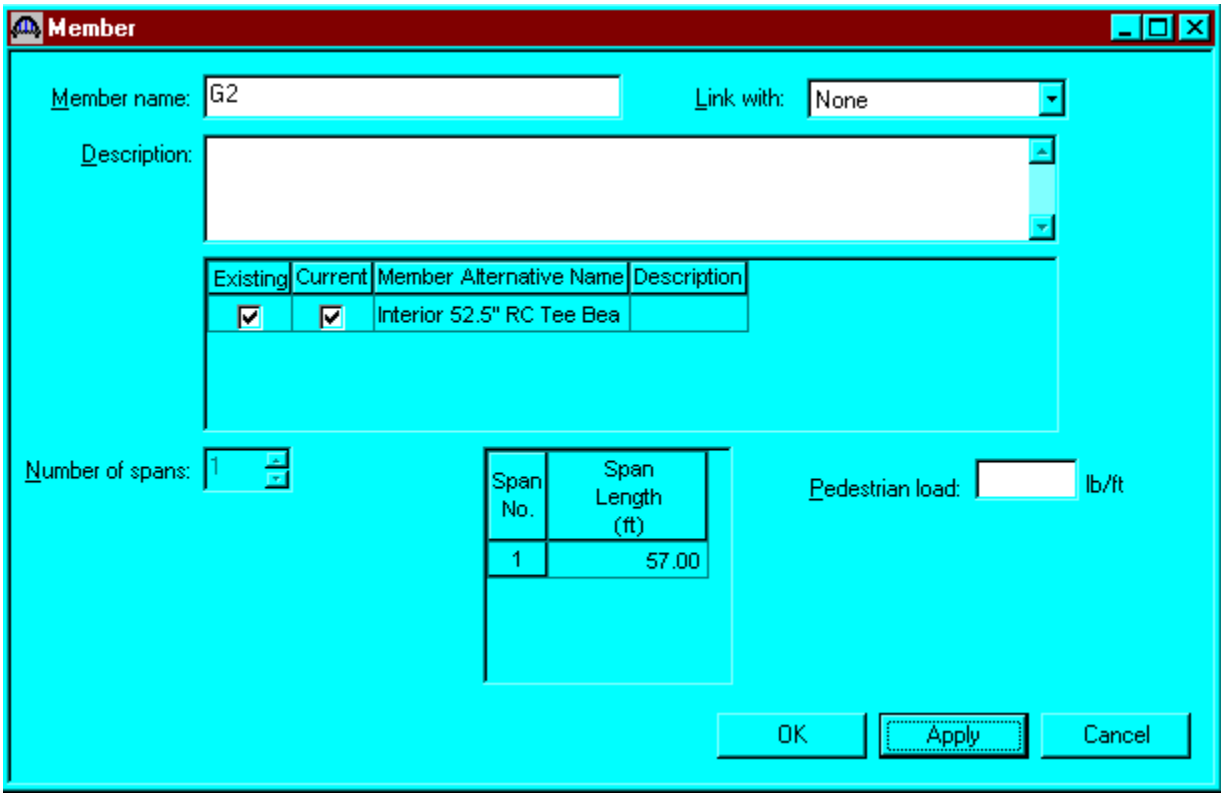
Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



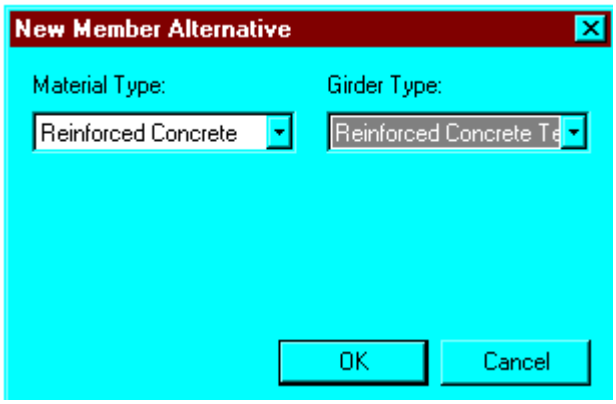
The partially expanded Bridge Workspace tree is shown below:



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.

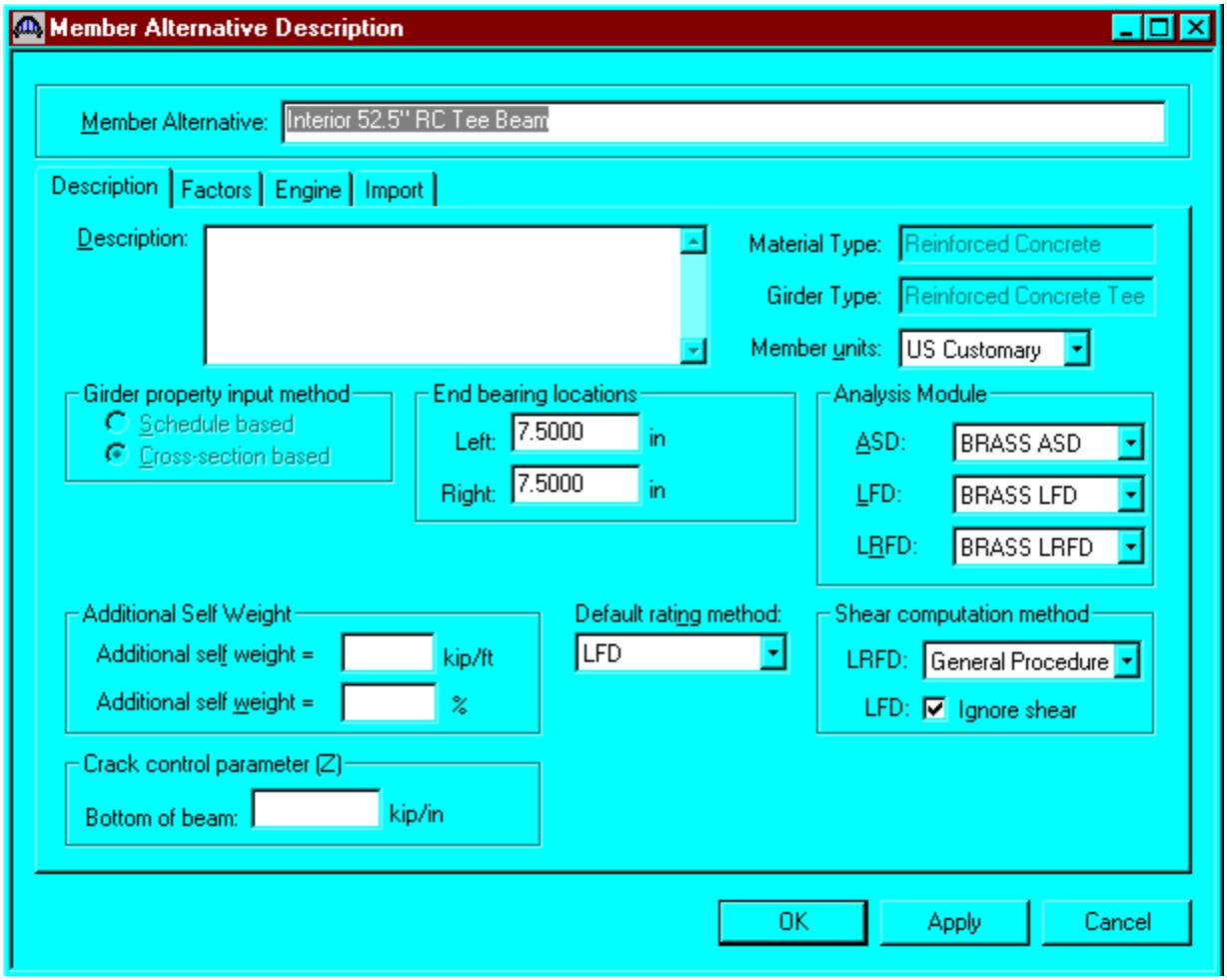


Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.



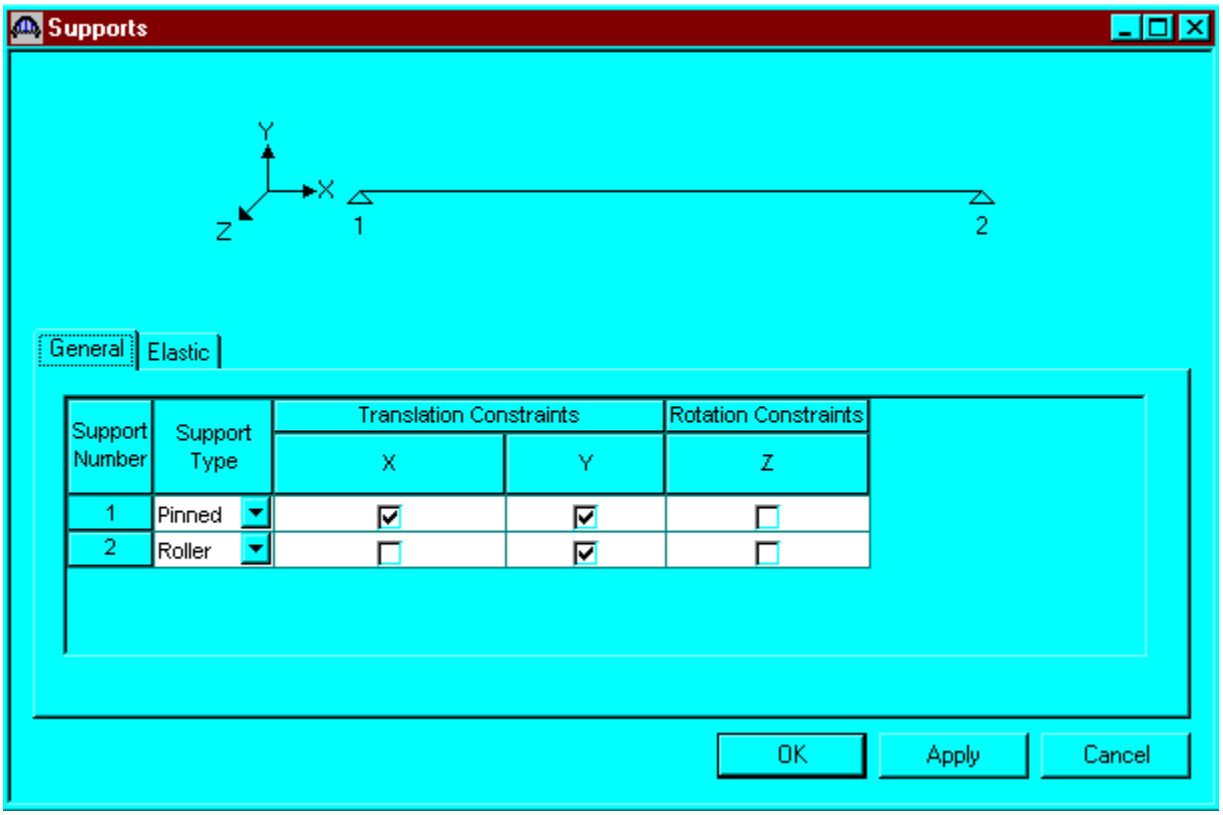
Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below.

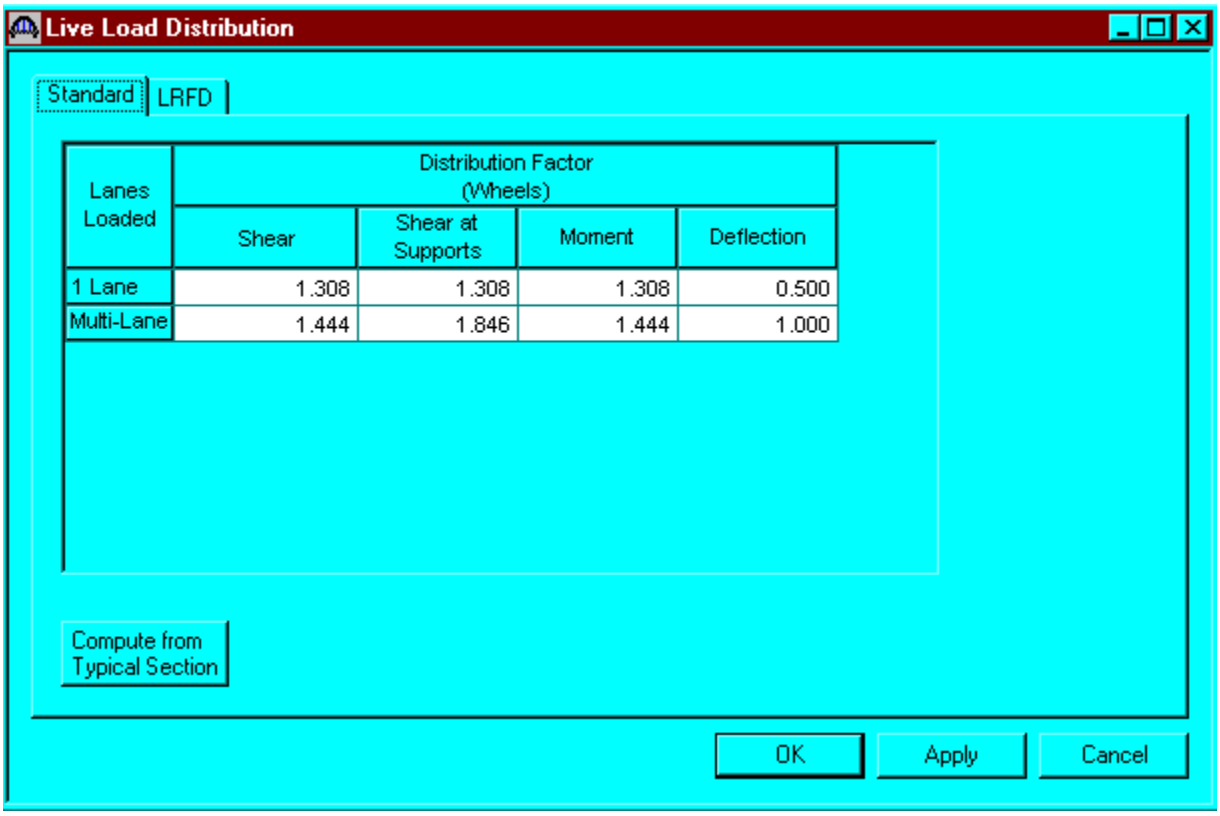


Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

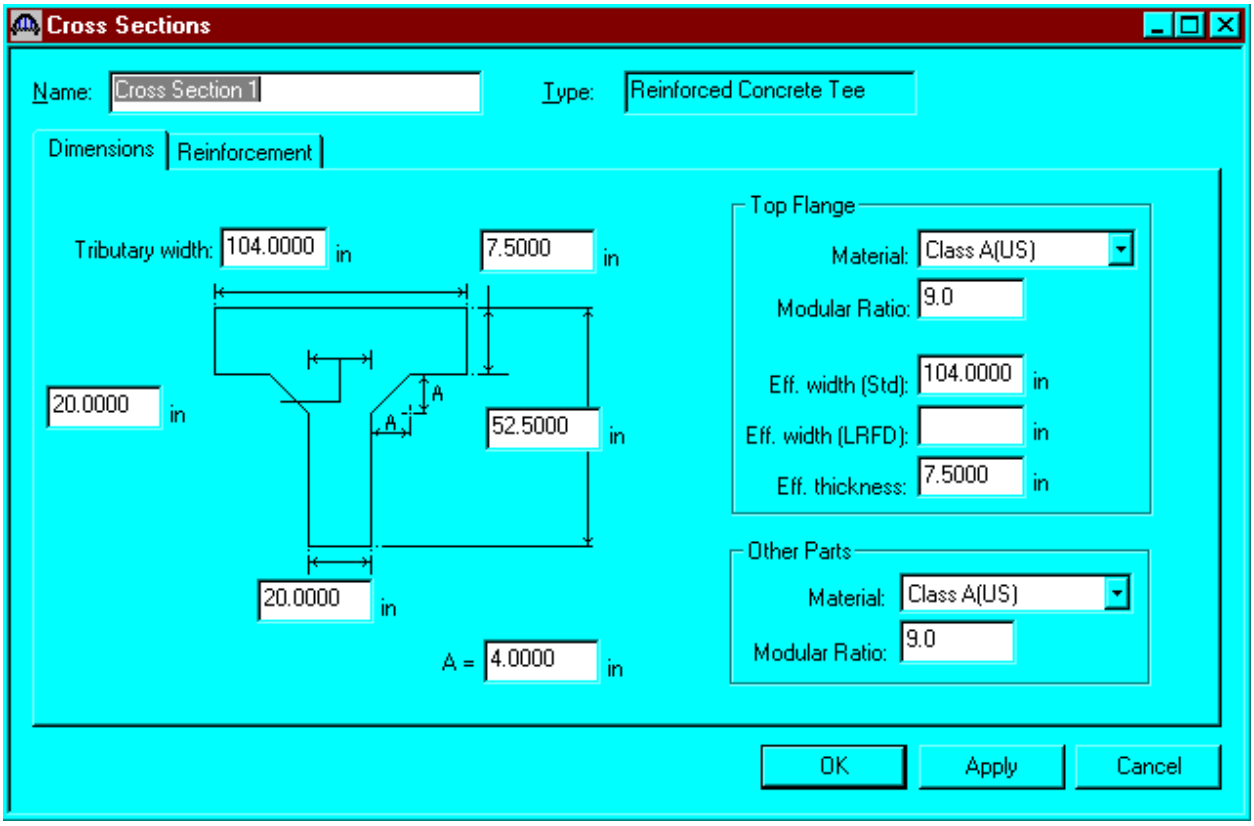
Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



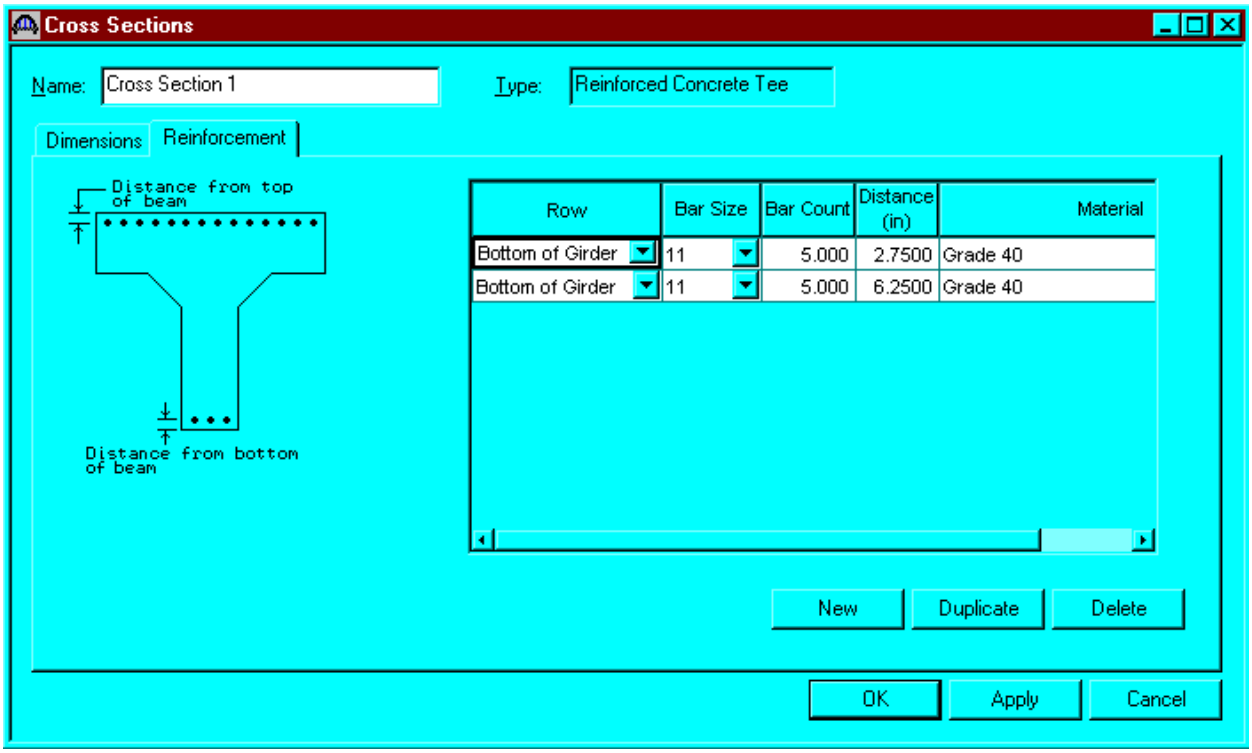
Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to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



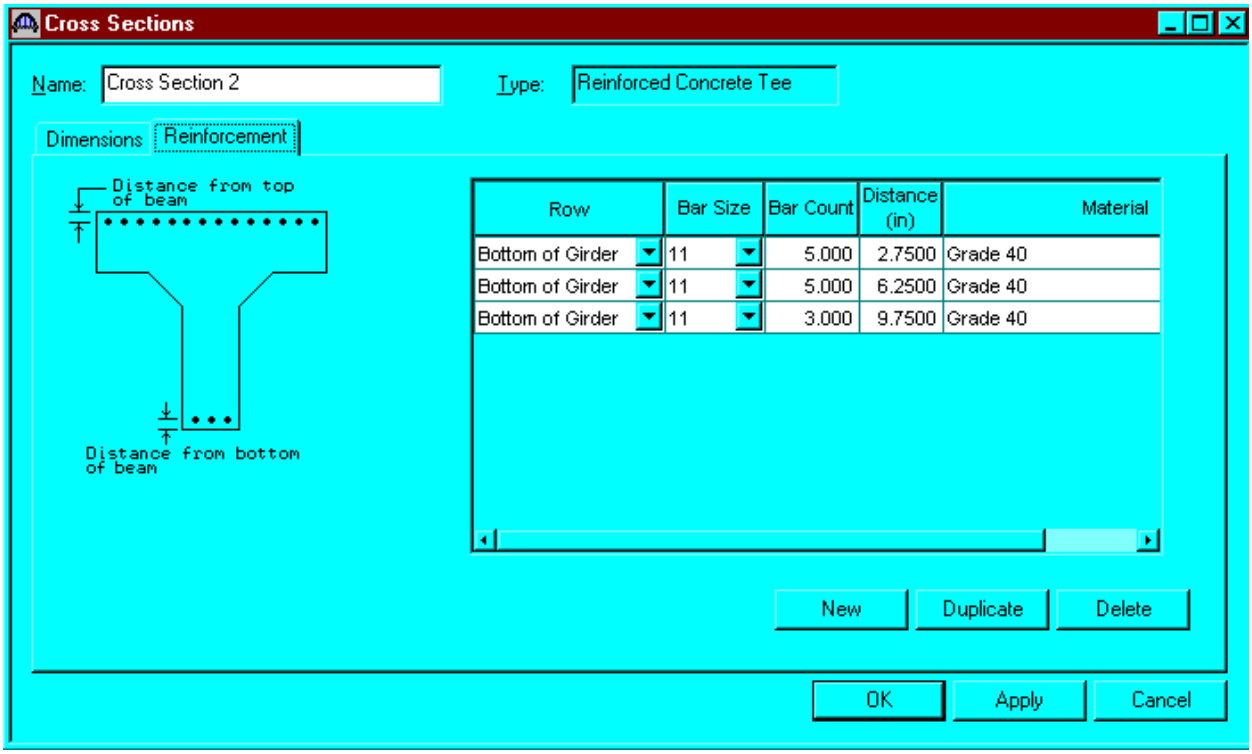
Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.

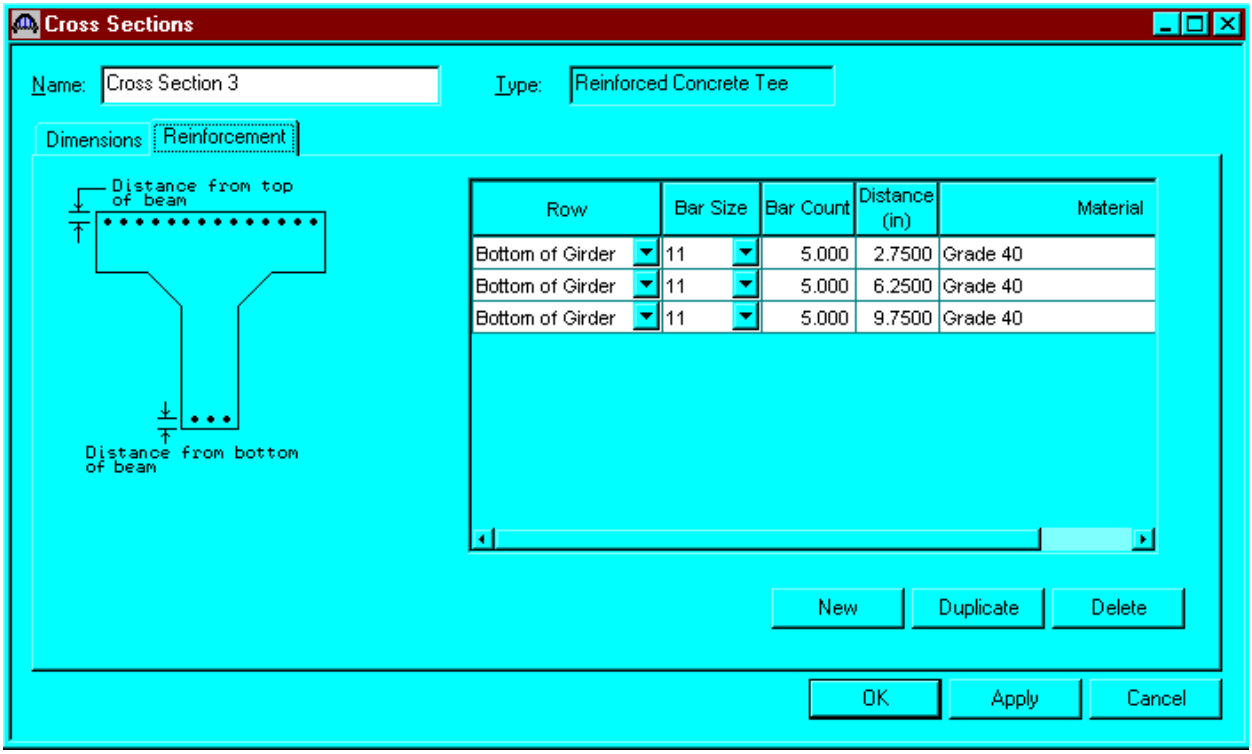


Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

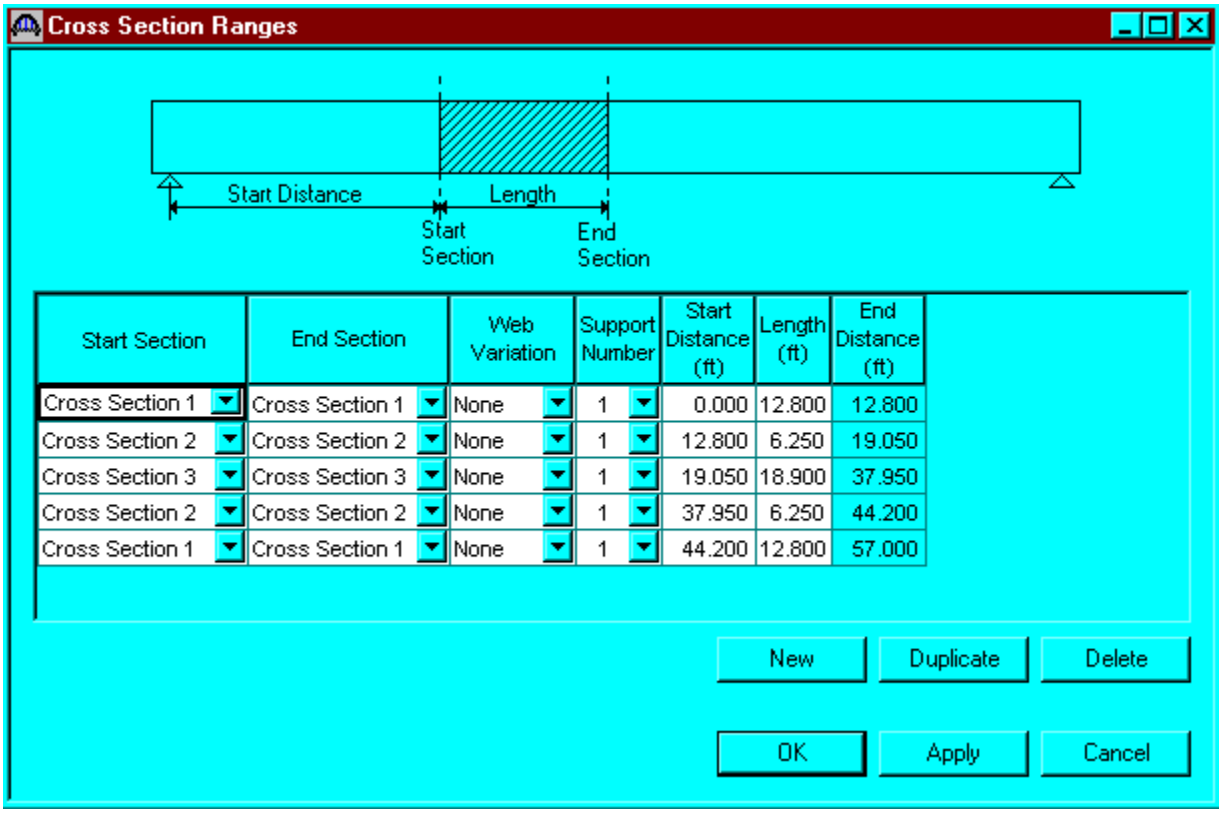


Using the same techniques, create cross section 2, cross-section 3 and define their associated reinforcement patterns.

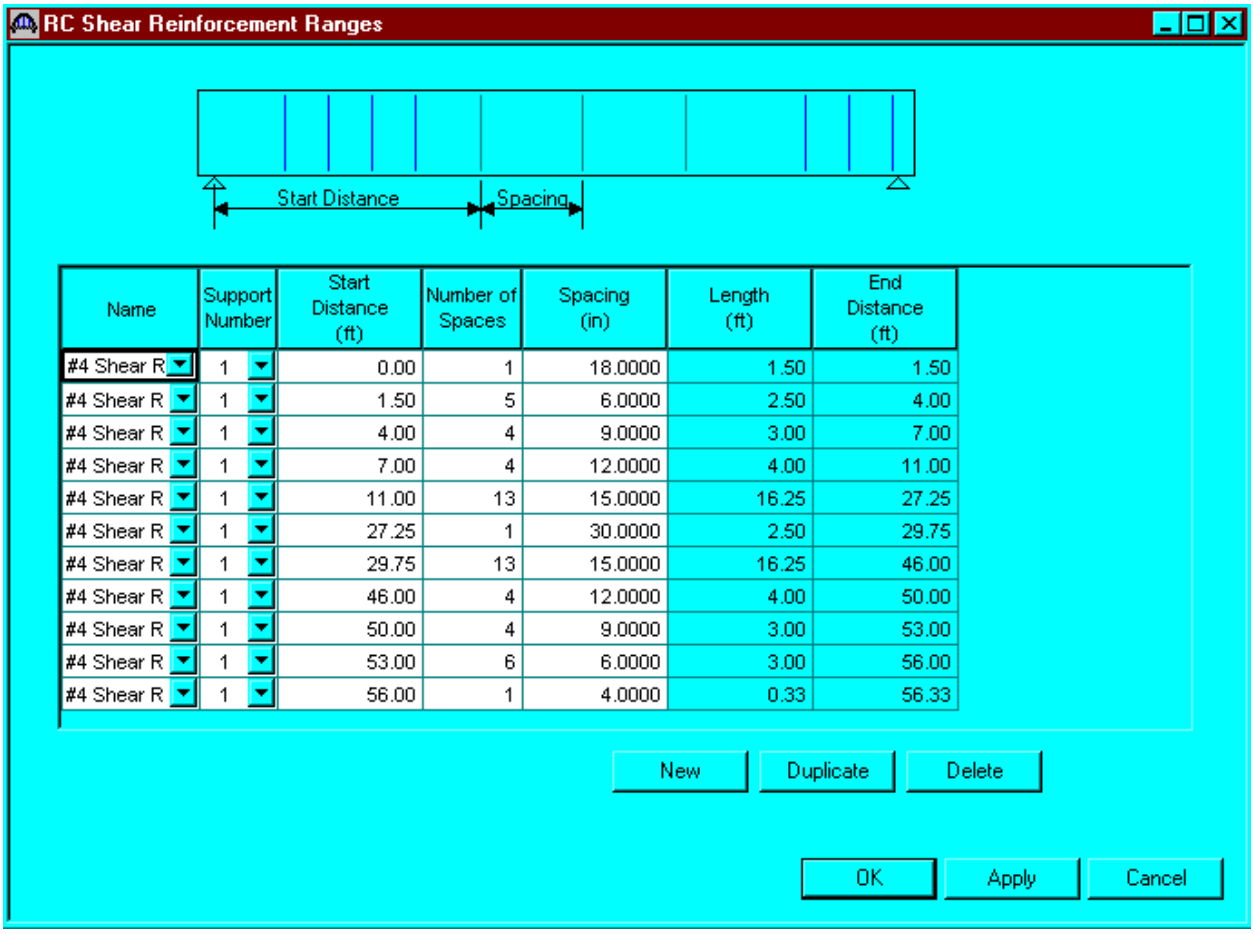



Cross Sections
Name: Cross Section 3
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Bar Size
Bar Count
Distance (in)
Material
Bottom of Girder
11
5.000
2.7500
Grade 40
Bottom of Girder
11
5.000
6.2500
Grade 40
Bottom of Girder
11
5.000
9.7500
Grade 40
New
Duplicate
Delete
OK
Apply
Cancel

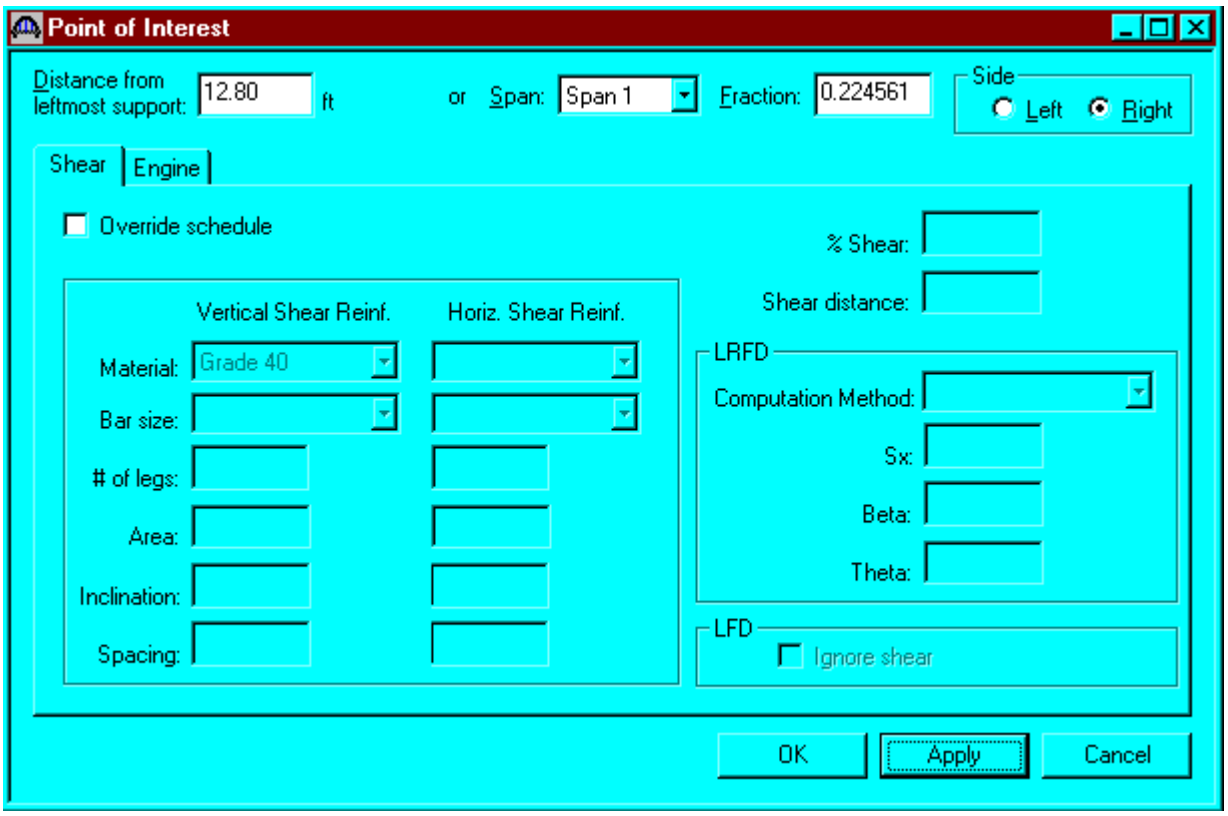
The Cross Section Ranges window is shown below. Define the ranges over which the cross sections apply.



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



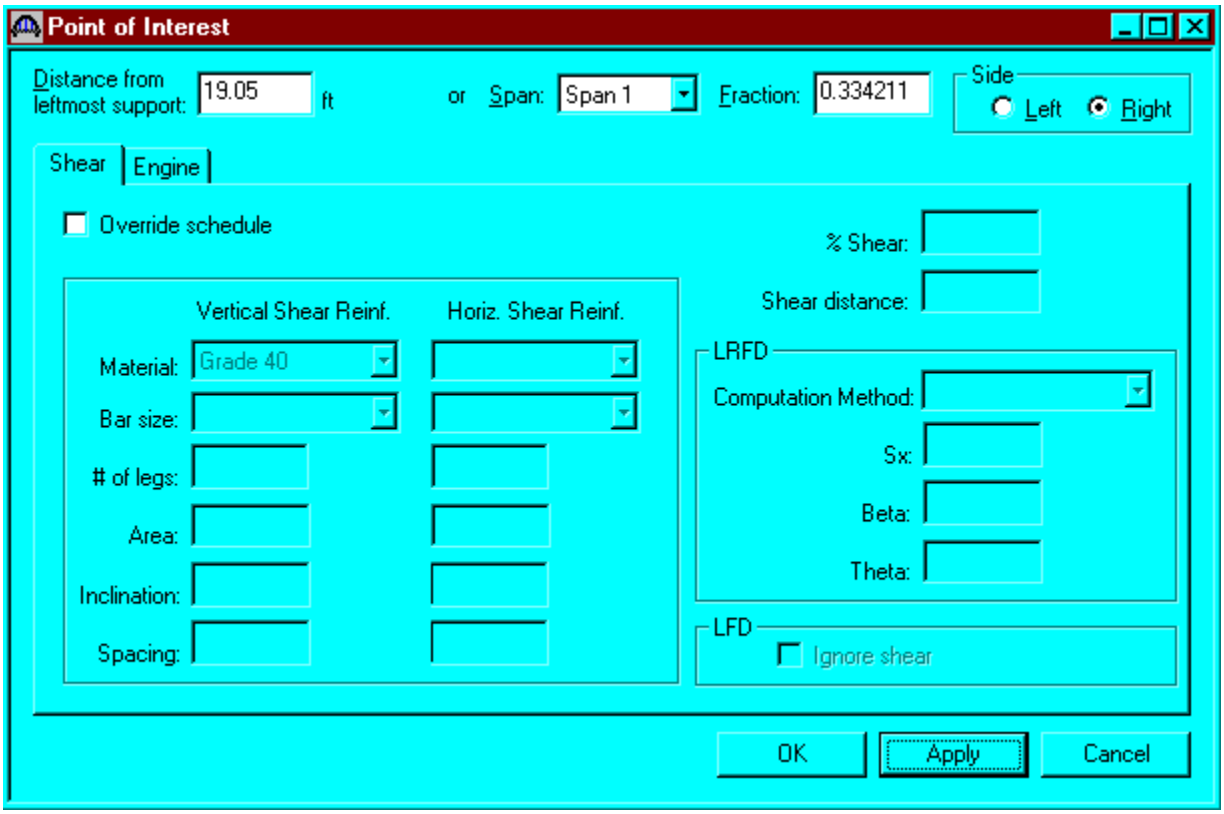
Define points of interest using the Points of Interest window shown below.

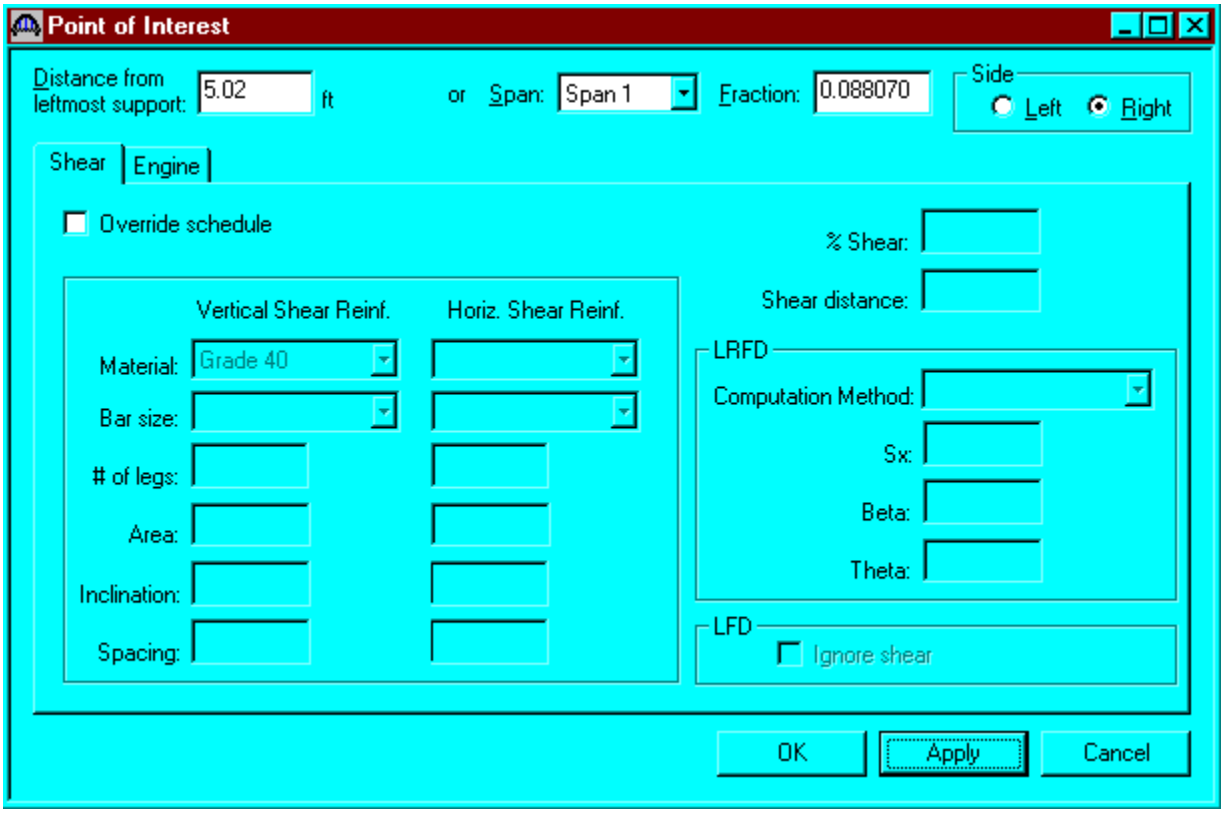


The Point of Interest window enables the user to enter points of interest in addition to those that are automatically generated by the program.

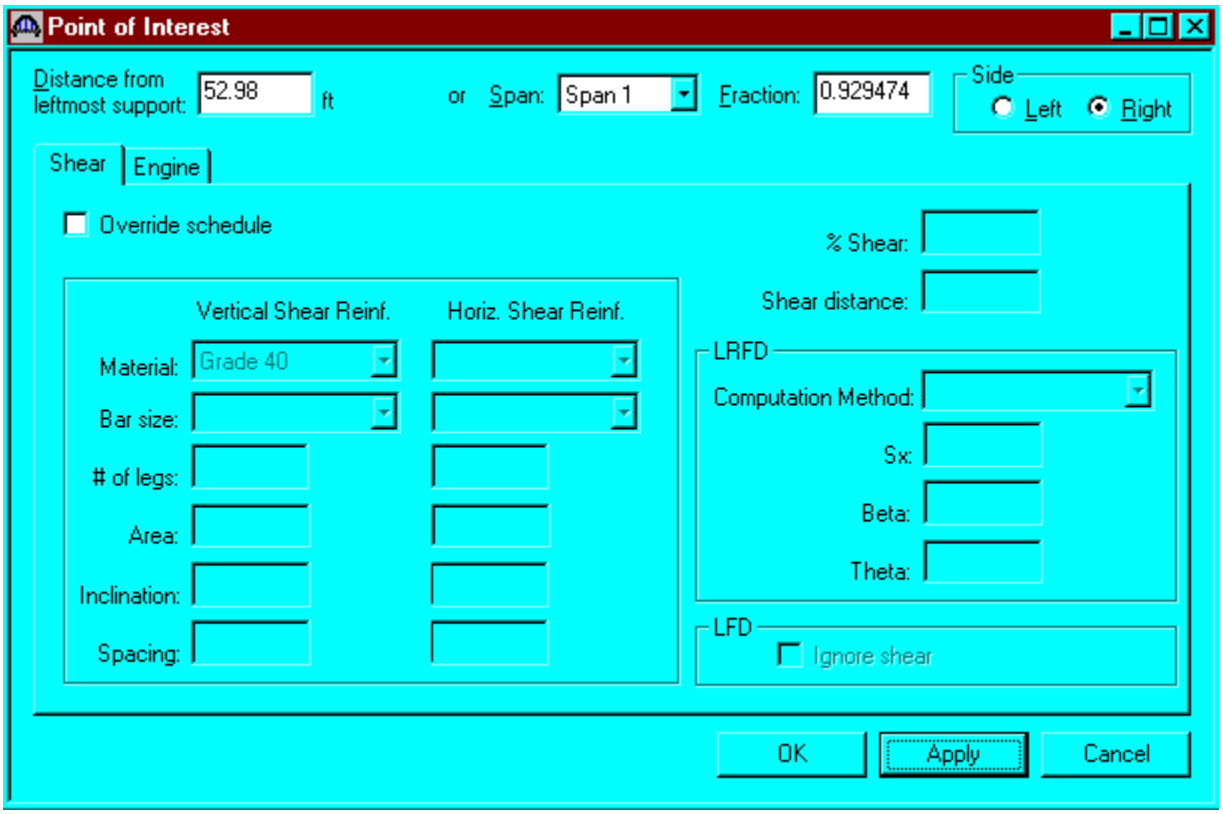
15 bar diameter = 15*(11/8) = 1.712′
Clear Span/20 = (57-1.83)/20 = 2.75′
Effective Depth = 46.25/12 = 3.85′ Use 3.8′

First rebar cutoff from left support = 12.8′
Second rebar cutoff from left support = 19.05′


Point of Interest
Distance from leftmost support:
19.05
ft
or
Span:
Span 1
Fraction:
0.334211
Side
Left
Right
Shear
Engine
Override schedule
% Shear:
Shear distance:
Vertical Shear Reinf.
Horiz. Shear Reinf.
Material:
Grade 40
Bar size:
# of legs:
Area:
Inclination:
Spacing:
LRFD
Computation Method:
Sx:
Beta:
Theta:
LFD
Ignore shear
OK
Apply
Cancel

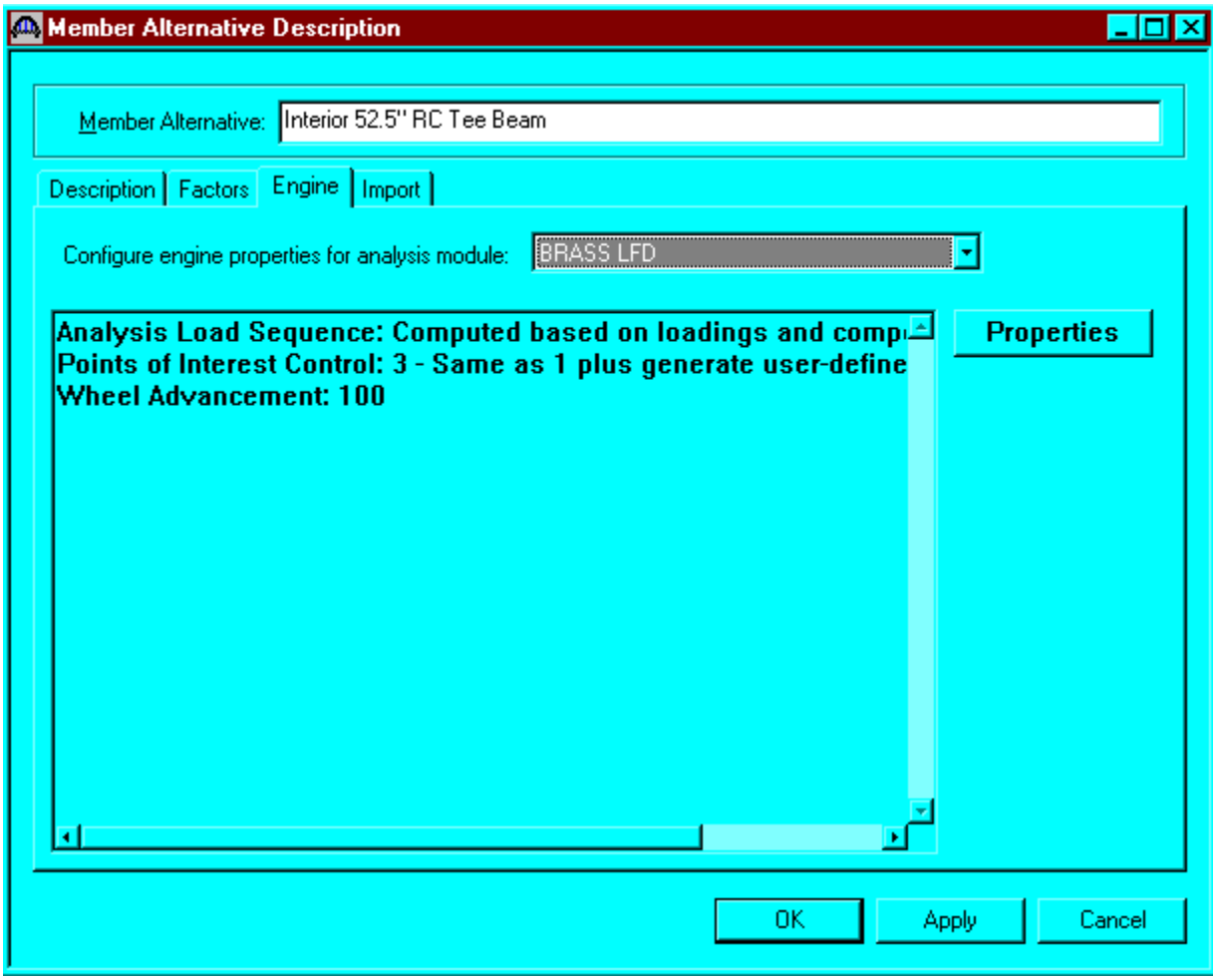


Shear Check: d = 52.5”-6.25” = 46.25” = 3.85’
Shear at a distance ‘d’ from the free edge of the left support + 1.167’ = 3.85’ + 1.167’ = 5.02’

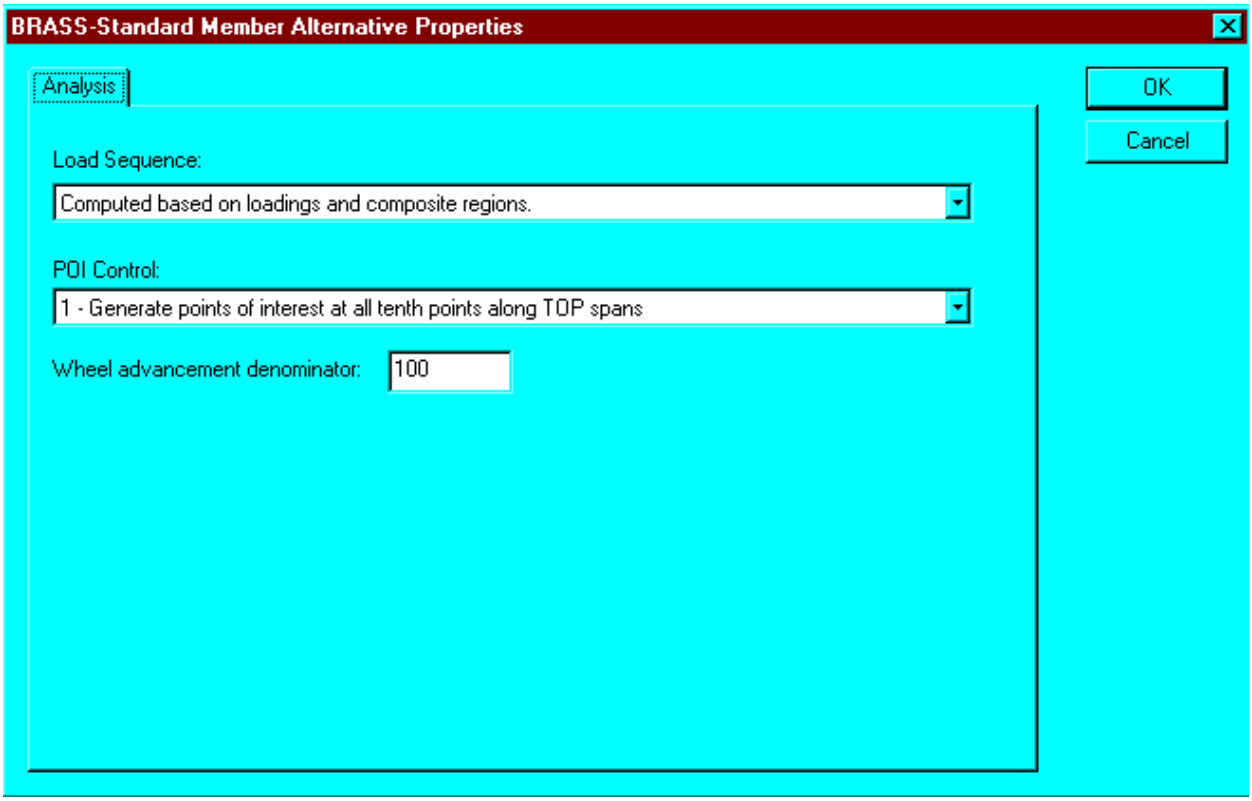


Shear Check: d = 52.5”-6.25” = 46.25” = 3.85’
Shear at a distance ‘d’ from the free edge of the right support + 0.167’ = 3.85’ + 0.167’ = 4.02’
Therefore, Distance from the left support = 57.0’- 4.04’ = 52.98’

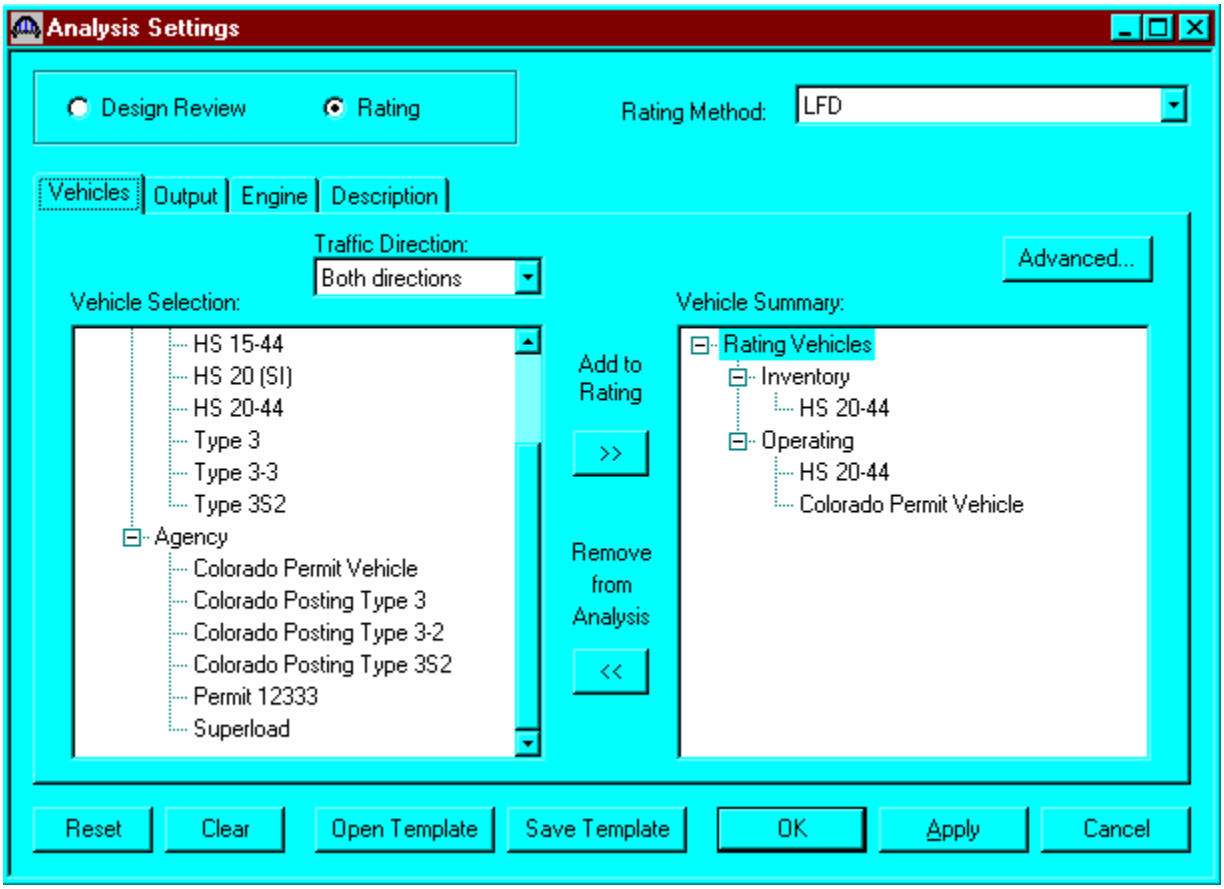
Open the Member Alternative Description window and click the Engine tab as shown below.



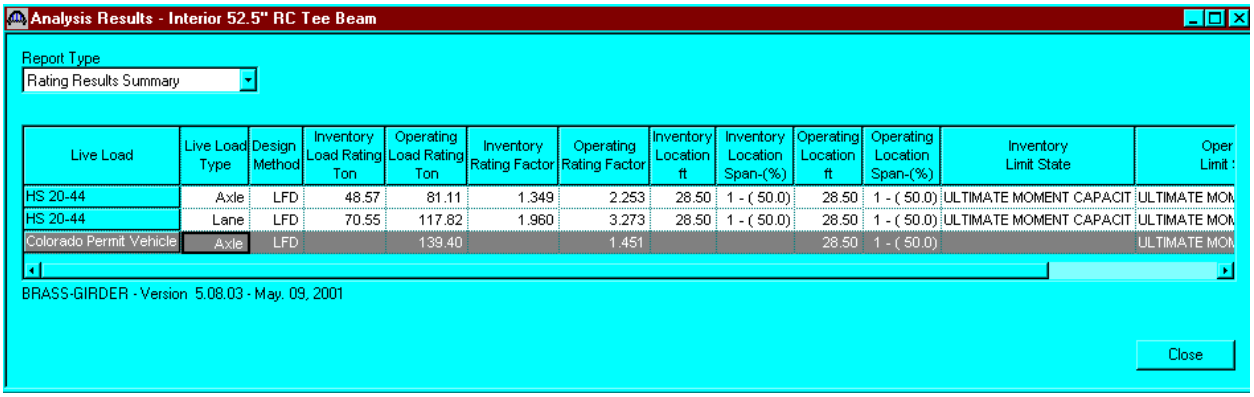
Click the Properties button to edit the engine properties for BRASS LFD.



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 MOM
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 MOM
Colorado Permit Vehicle	Axle	LFD		139.40		1.451			28.50	1 - (50.0)		ULTIMATE MOM

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

Close

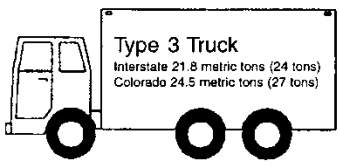
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

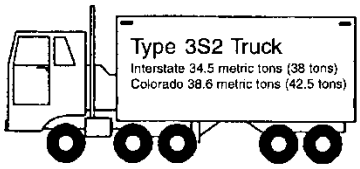
Rated using
Asphalt thickness: 50 mm (2 in.)
☐ Colorado legal loads
☒ Interstate legal loads

Structure #	O-18-BY(S.B.)
State highway #	I-25
Batch I.D.	
Structure type	CSG
Parallel structure #	O-18-CD(N.B.)

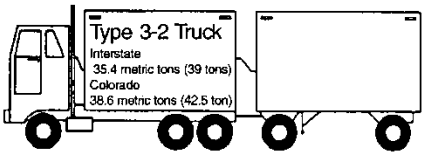
Structural member	INTERIOR GIRDER	SLAB		
	Metric tons (Tons)			
Inventory	43.6 (48)	33.6 (37)	( )	( )
Operating	73.6 (81)	56.4 (62)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	126.3 (139)	( )	( )	( )



_____ (_____)
Metric tons Tons



_____ (_____)
Metric tons Tons



_____ (_____)
Metric tons Tons

Comments

Control Member: Deck; Rated for 2" HBP
Load Capacity: 62 Tons
Girder: Only Interior Girder Rated; Rated for 2" HBP

Color Code: White

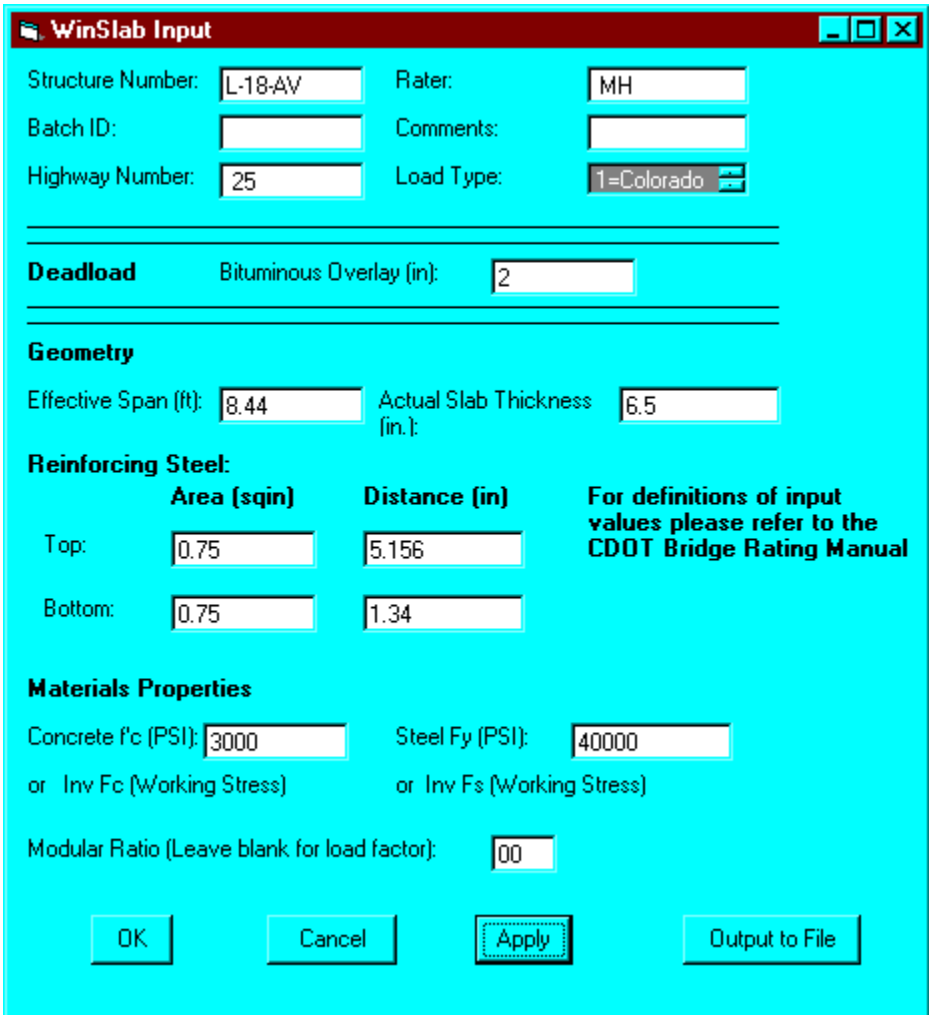
Project No: I-25-1(21)31

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/95

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



Effective Span Length: Per AASHTO Article 3.24.1.2(a)

(Clear span)*1/cos27.3° = (9.00-1.50)*1/cos27.3° = 8.440’

Distance to Top Steel = 5.156”
Distance to Bottom Steel = 1.344”

Top Steel Area: #6 @ 12 = 0.440
#5 @ 12 = 0.310
Σ = 0.750 in*in

Bott. Steel Area: #6 @ 12 = 0.440
#5 @ 12 = 0.310
Σ = 0.750 in*in

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

```
WinSlab Rating Version 1     Date: 1/14/2002

 Structure NO. L-18-AV     Rater:  MH     State HWY NO. =  25
     Batch ID=         Description:

 LOAD FACTOR RATING-COMP STEEL NOT USED

 *** Warning: Slab thickness violates old AASHTO 1.5.40(B)***

 INPUT DATA

       Bituminous Overlay(in)=    2.000
       Eff. Span(ft)=             8.440          Slab Thickness(in)= 6.500
       Top Reinf. (sq.in)=         0.75          Eff. Depth(in) =    5.156
       Bottom Area(sq.in)=         0.75          Bottom Dist.(in)=   1.34
       Conc. Strength(PSI) Inv =   3000          Oper. =             3000
       Steel Yield (PSI)   Inv =  40000          Oper. =             40000
       Modular Ratio =                9

Dead Load Moment   0.75 K-Ft
LL+I Moment        5.43 K-Ft
Gross Weight       36.0 Tons
                                        Inventory     Operating
Actual Concrete Stress      (PSI)     1051.42       1650.22
Actual Reinf. Steel Stress  (PSI)    18660.60      29288.22
Actual Comp. Steel Stress   (PSI)     4307.46       6760.66
Member Capacity             (K-Ft)      10.50         10.50
Member Capacity (LL+I)      (K-Ft)       9.52          9.52
     Rating                 (Tons)      29.15         48.58
```

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

Effective slab width: Per AASHTO Article 8.10.1.1

0.25(L)= 0.25(41*12)= 123”
12t+ Web Thickness = (12*6.5)+ 18 = 96.0” Controls
C.L. - C.L. of girder= 9.00’= 108”

Dead Load:

Intermediate Diaphragm = (0.67)*(2.00)*(9.00-1.50)*(1/Cos27.3°)*(0.150)
= 1.696 kips Use 1.7 kips

Abutment Diaphragm = ((4.81)*(1)*(7.5)+(2.1)*(1)*(7.5))*1/Cos27.3°*0.150
= 8.75 kips Use 9.0 kips

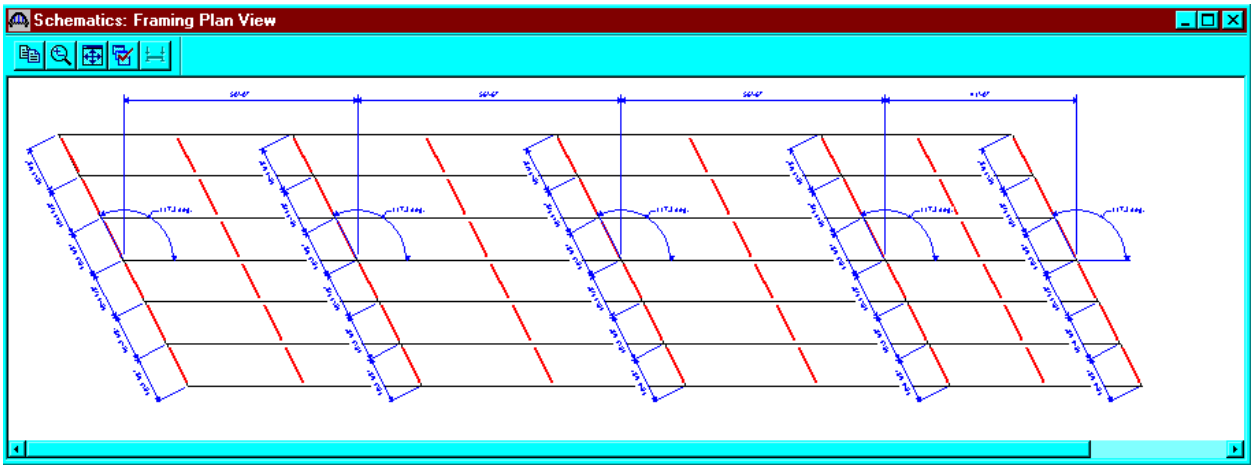
Pier Diaphragm = (2)*(6.5)*(7.5)*(1/Cos27.3°)*(0.15)
= 16.50 kips Use 16.50 kips

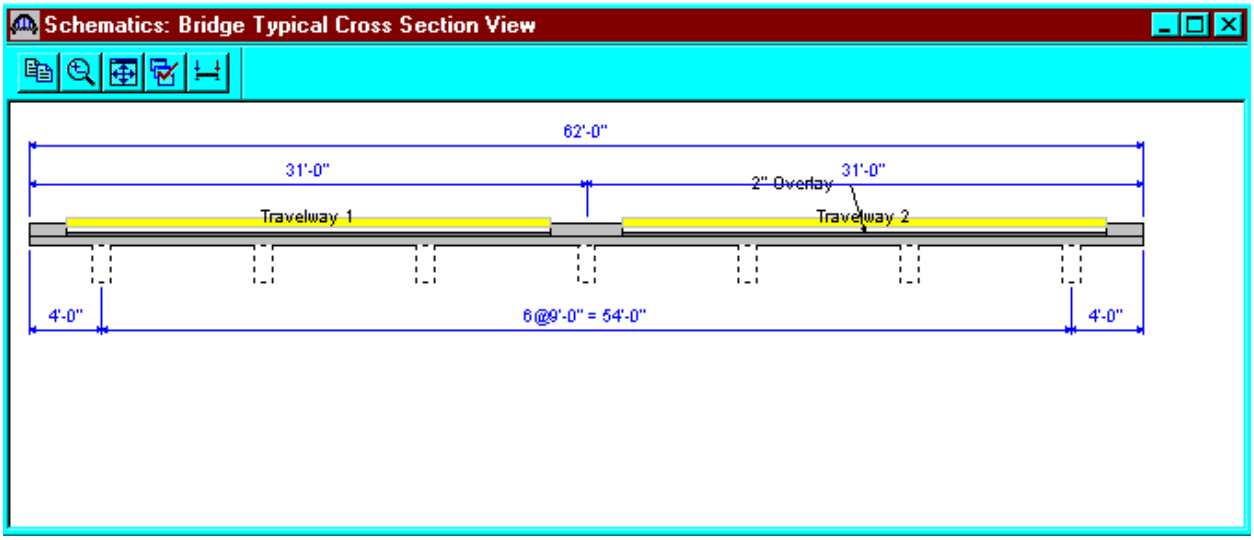
Distribution Factor:

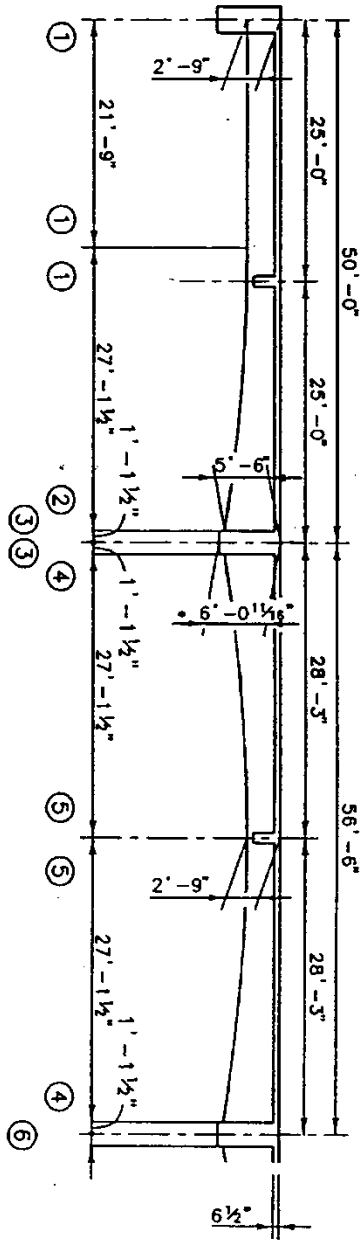
Multi-Lane = S/6 = 9.00/6 = 1.500

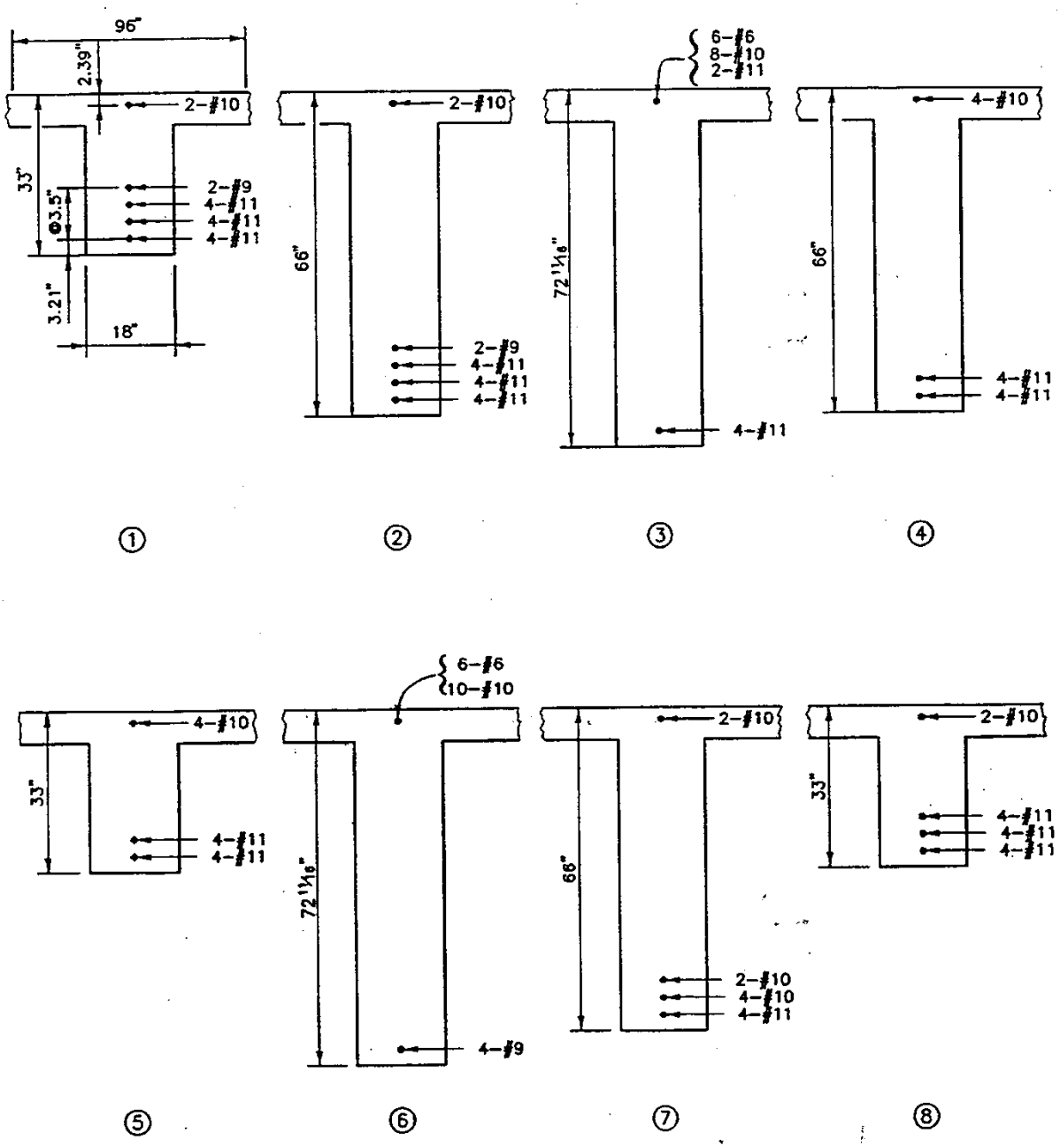
Single Lane = 1+ 3.00/9.00 = 1.333

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

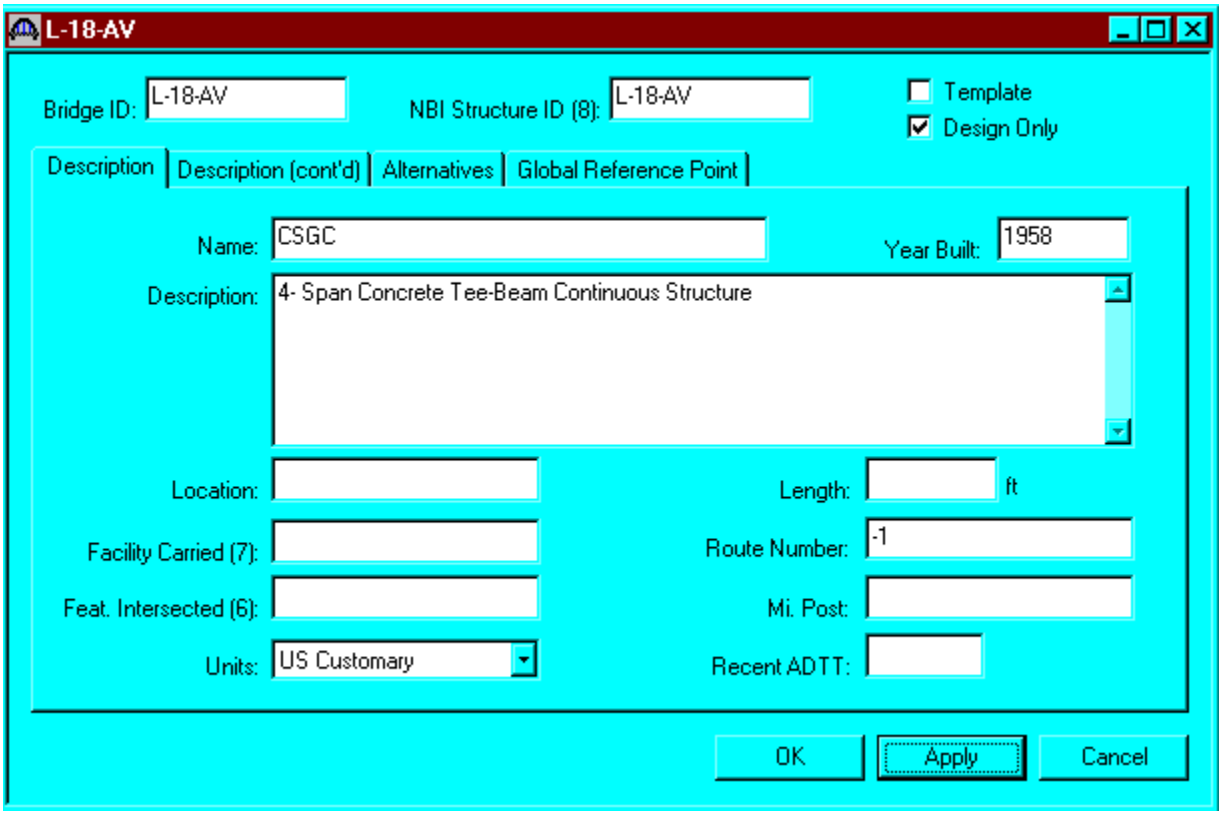





SPAN 1
SPAN 2
SPAN 3
SPAN 4
* Varies, Min. 6'-0 1/16" @ G-6
ELEVATION ~ G-6


96"
2.39"
2-#10
33"
2-#9
4-#11
4-#11
4-#11
Ø3.5"
3.21"
18"
66"
2-#10
2-#9
4-#11
4-#11
4-#11
6-#6
8-#10
2-#11
72 1/16"
4-#11
4-#10
66"
4-#11
4-#11
①
②
③
④
4-#10
33"
4-#11
4-#11
6-#6
10-#10
72 1/16"
4-#9
2-#10
66"
2-#10
4-#10
4-#11
2-#10
33"
4-#11
4-#11
4-#11
⑤
⑥
⑦
⑧

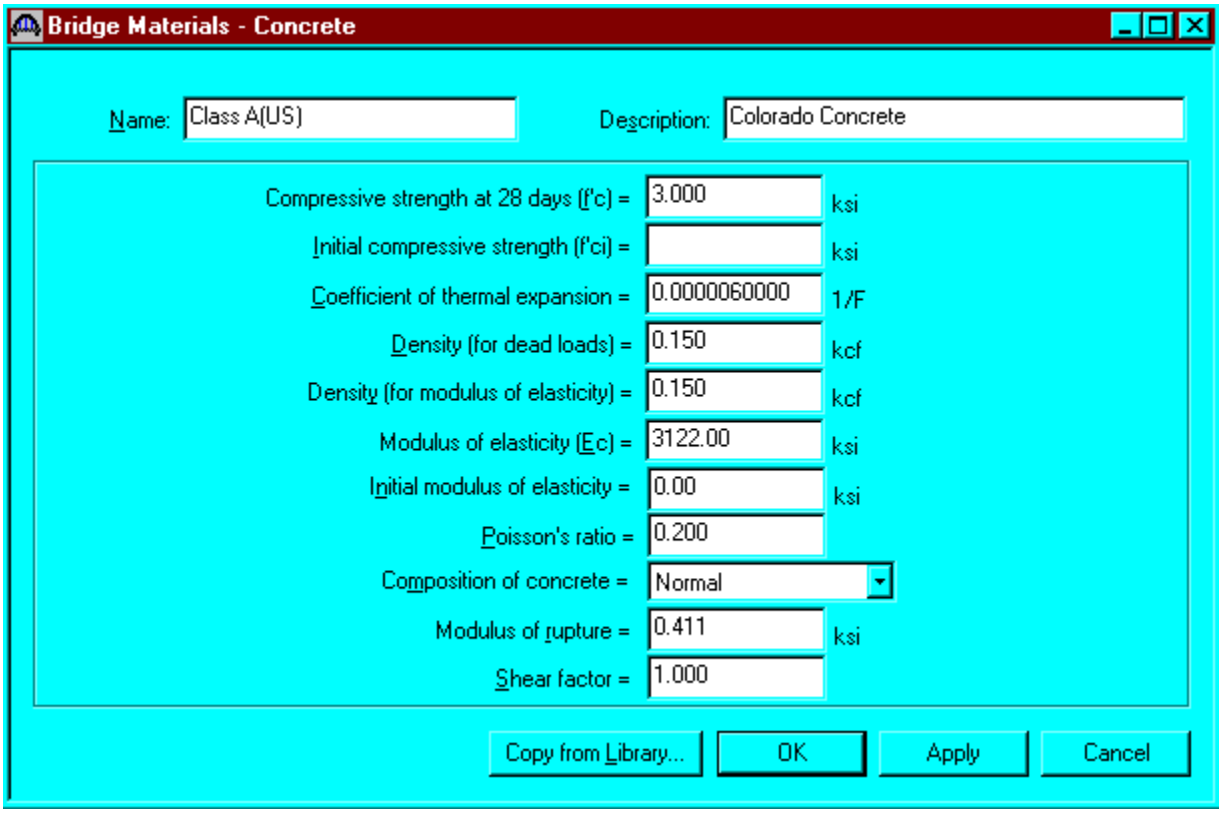
From the bridge explorer, create a new bridge and enter the following information.



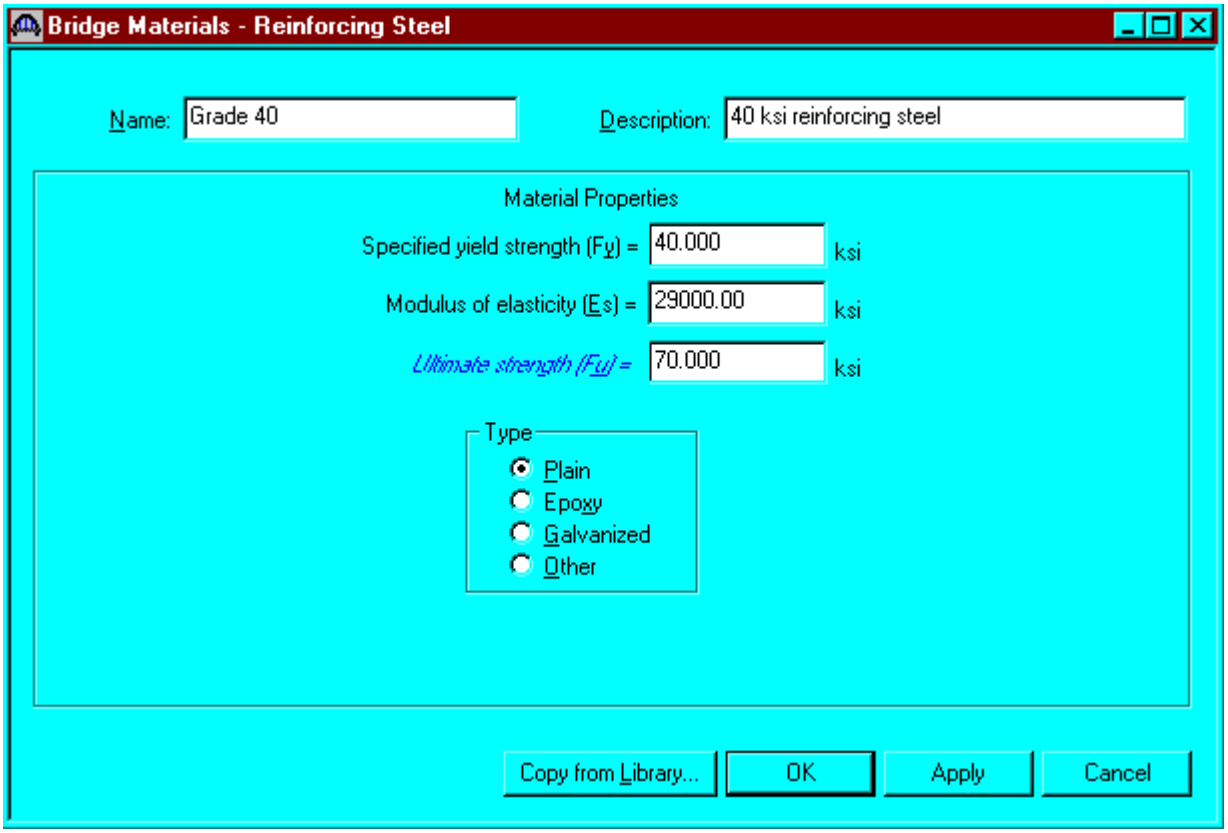
Click OK. This saves the data to memory and closes the window.

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.

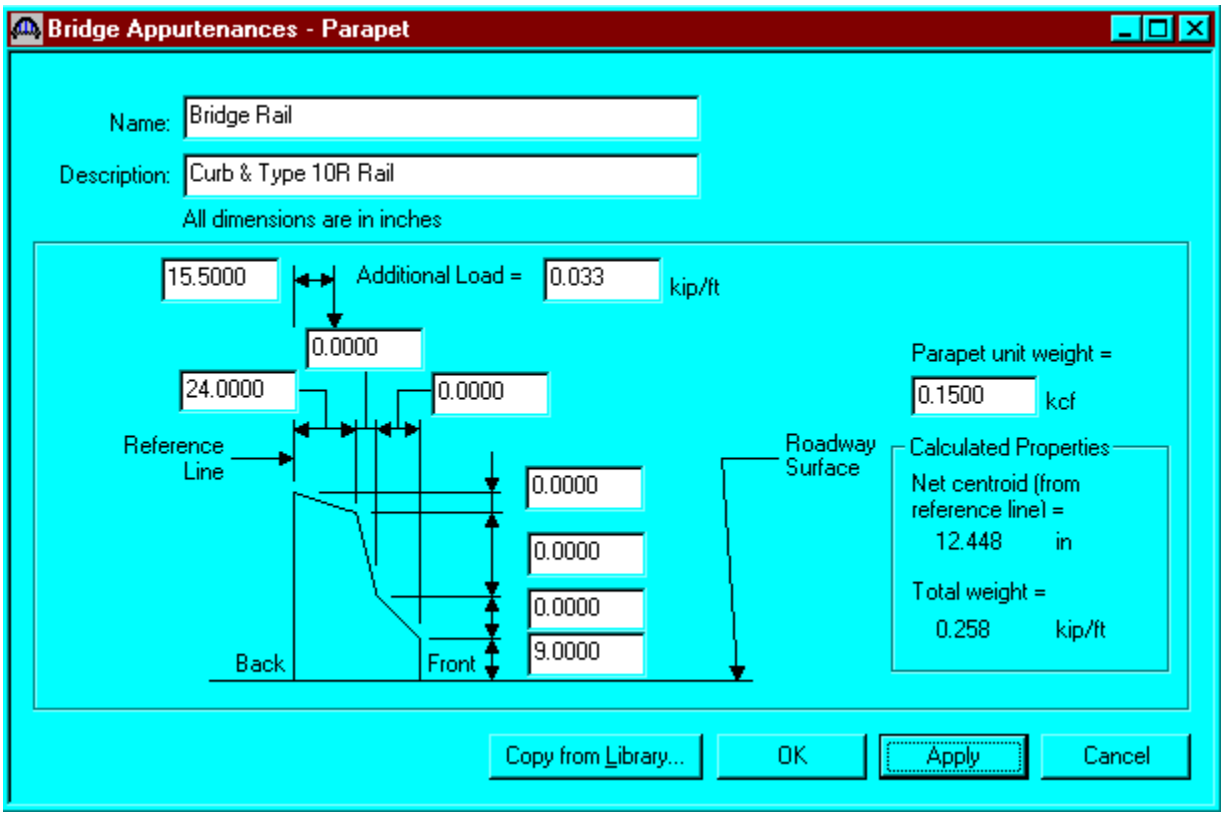
To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Concrete from the library. Click OK and the following window will open. Click OK to save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



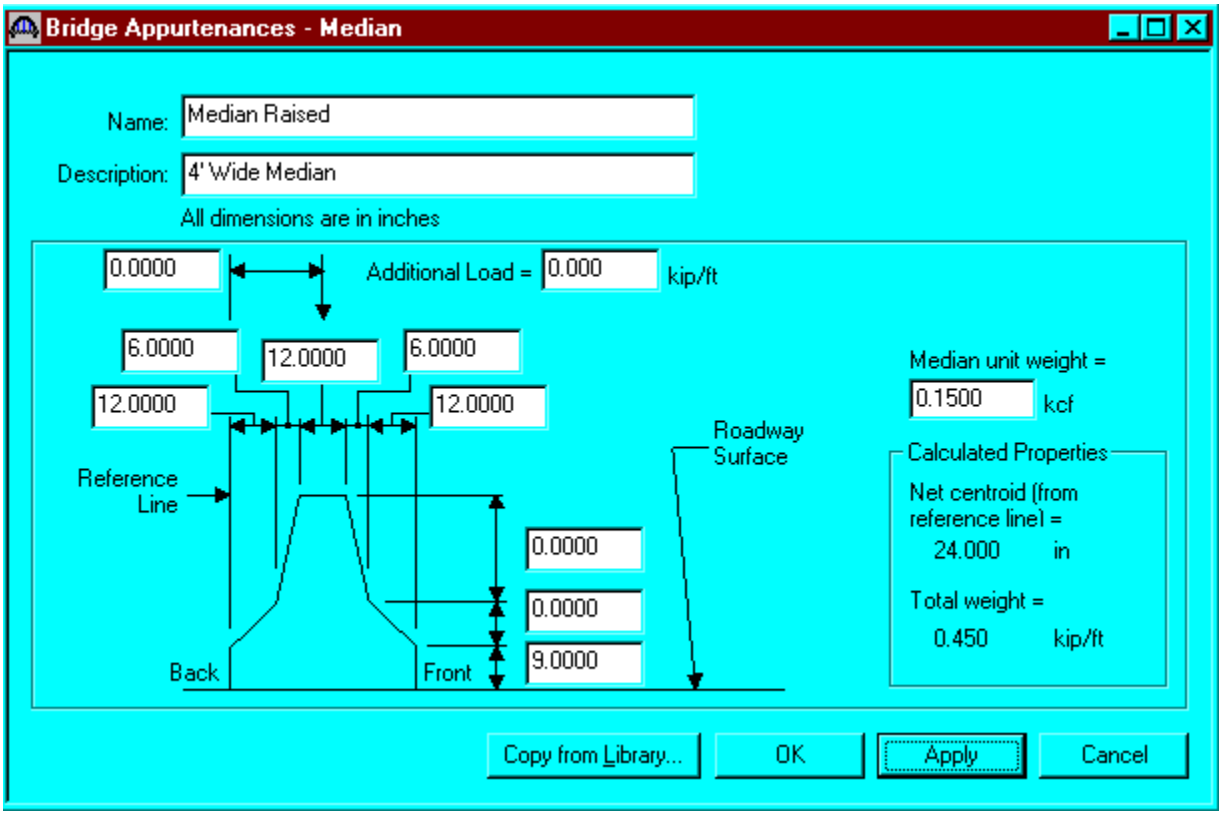
Using the same techniques, create the following Reinforcing Steel Material to be used for the girder.



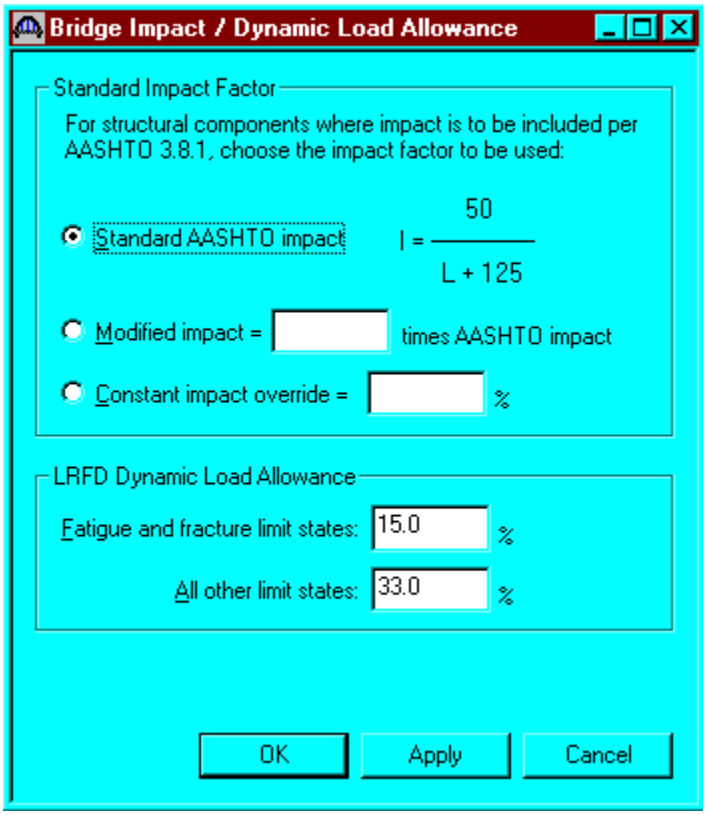
To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, and select New. Fill in the parapet properties as required. Click OK to save the data to memory and close the window.



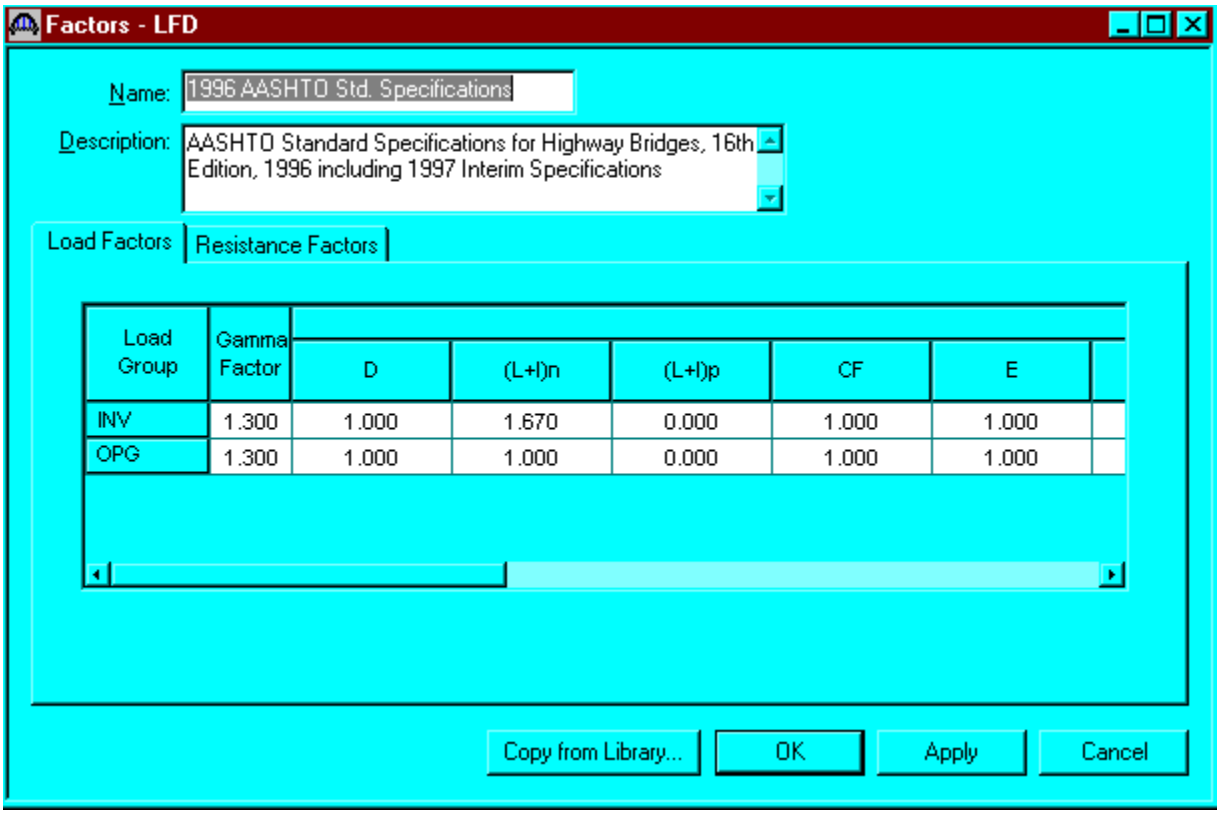
Right mouse click on Median in the tree, and select New. Fill in the median properties as required. Click OK to save the data to memory and close the window.



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.

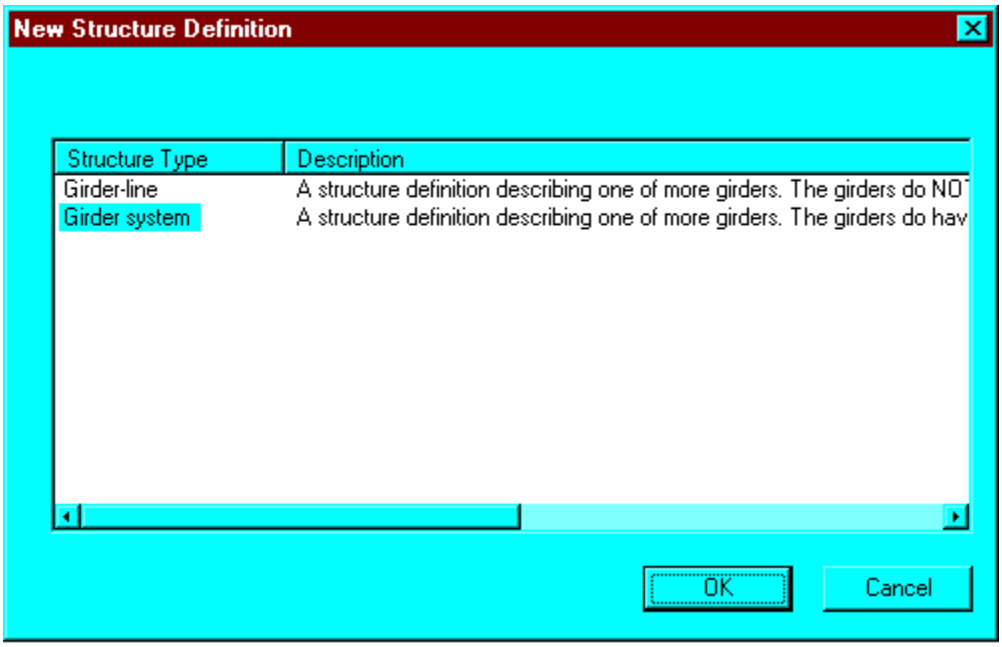


Click on Factors, right mouse click on LFD and select New. The LFD-Factors window will open. Click the Copy from Library button and select the 1996 AASHTO Standard Specifications from the library. Click Apply and then OK to save data to memory and close the window.

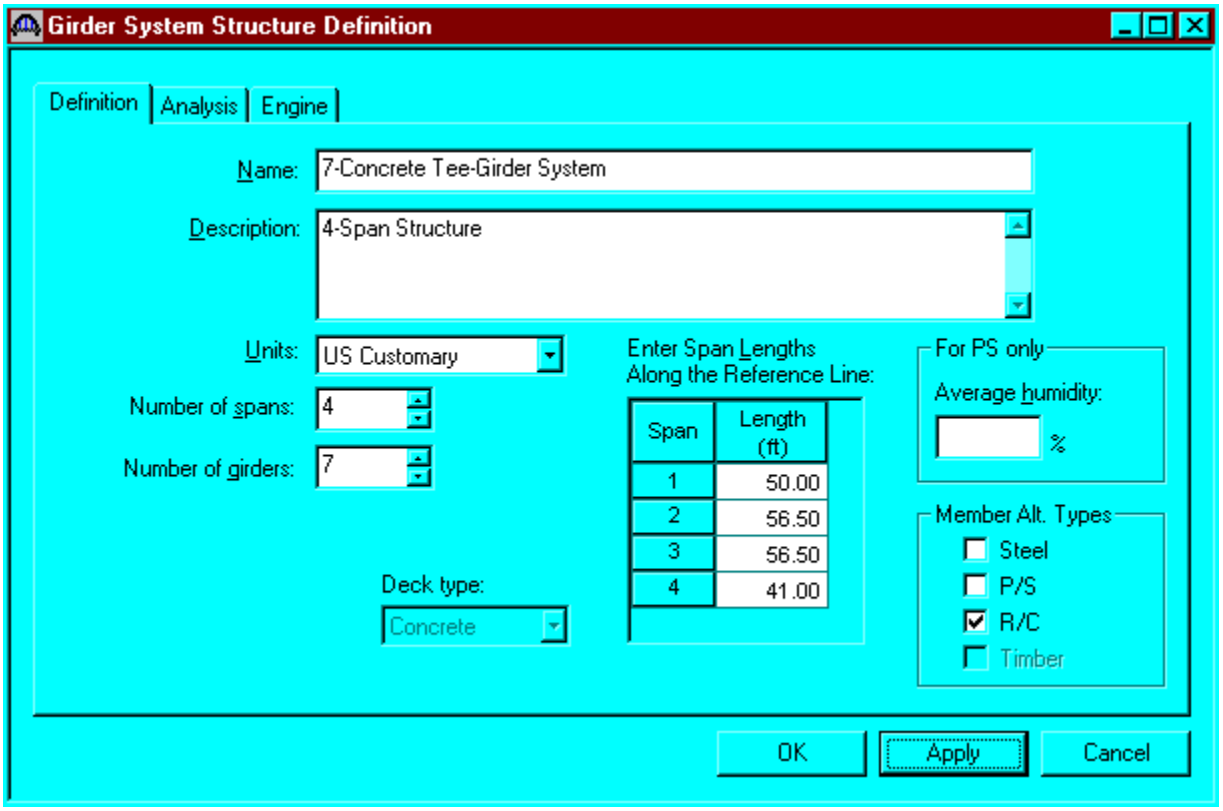


We will now skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

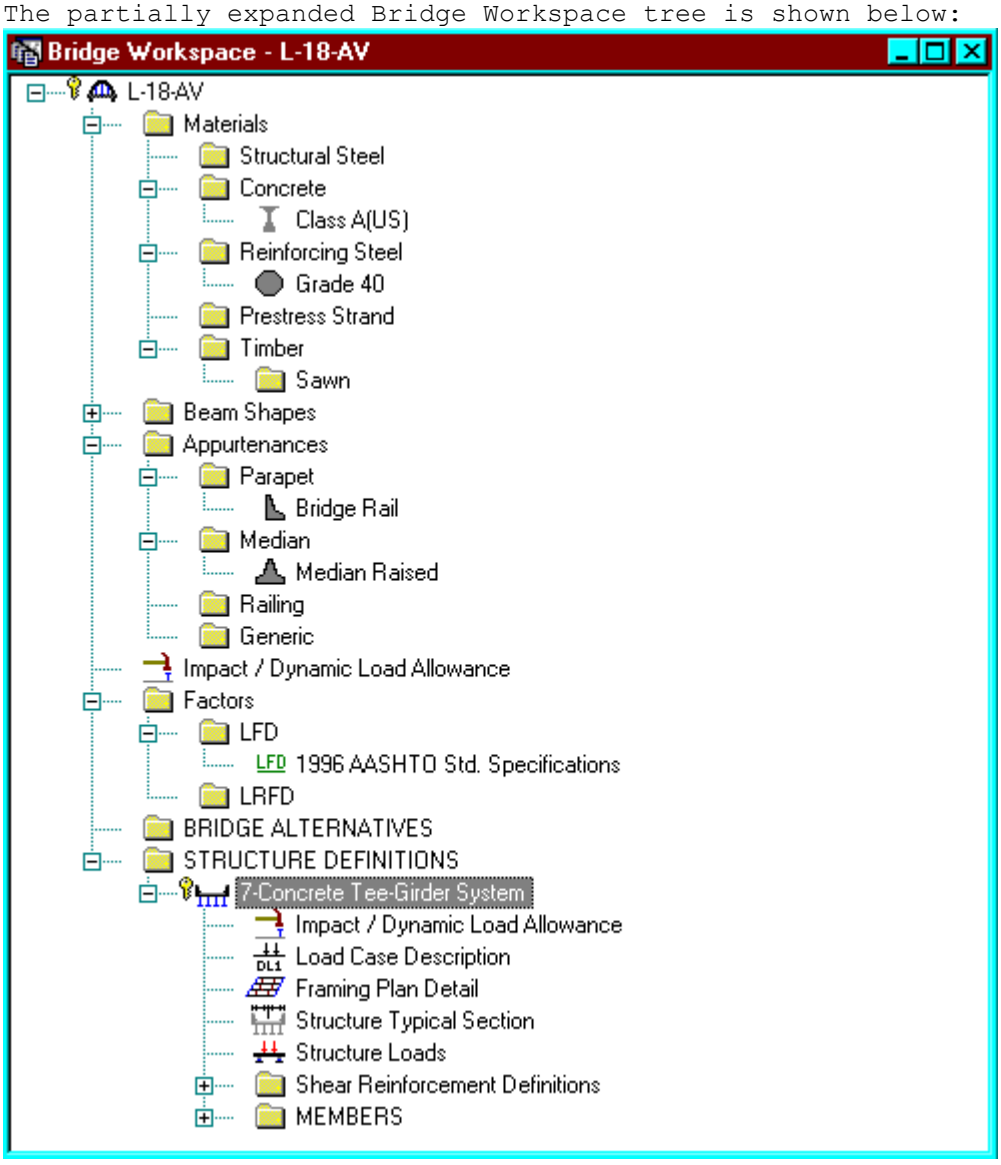
Double click on STRUCTURE DEFINITION (or click on STRUCTURE DEFINITION and select File/New from the menu or right mouse click on STRUCTURE DEFINITION and select New from the popup menu) to create a new structure definition. The following dialog box will appear.



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.

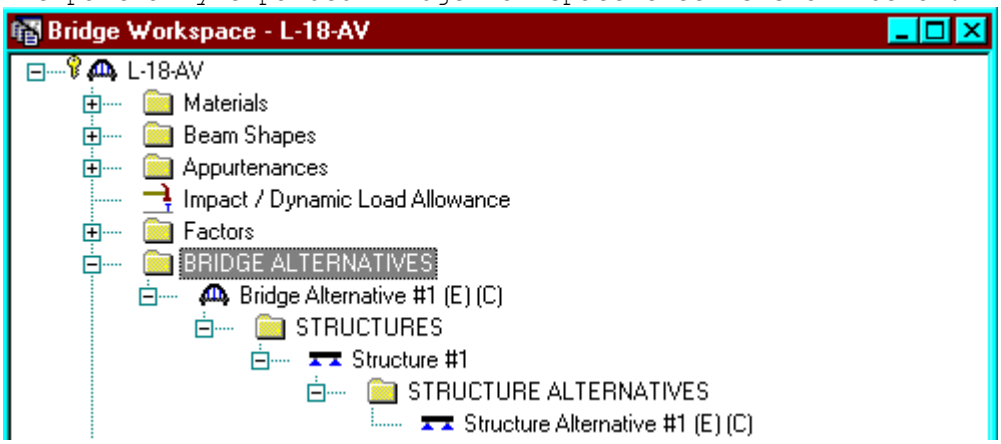


The partially expanded Bridge Workspace tree is shown below:

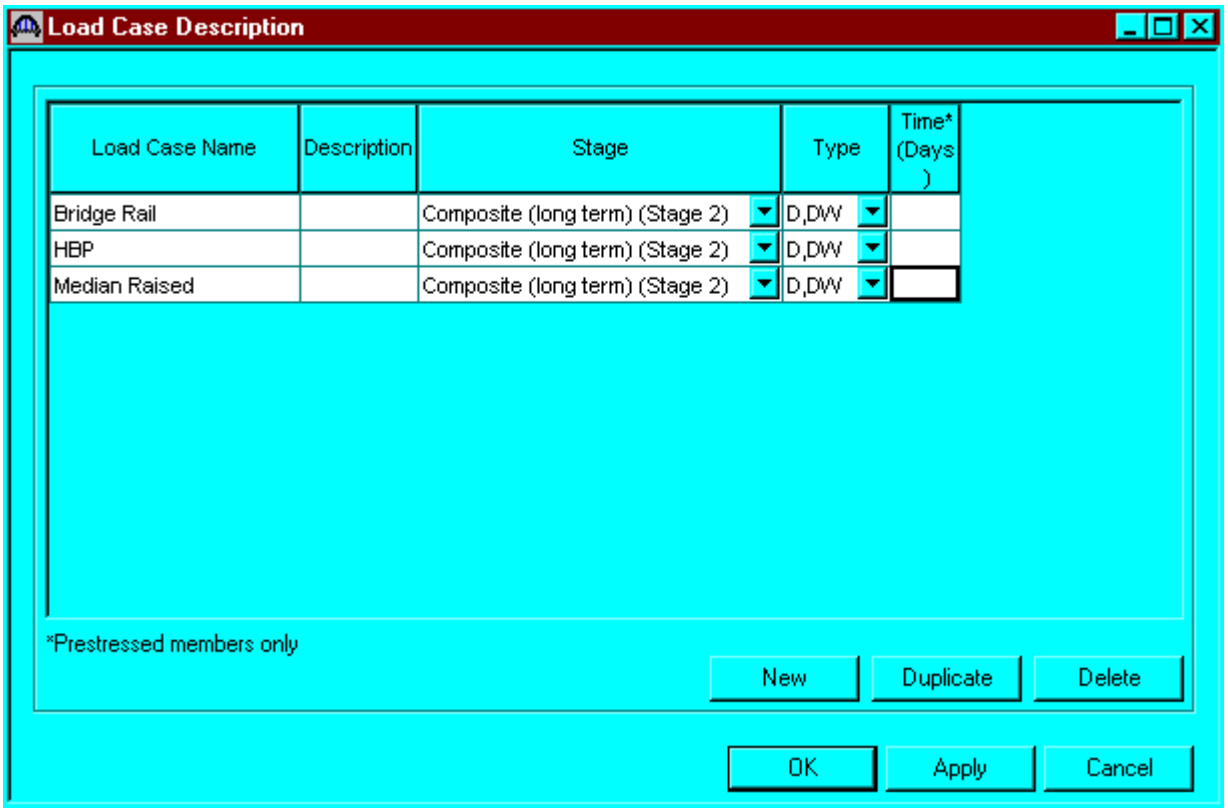


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

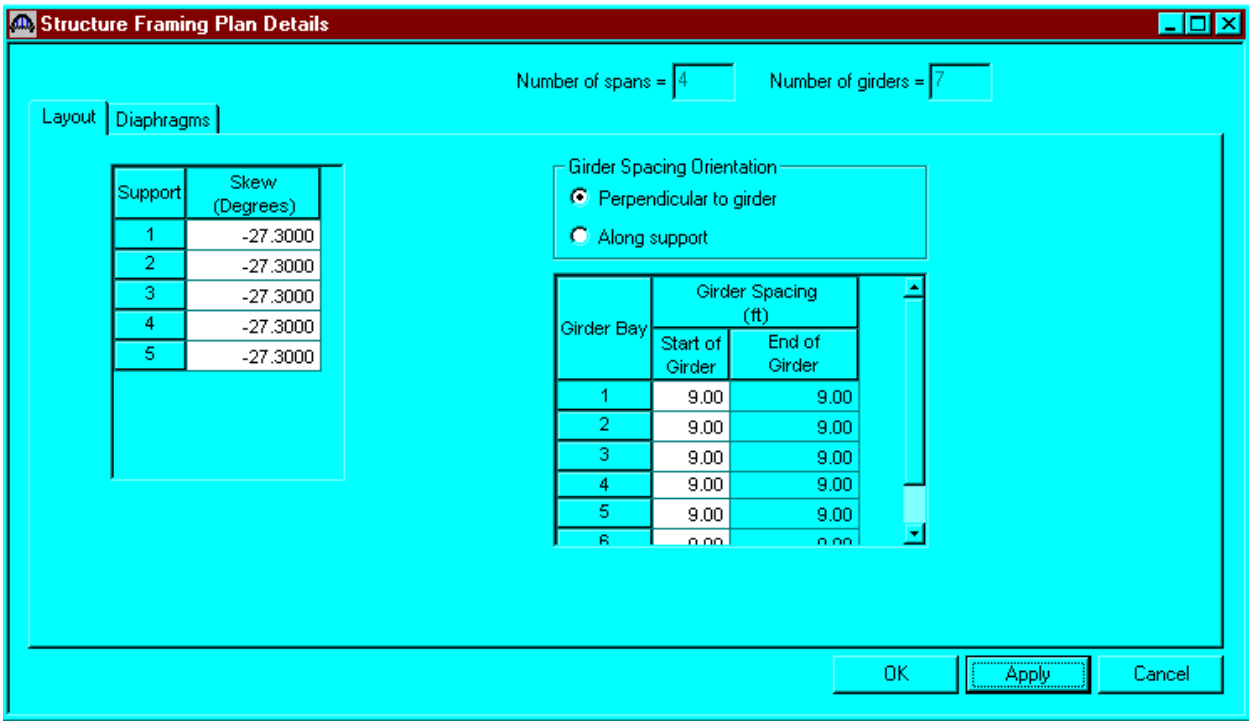
The partially expanded Bridge Workspace tree is shown below:



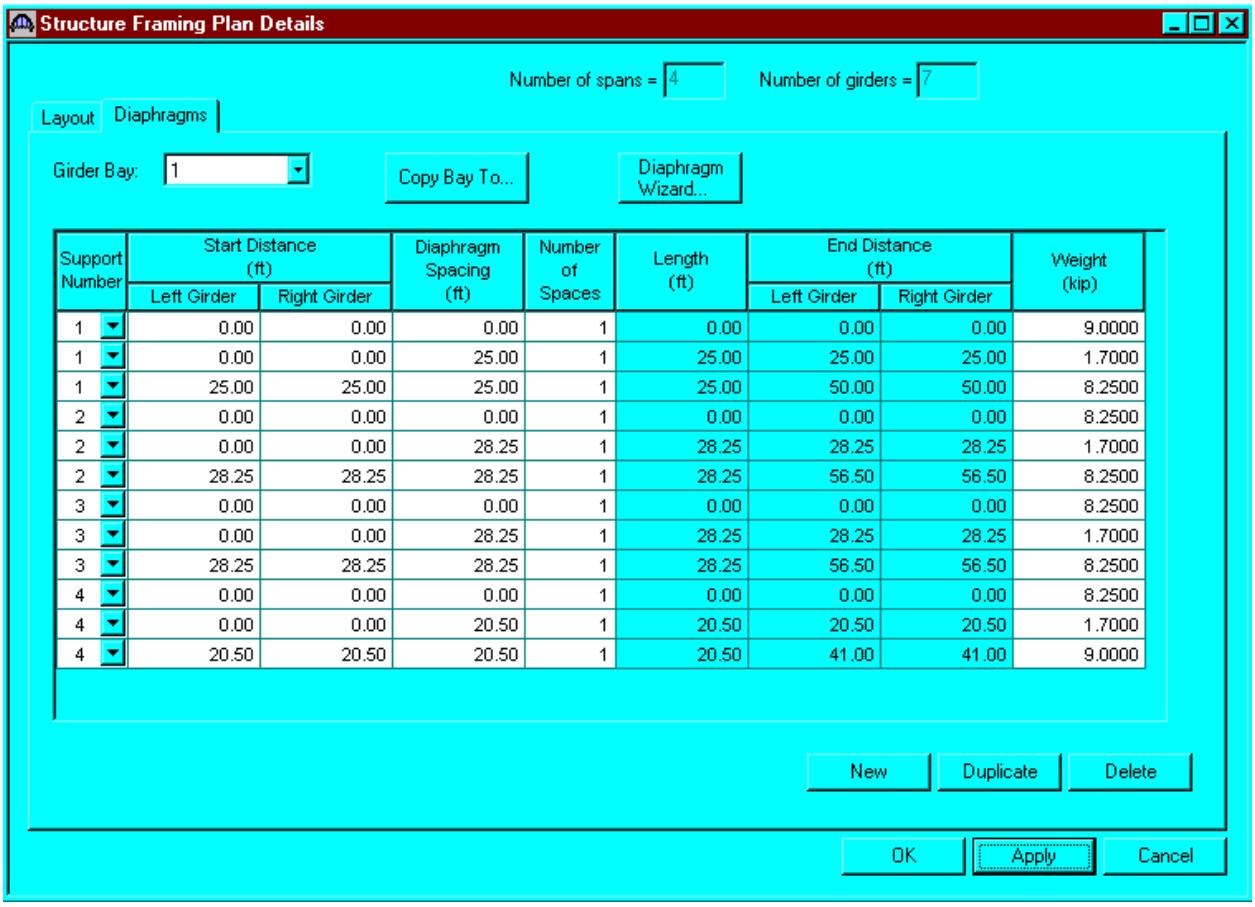
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed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



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

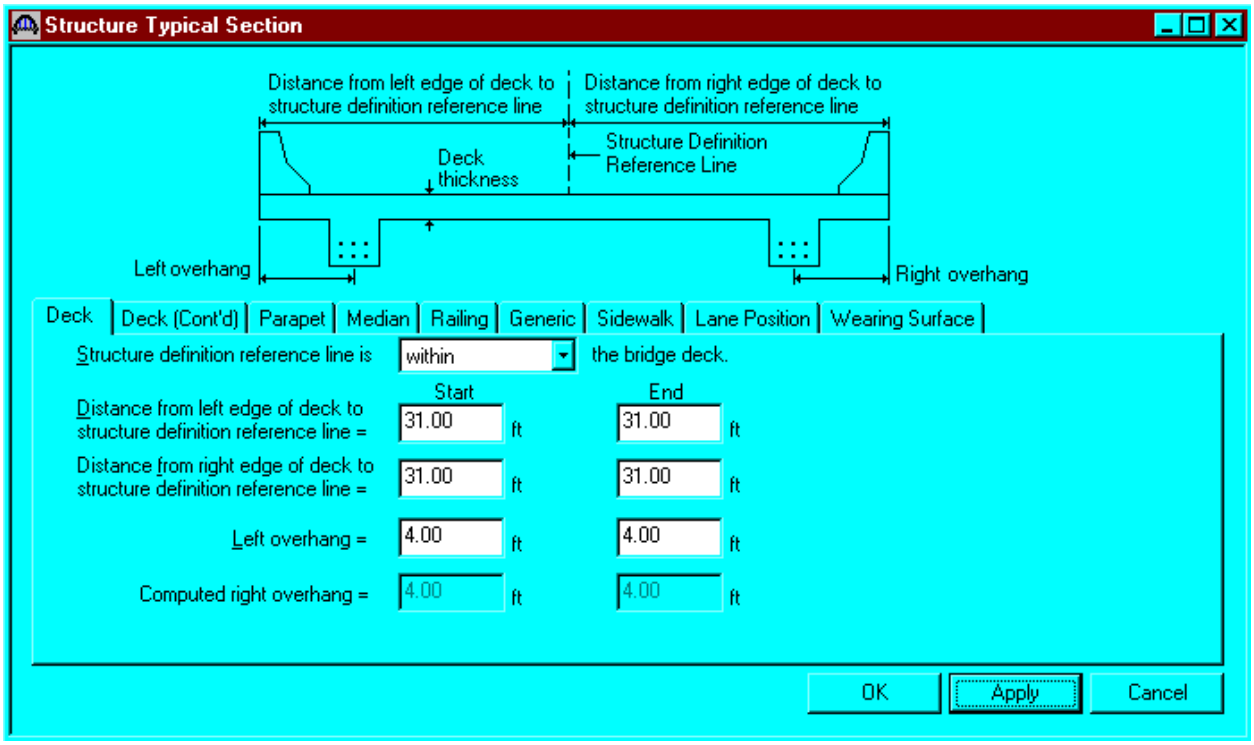


If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

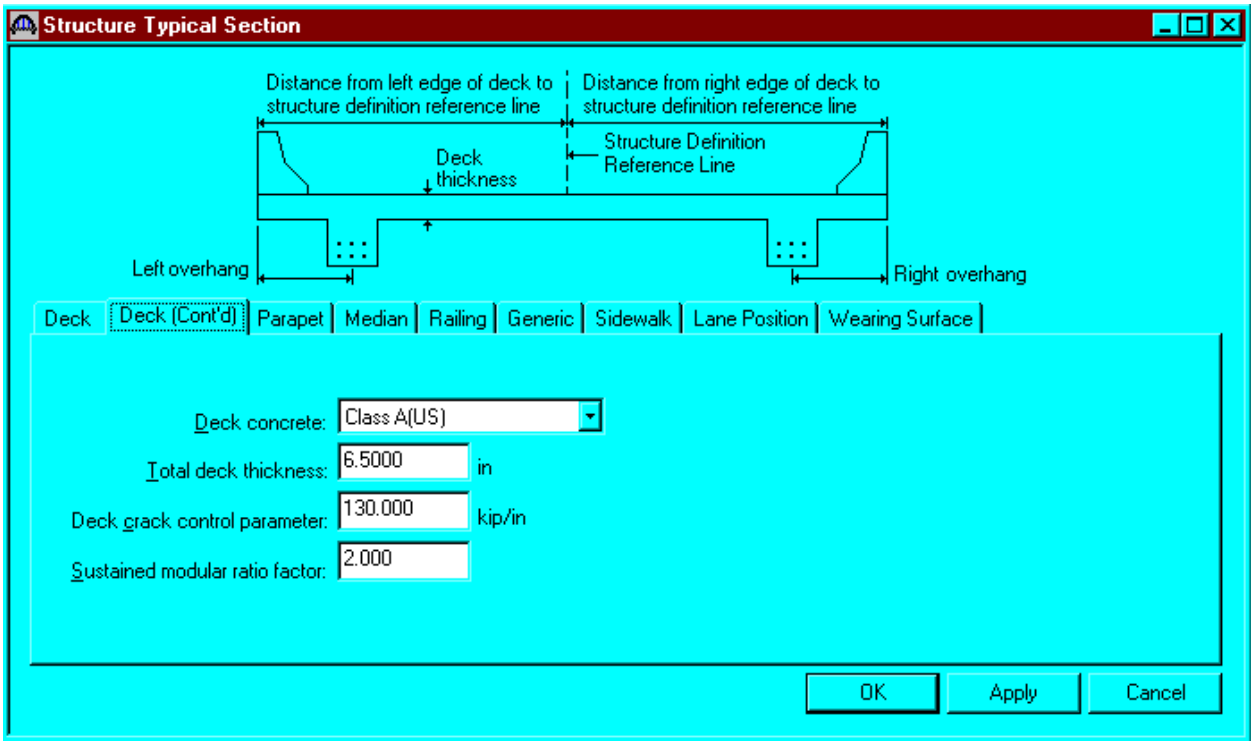


Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Weight (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	9.0000
1	0.00	0.00	25.00	1	25.00	25.00	25.00	1.7000
1	25.00	25.00	25.00	1	25.00	50.00	50.00	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

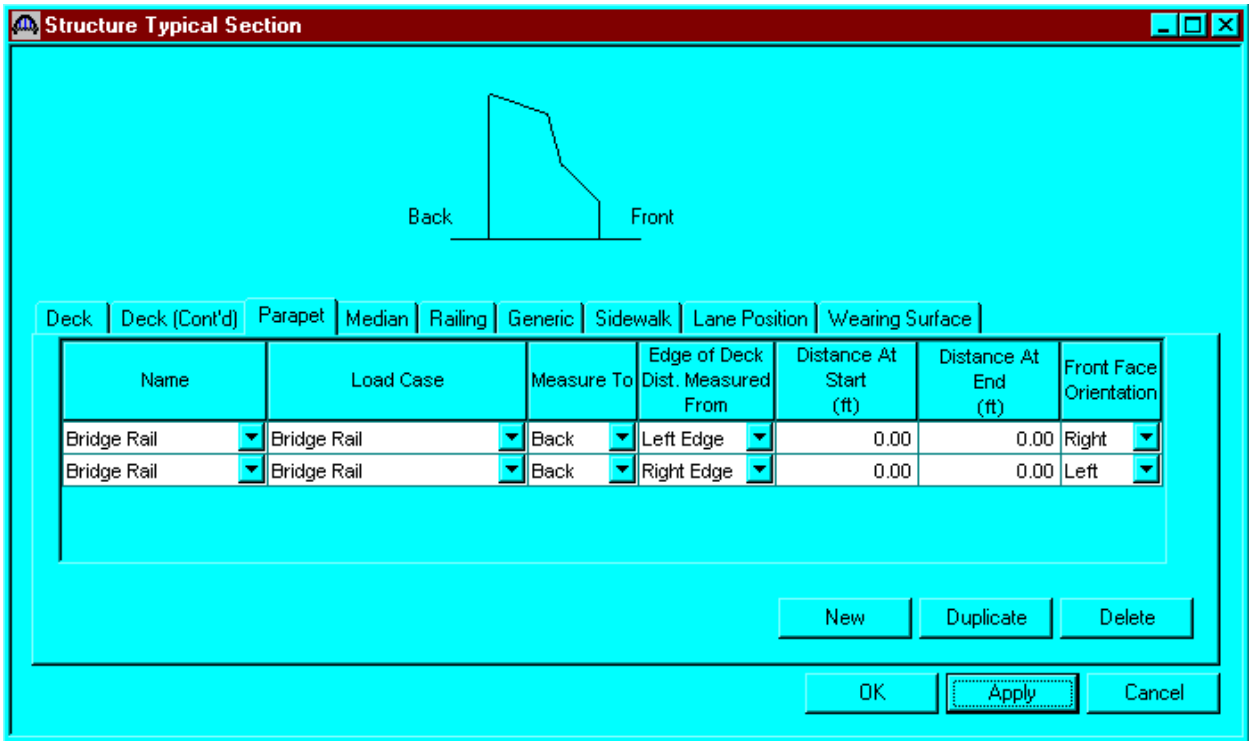
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



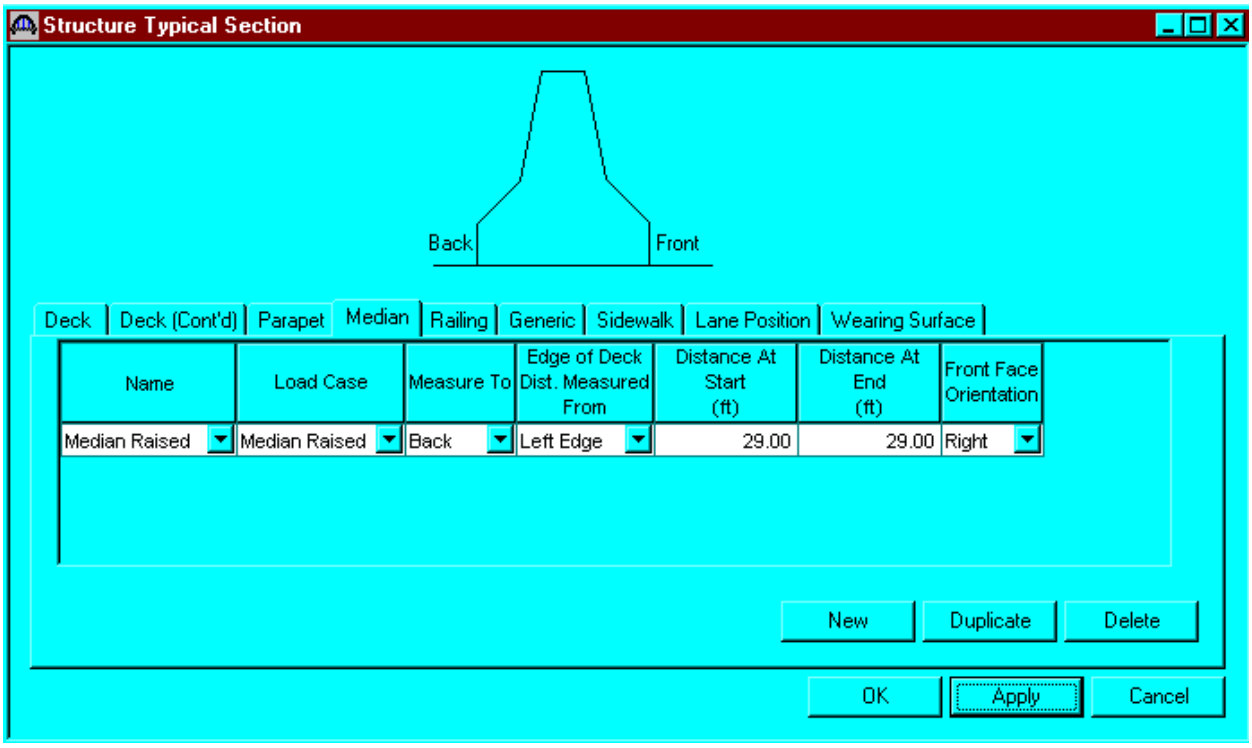
The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



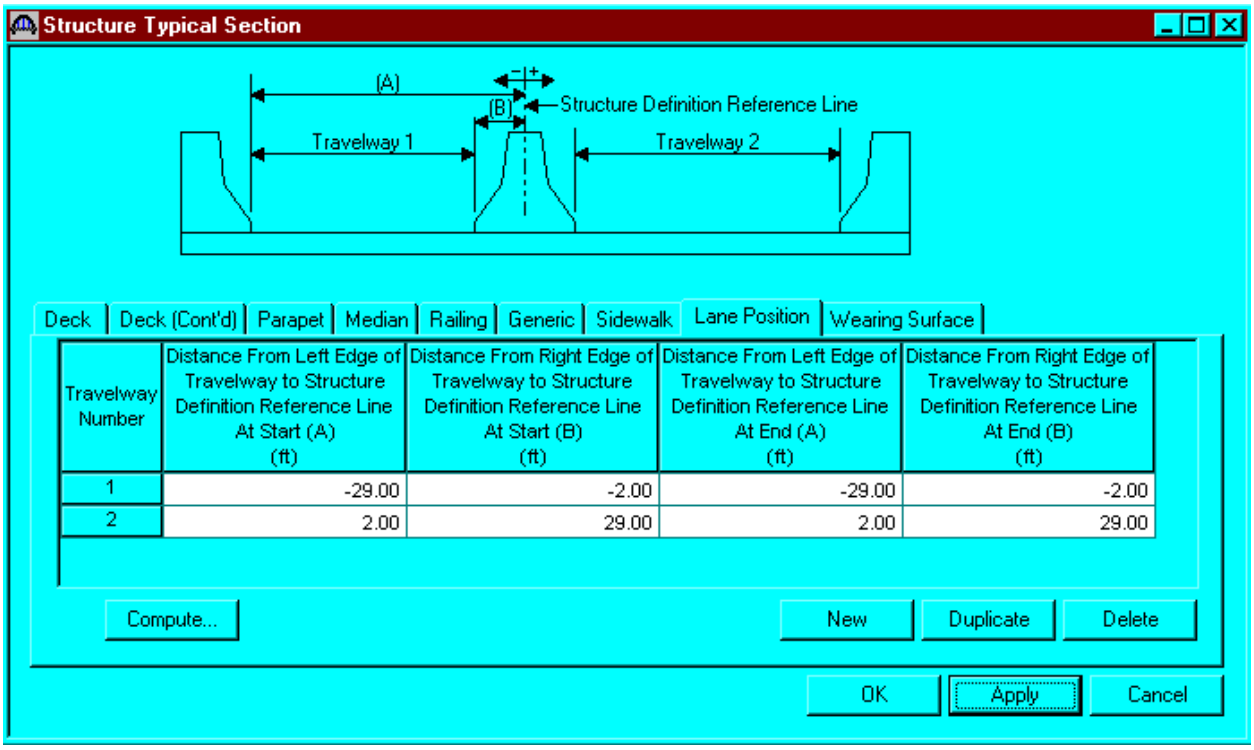
Parapets:
Add two parapets as shown below.



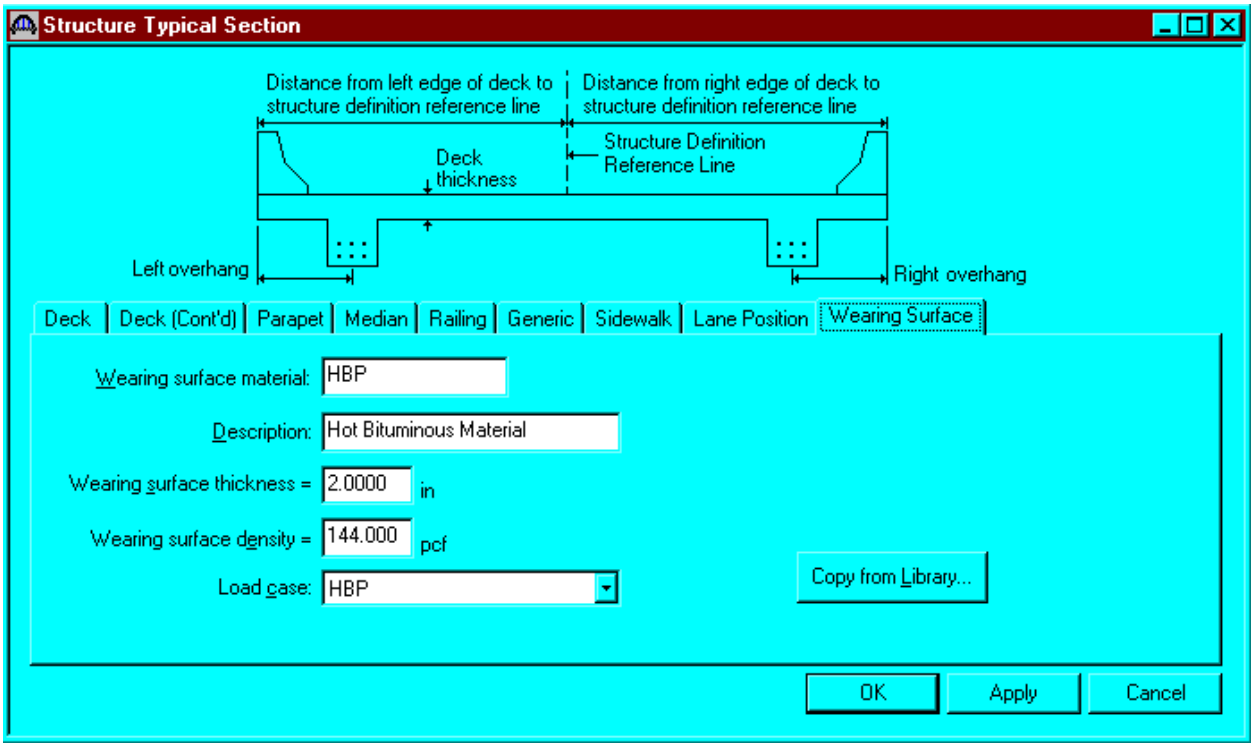
Median:
Add one median as shown below.



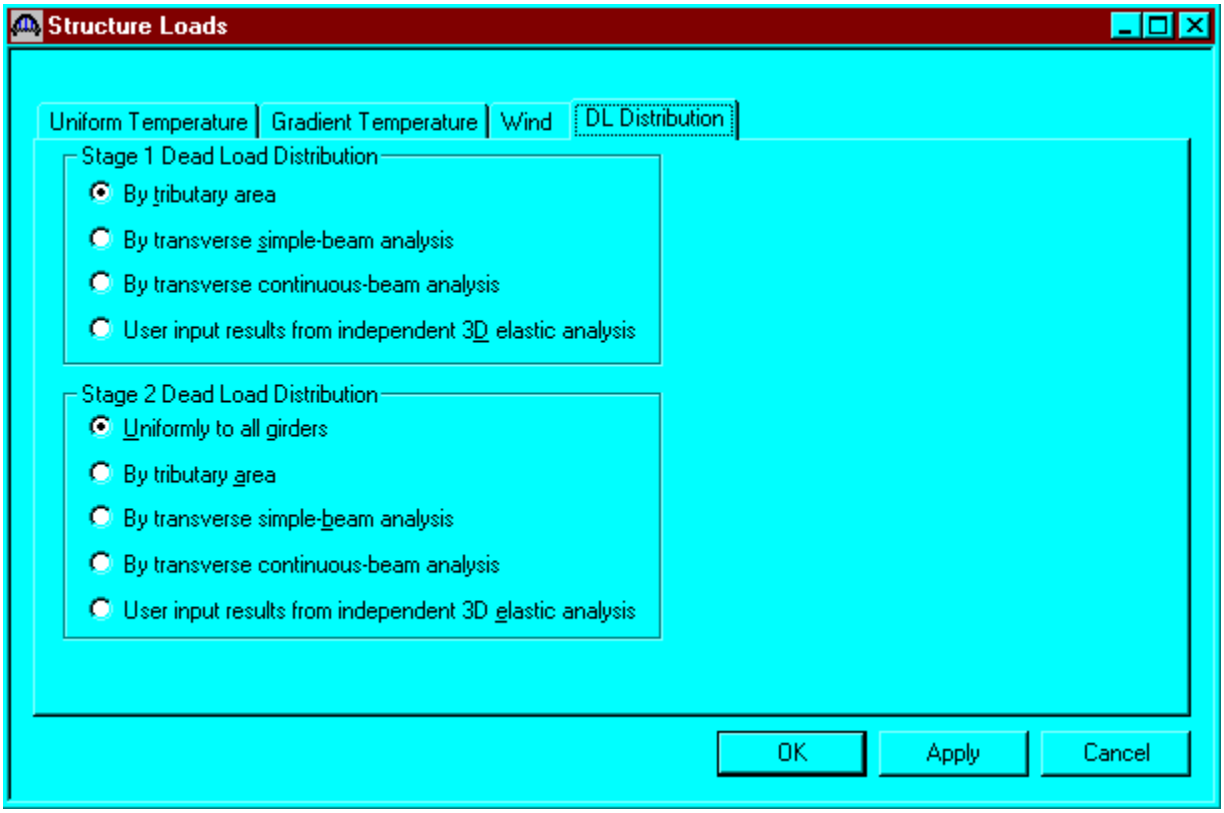
Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to apply the computed values. The Lane Position tab is populated as shown below.



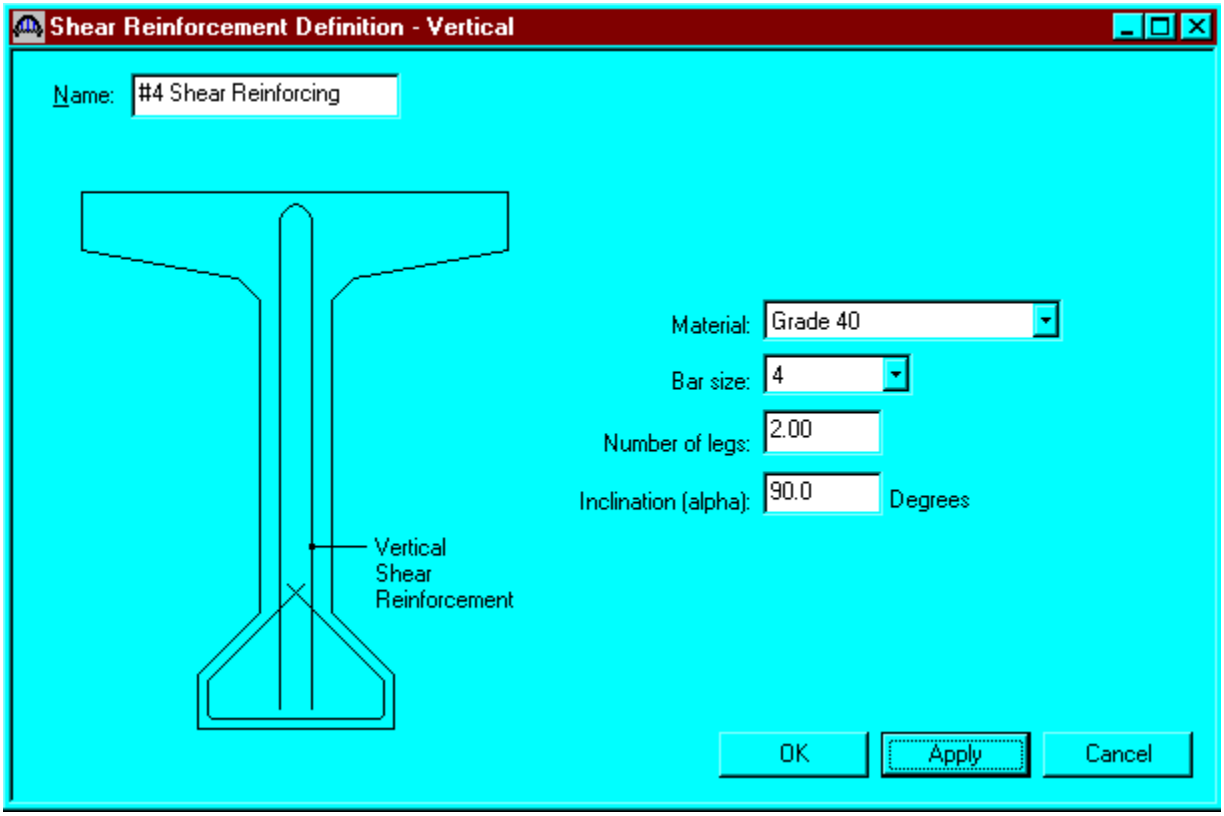
Enter the following wearing surface information on the Wearing Surface tab.



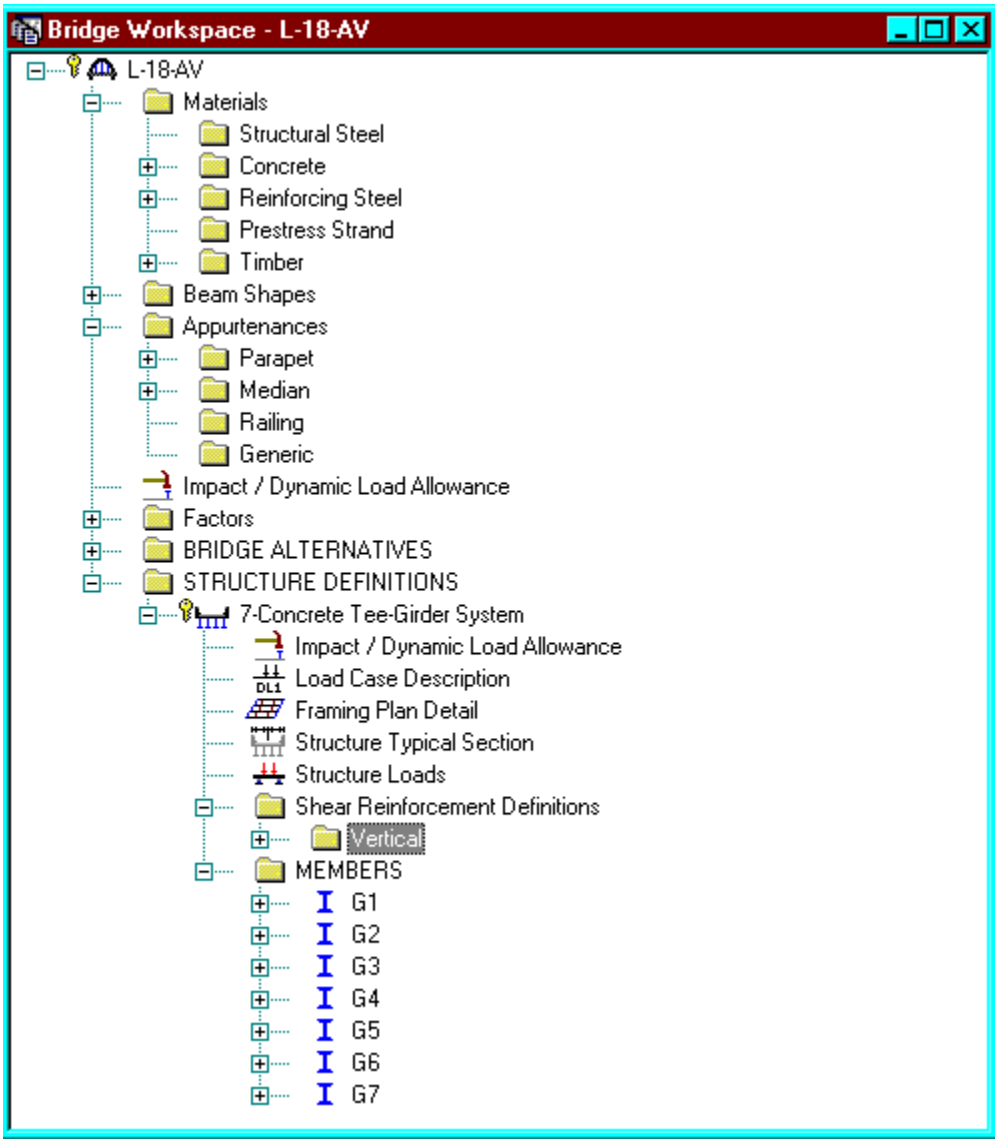
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



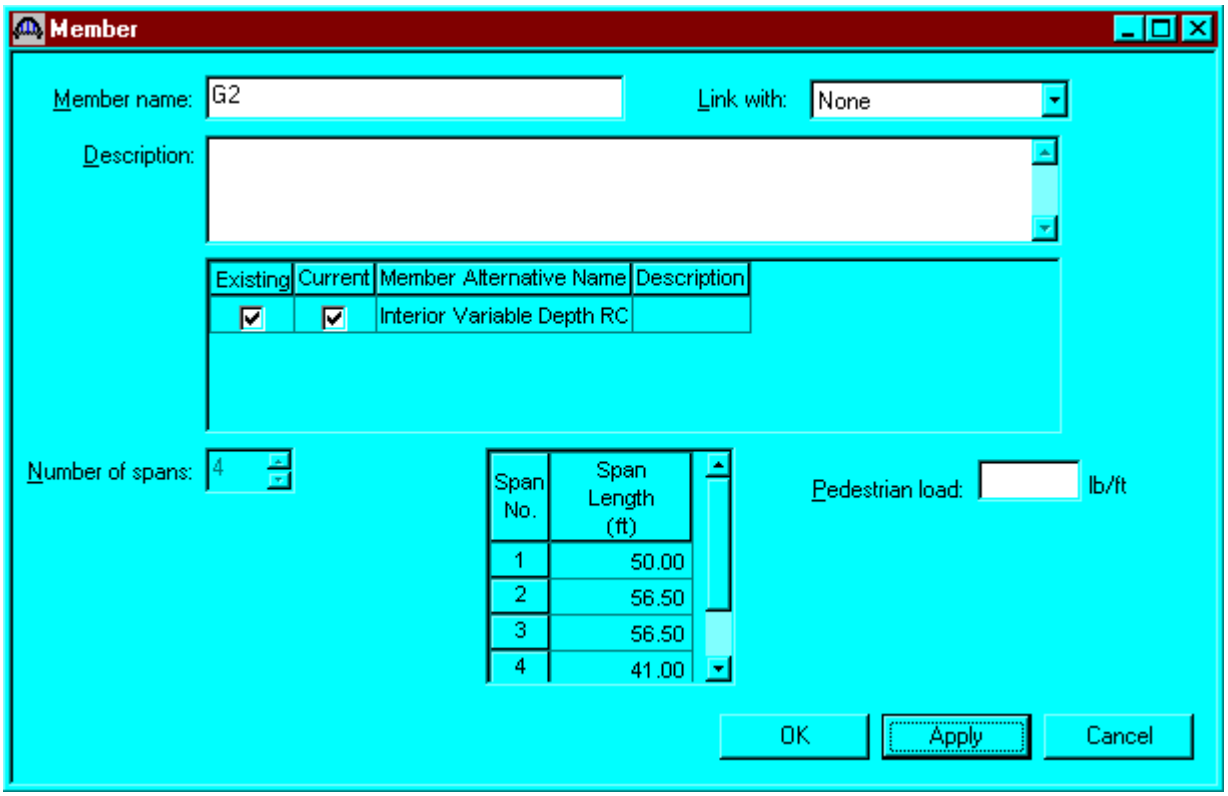
Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



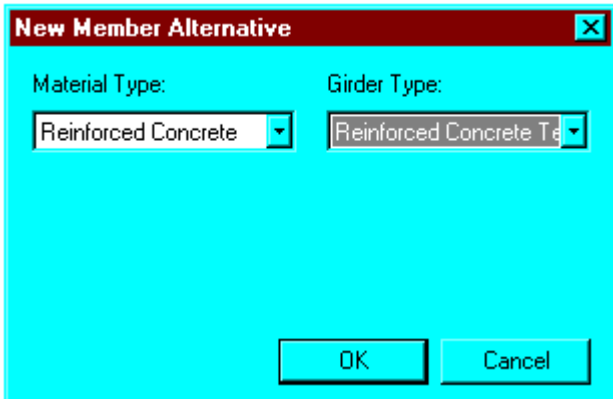
The partially expanded Bridge Workspace tree is shown below:



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.

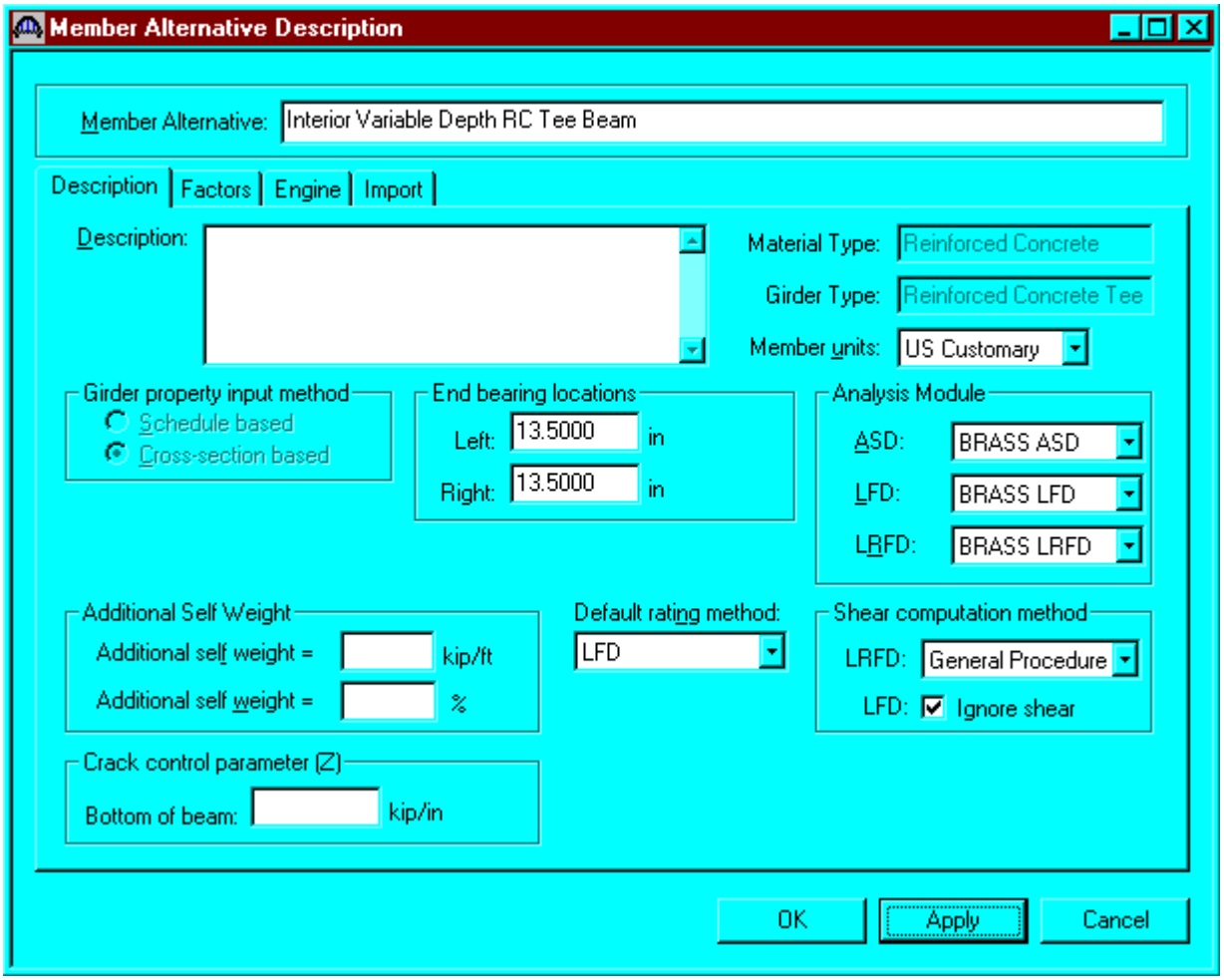


Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Reinforced Concrete for the Material Type and Reinforced Concrete Tee for the Girder Type.



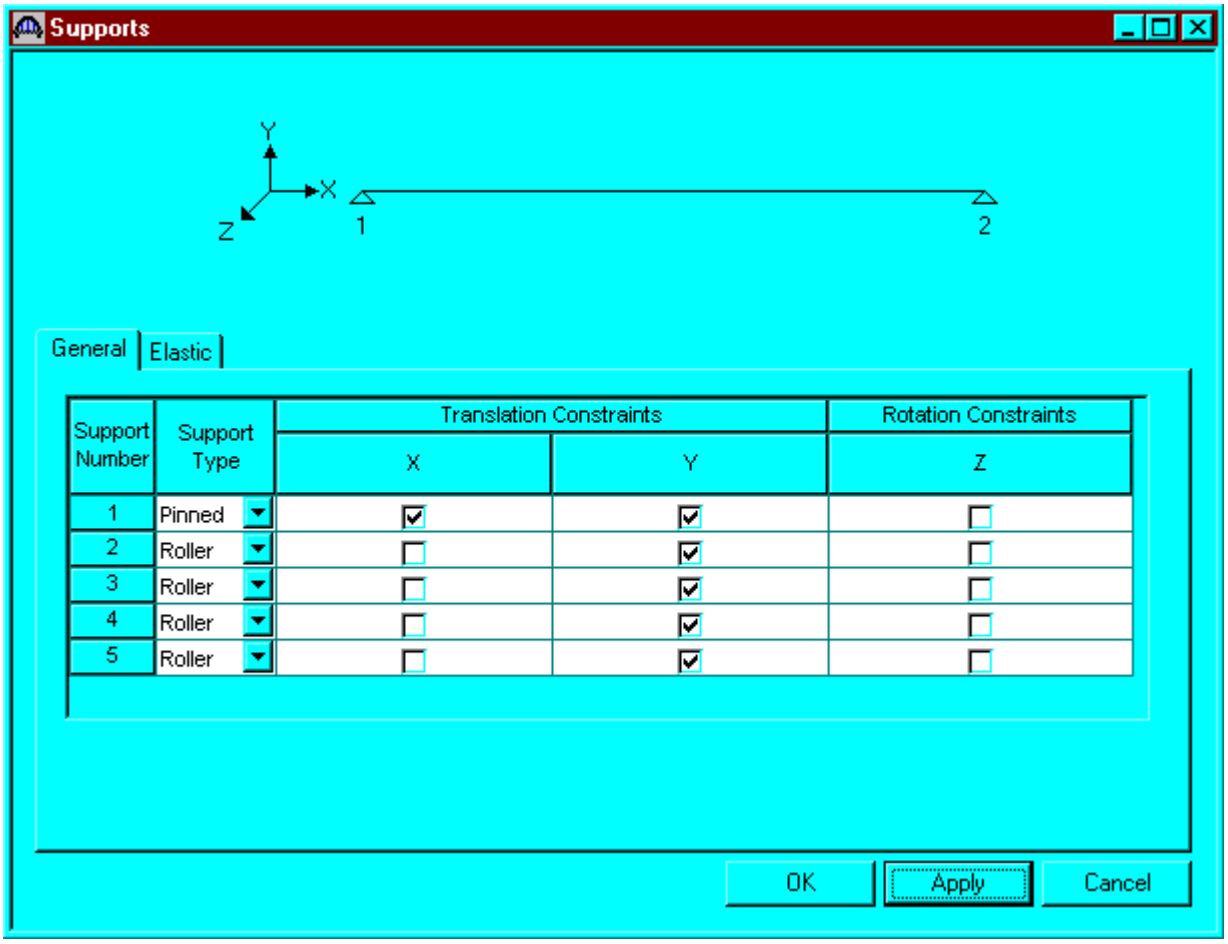
Click OK to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below.

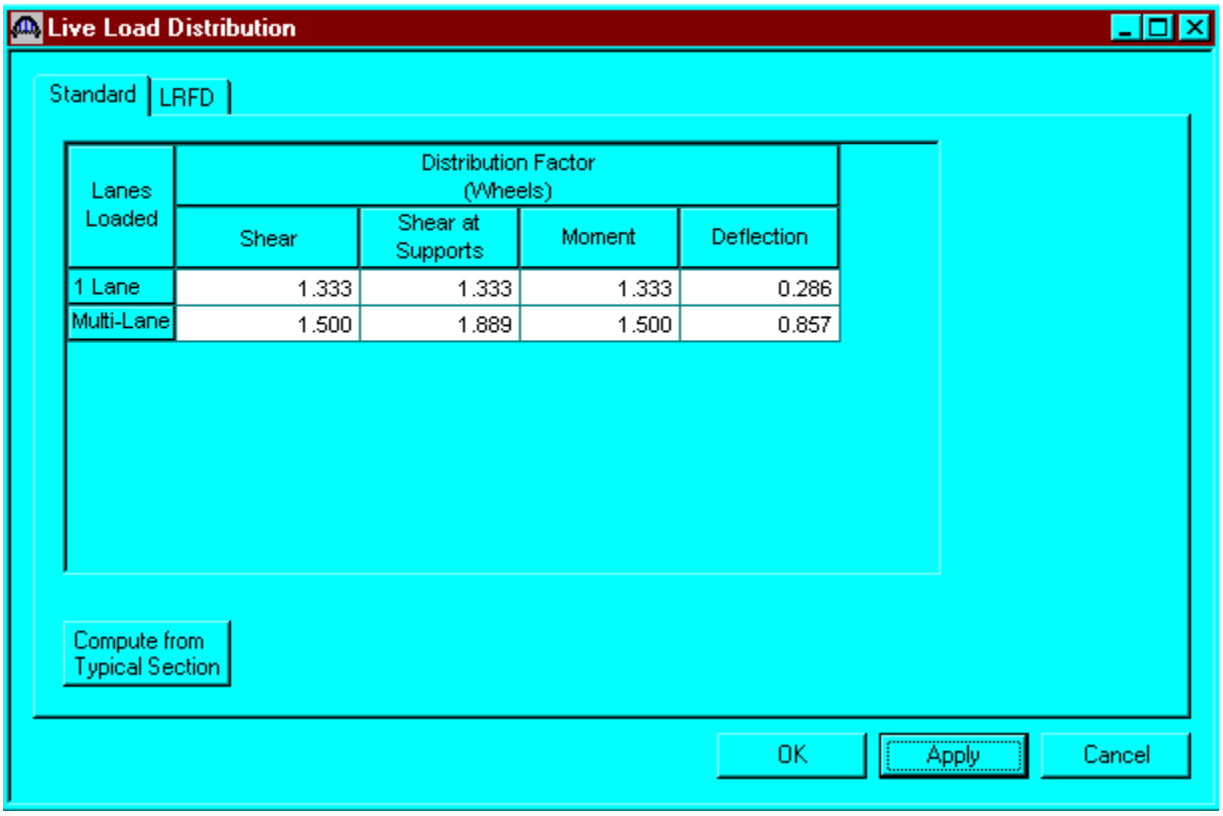


Shear computation method: Check this box if the AASHTO LFD shear specifications should be ignored in the analysis.

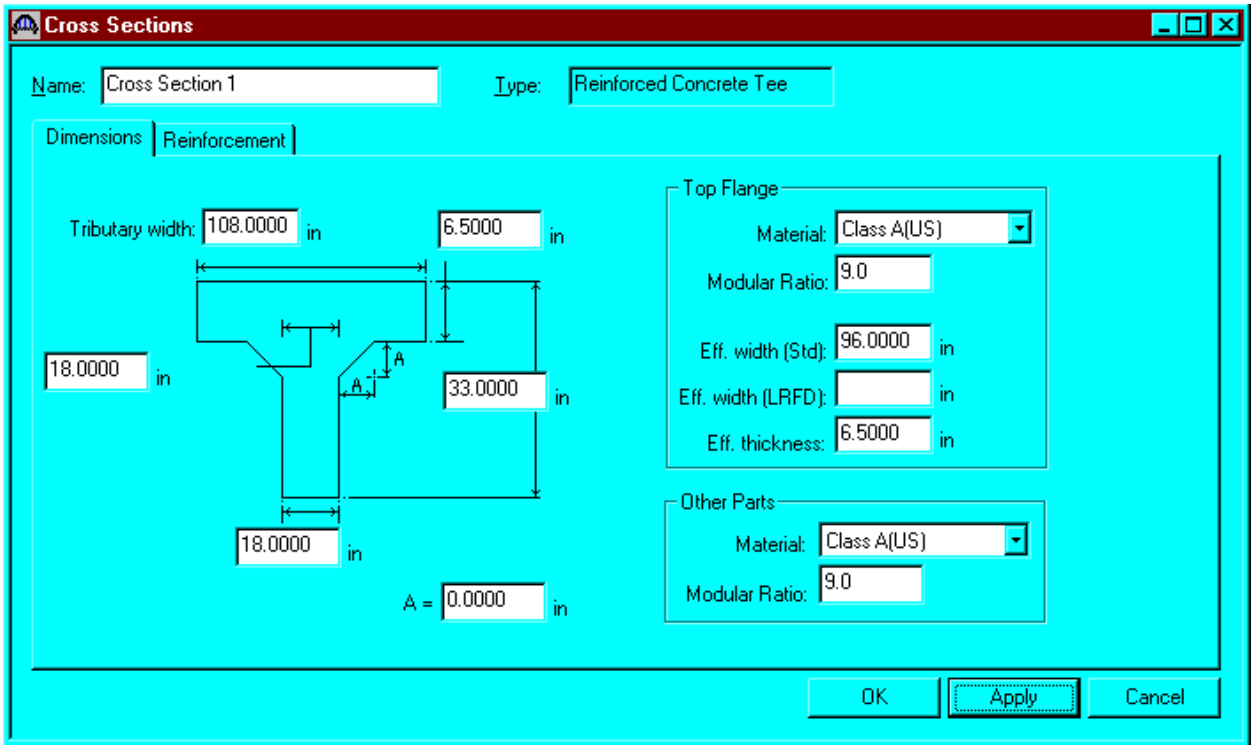
Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



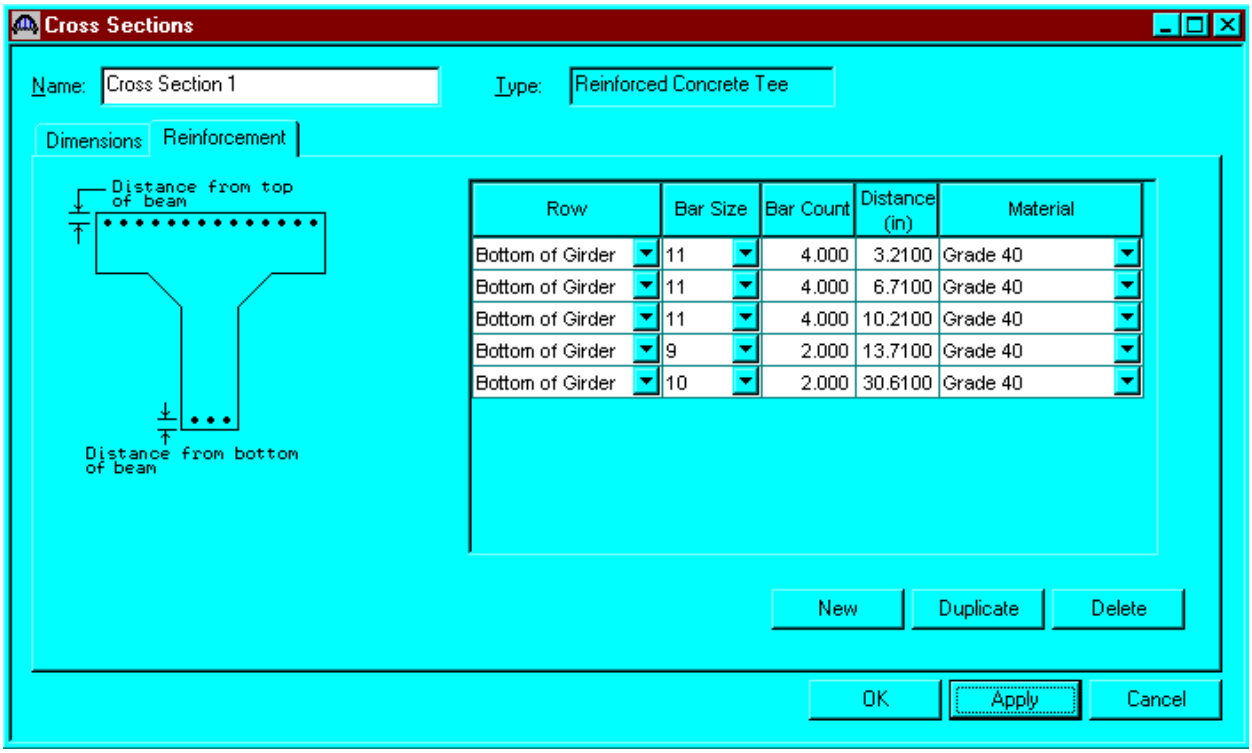
Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23. Click Apply and then OK to save data to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



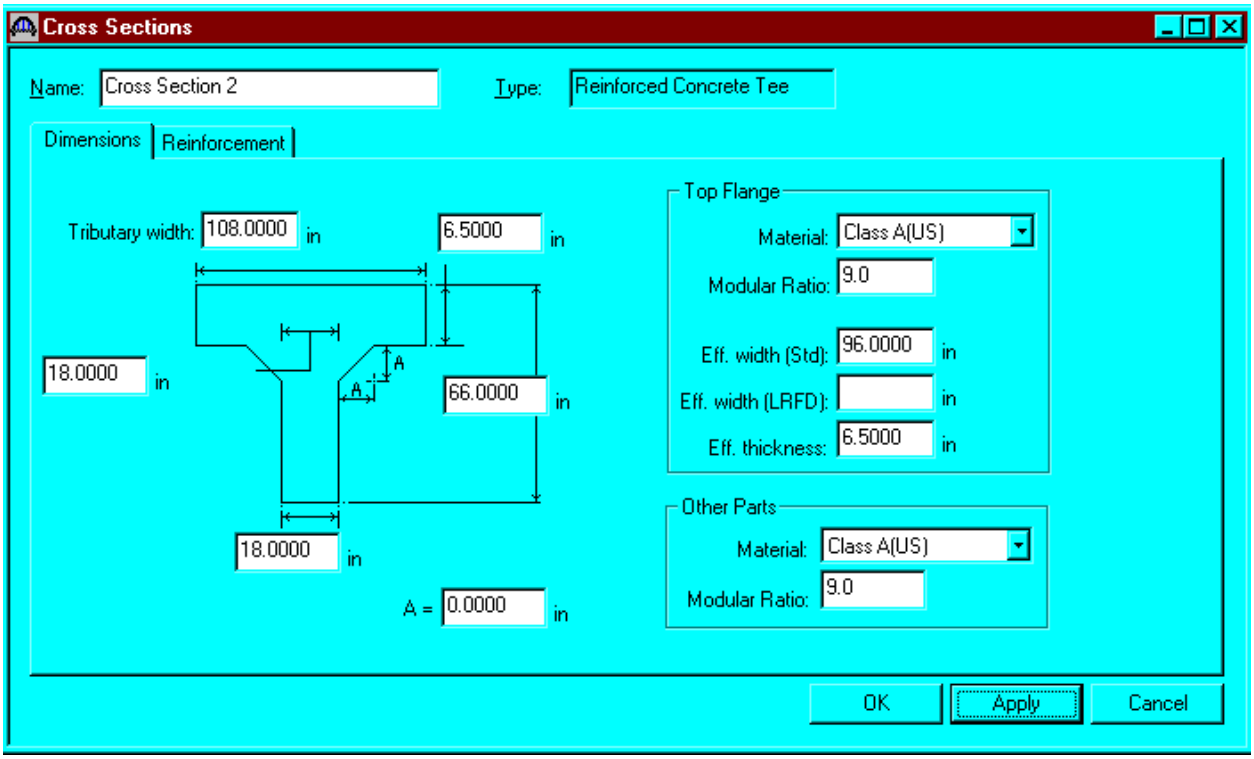
Double click on Cross Sections in the tree to create the cross section that defines the girder geometry. The Cross Section window is shown below. Define cross section 1 as shown below. Click apply and then the Reinforcement tab.

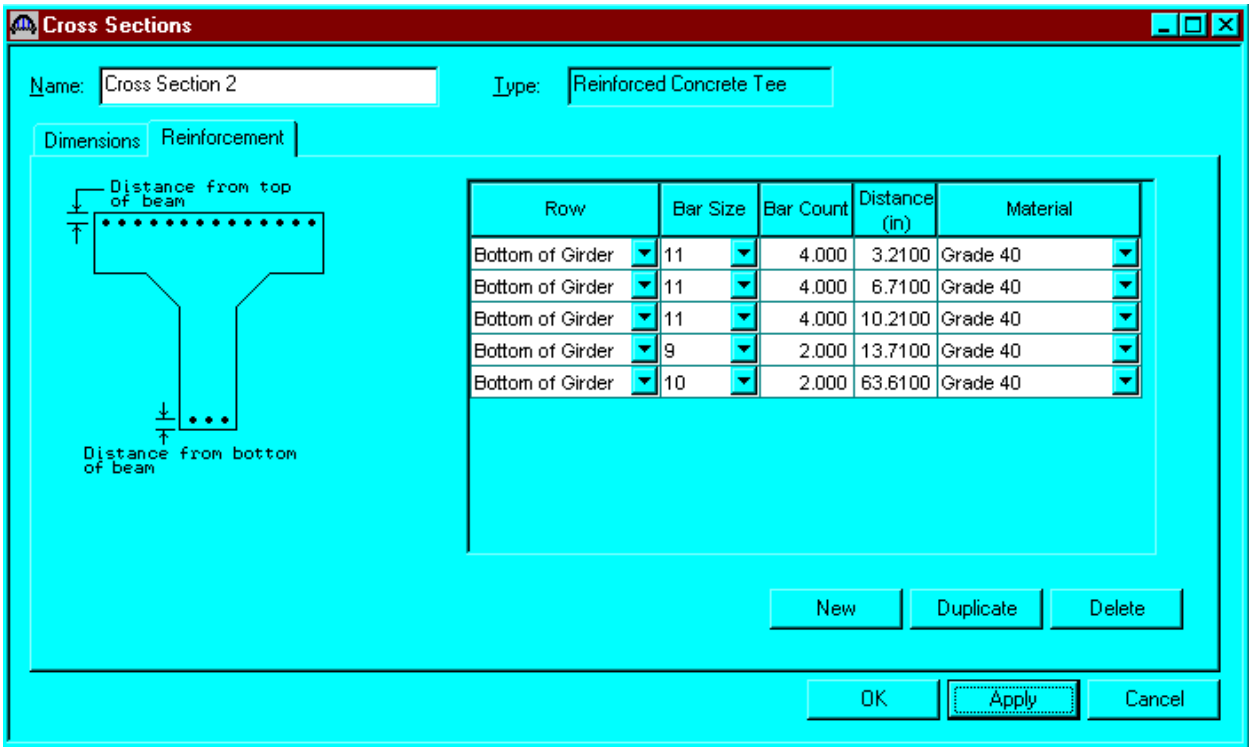


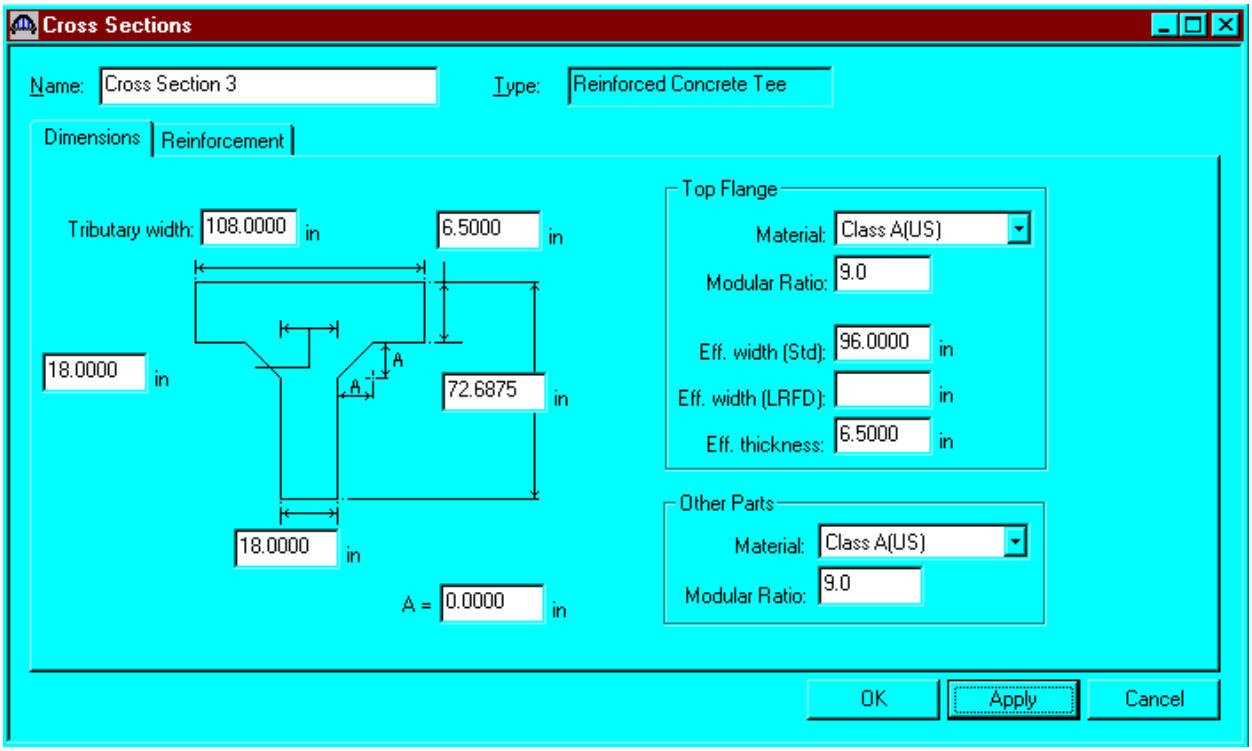
Define reinforcements for Cross Section 1. Click OK to save data to memory and close the window.

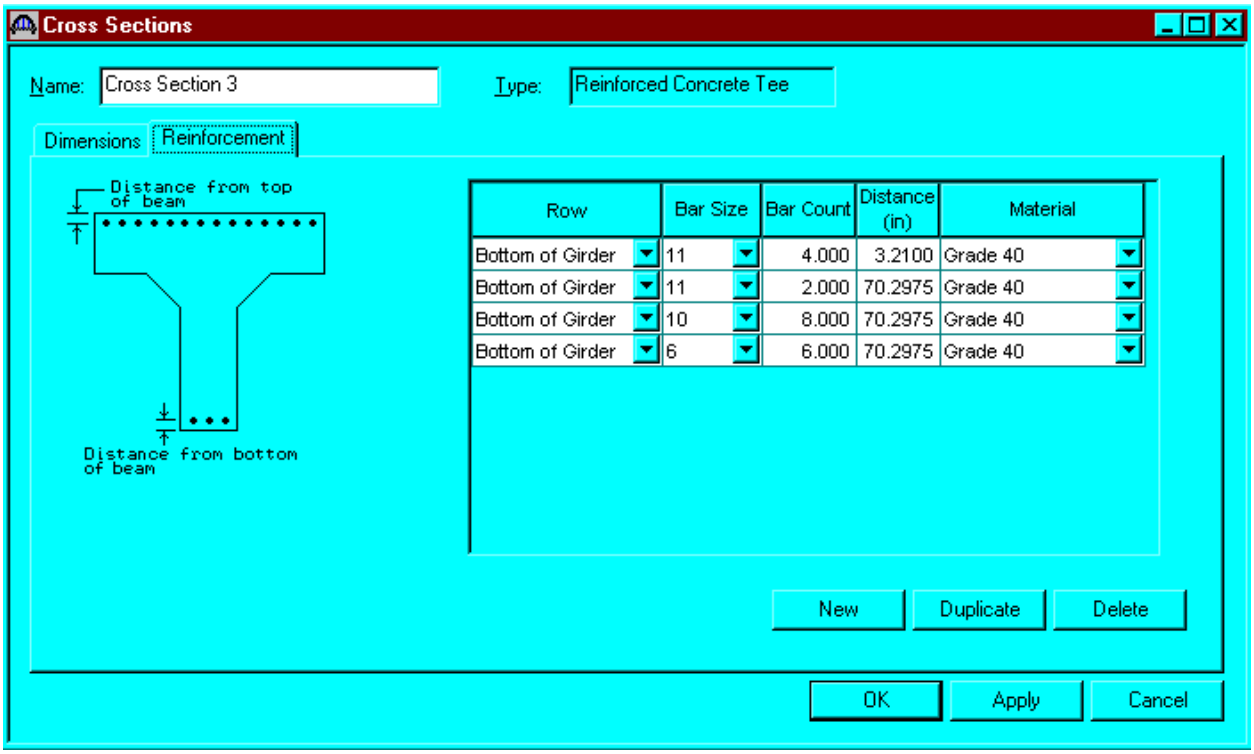


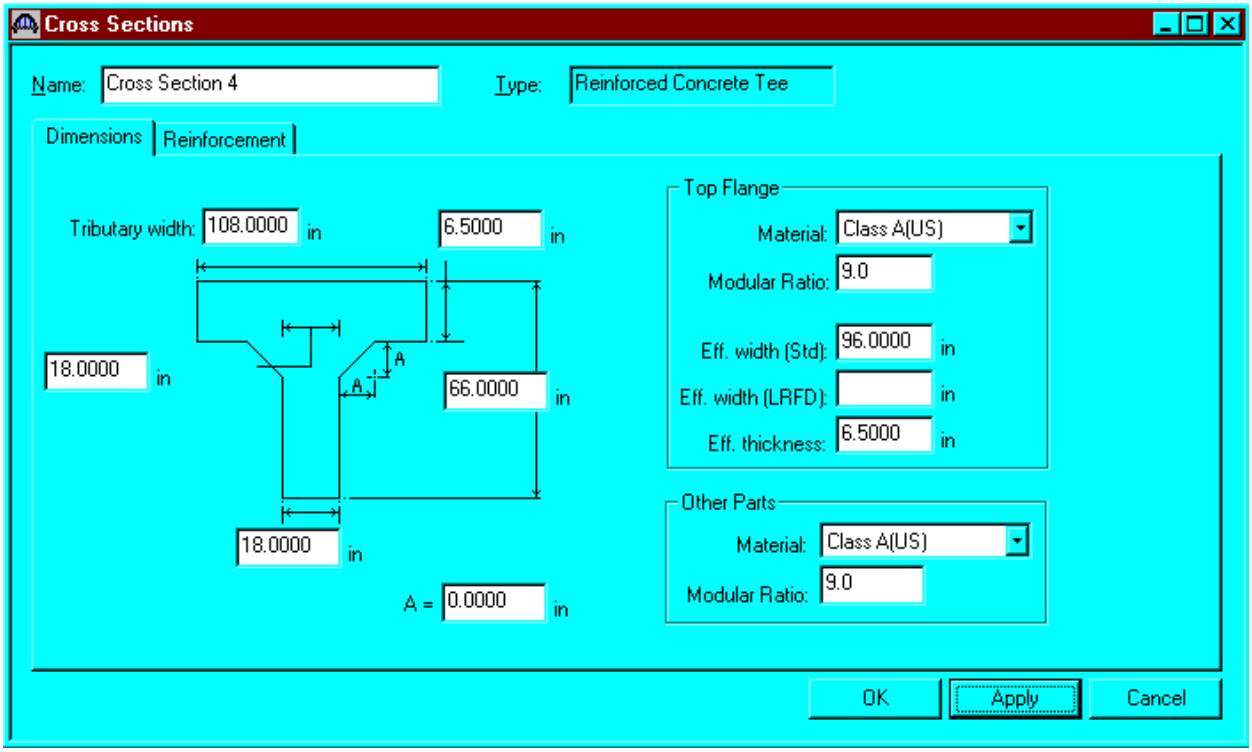
Using the same techniques, create cross sections 2 thru 8, and define their associated reinforcement patterns.

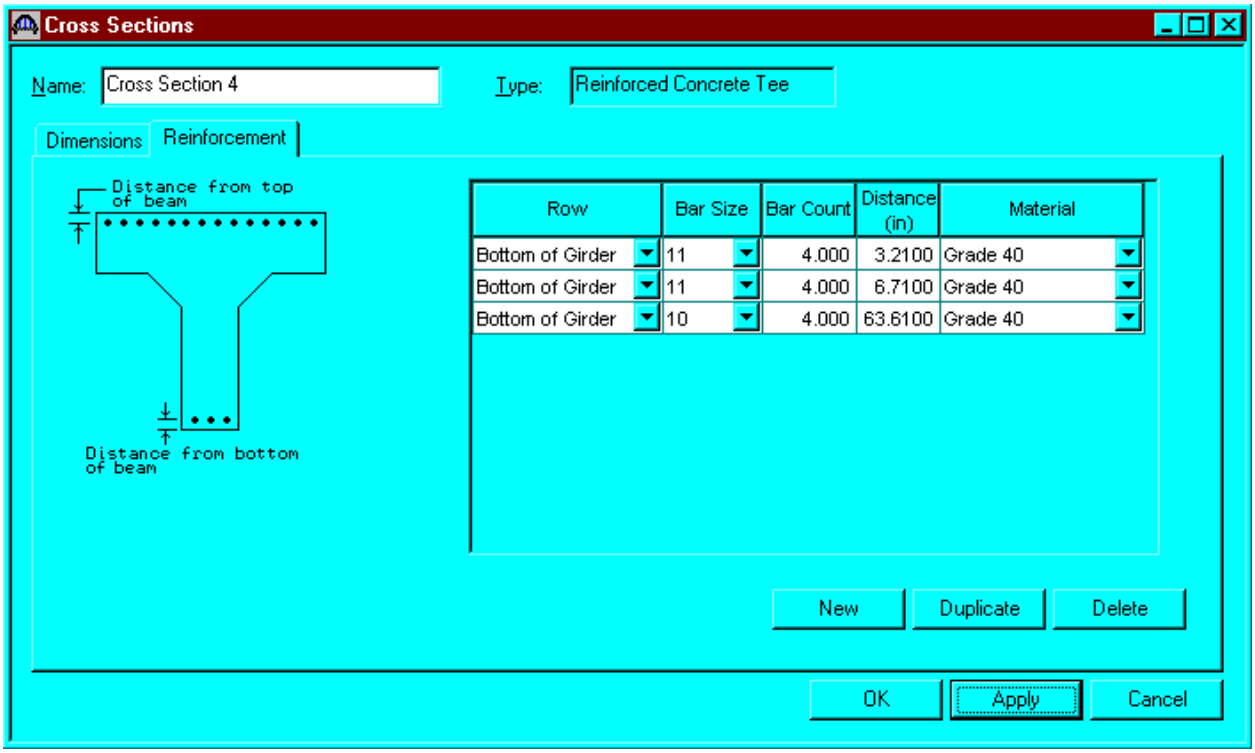


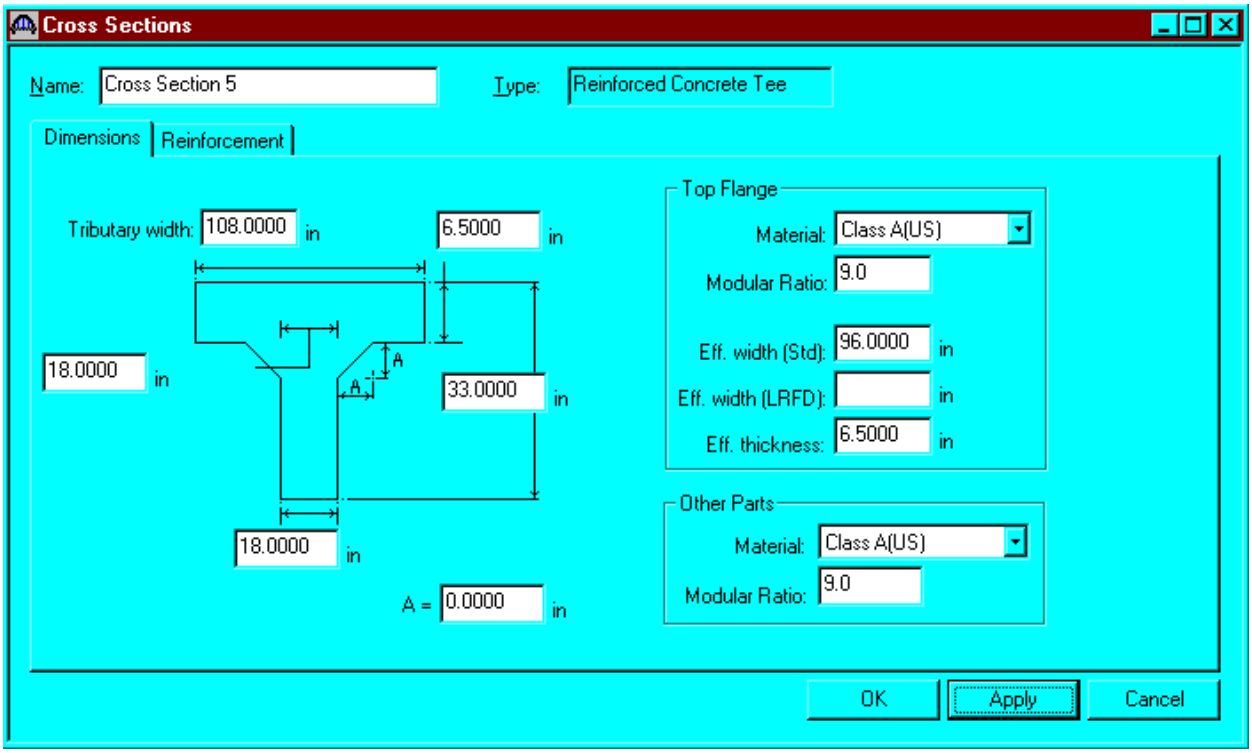


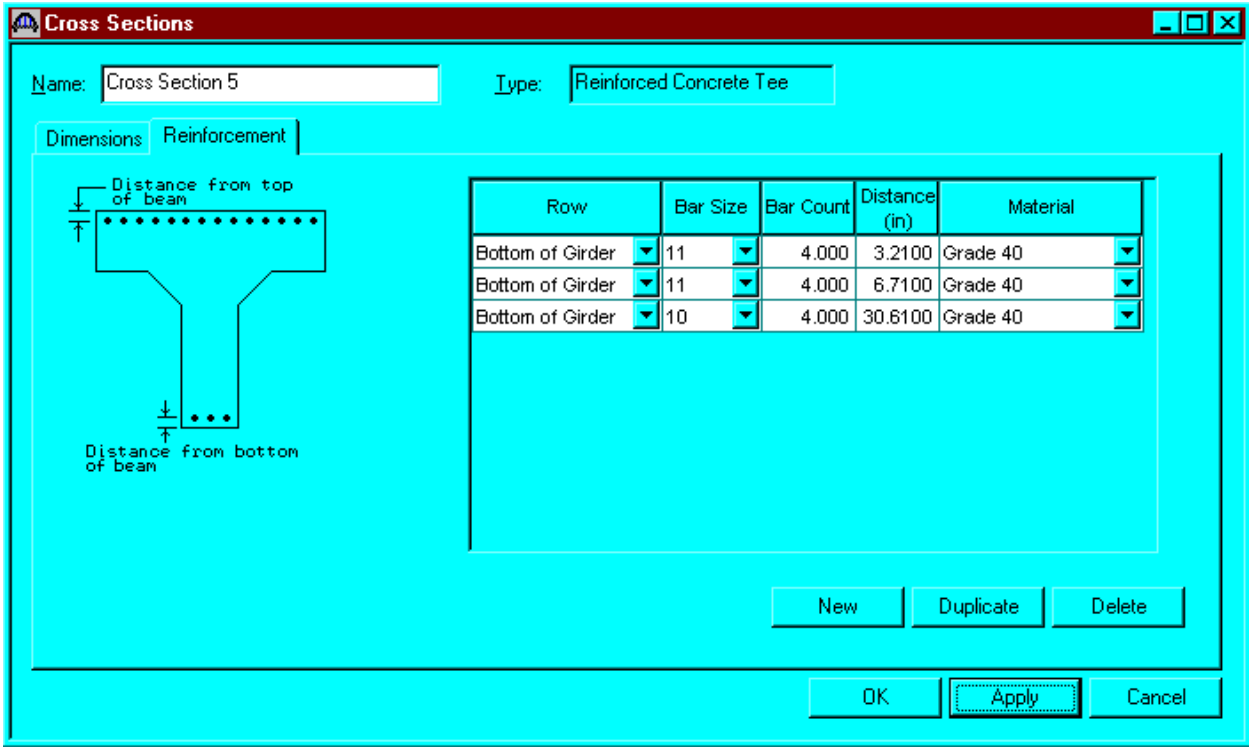

Cross Sections
Name: Cross Section 3
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
72.6875 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel

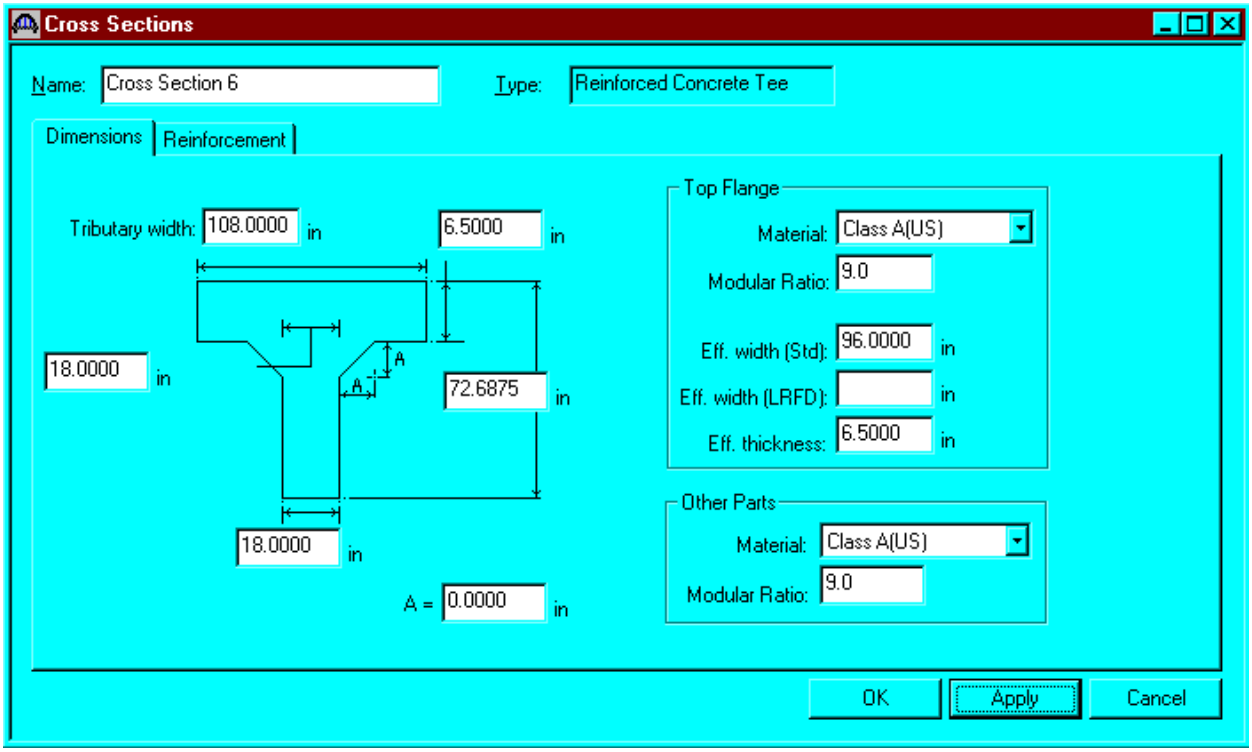

Cross Sections
Name: Cross Section 3
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Bar Size
Bar Count
Distance (in)
Material
Bottom of Girder 11 4.000 3.2100 Grade 40
Bottom of Girder 11 2.000 70.2975 Grade 40
Bottom of Girder 10 8.000 70.2975 Grade 40
Bottom of Girder 6 6.000 70.2975 Grade 40
New
Duplicate
Delete
OK
Apply
Cancel

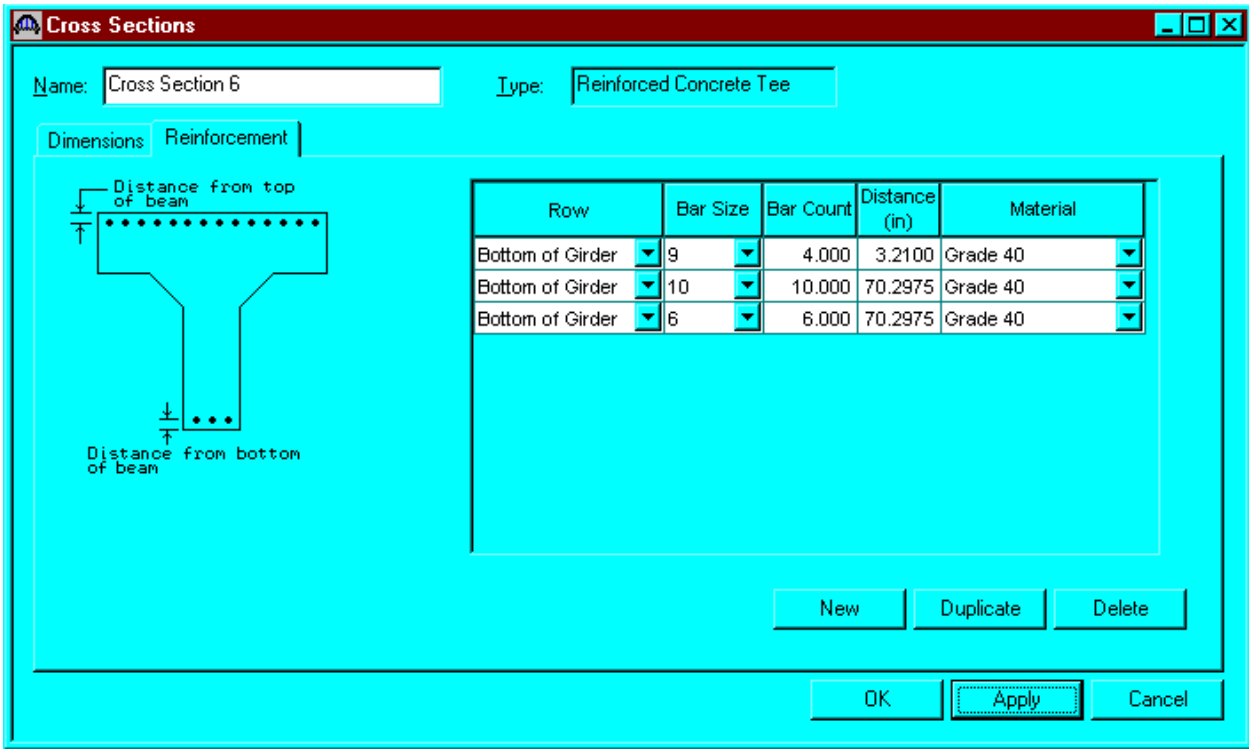

Cross Sections
Name: Cross Section 4
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
66.0000 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel

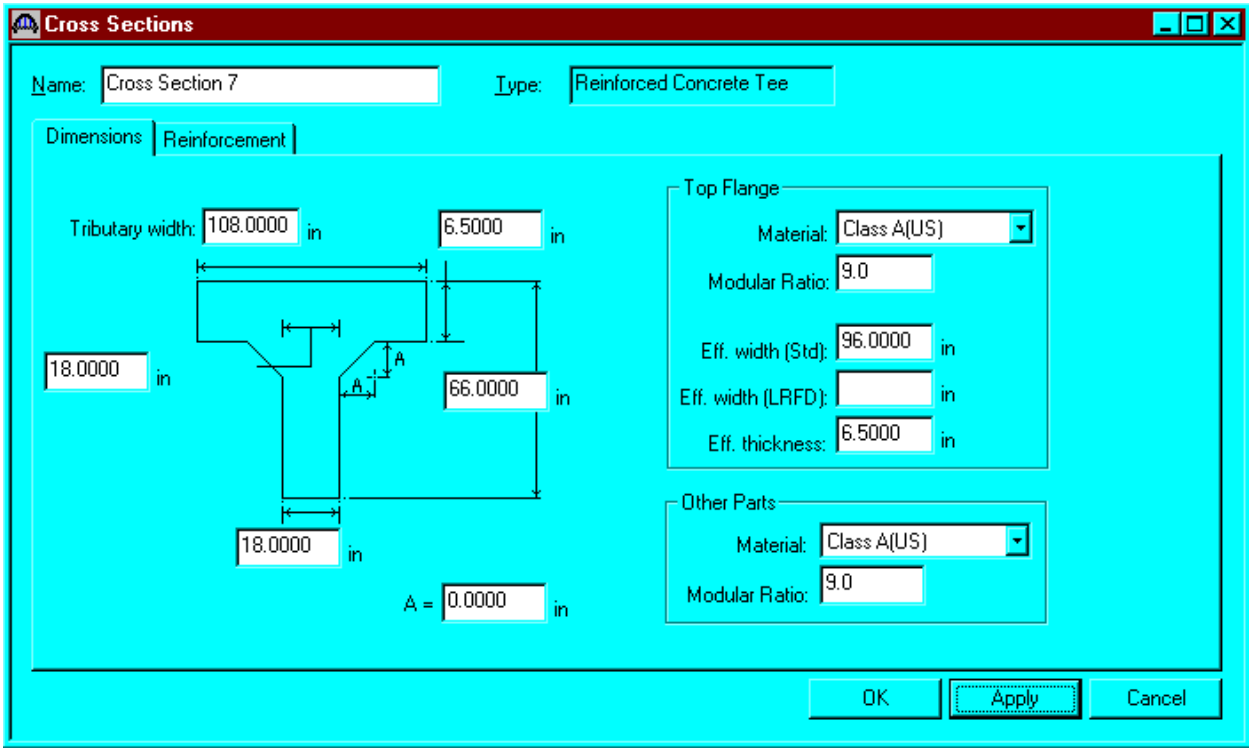

Cross Sections
Name: Cross Section 4
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Bar Size
Bar Count
Distance (in)
Material
Bottom of Girder 11 4.000 3.2100 Grade 40
Bottom of Girder 11 4.000 6.7100 Grade 40
Bottom of Girder 10 4.000 63.6100 Grade 40
New
Duplicate
Delete
OK
Apply
Cancel

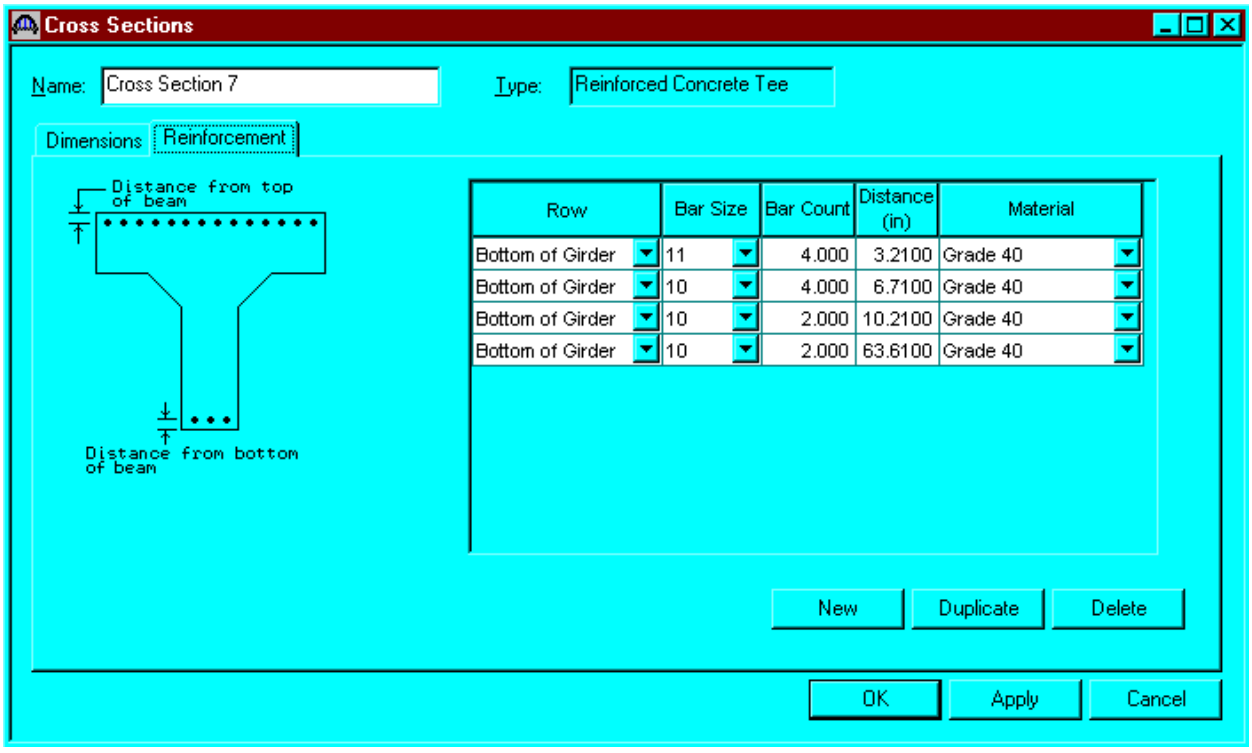

Cross Sections
Name: Cross Section 5
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
33.0000 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel

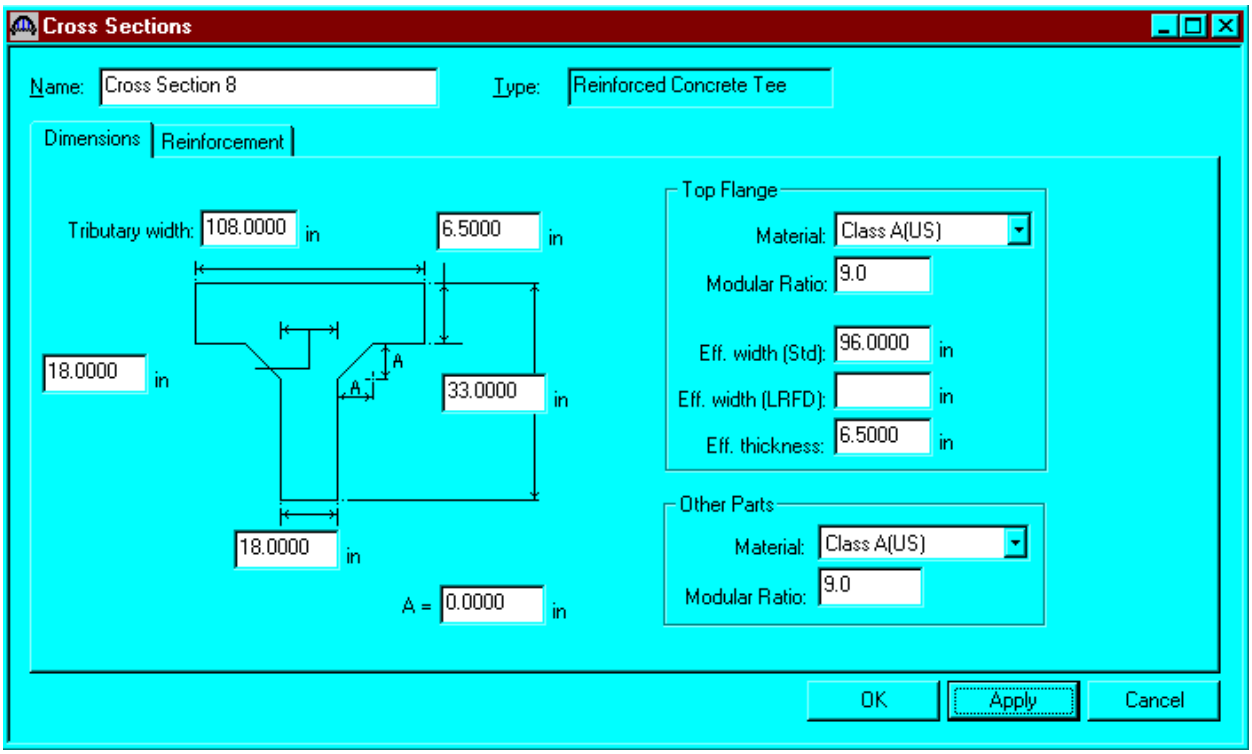

Cross Sections
Name: Cross Section 5
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Bar Size
Bar Count
Distance (in)
Material
Bottom of Girder 11 4.000 3.2100 Grade 40
Bottom of Girder 11 4.000 6.7100 Grade 40
Bottom of Girder 10 4.000 30.6100 Grade 40
New
Duplicate
Delete
OK
Apply
Cancel

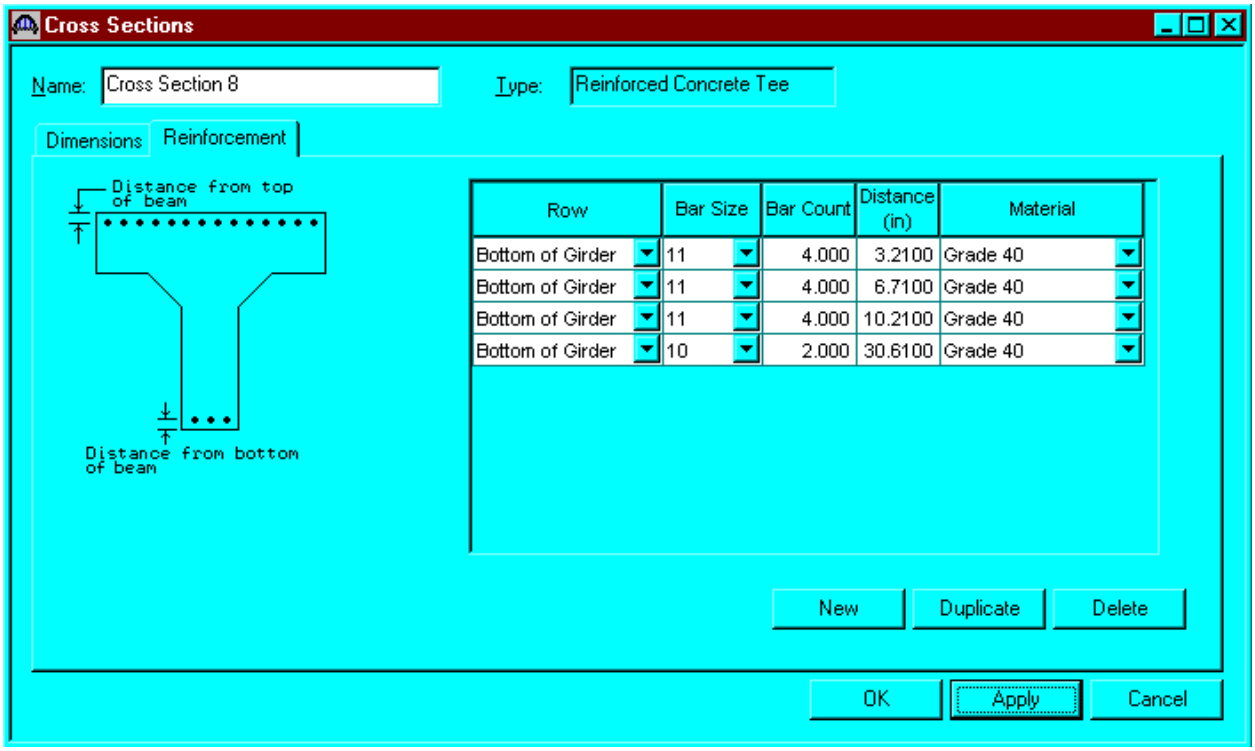

Cross Sections
Name: Cross Section 6
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
72.6875 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel


Cross Sections
Name: Cross Section 6
Type: Reinforced Concrete Tee
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

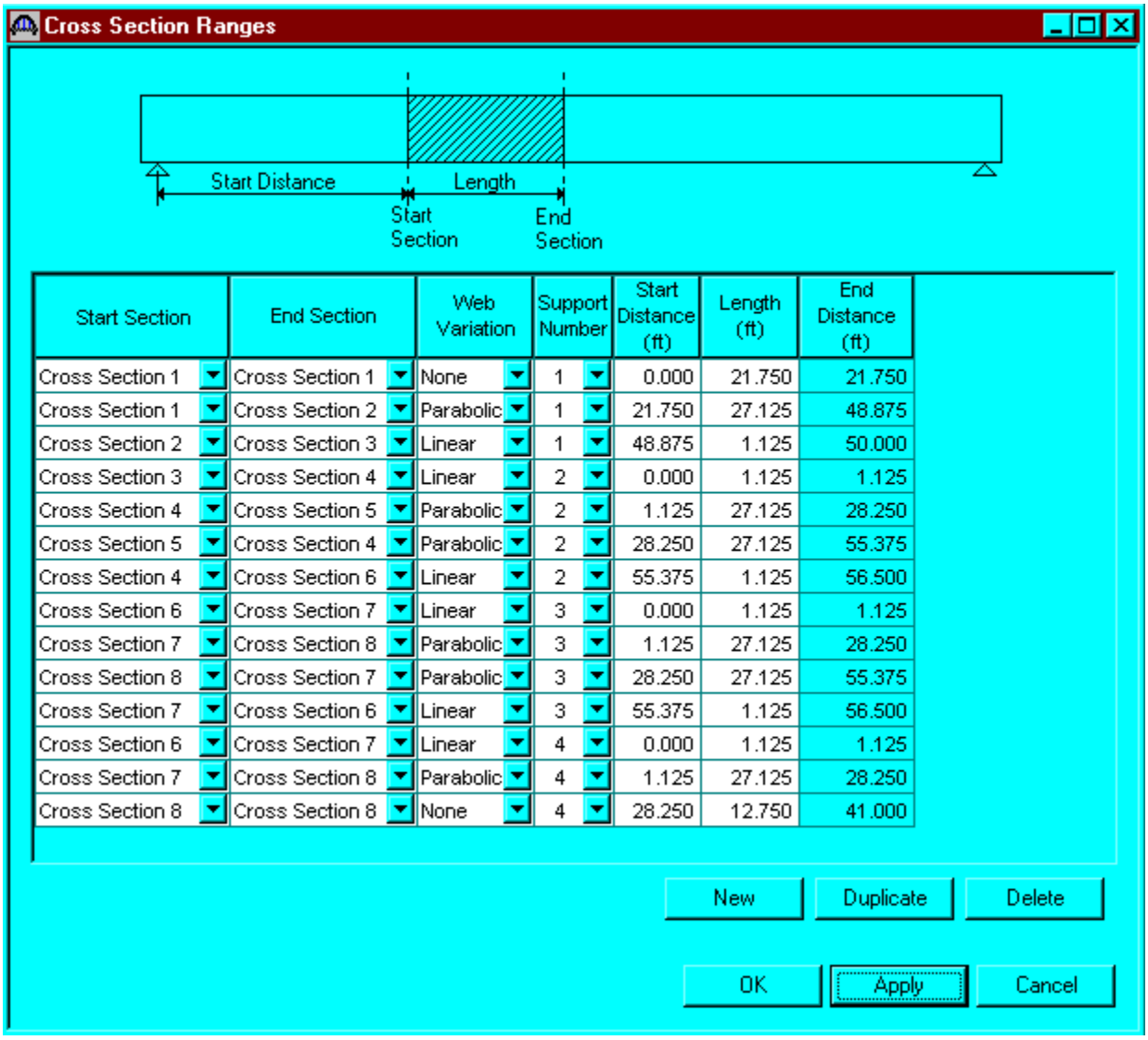

Cross Sections
Name: Cross Section 7
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
66.0000 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel


Cross Sections
Name: Cross Section 7
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
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: Cross Section 8
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Tributary width: 108.0000 in
6.5000 in
18.0000 in
33.0000 in
18.0000 in
A = 0.0000 in
Top Flange
Material: Class A(US)
Modular Ratio: 9.0
Eff. width (Std): 96.0000 in
Eff. width (LRFD): in
Eff. thickness: 6.5000 in
Other Parts
Material: Class A(US)
Modular Ratio: 9.0
OK
Apply
Cancel

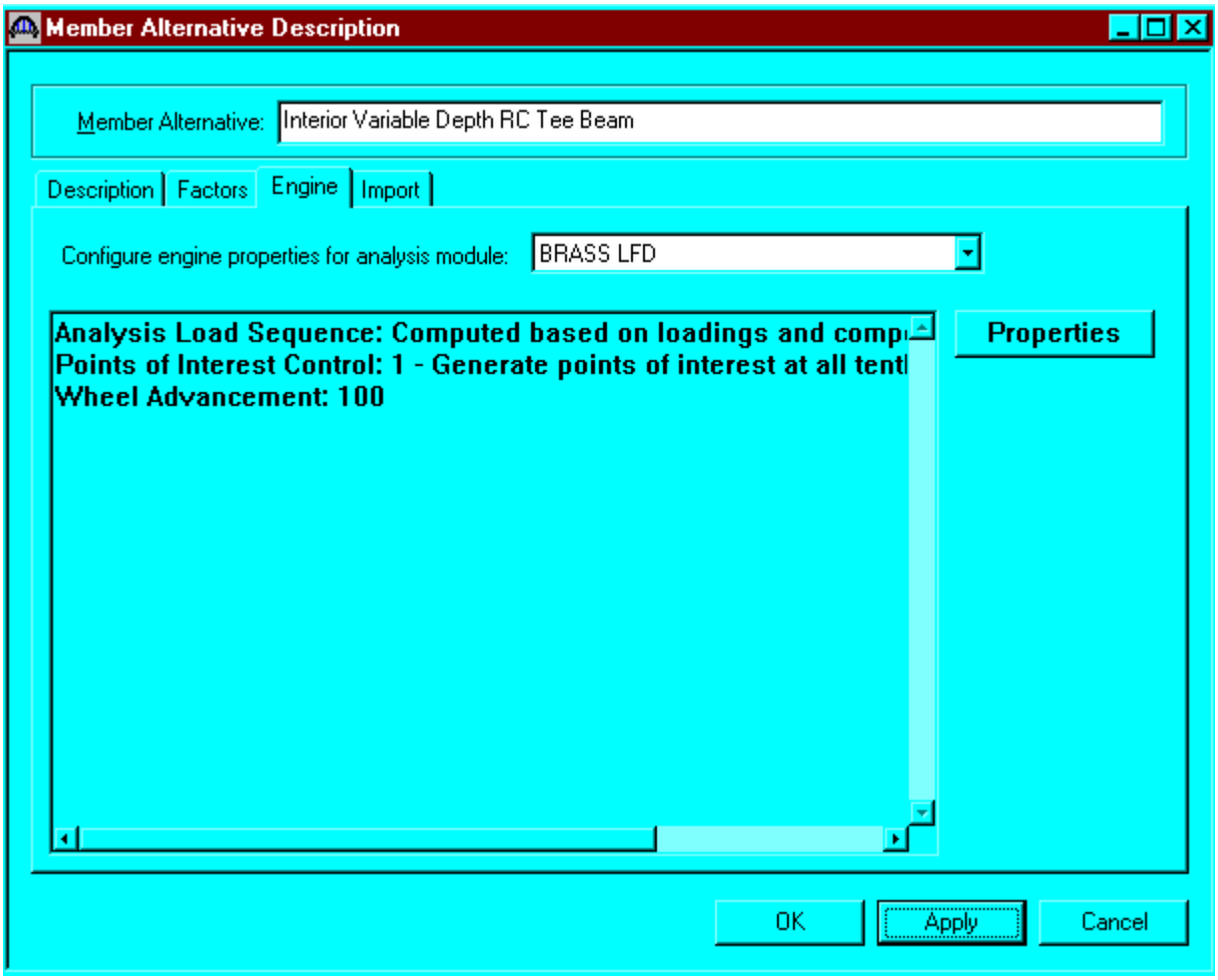

Cross Sections
Name: Cross Section 8
Type: Reinforced Concrete Tee
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Bar Size
Bar Count
Distance (in)
Material
Bottom of Girder 11 4.000 3.2100 Grade 40
Bottom of Girder 11 4.000 6.7100 Grade 40
Bottom of Girder 11 4.000 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.

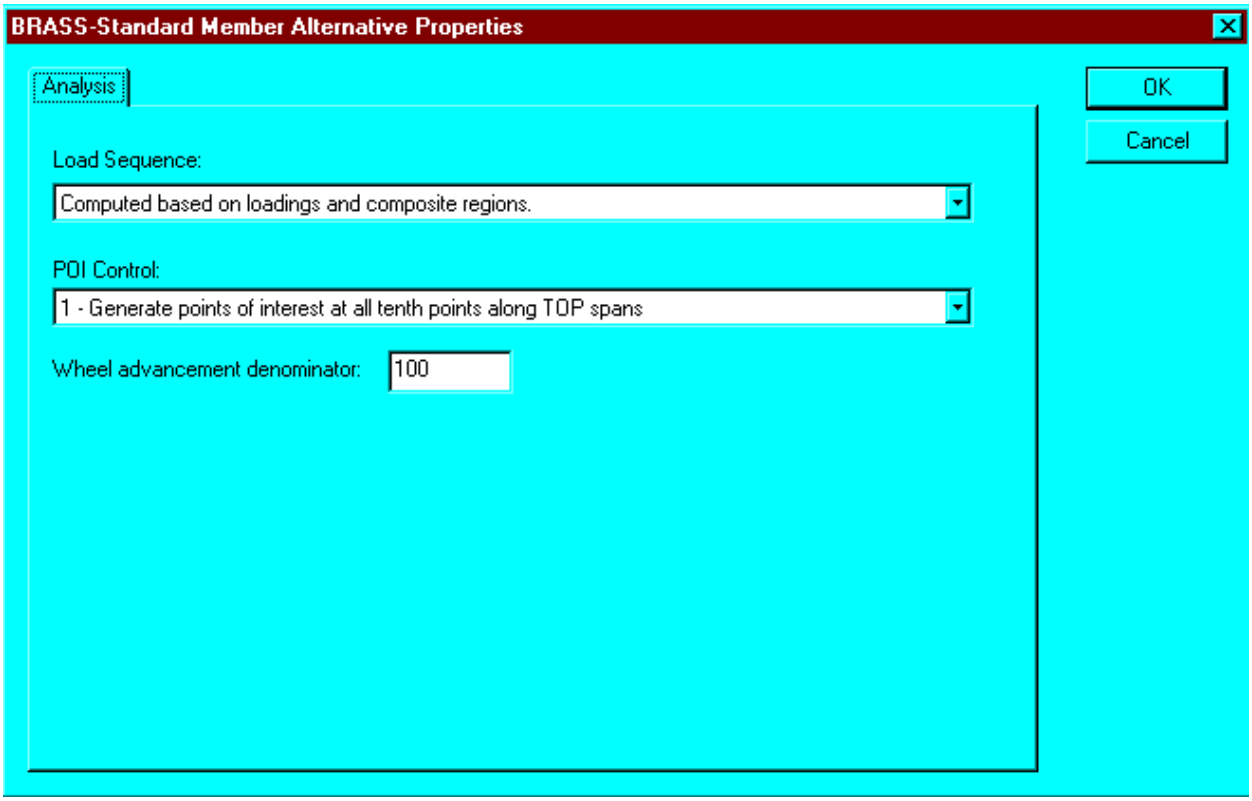


Start Section	End Section	Web Variation	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Cross Section 1	Cross Section 1	None	1	0.000	21.750	21.750
Cross Section 1	Cross Section 2	Parabolic	1	21.750	27.125	48.875
Cross Section 2	Cross Section 3	Linear	1	48.875	1.125	50.000
Cross Section 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

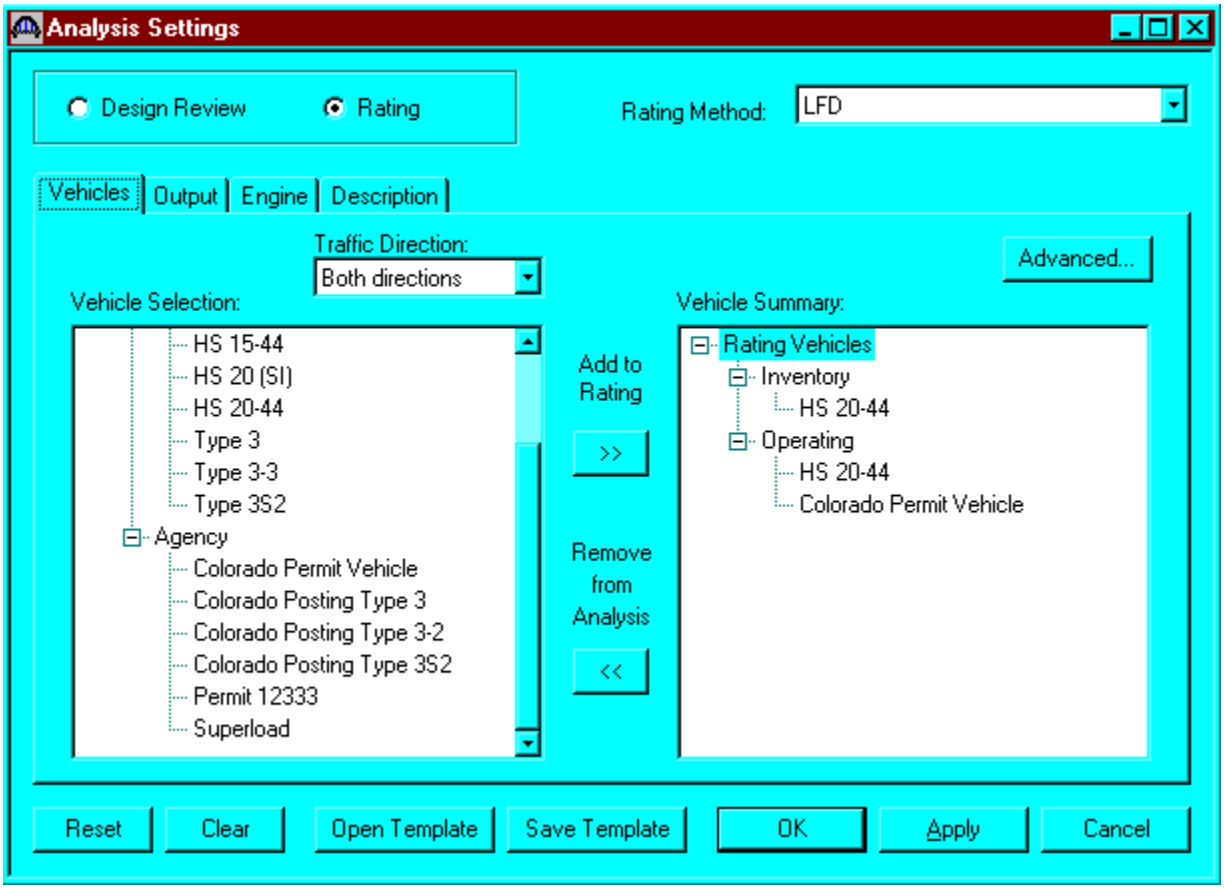
Open the Member Alternative Description window and click the Engine tab as shown below.



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



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

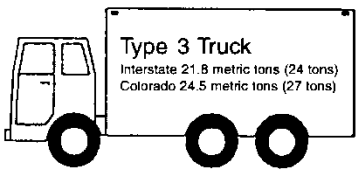
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

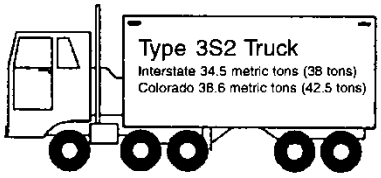
Structure #	L-18-AV
State highway #	I25 Overpass
Batch I.D.	
Structure type	CSGC
Parallel structure #	

Rated using
Asphalt thickness: 50 mm (2 in.)
☑ Colorado legal loads
☐ Interstate legal loads

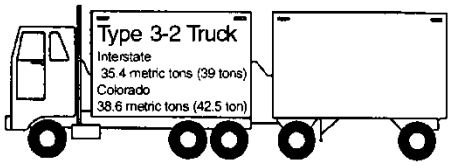
Structural member	INTERIOR GIRDER @ 2.5 PT	SLAB		
	Metric tons (Tons)			
Inventory	40.0 (44)	26.4 (29)	( )	( )
Operating	67.3 (74)	44.5 (49)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	160.0 (176)	( )	( )	( )



_____ (_____)
Metric tons Tons



_____ (_____)
Metric tons Tons



_____ (_____)
Metric tons Tons

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

Previous editions are obsolete and may not be used

CDOT Form #1187a 1/95