9A-1 INTRODUCTION TO RATING PRESTRESSED CONCRETE GIRDER BRIDGES

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

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

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

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

I. General

A. Prestressed concrete girders, either simple span, or simple spans made continuous, shall be rated using the VIRTIS computer program. Refer to subsection 9A-3 for information on this program.

B. When the LFD method is used for rating girders, unless a more rational methodology like the modified compression field theory in the AASHTO LRFD code is adopted for use, prestressed girders shall not be rated for shear. However, during the design process, all prestressed girders shall be checked for shear using the appropriate AASHTO code.

C. Double-tee structures without a poured in place composite deck or a full depth diaphragm shall use the live load distribution factor as prescribed in the AASHTO LRFD Specifications. The exterior girder distribution factor shall be calculated using the lever rule.

D. Double-tee structures with a poured in place composite deck or a full depth rigid diaphragm/bracing system with a rotational stiffness roughly equal to a poured in place deck, the live load distribution factor for Concrete T-Girders as prescribed in Table 3.23.1 of the AASHTO Standard Specifications for Highway Bridges, 16th Edition, shall be used.

E. When using the AASHTO LRFD Multi-Beam live load distribution factor and load restrictions are required, a rational method may be used for the live load distribution factor calculation, including the use of the LDFAC program.

F. The rater shall be responsible for determining whether stress-relieved or low-relaxation strands were used in the bridge. If it is not possible to discern what type of strand was used, then the rater shall assume that stress-relieved strands were used prior to December, 1983, and low-relaxation strands thereafter.

G. Prestressed concrete girder bridges with complex geometric alignment i.e., flared girder bridges or girders with a variable overhang, shall be modeled as simple, straight beams on pin or roller supports. The Virtis program output results can then be supplemented by hand calculations to consider any significant influences, as necessary.

H. For effective slab widths, the b in the equation (12t+b) shall be the width of the top flange of the girder, not the web.

II. Girders Requiring Rating

A. Interior Girders - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, number of prestressing strands, differences in loads or moments, concrete strength, etc.

B. Exterior Girders - An exterior girder shall be rated under the following guidelines:

1. When the section used for an exterior girder is different than the section used for an interior girder.

2. When the overhang is greater than S/2.

3. The exterior unit of a multi-beam structure should be rated if it does not have a cast-in-place composite slab. For this case the dead loads due to sidewalks, curbs and railing shall be applied to only the exterior unit.

4. When the rater determines the rating would be advantageous in analyzing the overall condition of a structure.

III. Calculations

A. A set of calculations, separate from computer output, shall be submitted with each rating. These calculations shall include derivations for dead loads, derivations for live load distribution factors, and any other calculations or assumptions used for rating. The rater shall also indicate whether stress-relieved or low-relaxation strands were used in the rating calculations.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the nearest 5 pounds.

2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.

3. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders and diaphragms.

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

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

IV. Simple and Continuous Span Bridges

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

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

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

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

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

V. Rating Reporting/Package Requirements

The rater and checker shall complete the rating documentation as described in Section 1 of this manual. The rating package requirements shall be per Section 1-13 of this manual and as amended herein:

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

9A-3 GUIDELINES FOR USING THE VIRTIS RATING PROGRAM

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

A maximum of thirteen (13) spans and twelve (12) girder lines can be modeled using the program. When a structure model is finalized, it can be rated using the ASD or the LFD method. The LRFD rating module is currently being developed and will be available in the future. When a structure model is being generated and before any analysis can be performed, it is recommended that Virtis users save the data to memory periodically. This can be accomplished by using the File and Save feature of this program.

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

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

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

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

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

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

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

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

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

INVENTORY RATING

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

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

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

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

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

OPERATING RATING

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

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

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

NOTE:

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

9A-5 RATING PRESTRESSED CONCRETE GIRDER BRIDGES WITHOUT PLANS

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

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

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

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

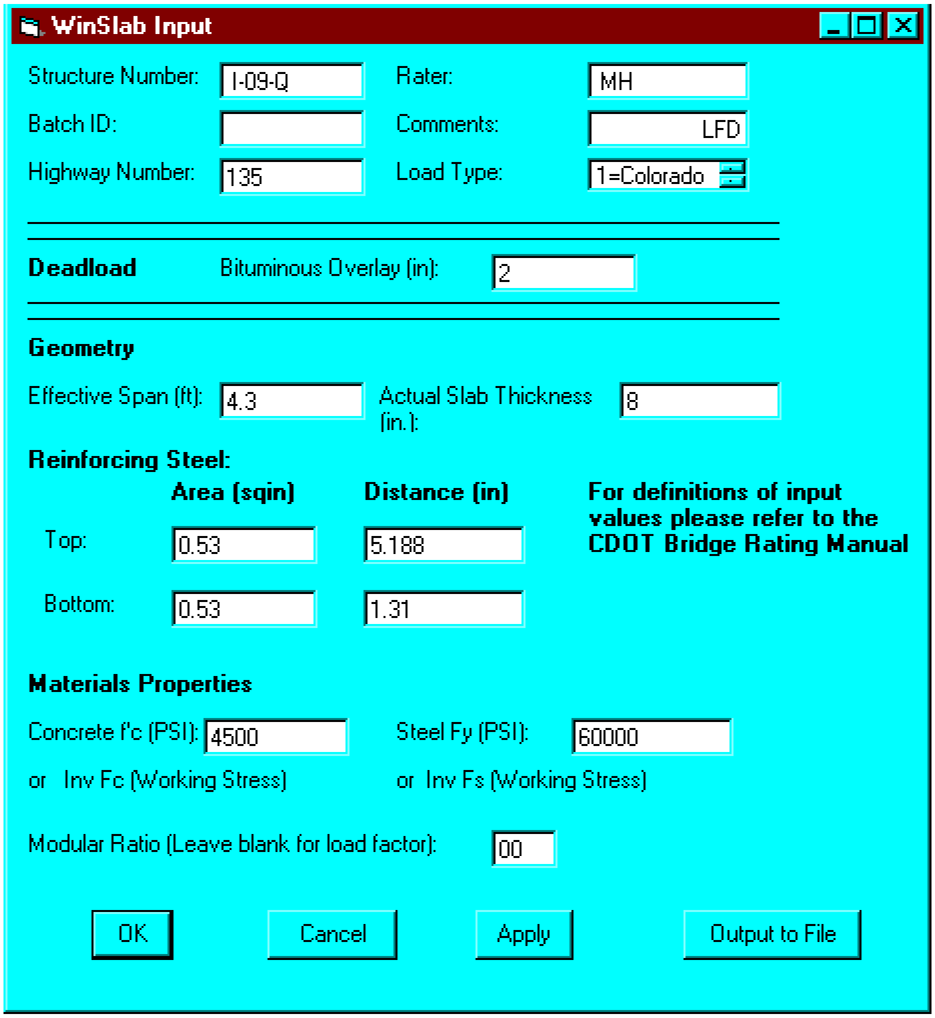
9A-6 PRESTRESSED CONCRETE GIRDER BRIDGE RATING EXAMPLES

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

Colorado BT girder shapes included:

Colorado BT girder shapes included:

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



Effective Span Length: Per AASHTO Article 3.24.1.2(b)

Clear distance between flanges + 1/2 flange width = 30″+1/2(43)=51.5″
=4.3′

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

```
WinSlab Rating Version 1     Date: 10/12/2001

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

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

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

Dead Load Moment   0.23 K-Ft
LL+I Moment        3.28 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)    1384.70       2268.79
Actual Reinf. Steel Stress  (PSI)   26715.30      43772.27
Actual Comp. Steel Stress   (PSI)    3069.34       5029.03
Member Capacity             (K-Ft)     11.55         11.55
Member Capacity (LL+I)      (K-Ft)     11.25         11.25
     Rating                 (Tons)     57.05         95.09
```

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

Effective slab width: Per AASHTO Article 9.8.1.1

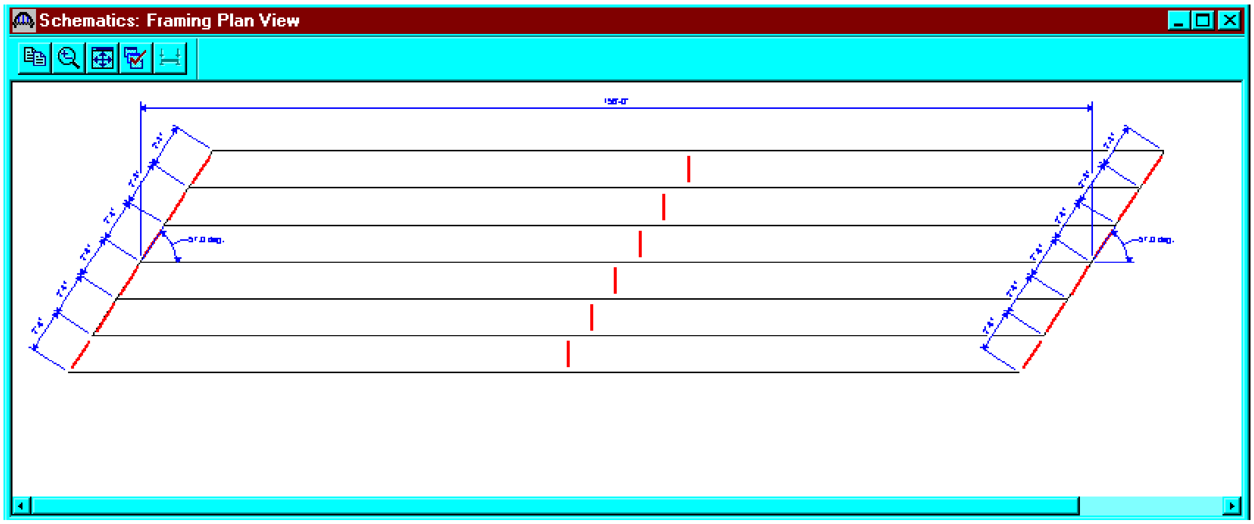
0.25(L)= 0.25(156*12)= 468″
12t+ b = 12*8+ 43= 139″
C.L. - C.L. of girder= 6.0833′=73″ Controls

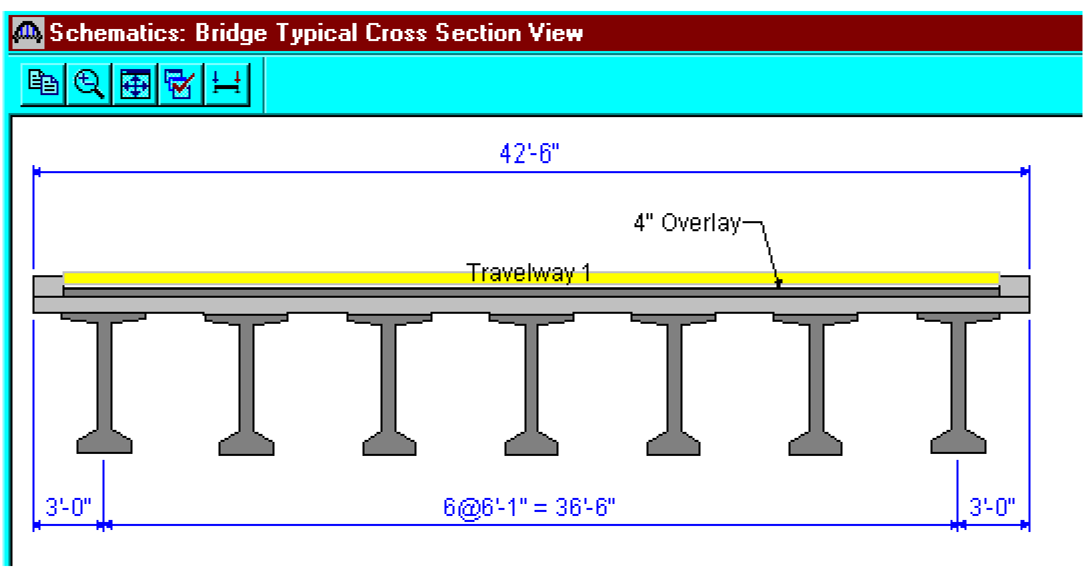
Dead Load:

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

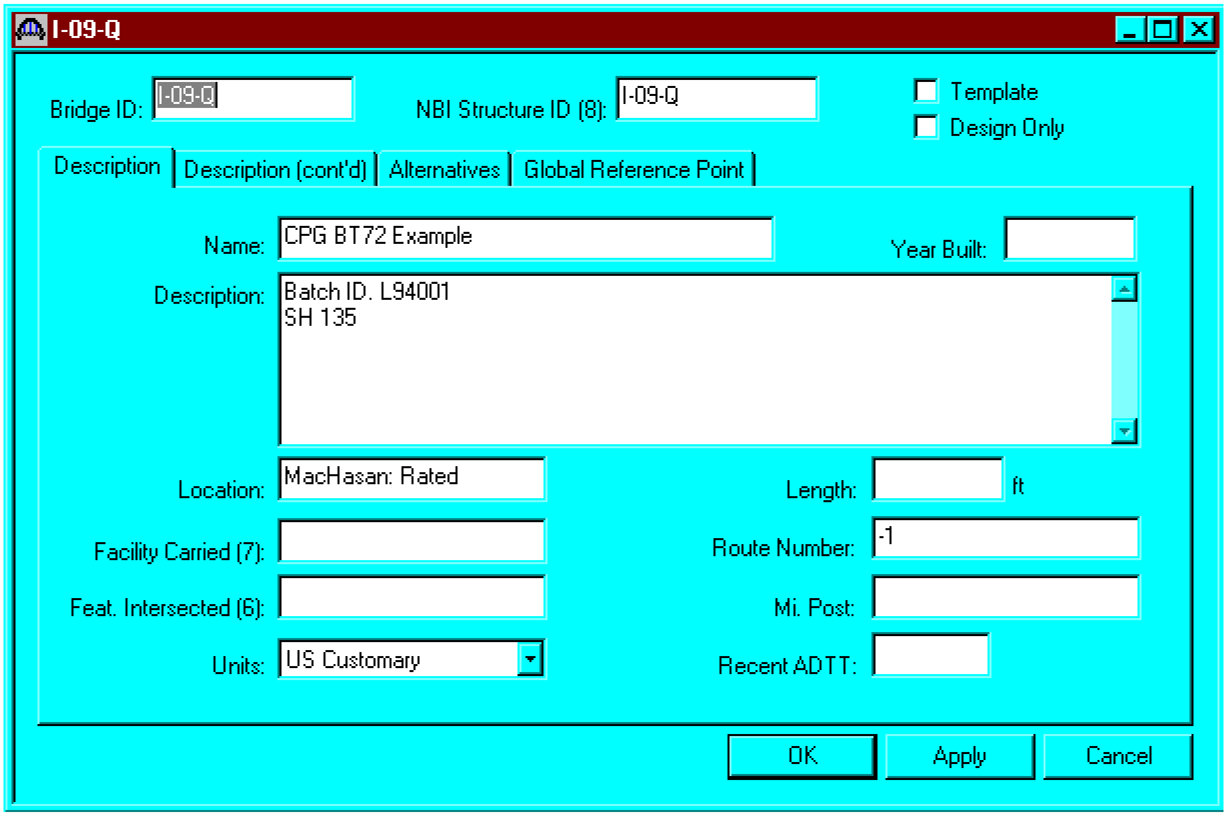
Abutment Diaphragm = ((2.67)*(80.5/12)*6.0833*(1/sin57°) – (864/144)*(21/12)*(1/sin57°))*(0.150)= 17.6 kips
Use 18.0 kips

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





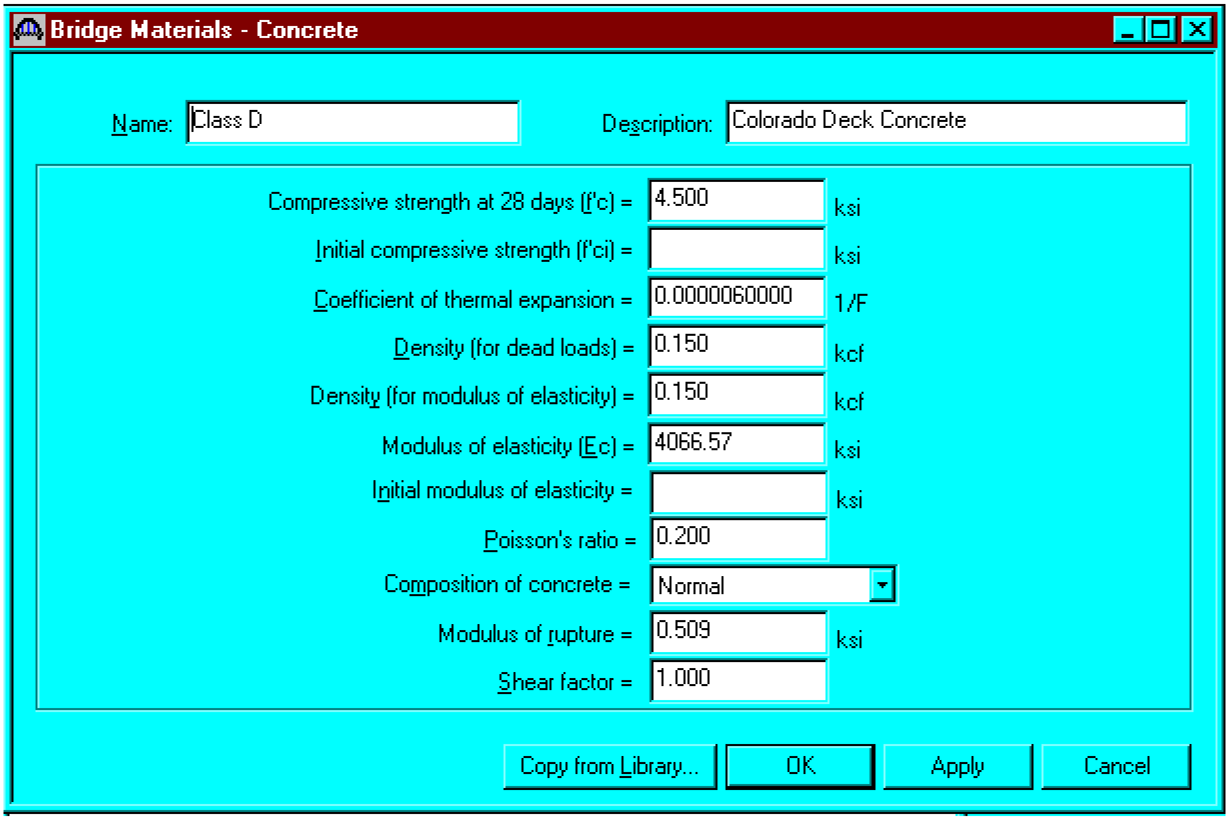
From the bridge explorer, create a new bridge and enter the following information.



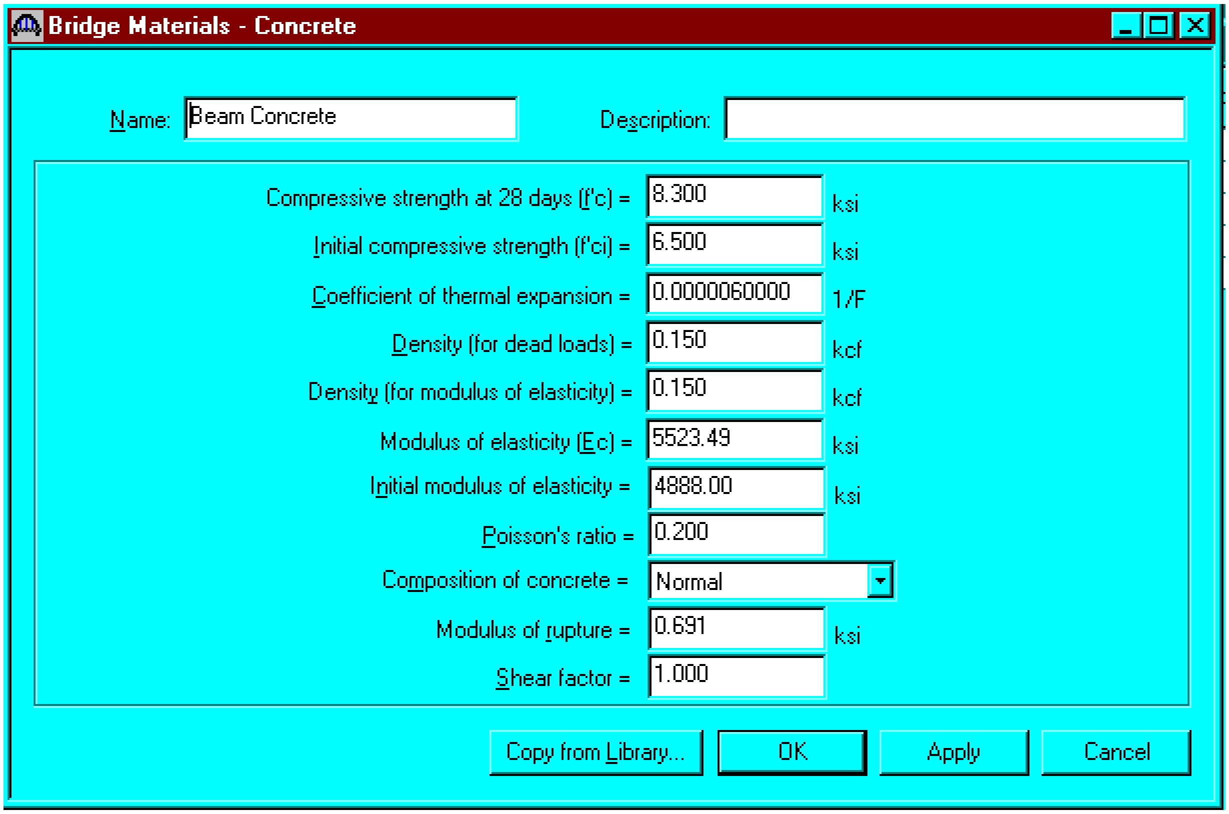
Click OK. This saves the data to memory and closes the window.

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

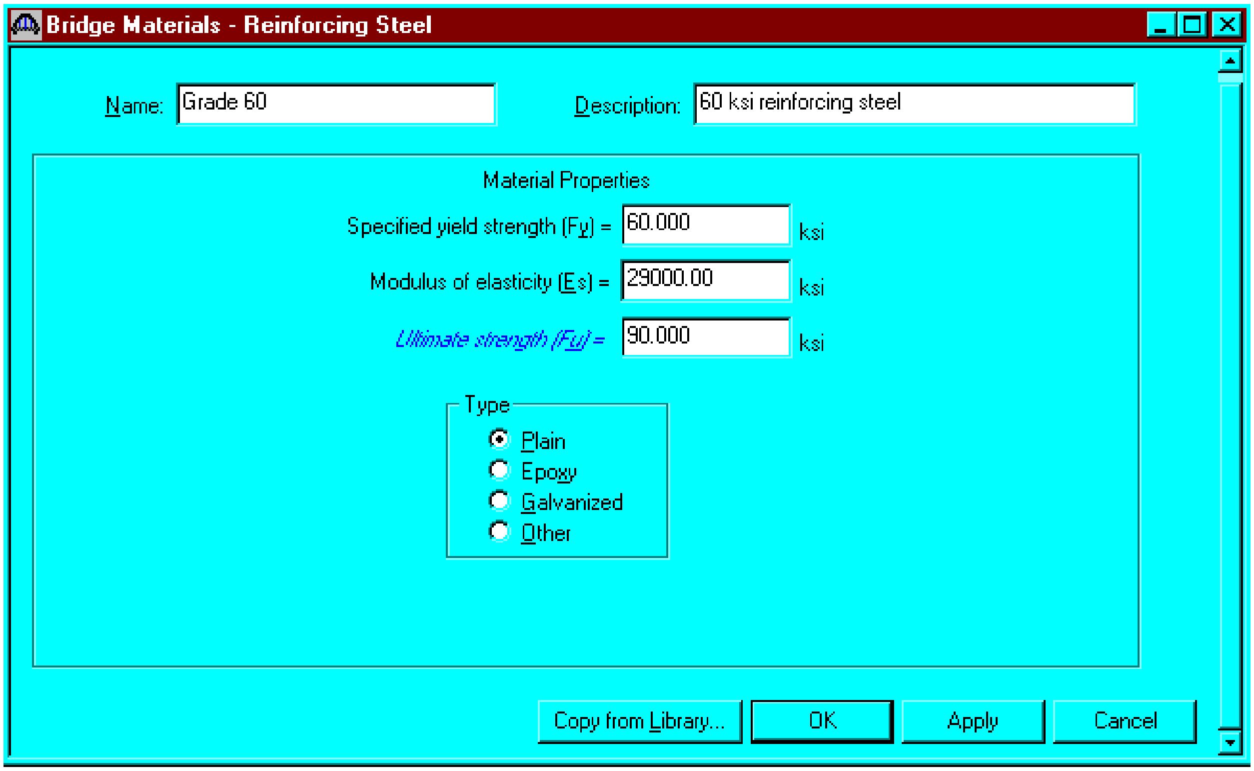
To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to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

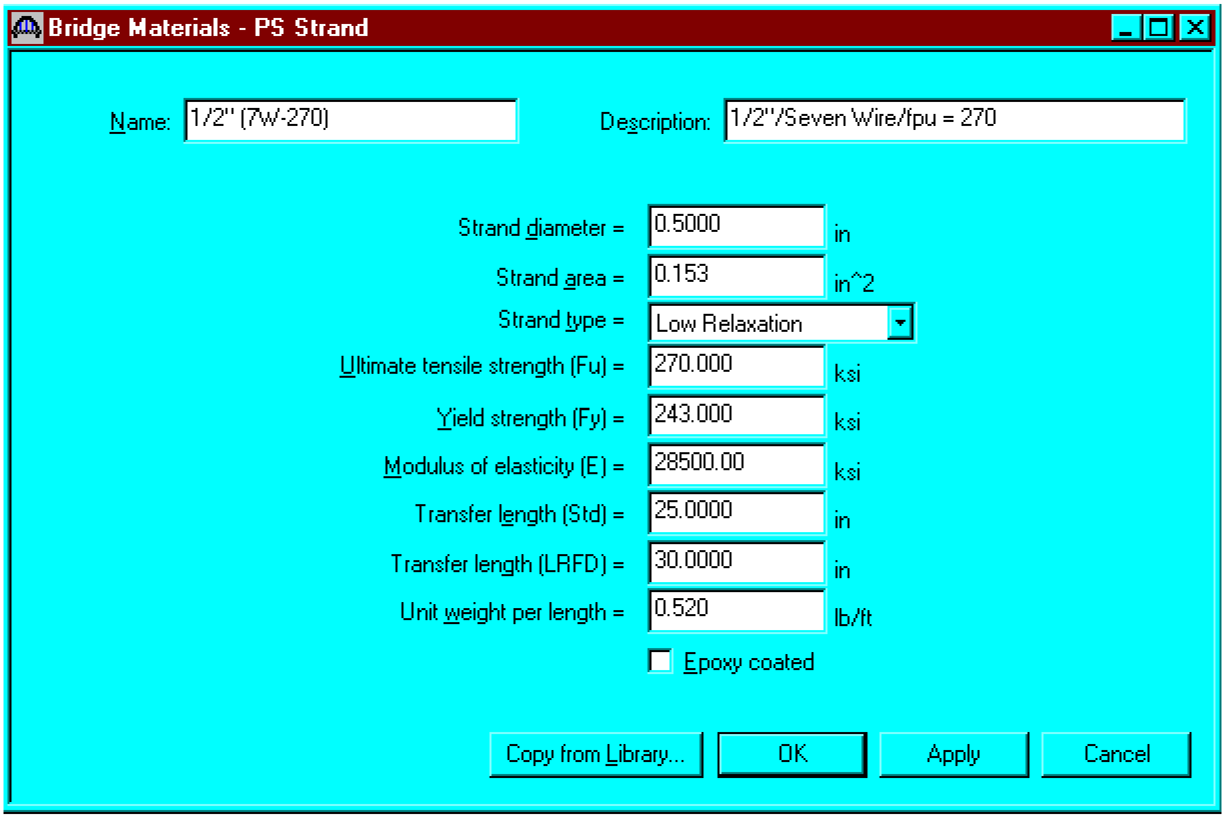


Using the same techniques, create a new concrete material to be used for the girder.



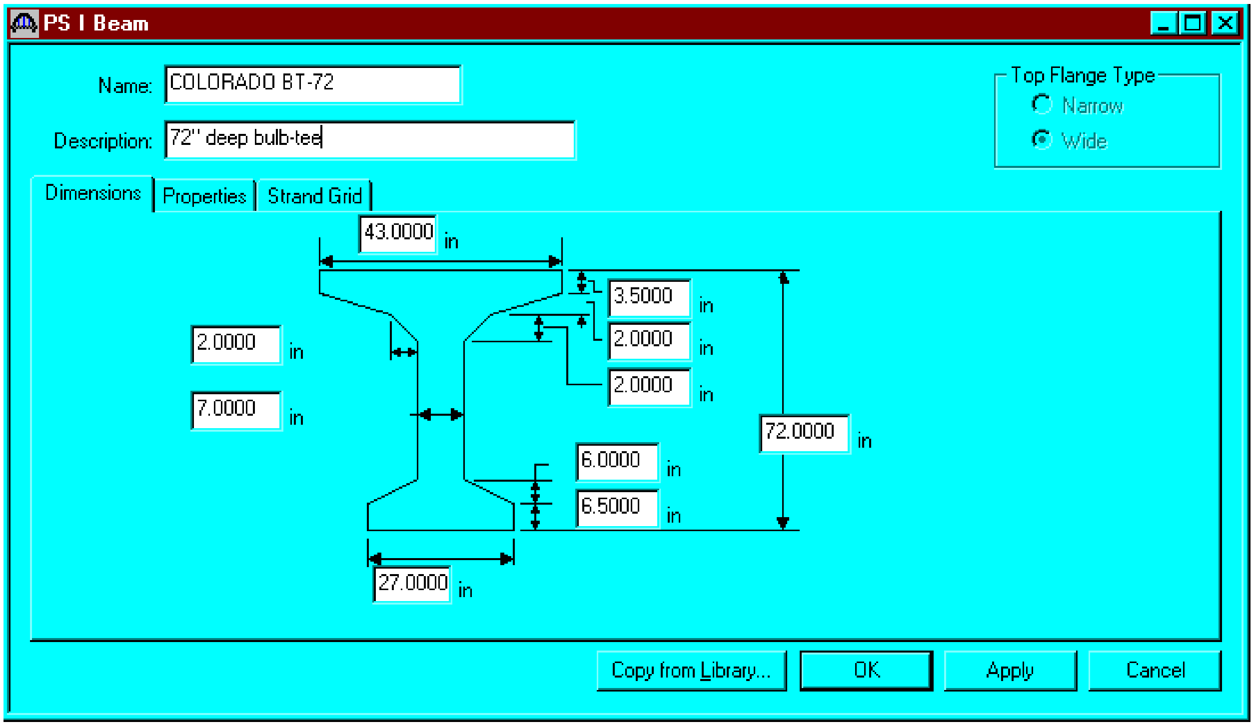
Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.





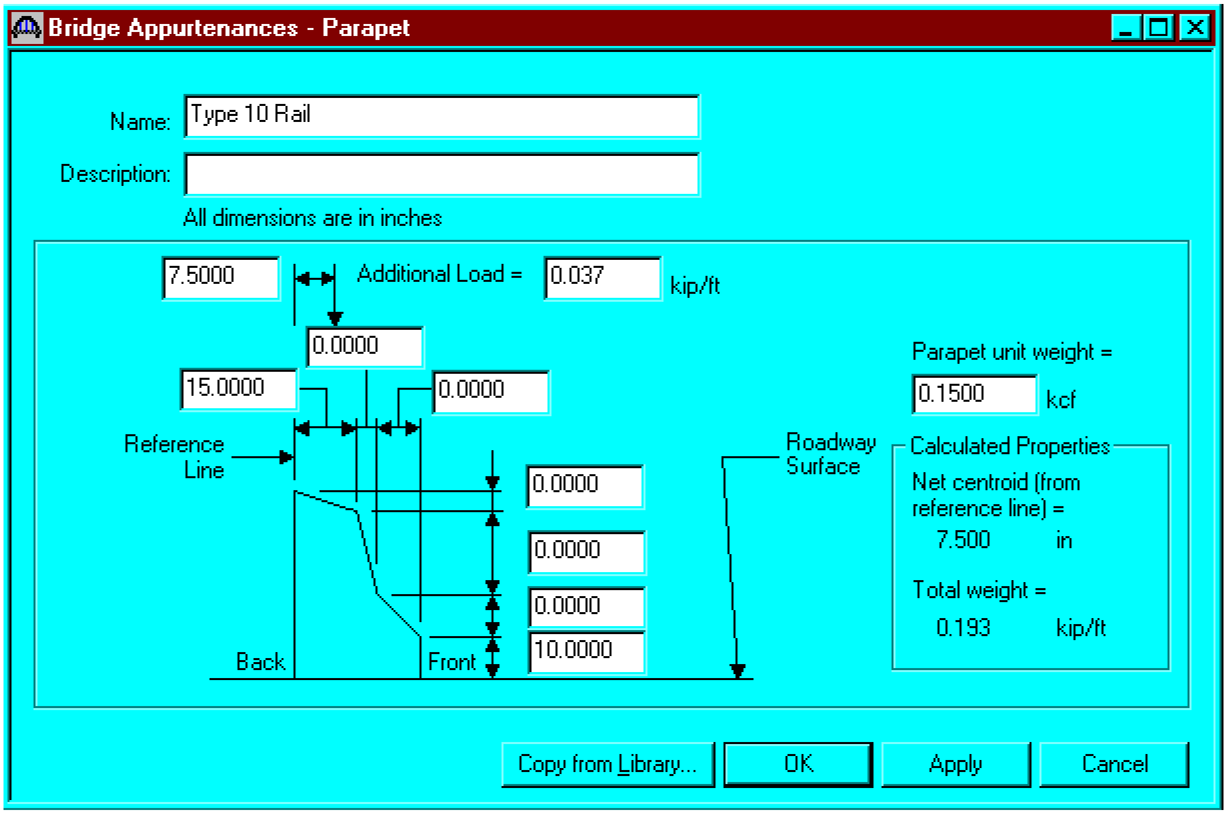
Bridge Materials - PS Strand
Name: 1/2" (7W-270)
Description: 1/2"/Seven Wire/fpu = 270
Strand diameter = 0.5000 in
Strand area = 0.153 in^2
Strand type = Low Relaxation
Ultimate tensile strength (Fu) = 270.000 ksi
Yield strength (Fy) = 243.000 ksi
Modulus of elasticity (E) = 28500.00 ksi
Transfer length (Std) = 25.0000 in
Transfer length (LRFD) = 30.0000 in
Unit weight per length = 0.520 lb/ft
Epoxy coated
Copy from Library...
OK
Apply
Cancel

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



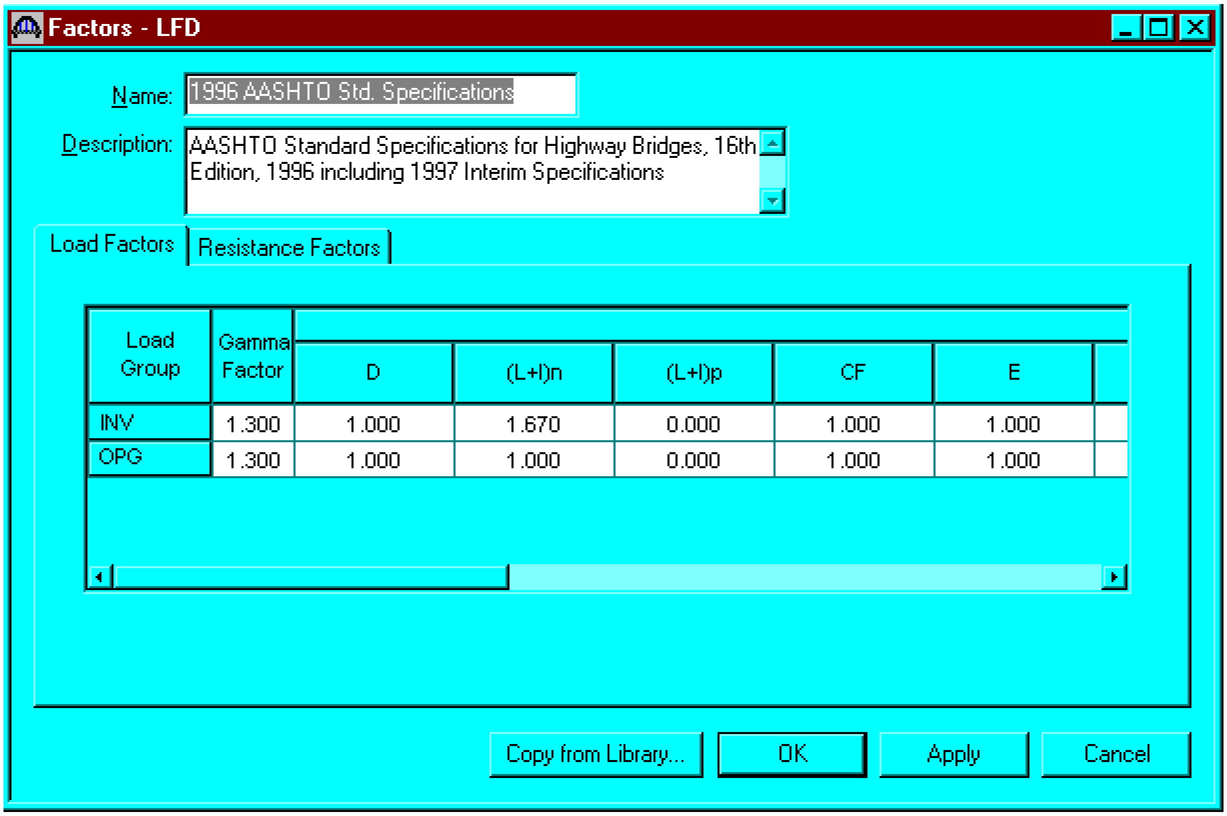
Click OK to save to the memory and close the window.

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

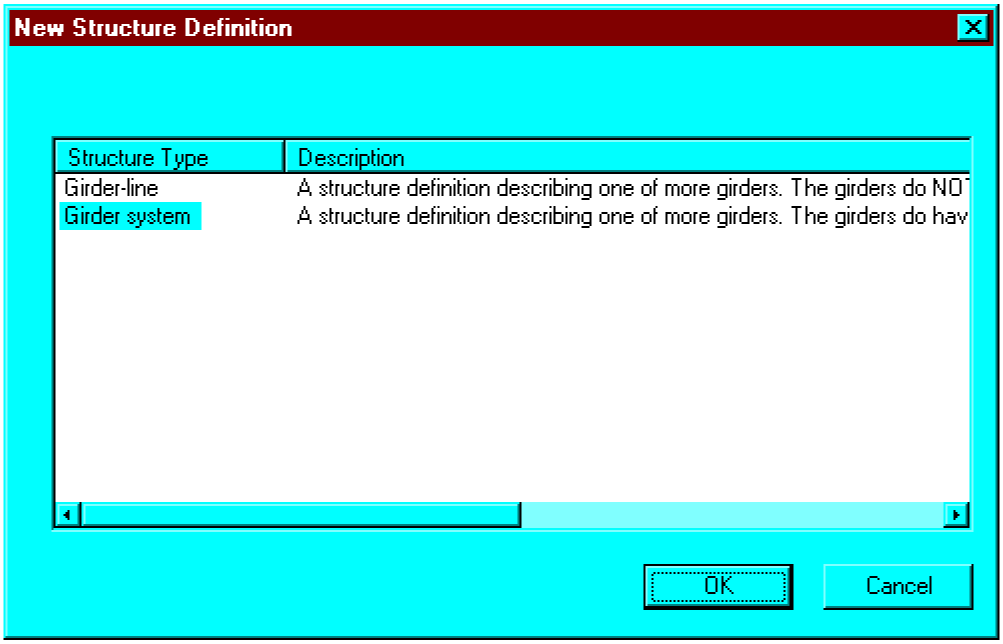


The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

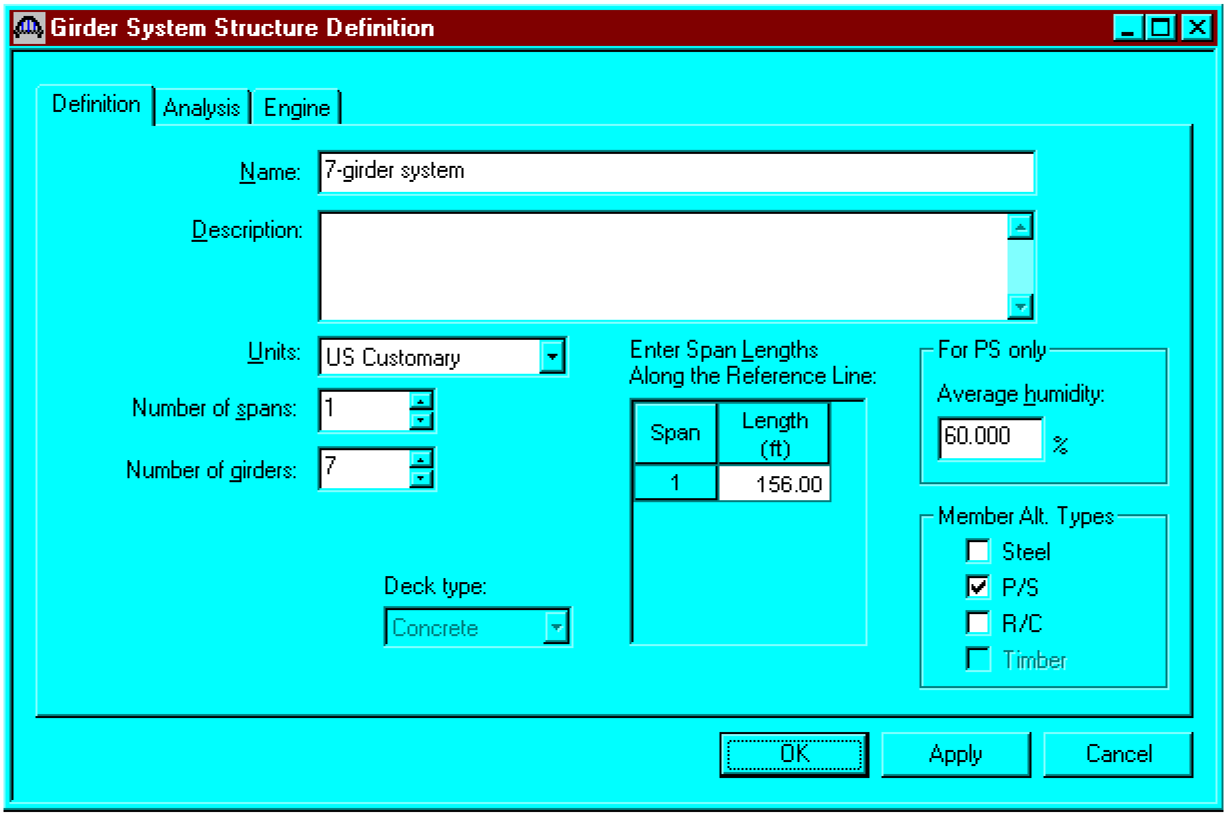
This window shows the LFD load factors.



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.

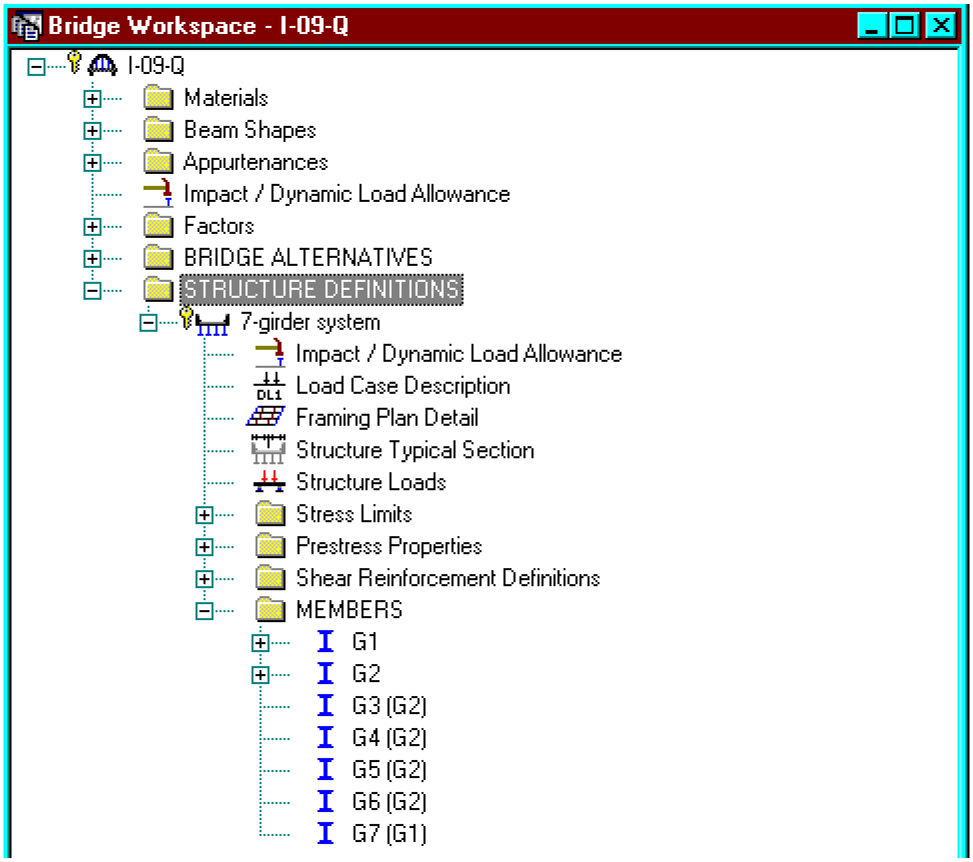


Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



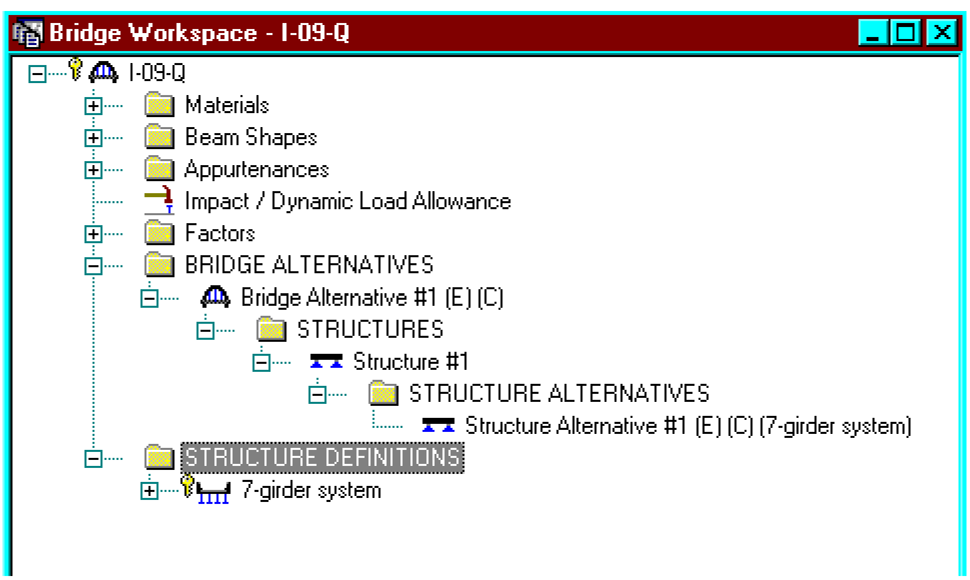
Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

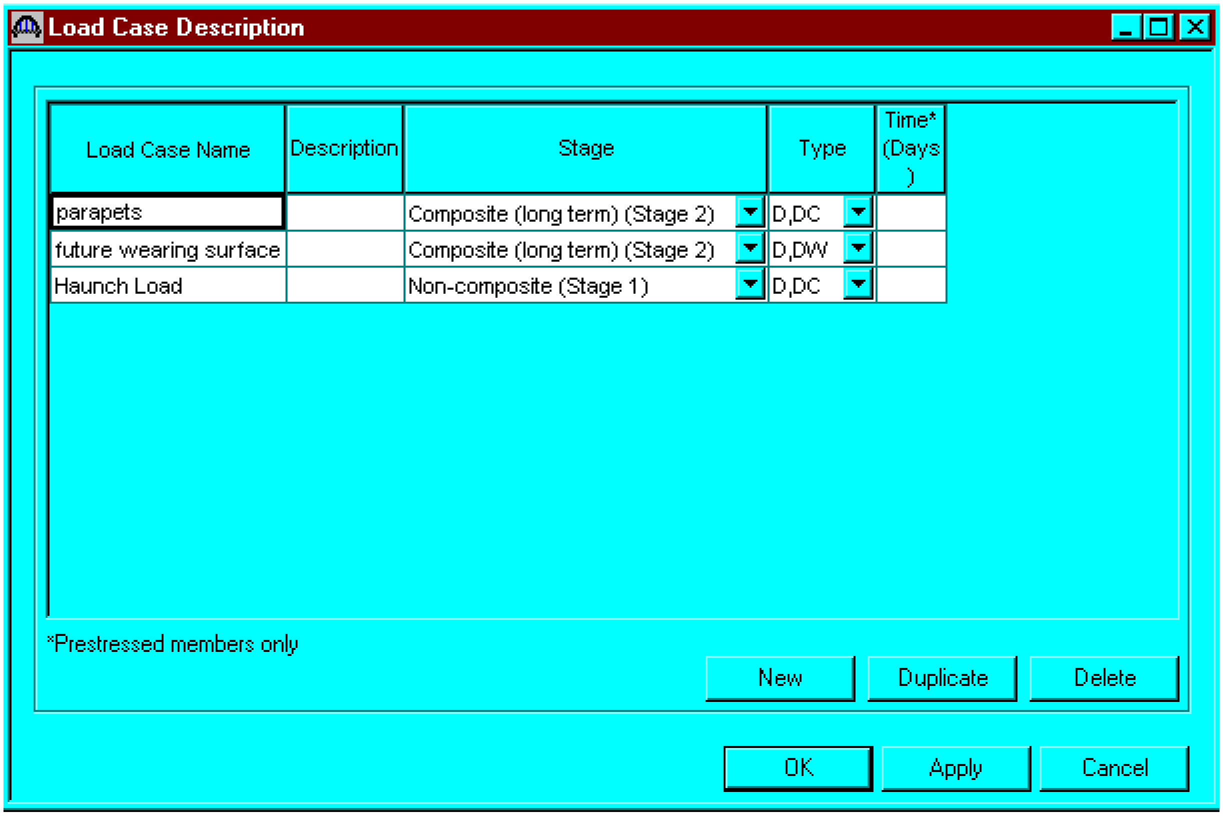


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

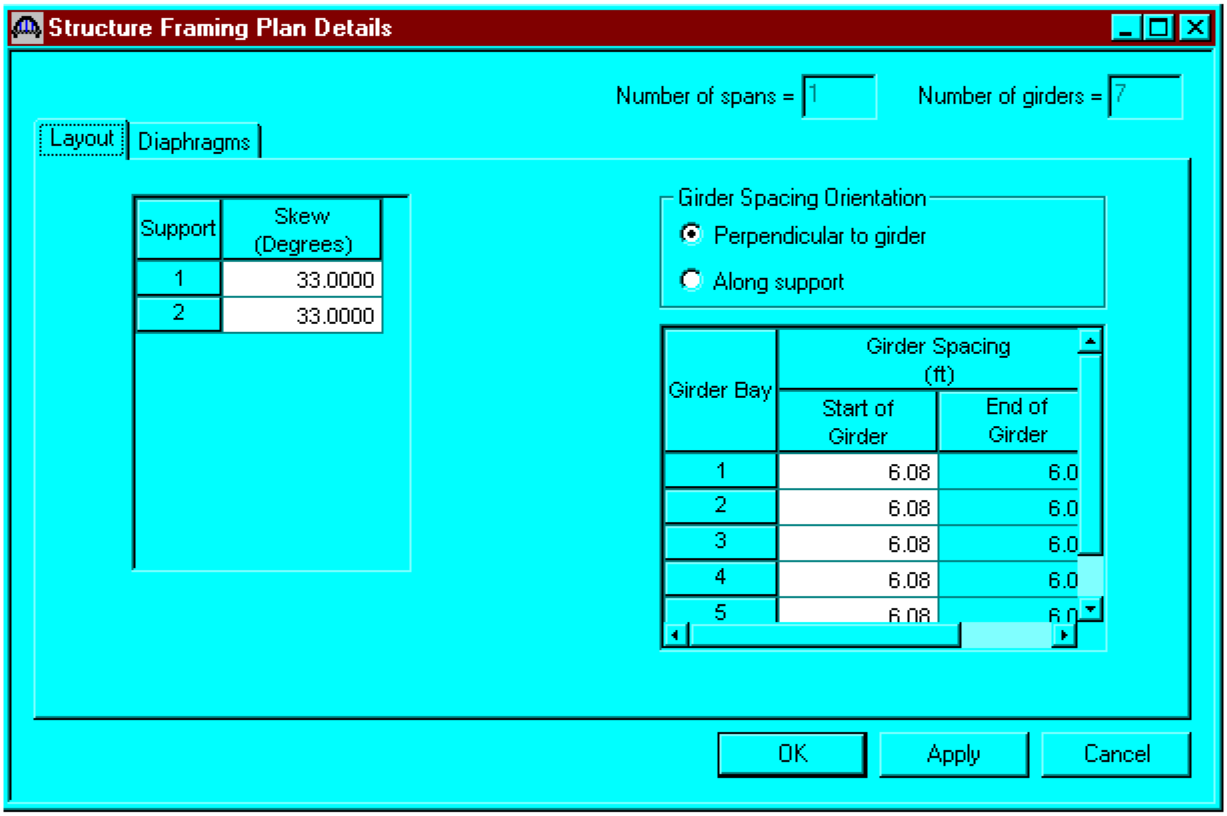
The partially expanded Bridge Workspace tree is shown below:



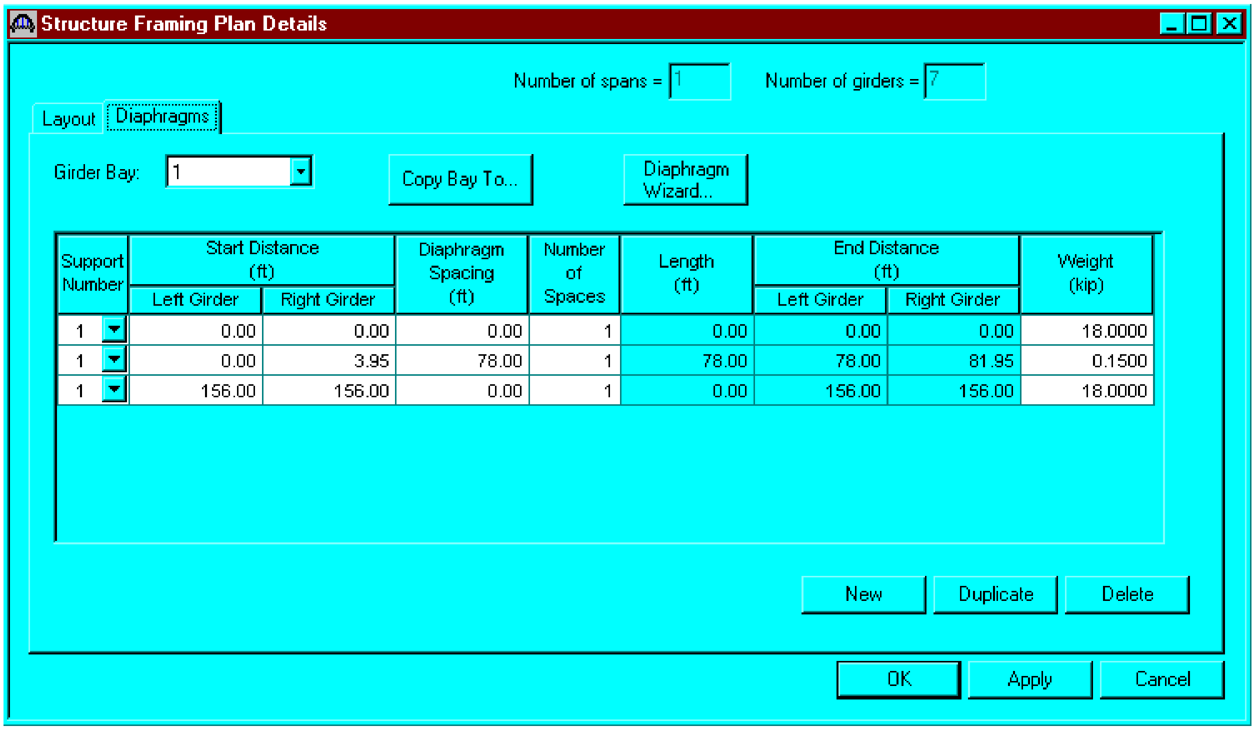
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed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



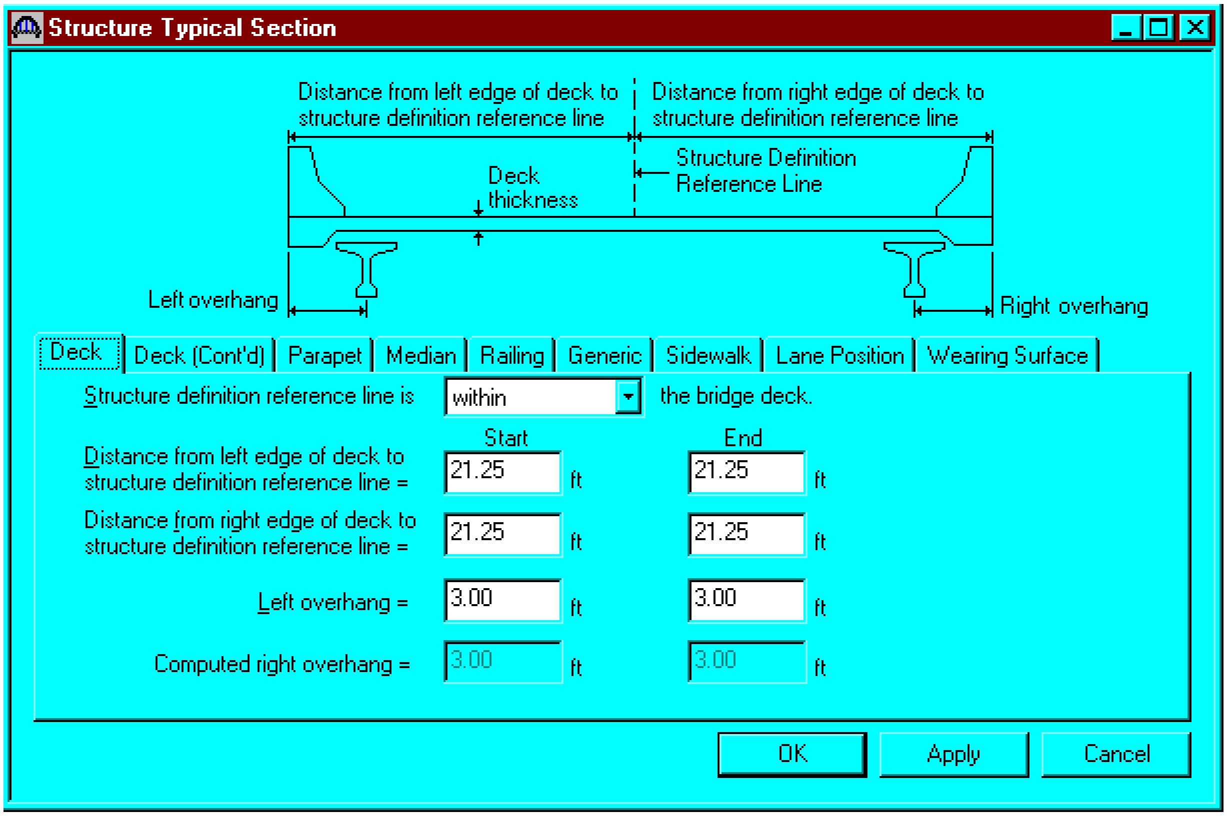
Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



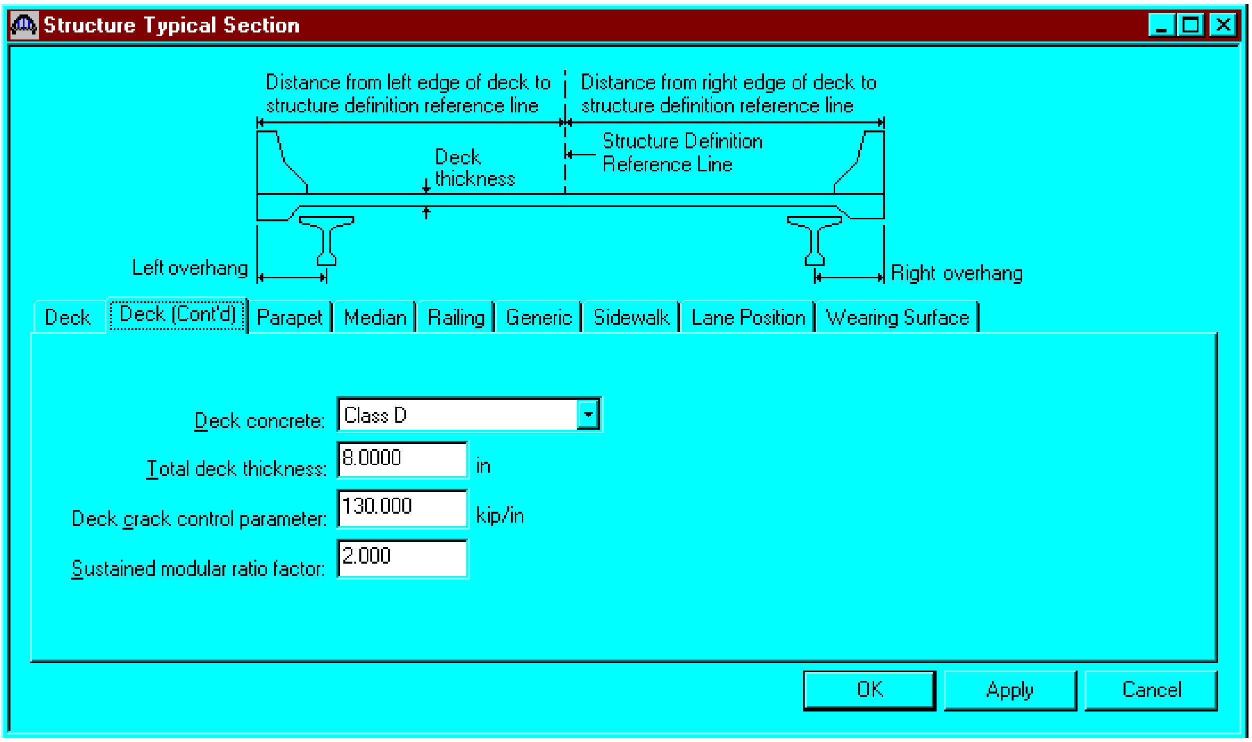
If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.



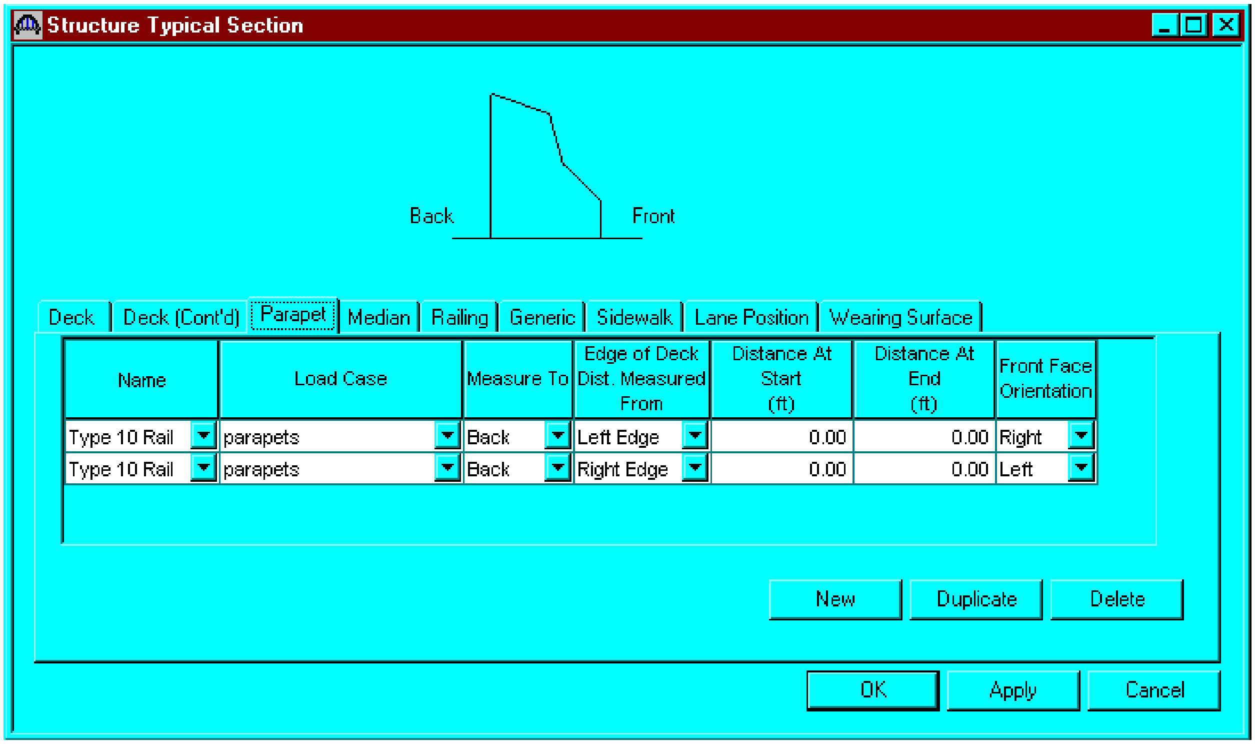
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



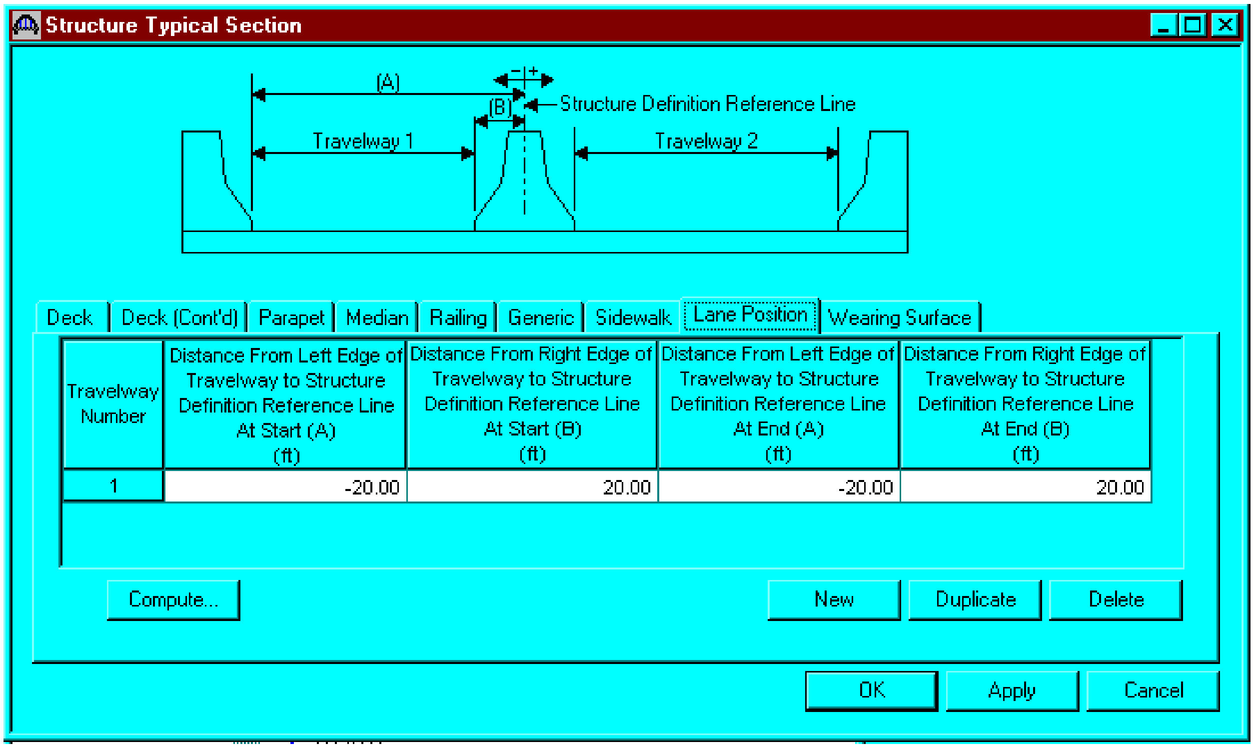
The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



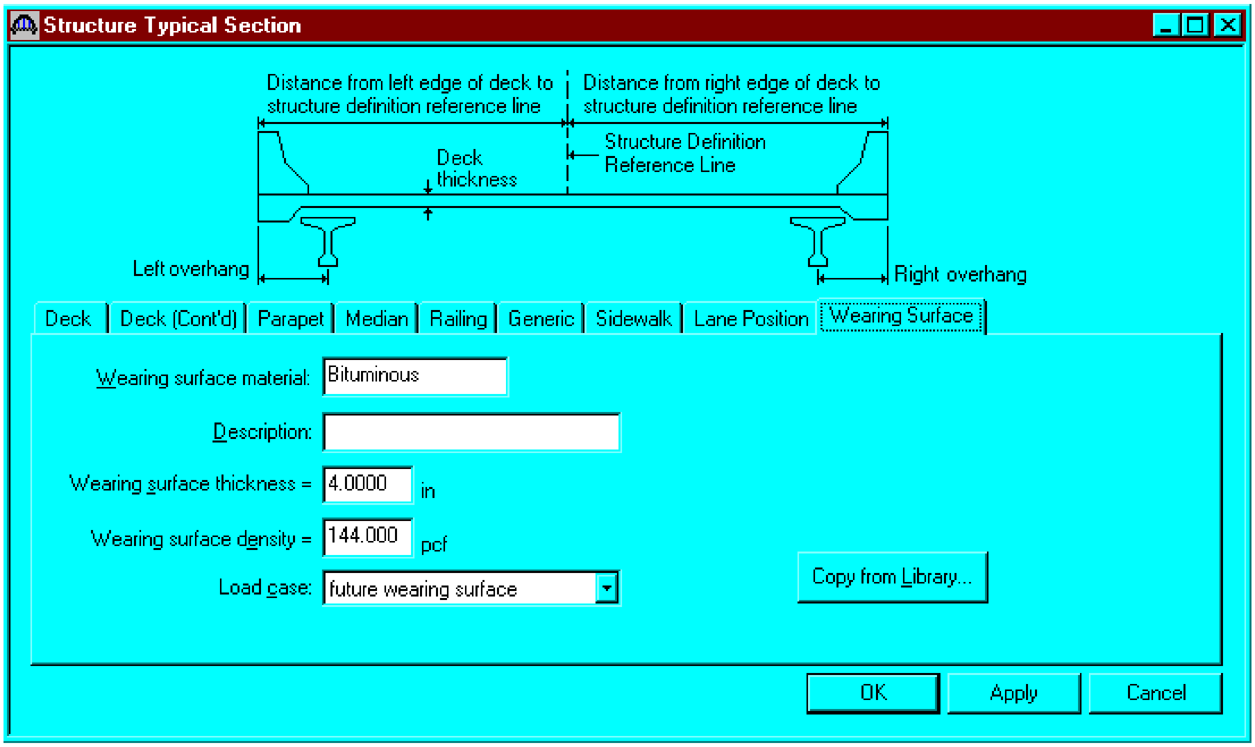
Parapets:
Add two parapets as shown below.



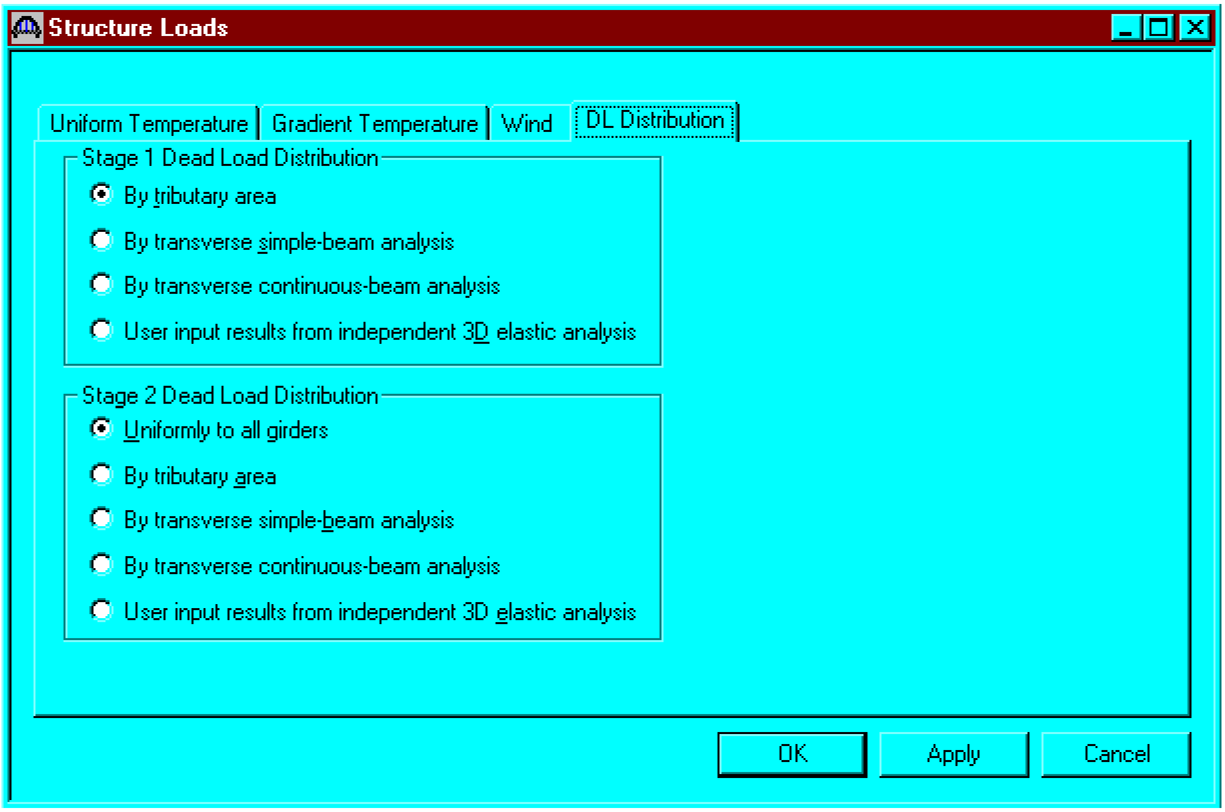
Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.



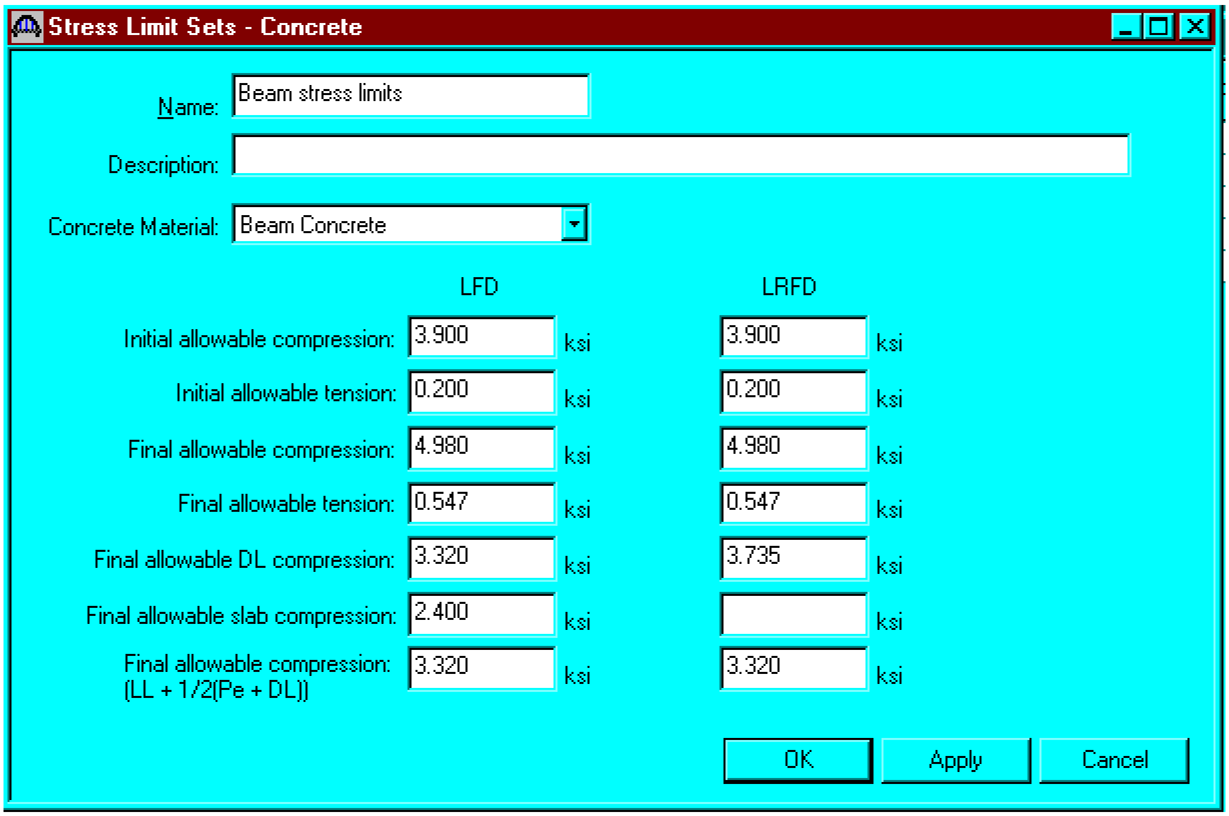
Enter the following wearing surface information on the Wearing Surface tab.



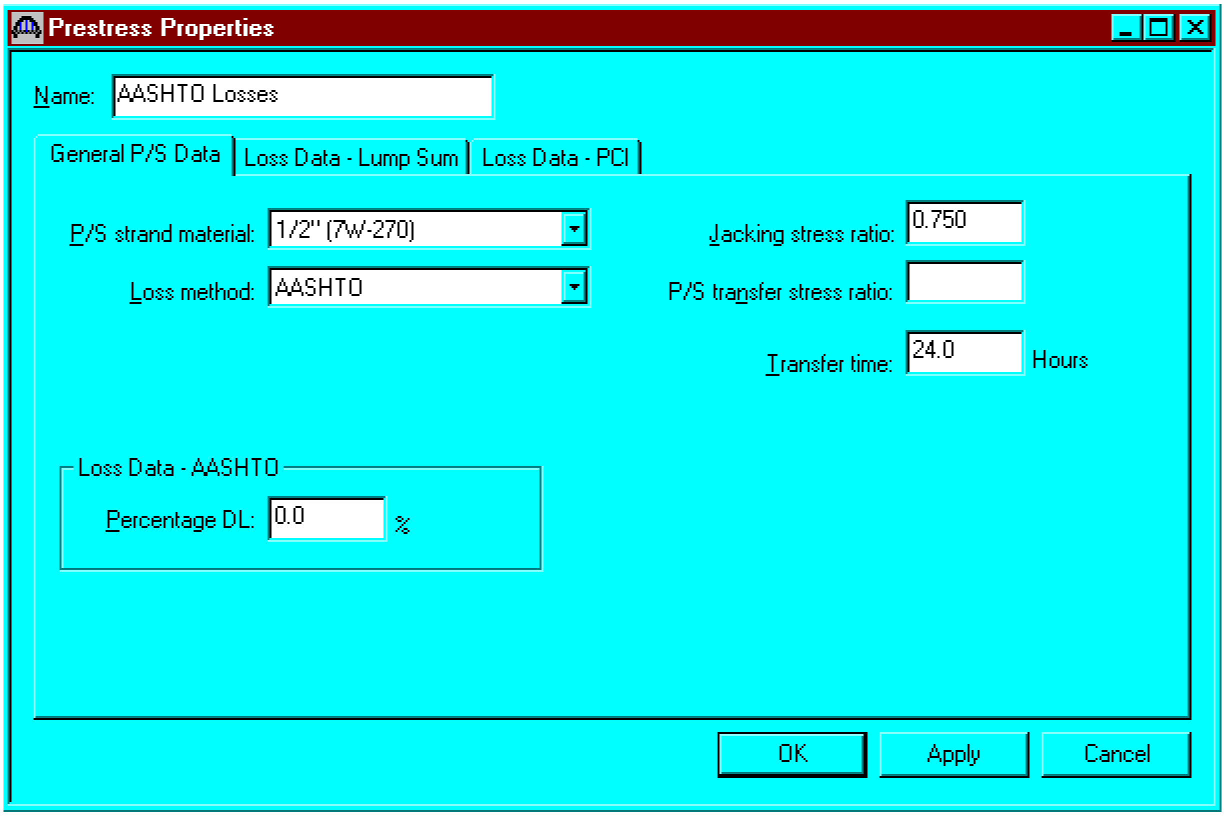
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



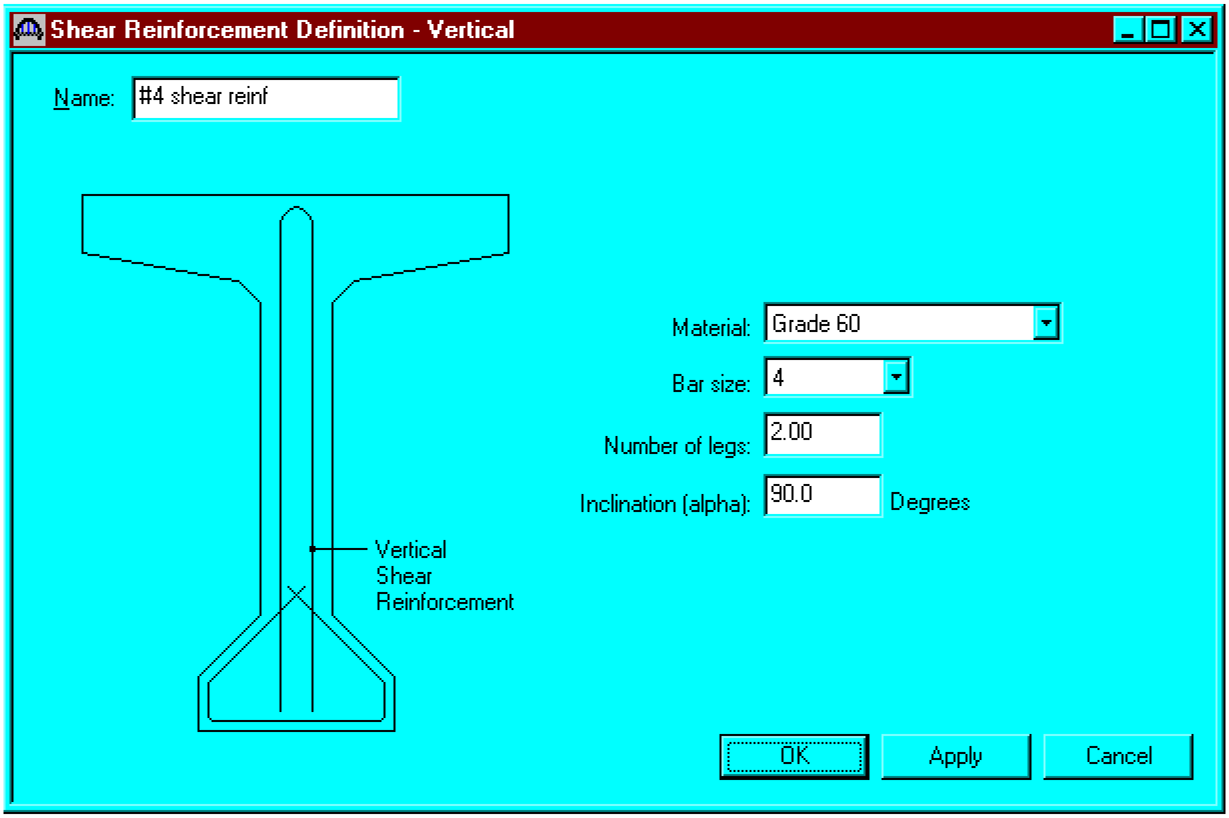
A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “Beam Concrete” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications.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



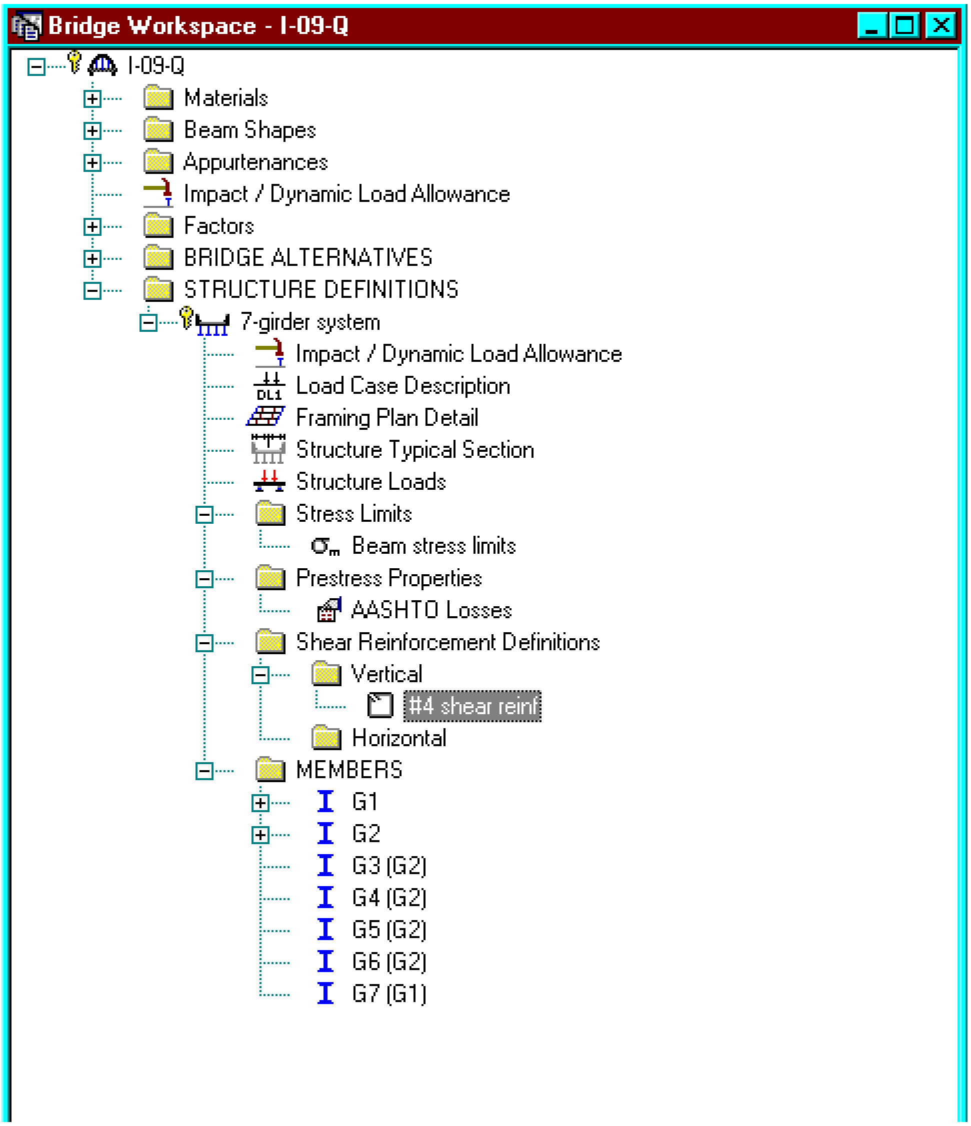
Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the “General P/S Data” tab is required.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



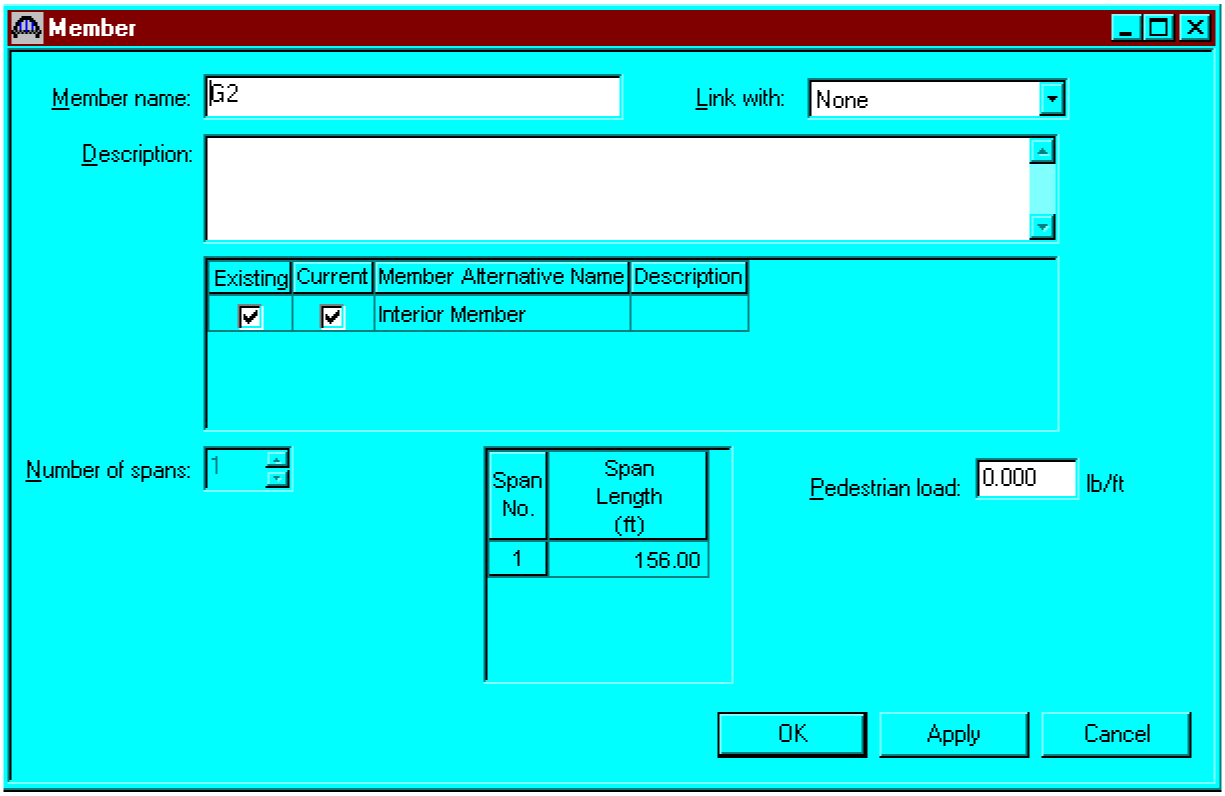
Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



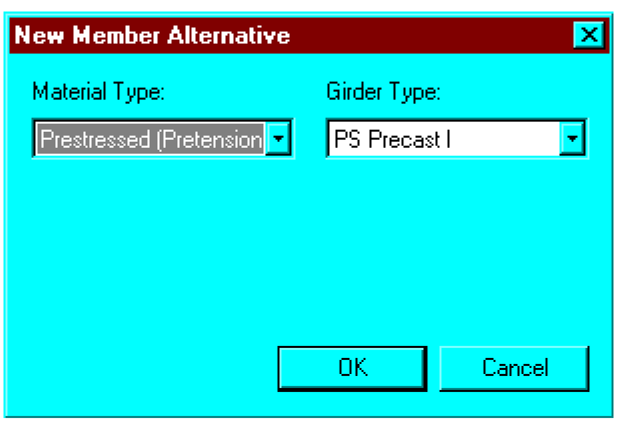
The partially expanded Bridge Workspace tree is shown below:



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.

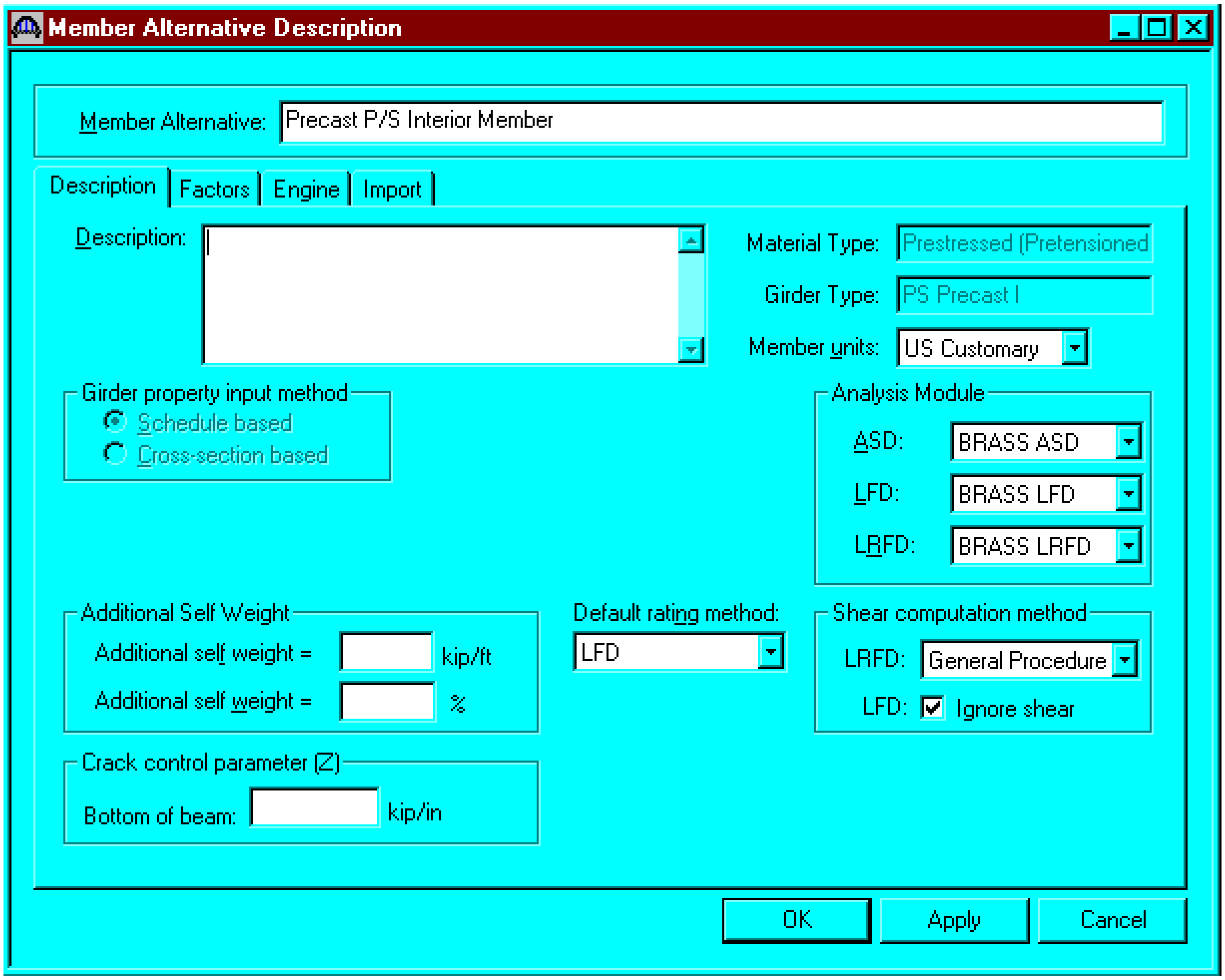


Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

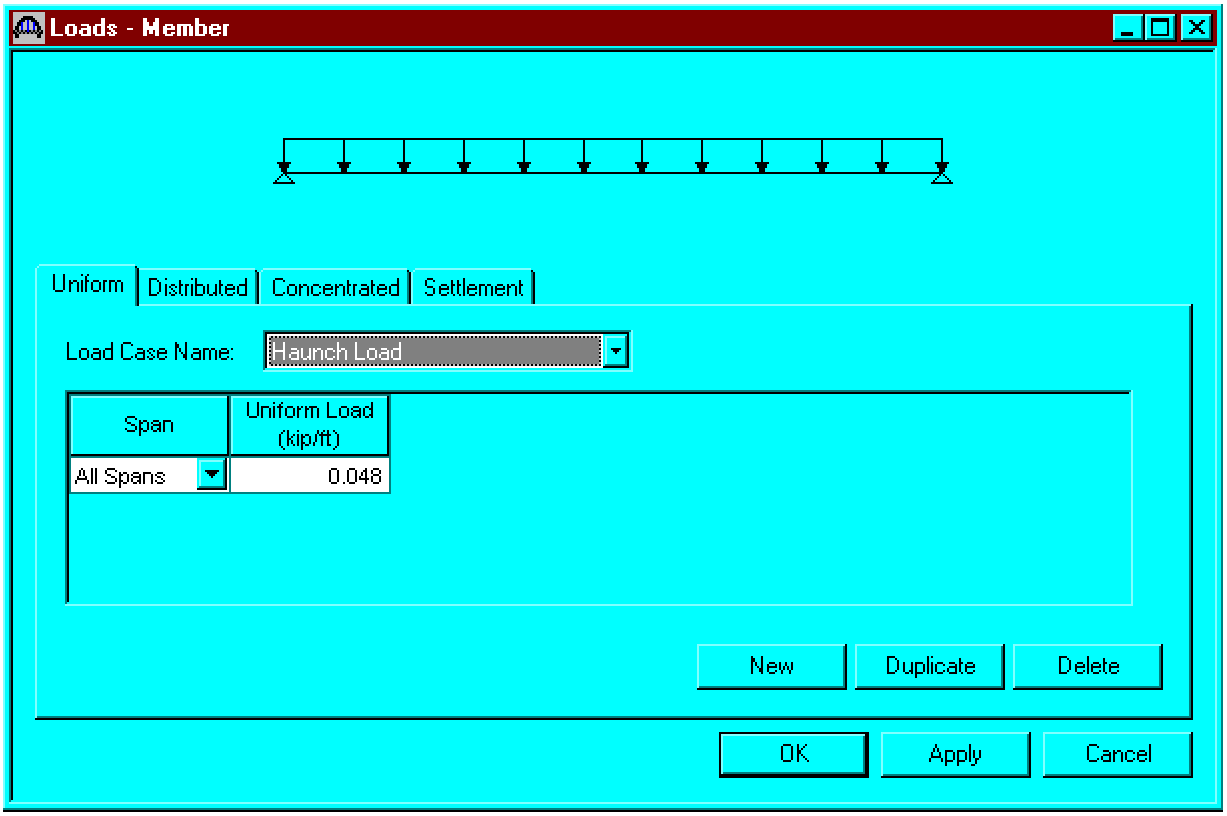


Click OK to close the dialog and create a new member alternative.

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



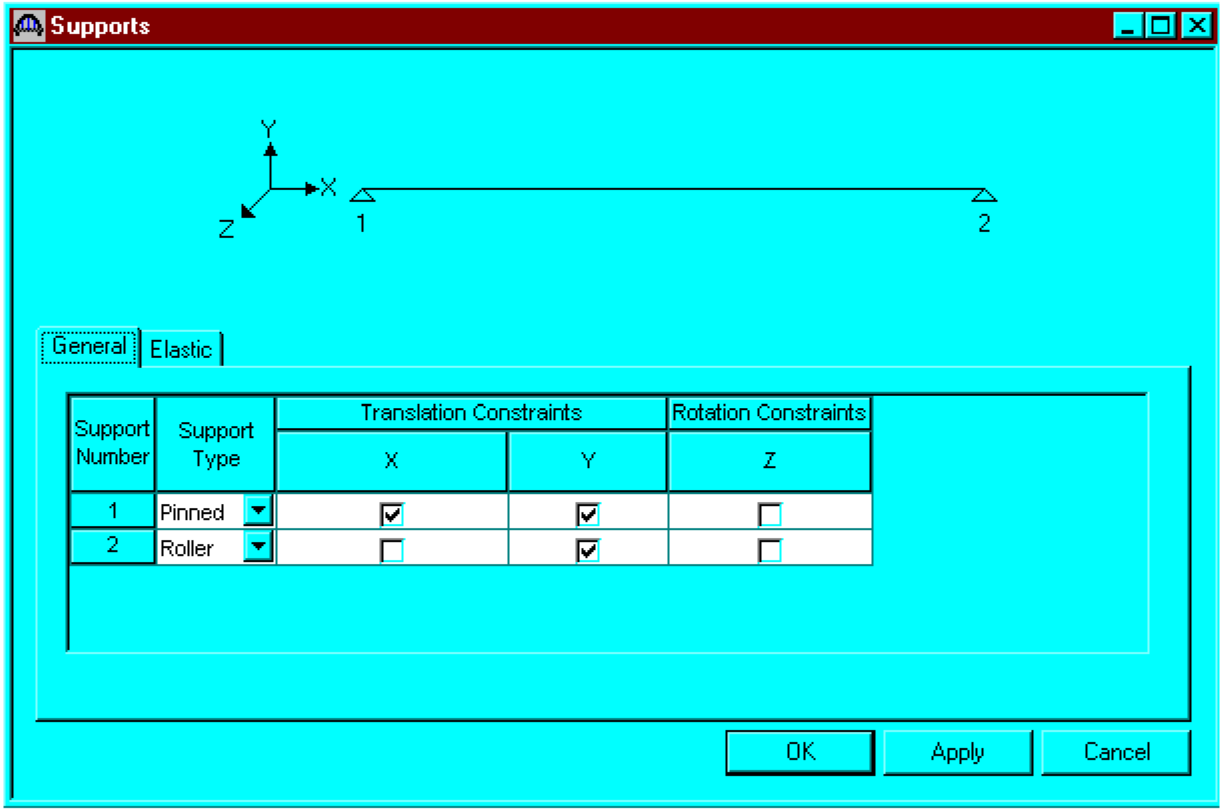
Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.



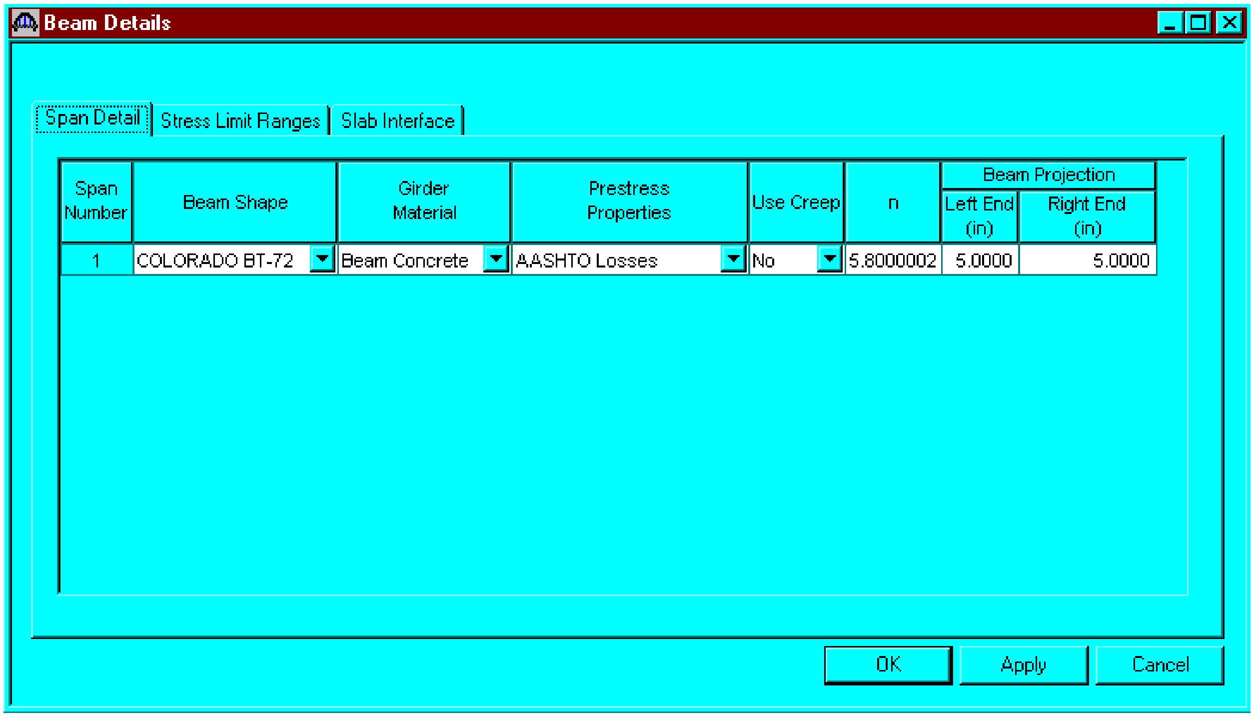
Calculated average haunch = 2.5”
Haunch used for section properties = 1.43”

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

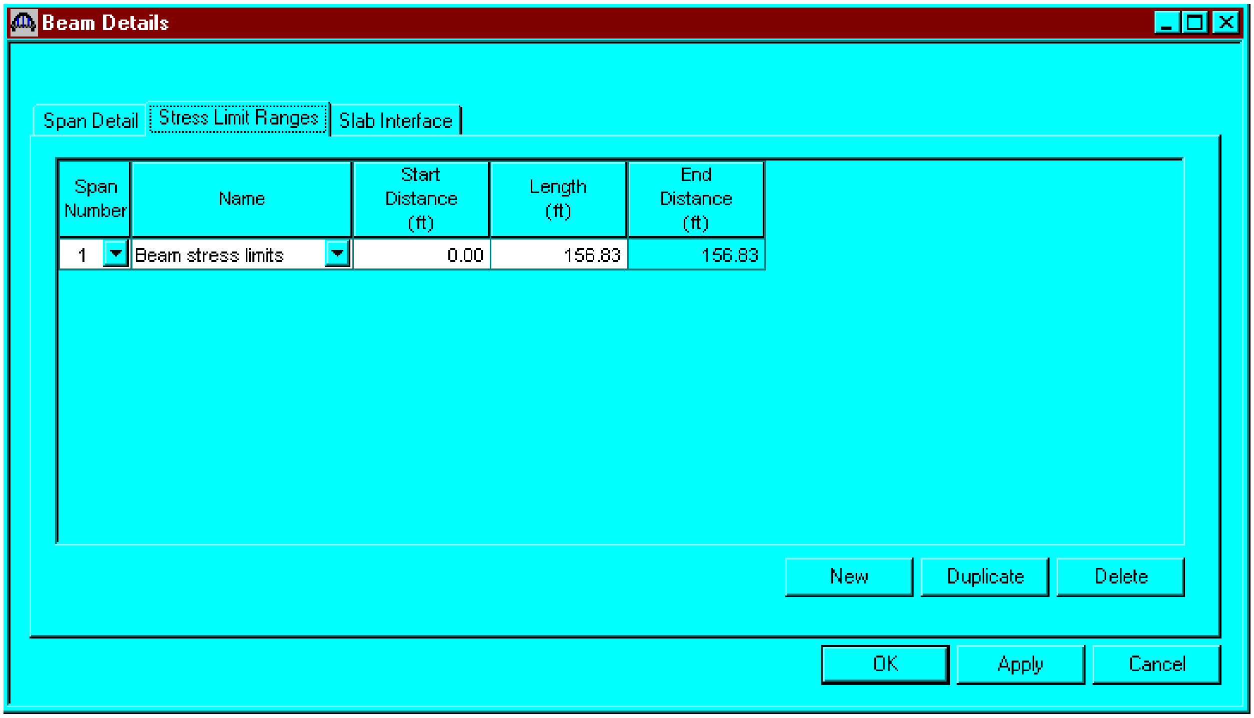
Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



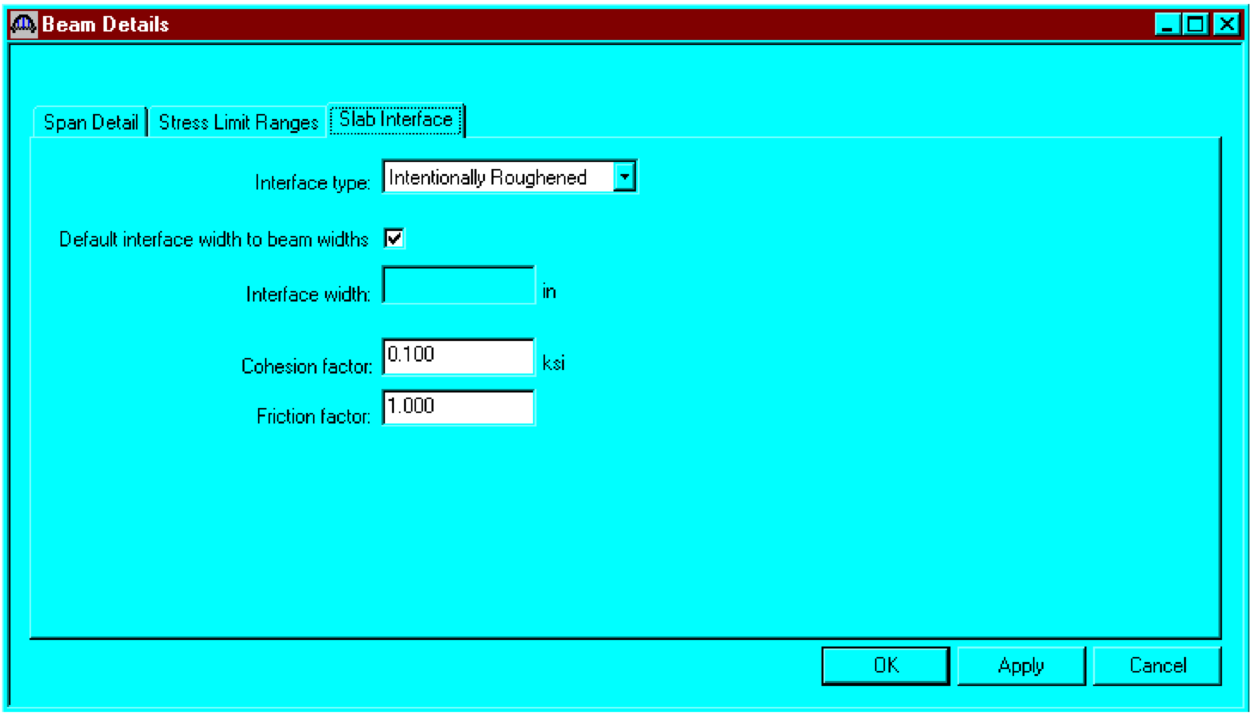
The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape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



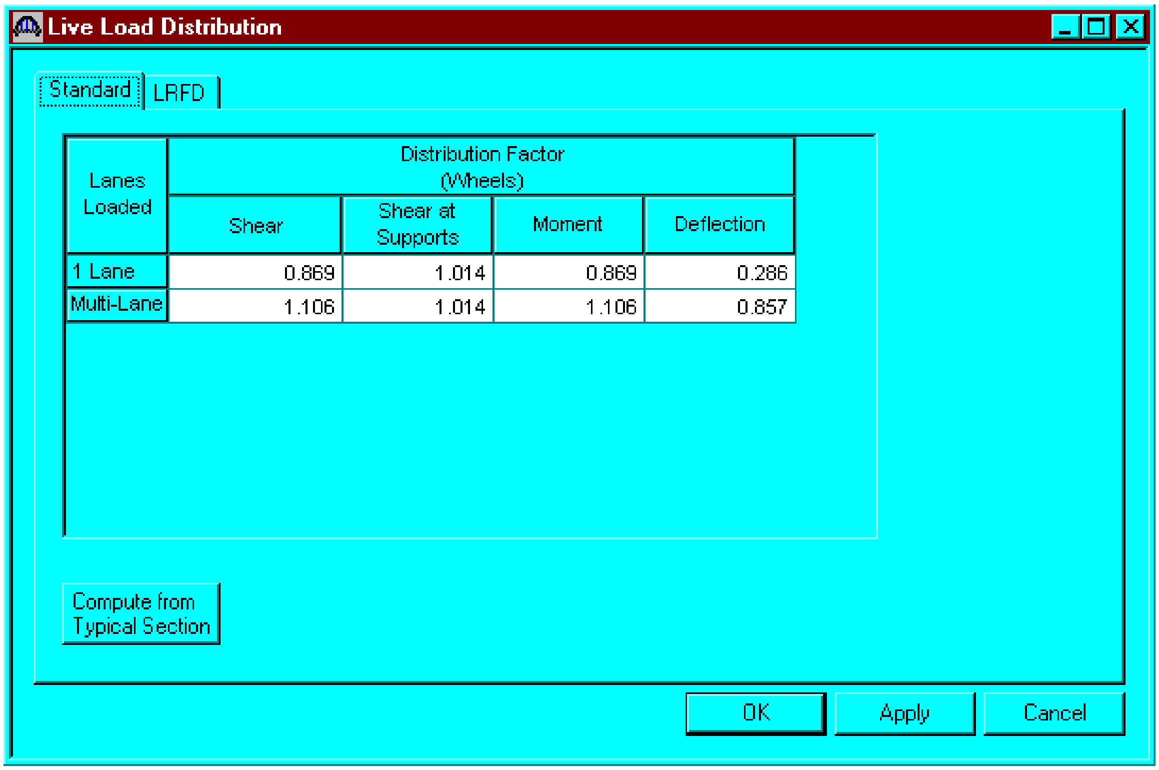
Note that the Stress Limit Ranges are defined over the entire length of the precast beam.



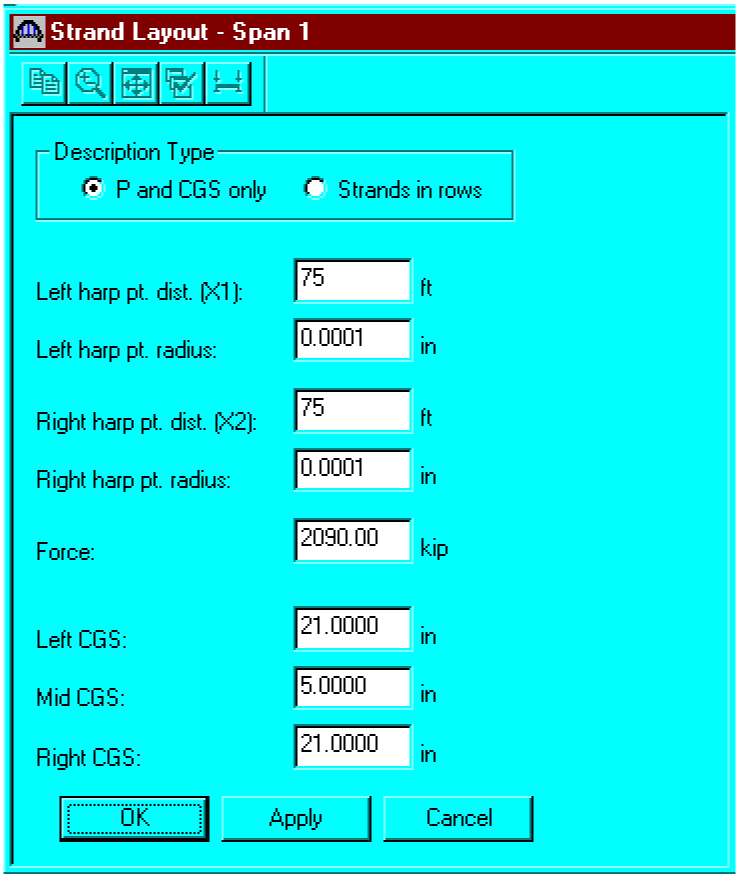
The defaults on the Slab Interface tab are shown below and are acceptable.



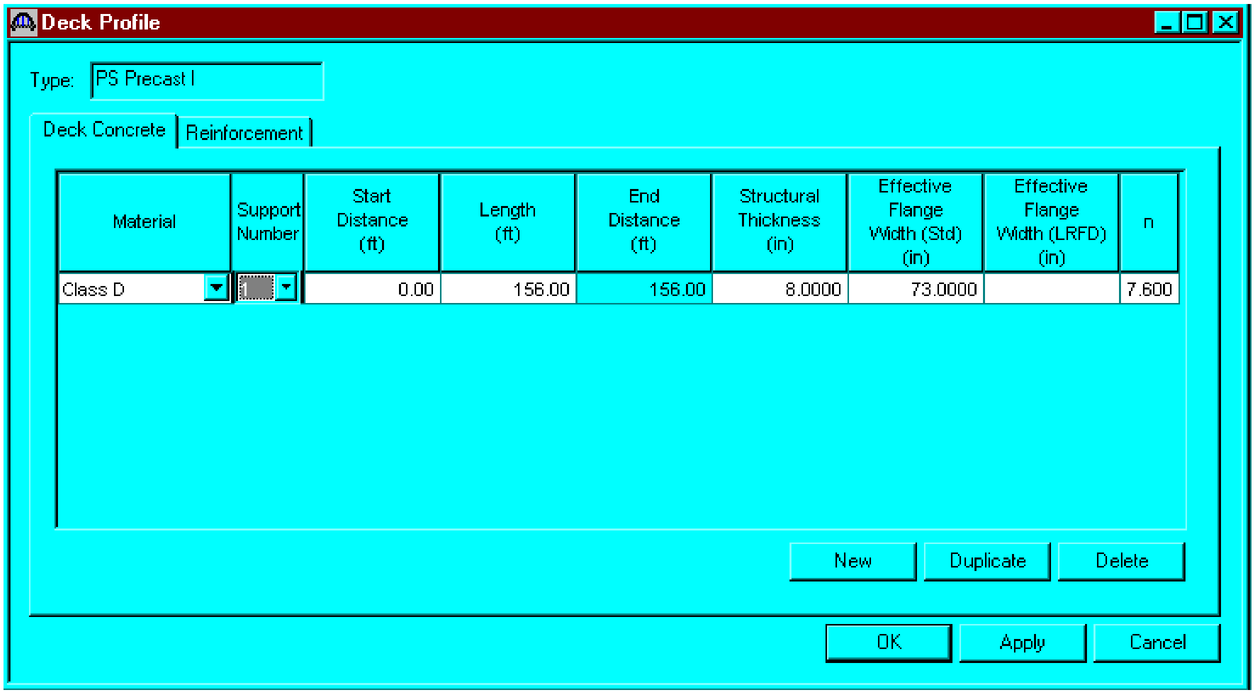
Double click on Live Load Distribution to enter live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23 and 3.28. Click Apply and then OK to save data to memory and close the window.



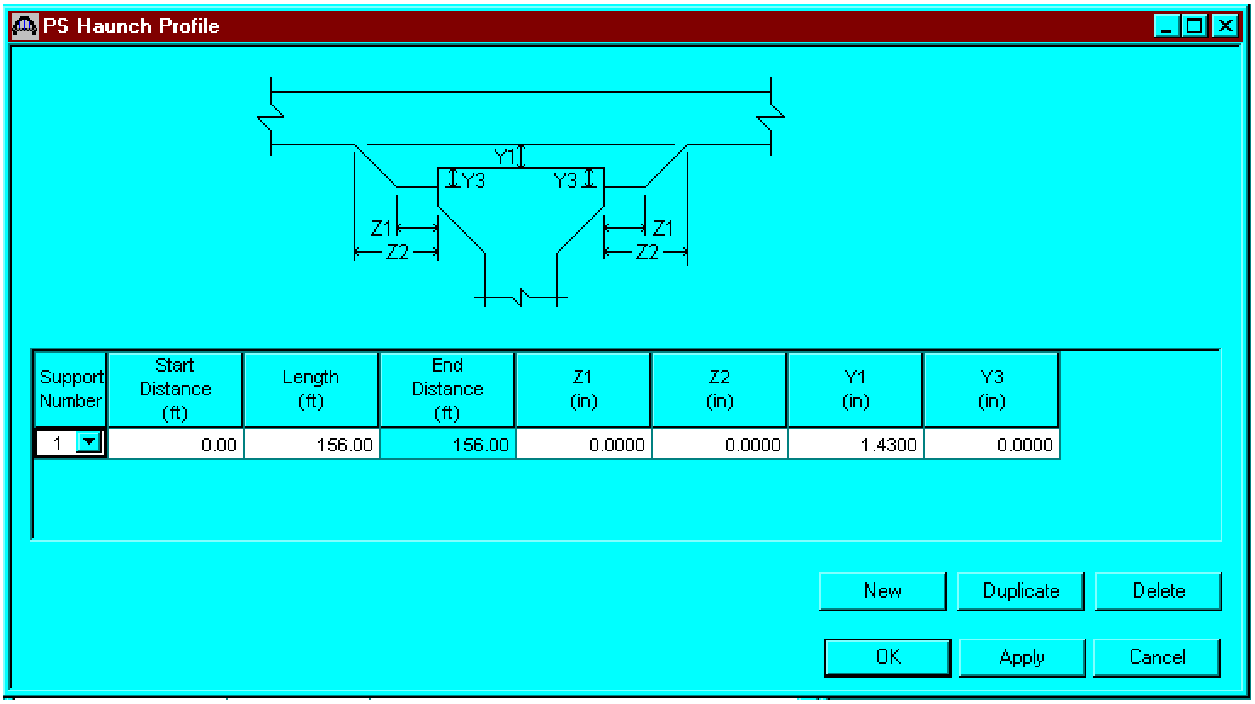
Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center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



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

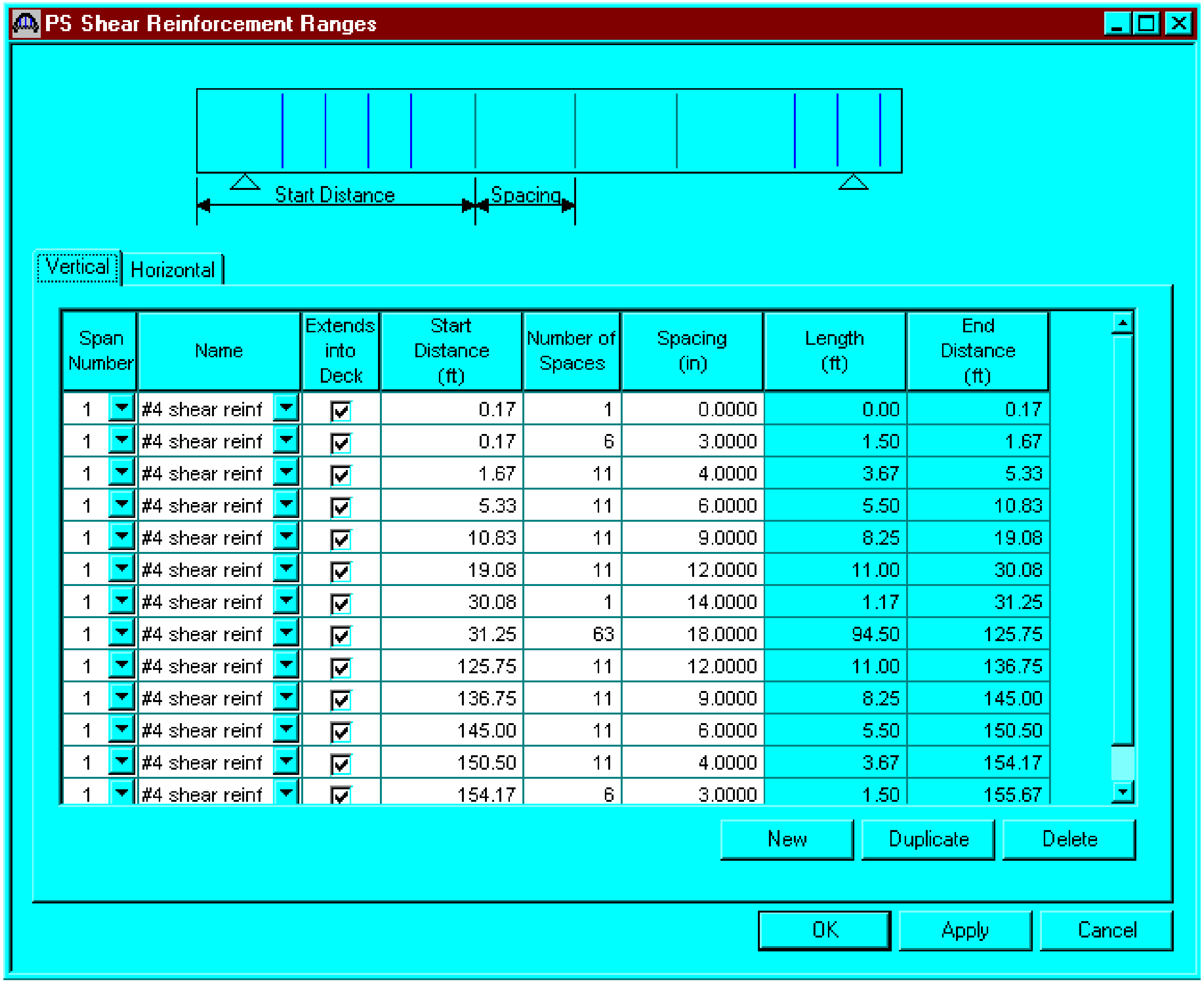


Double click on Haunch Profile in the tree to define the haunch profile for the girder.



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

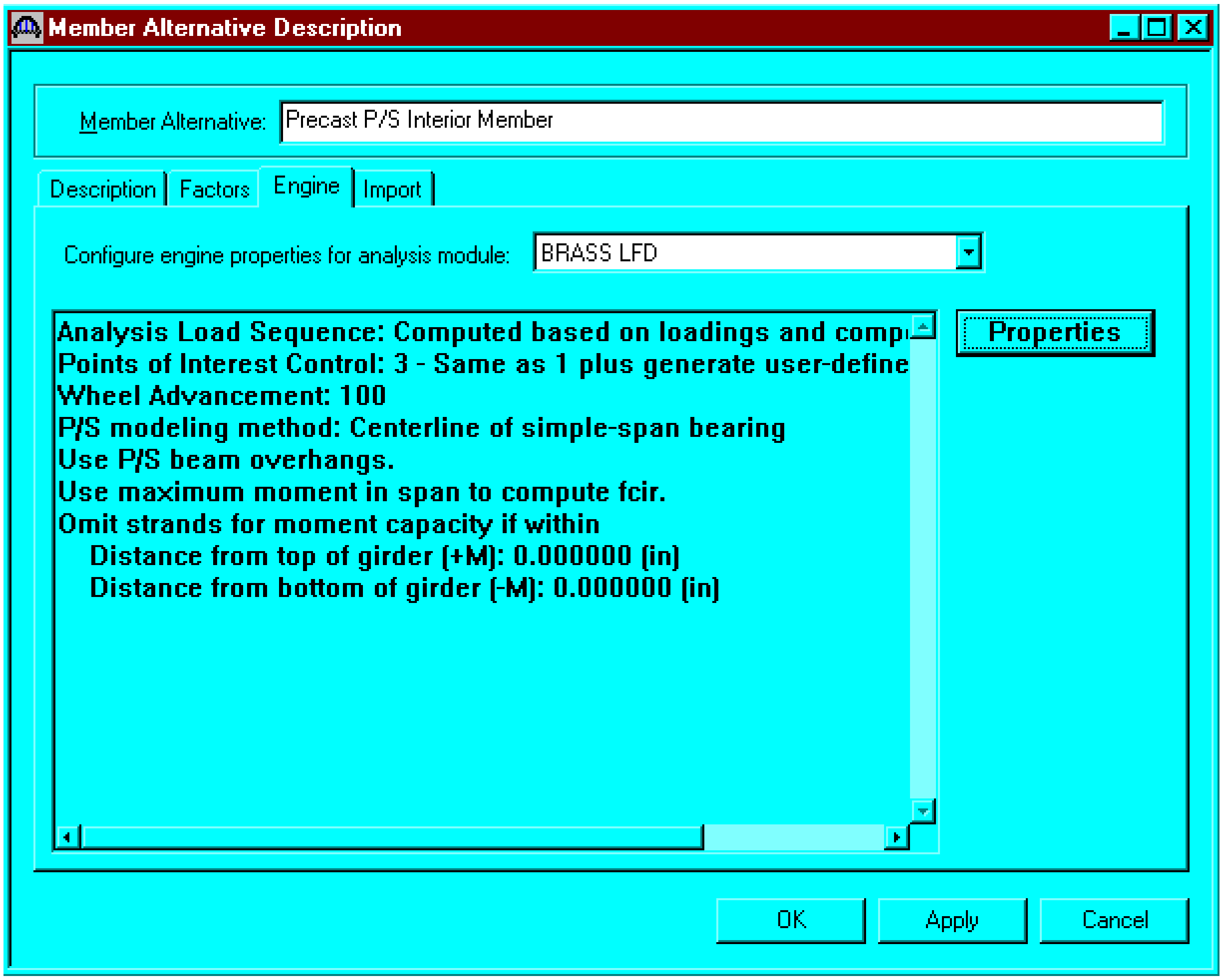
The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we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



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

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

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



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

Analysis Results - Precast P/S Interior Member

Report Type: Rating Results Summary

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

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

Close

Analysis Results - Precast P/S Interior Member

Report Type: Rating Results Summary

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

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

Close

COLORADO DEPARTMENT OF TRANSPORTATION
LOAD FACTOR RATING SUMMARY

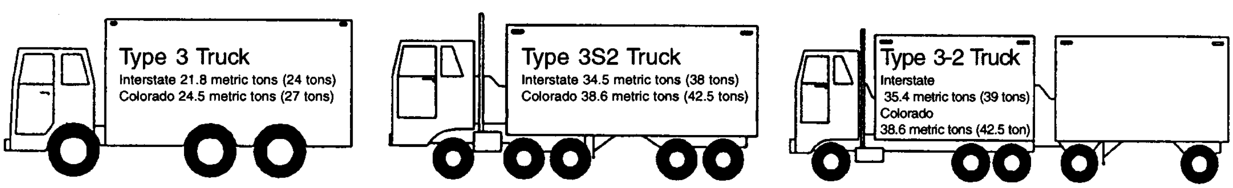
Structure #	I-09-Q
State highway #	135
Batch I.D.	
Structure type	CPG
Parallel structure #	

Rated using
Asphalt thickness: 102 mm (4 in.)
☒ Colorado legal loads
☐ Interstate legal loads

Structural member	INTERIOR GIRDER BT 72	SLAB		

Metric tons (Tons)

Inventory	26.4 (29)	51.8 (57)	( )	( )
Operating	125.4 (138)	86.4 (95)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	166.4 (183)	( )	( )	( )



Type 3 Truck	Type 3S2 Truck	Type 3-2 Truck
______ Metric tons (______ Tons)	______ Metric tons (______ Tons)	______ Metric tons (______ Tons)

Comments

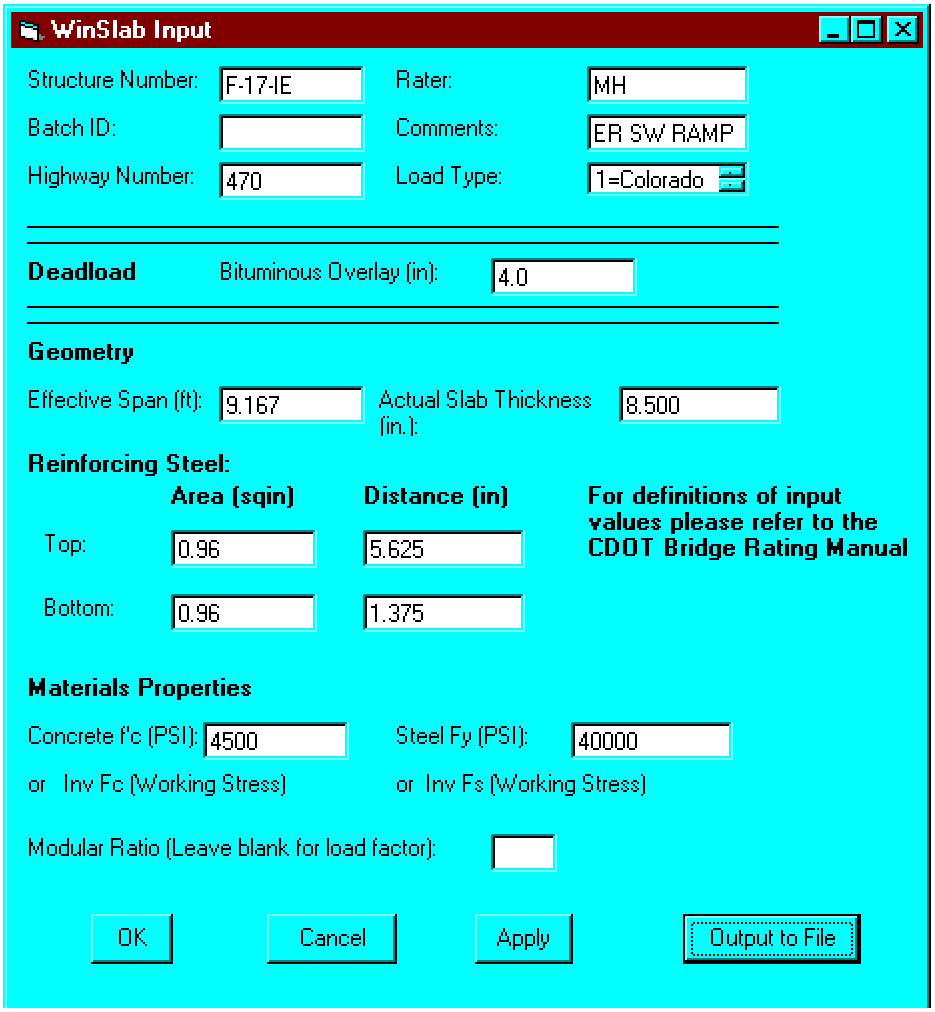
Control Member: Deck; Rated for 2" HBP
Load Capacity: 95 Tons
Girder: Only Interior Girder Rated; Haunch included in the section properties calculations;
BT 72 Girders; Rated for 4" HBP

Color Code: White

Project No: STR(CX) 0135(14)

Rated by	Date	Checked by	Date

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


WinSlab Input

Structure Number: F-17-IE
Rater: MH
Batch ID:
Comments: ER SW RAMP
Highway Number: 470
Load Type: 1=Colorado

Deadload Bituminous Overlay (in): 4.0

Geometry

Effective Span (ft): 9.167
Actual Slab Thickness (in.): 8.500

Reinforcing Steel:

	Area (sqin)	Distance (in)
Top:	0.96	5.625
Bottom:	0.96	1.375

For definitions of input values please refer to the CDOT Bridge Rating Manual

Materials Properties

Concrete f'c (PSI): 4500
Steel Fy (PSI): 40000
or Inv Fc (Working Stress)
or Inv Fs (Working Stress)

Modular Ratio (Leave blank for load factor):

OK Cancel Apply Output to File

Effective Span Length: Per AASHTO Article 3.24.1.2(a)

Clear distance between flanges = 11.5’-2.333’=9.167’

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

```
  WinSlab Rating Version 1     Date: 9/18/2001

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

 LOAD FACTOR RATING-COMP STEEL NOT USED

 INPUT DATA

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

Dead Load Moment   1.30 K-Ft
LL+I Moment        5.81 K-Ft
Gross Weight       36.0 Tons
                                    Inventory     Operating
Actual Concrete Stress      (PSI)    1220.64       1892.62
Actual Reinf. Steel Stress  (PSI)   19354.22      30008.88
Actual Comp. Steel Stress   (PSI)    5294.17       8208.66
Member Capacity             (K-Ft)     15.00         15.00
Member Capacity (LL+I)      (K-Ft)     13.31         13.31
     Rating                 (Tons)     38.09         63.48
```

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

Effective slab width: Per AASHTO Article 9.8.1.1

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

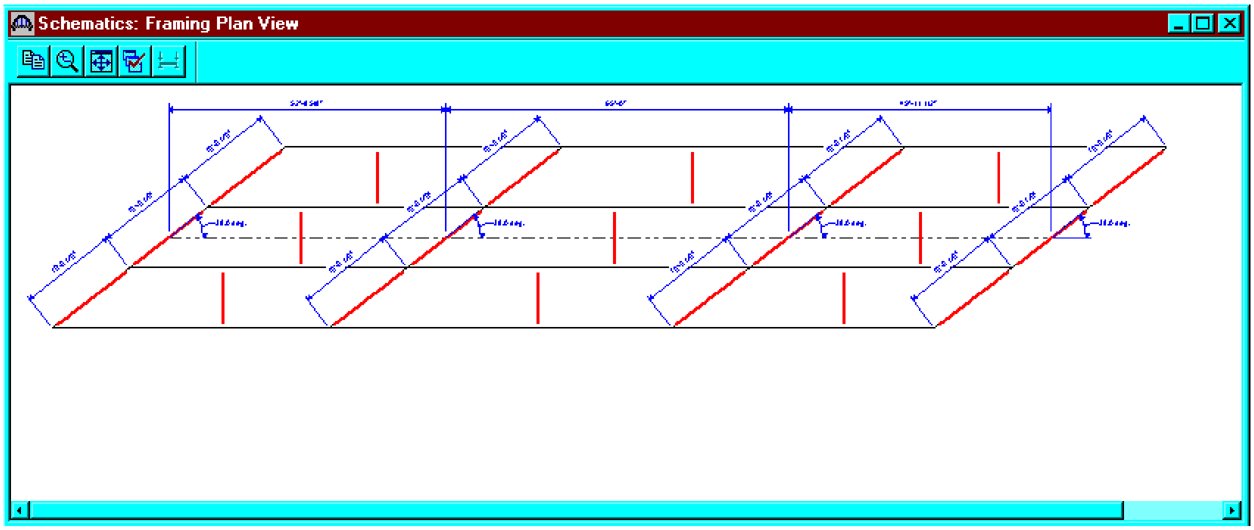
Dead Load:

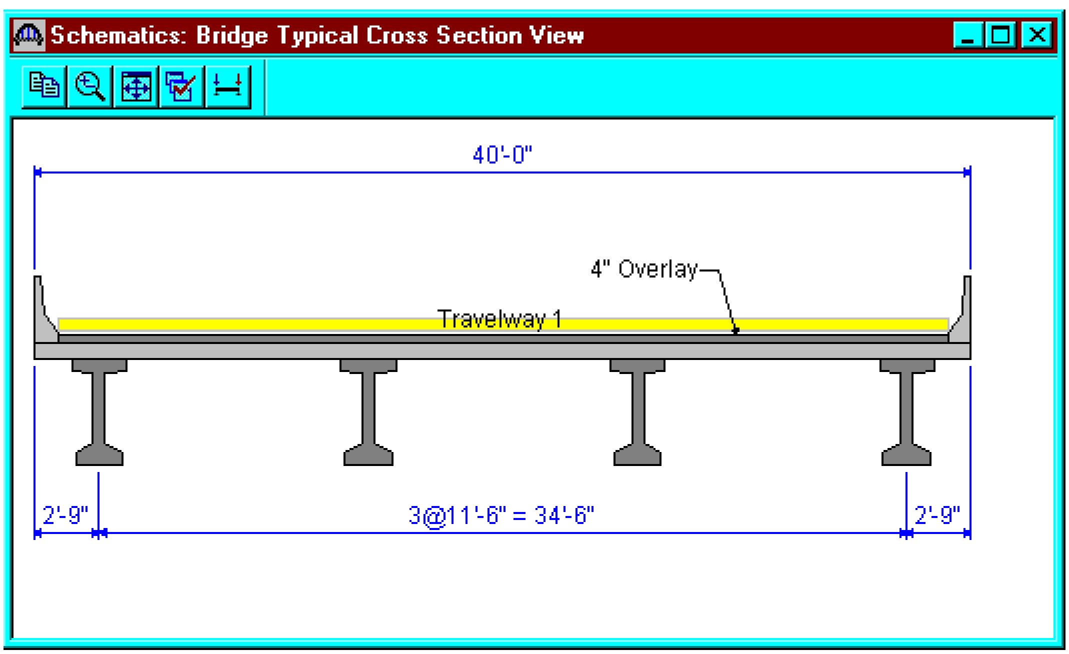
Intermediate Diaphragm = ((2)*(8/12)*(11.5) – (630/2)*(1/144)*(0.67))*(0.15)
= 2.09 kips   Use 2.1 kips

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

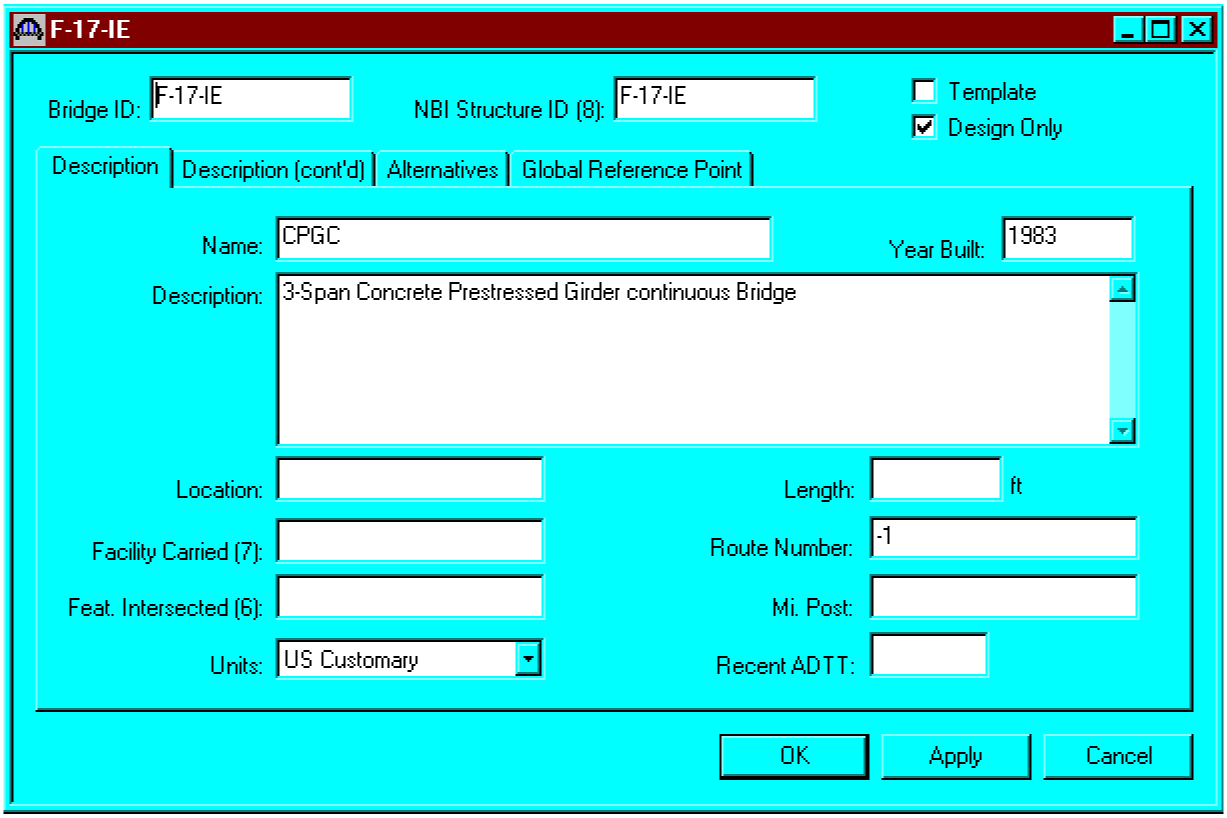
Pier Diaphragm = ((3.50)*(56.5/12)*(11.5)*(1/sin38°) – (630/144)*(29/12)*
(1/sin38°))*(0.150)= 43.6 kips
Use 44.0 kips

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





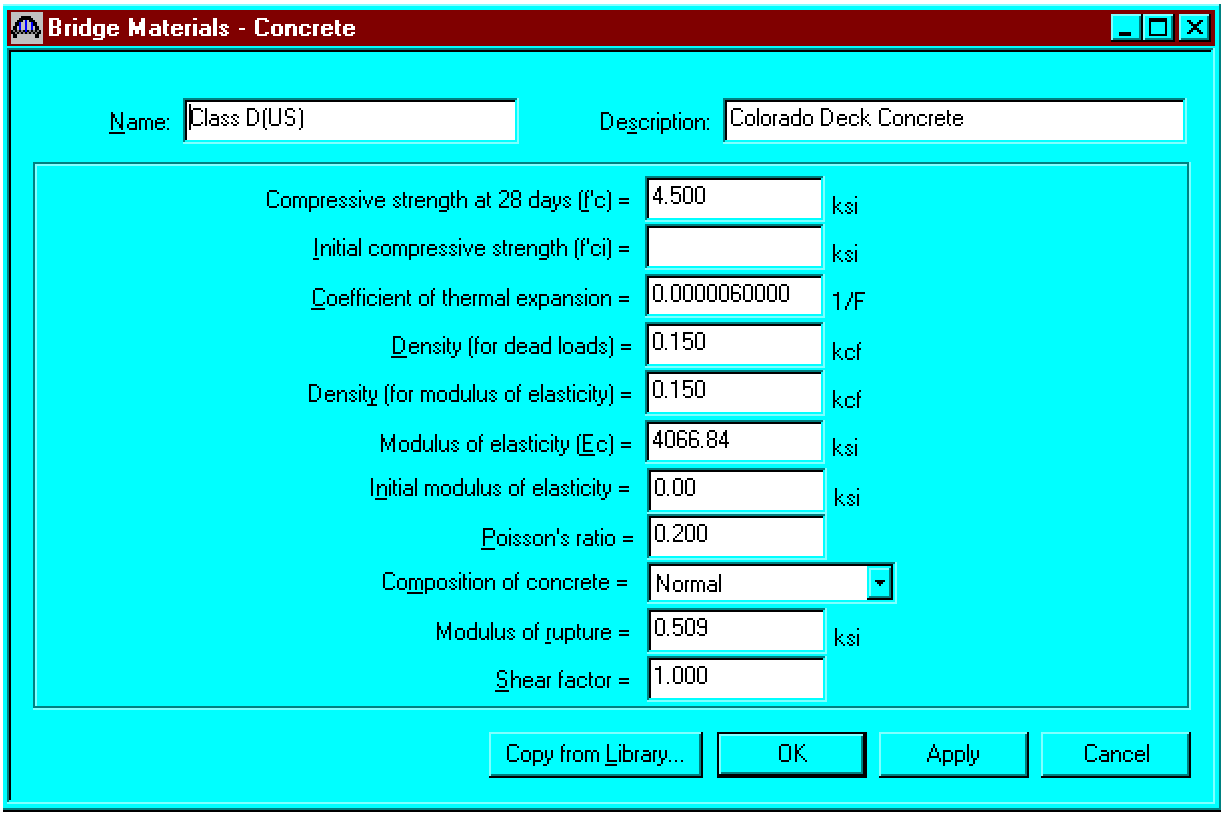
From the bridge explorer, create a new bridge and enter the following information.



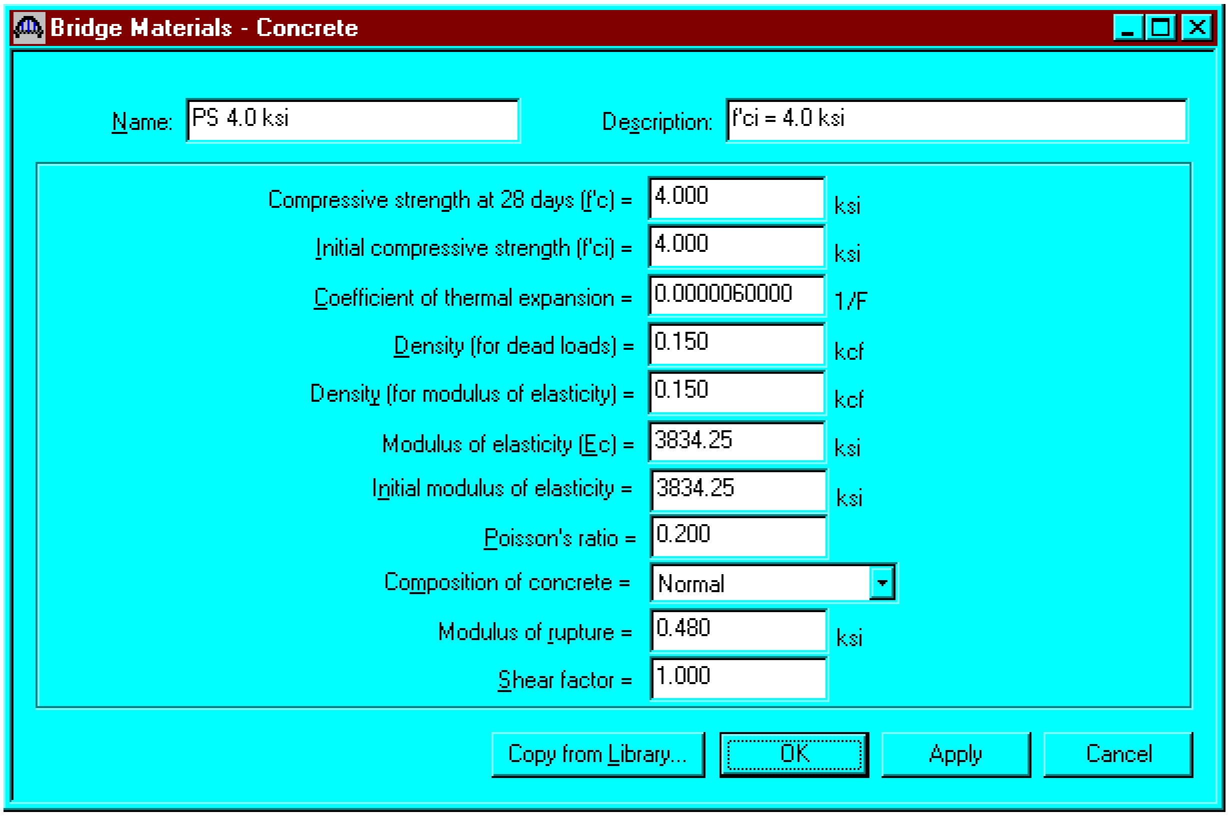
Click OK. This saves the data to memory and closes the window.

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

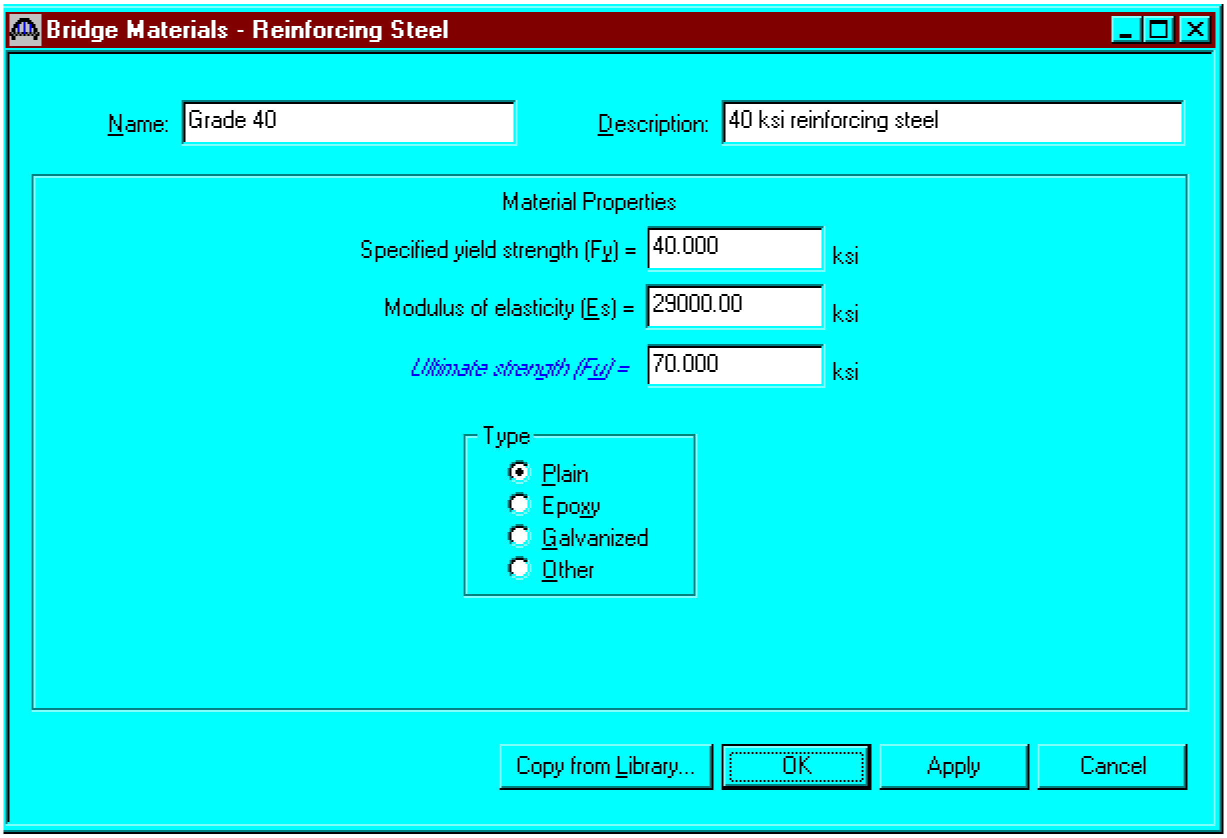
To add a new concrete material, click on Materials, Concrete, in the tree and select File/New from the menu (or right click on Concrete and select New). Click the Copy from Library button and select the Colorado Deck Concrete from the library. Click OK and the following window will open. Click OK to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

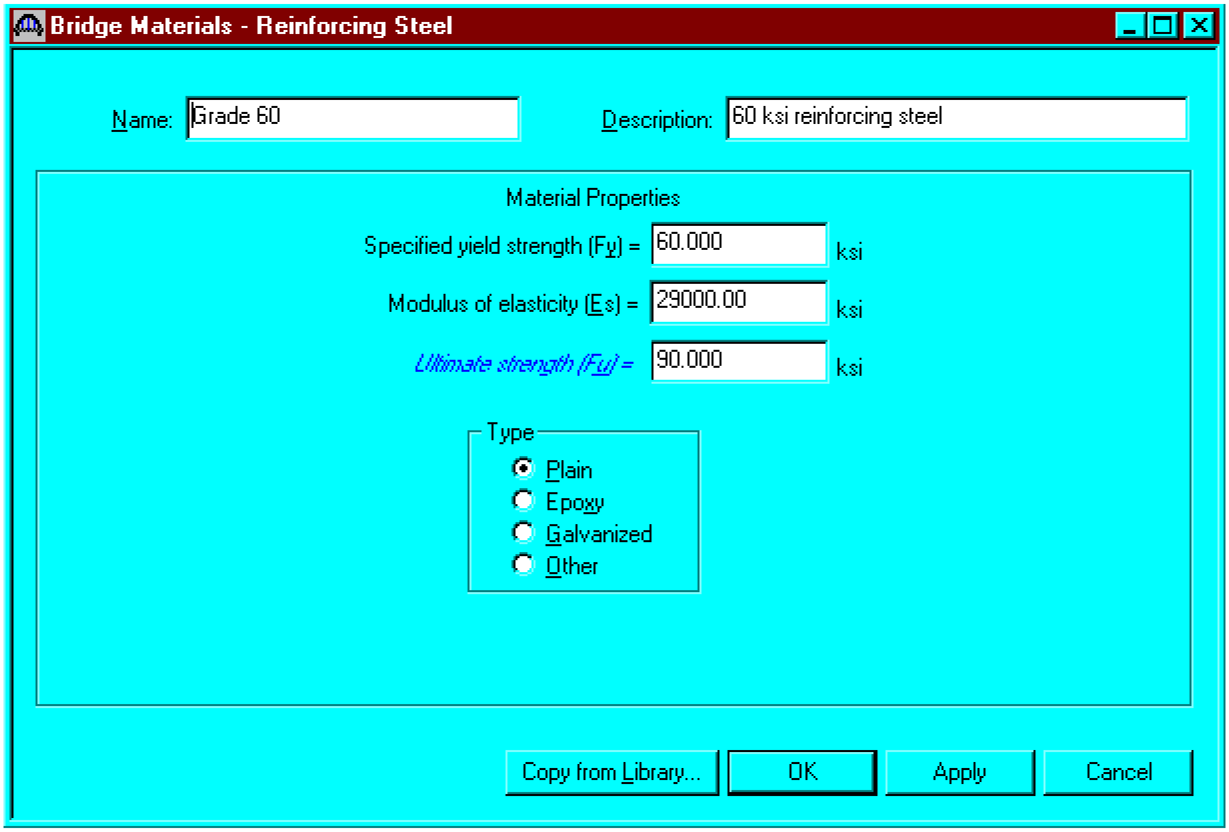


Using the same techniques, create a new concrete material to be used for the girder.

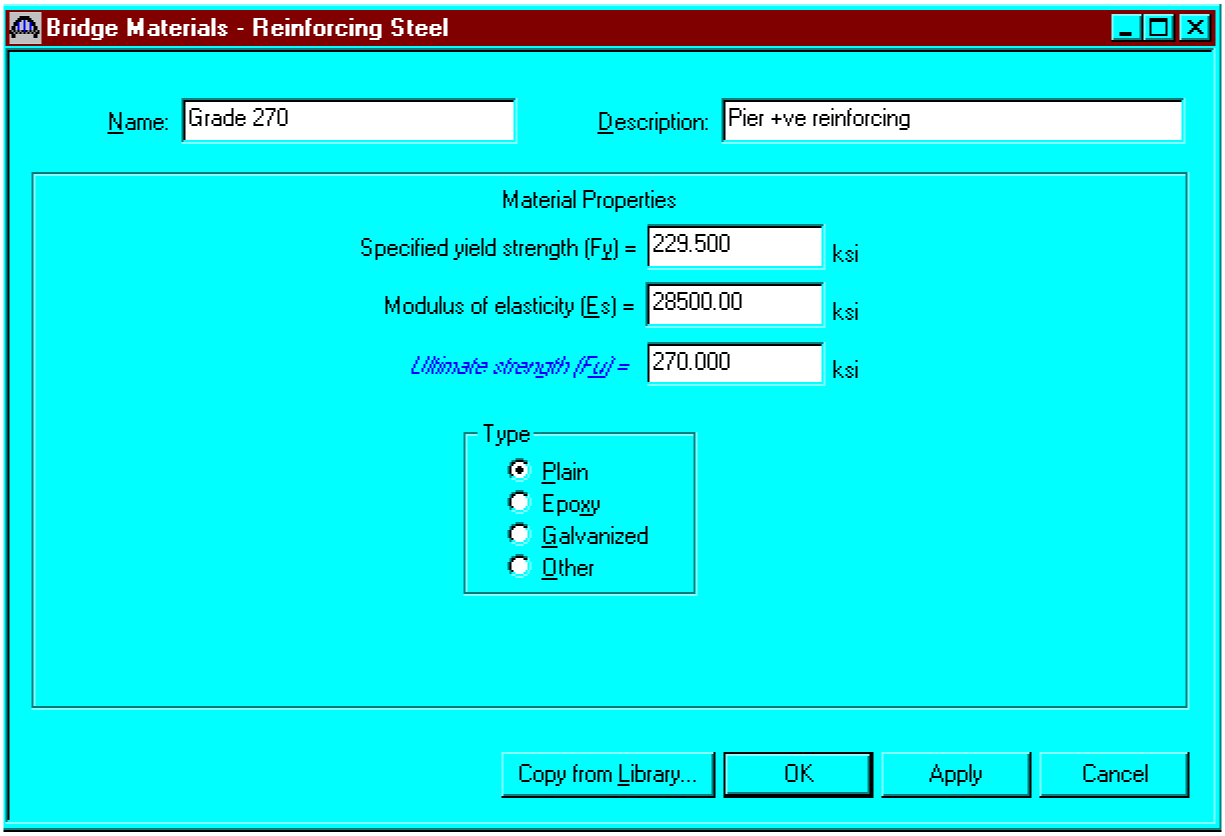


Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.

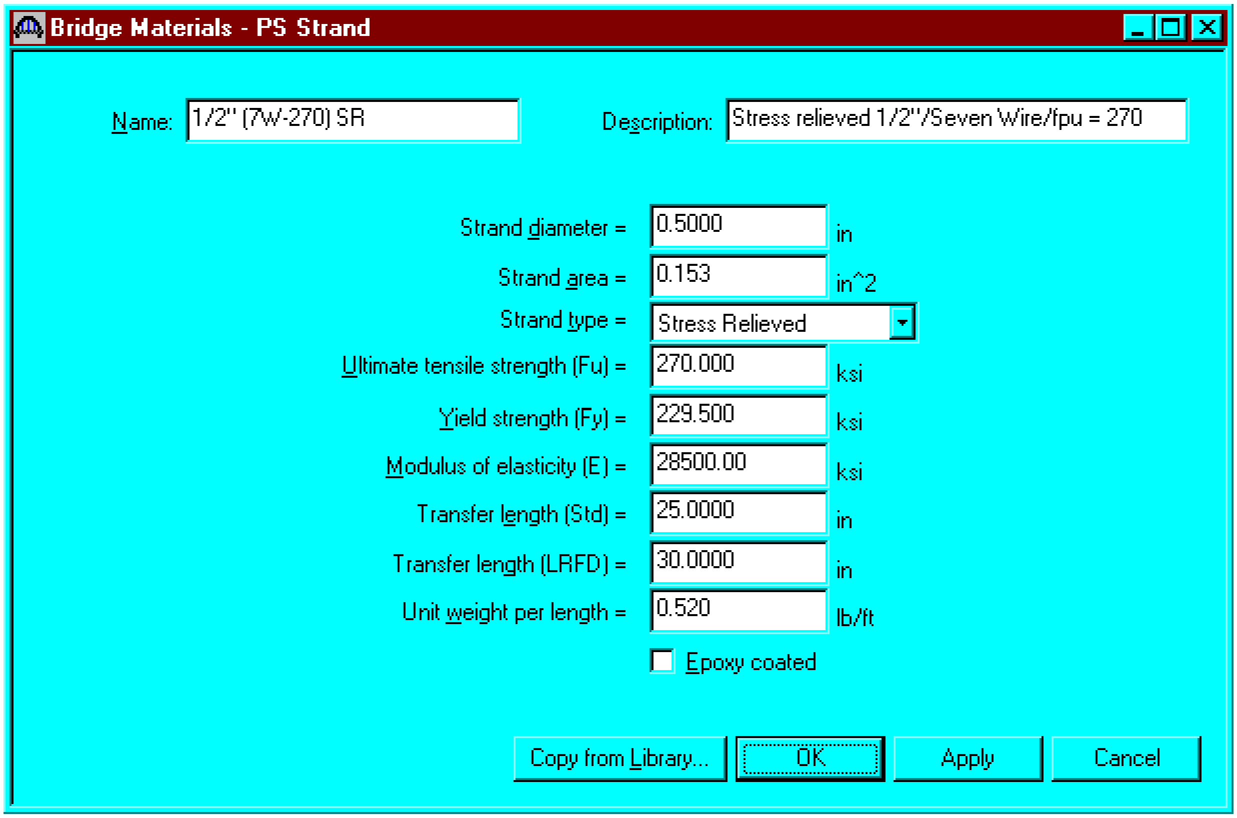




Bridge Materials - Reinforcing Steel
Name:
Grade 60
Description:
60 ksi reinforcing steel
Material Properties
Specified yield strength (Fy) =
60.000
ksi
Modulus of elasticity (Es) =
29000.00
ksi
Ultimate strength (Fu) =
90.000
ksi
Type
Plain
Epoxy
Galvanized
Other
Copy from Library...
OK
Apply
Cancel

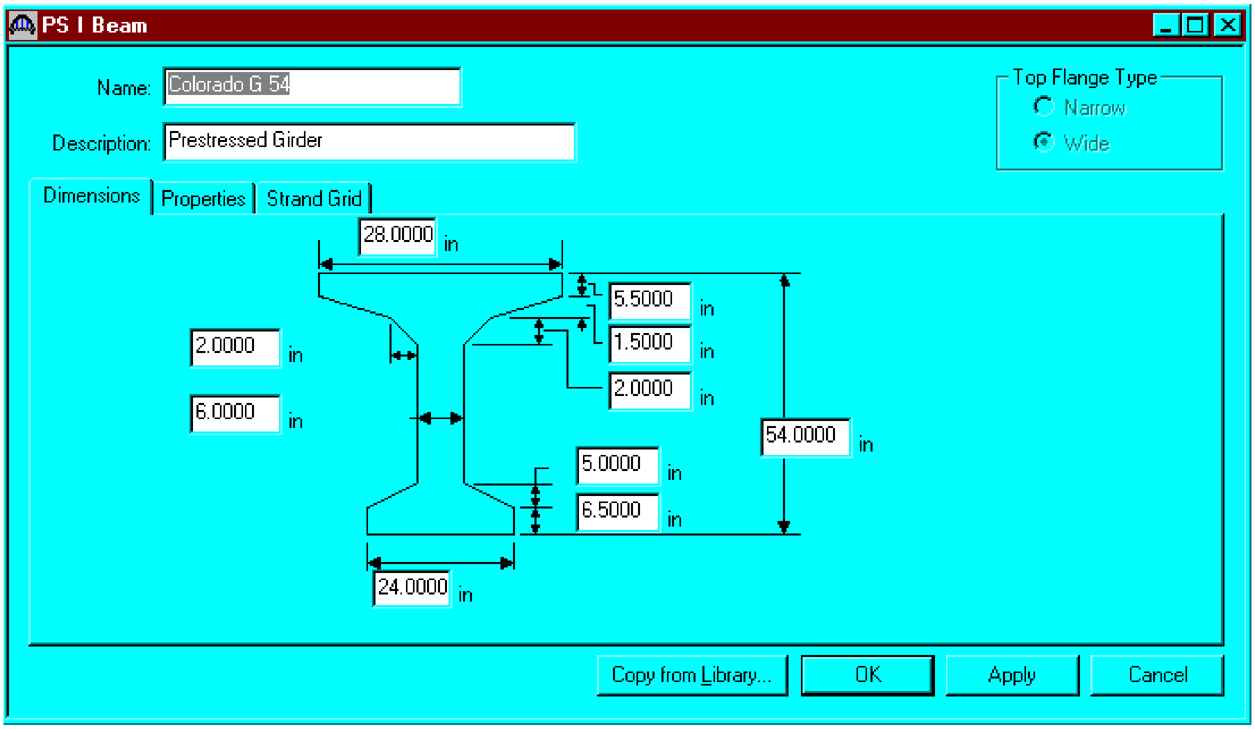


Bridge Materials - Reinforcing Steel
Name: Grade 270
Description: Pier +ve reinforcing
Material Properties
Specified yield strength (Fy) = 229.500 ksi
Modulus of elasticity (Es) = 28500.00 ksi
Ultimate strength (Fu) = 270.000 ksi
Type
Plain
Epoxy
Galvanized
Other
Copy from Library...
OK
Apply
Cancel



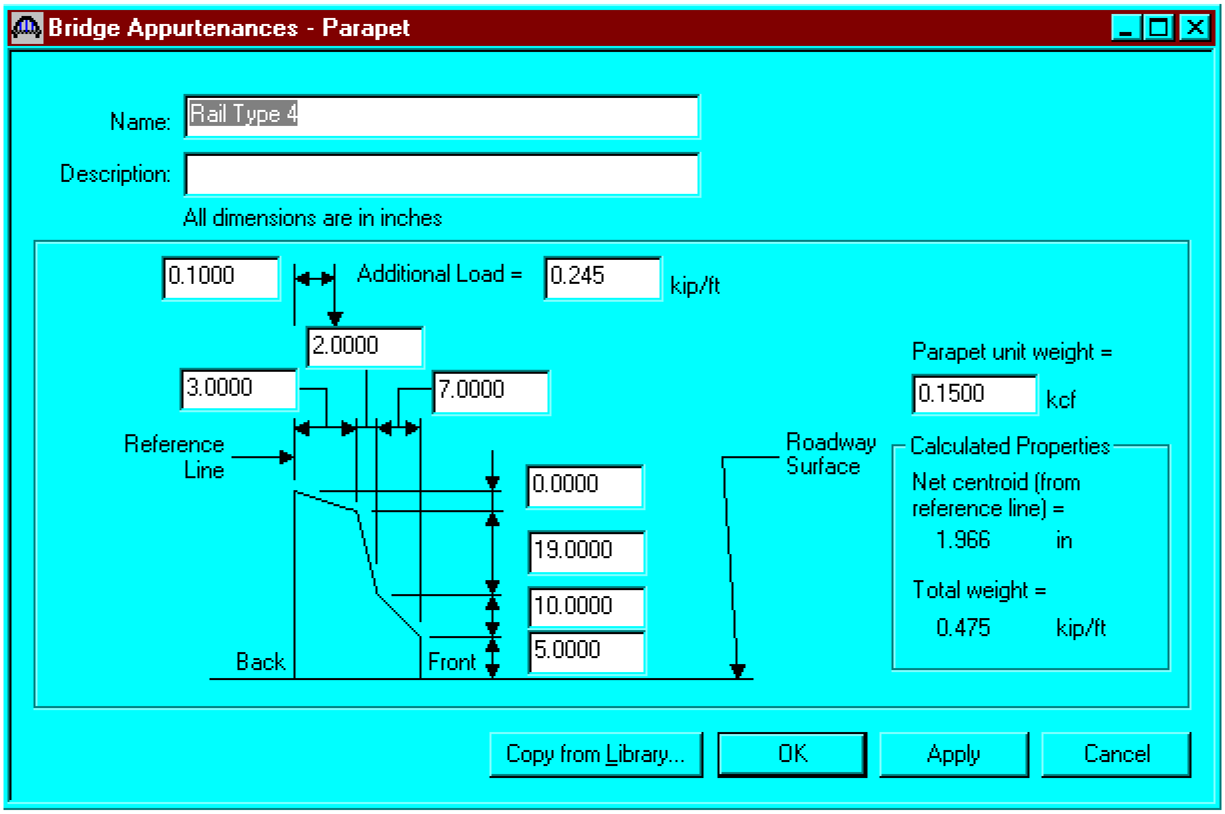
Bridge Materials - PS Strand
Name:
1/2" (7W-270) SR
Description:
Stress relieved 1/2"/Seven Wire/fpu = 270
Strand diameter =
0.5000
in
Strand area =
0.153
in^2
Strand type =
Stress Relieved
Ultimate tensile strength (Fu) =
270.000
ksi
Yield strength (Fy) =
229.500
ksi
Modulus of elasticity (E) =
28500.00
ksi
Transfer length (Std) =
25.0000
in
Transfer length (LRFD) =
30.0000
in
Unit weight per length =
0.520
lb/ft
Epoxy coated
Copy from Library...
OK
Apply
Cancel

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



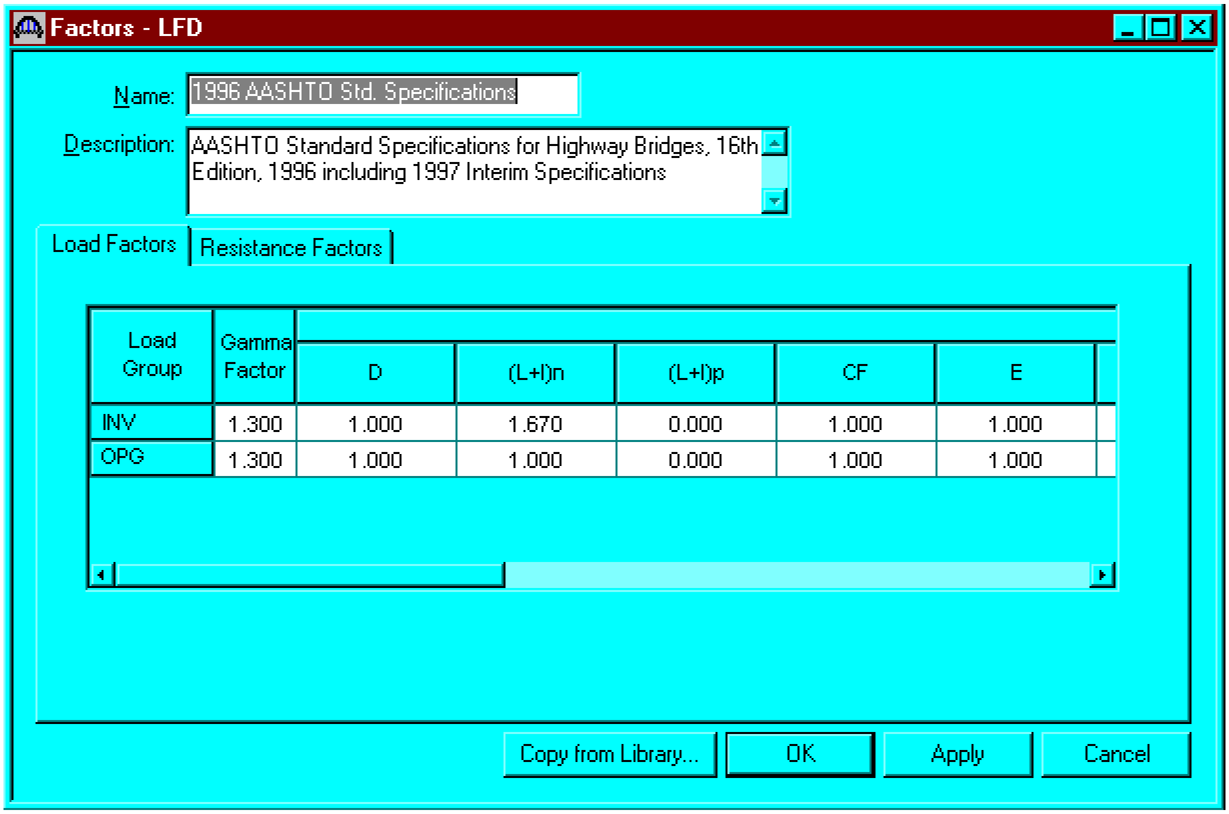
Click OK to save to the memory and close the window.

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

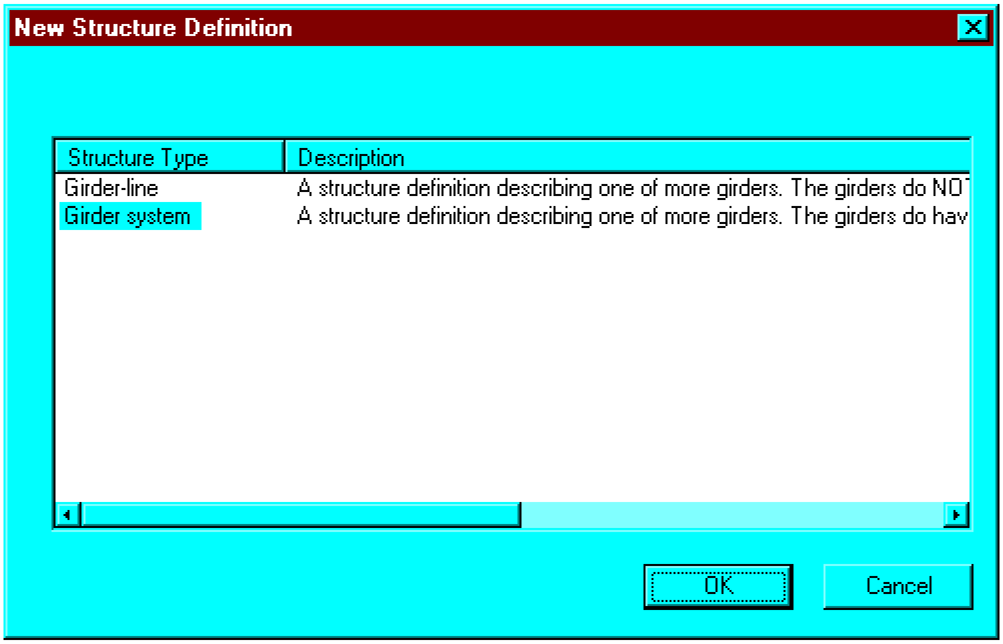


The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

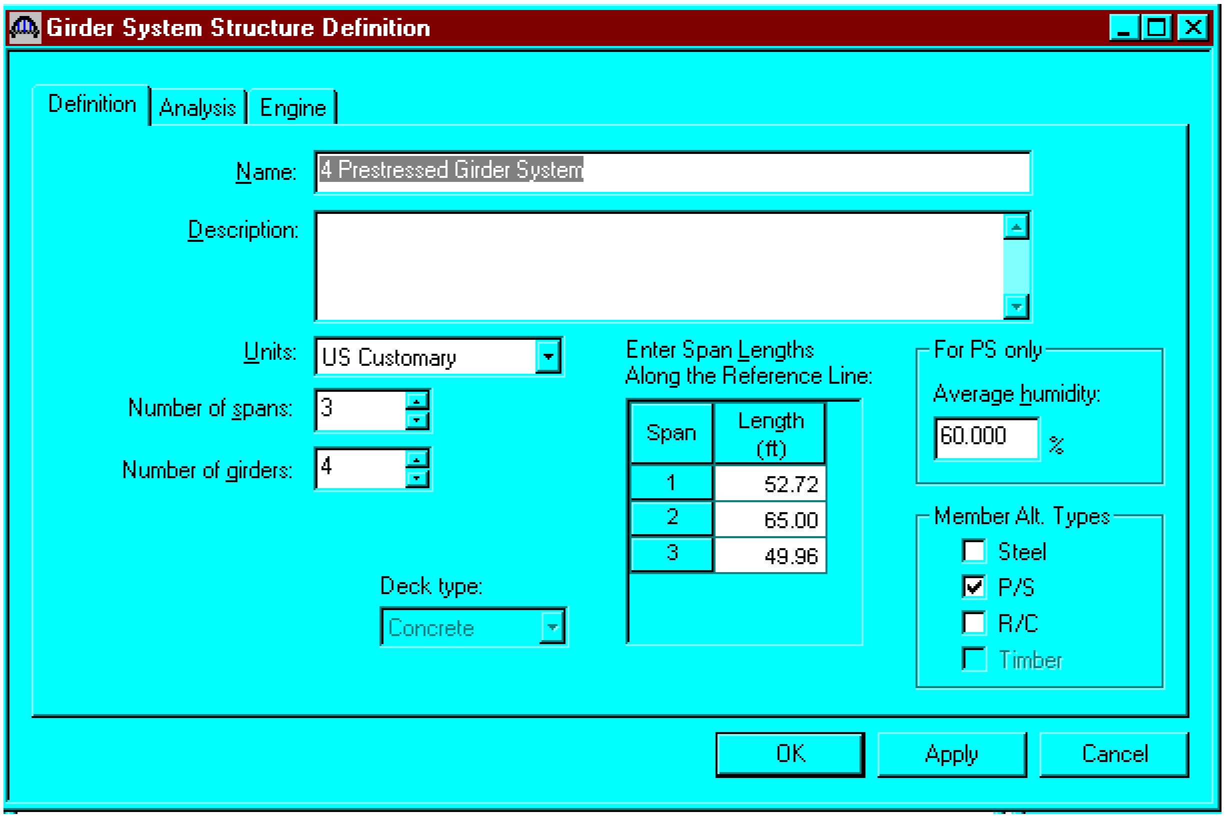
This window shows the LFD load factors.



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.

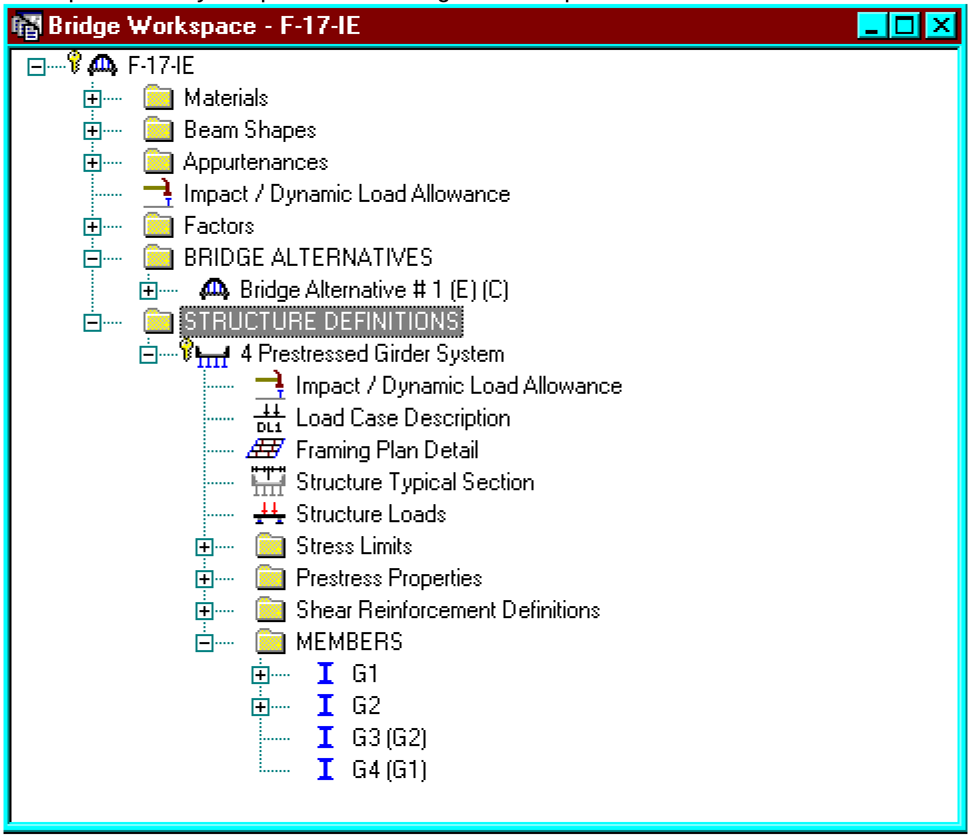


Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



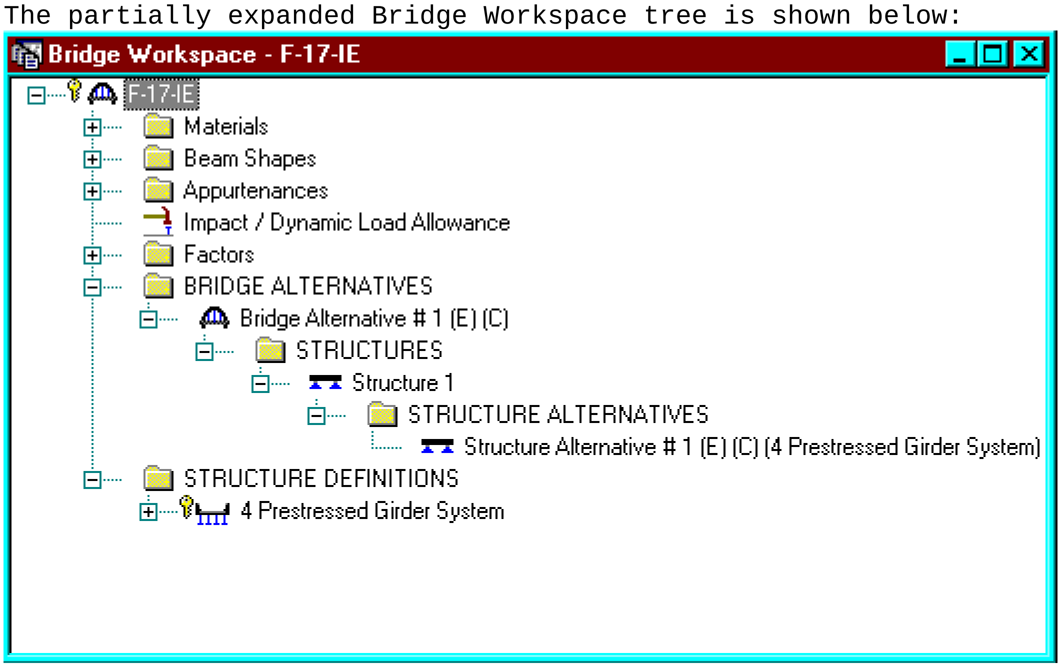
Span lengths for a prestressed girder structure made continuous for live loads shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

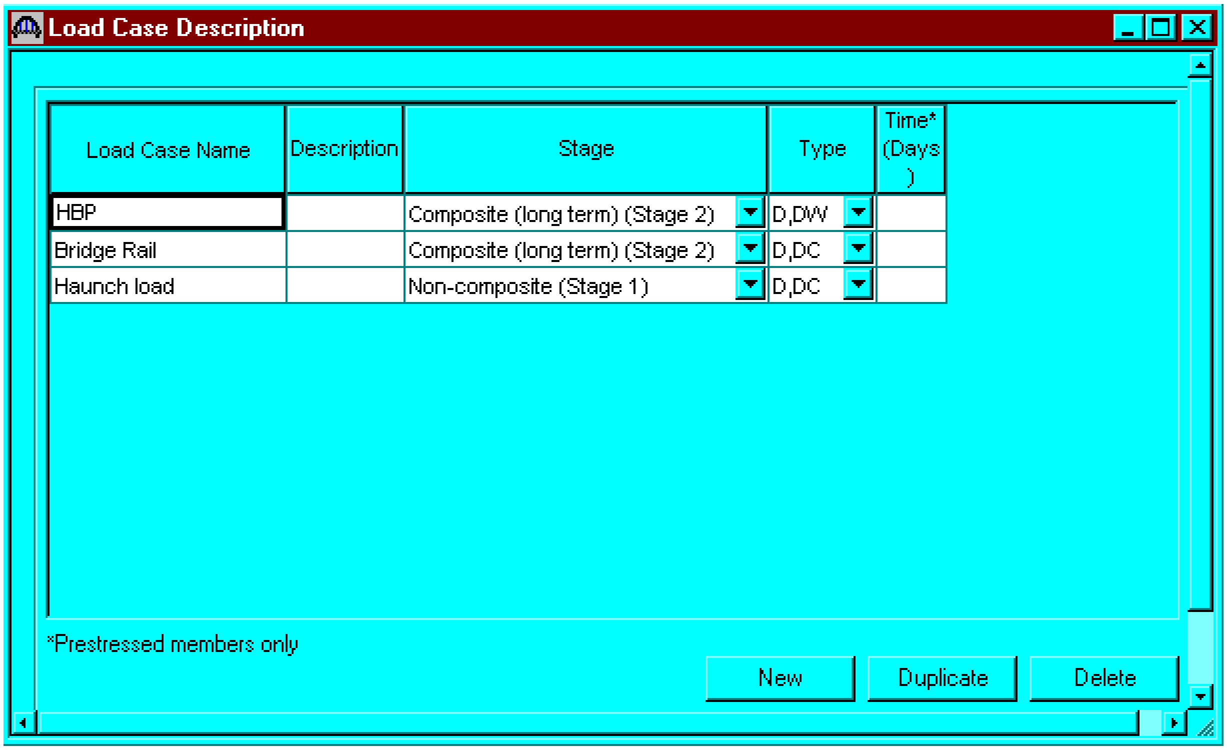


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

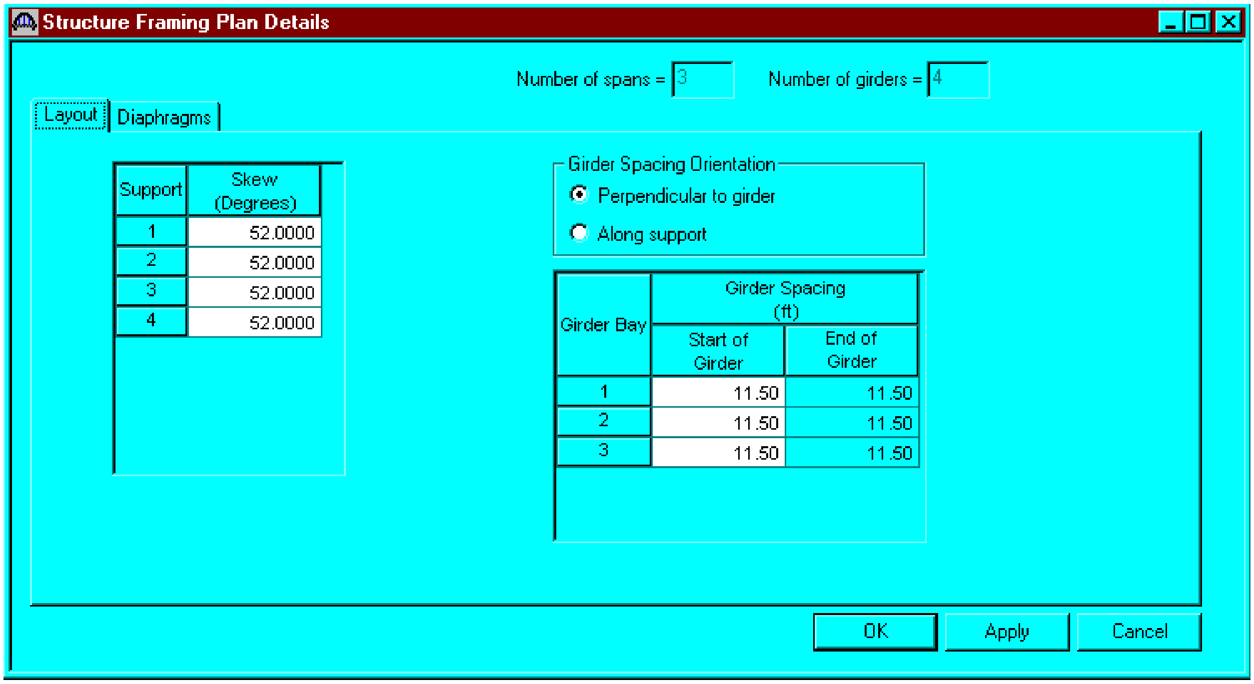
The partially expanded Bridge Workspace tree is shown below:



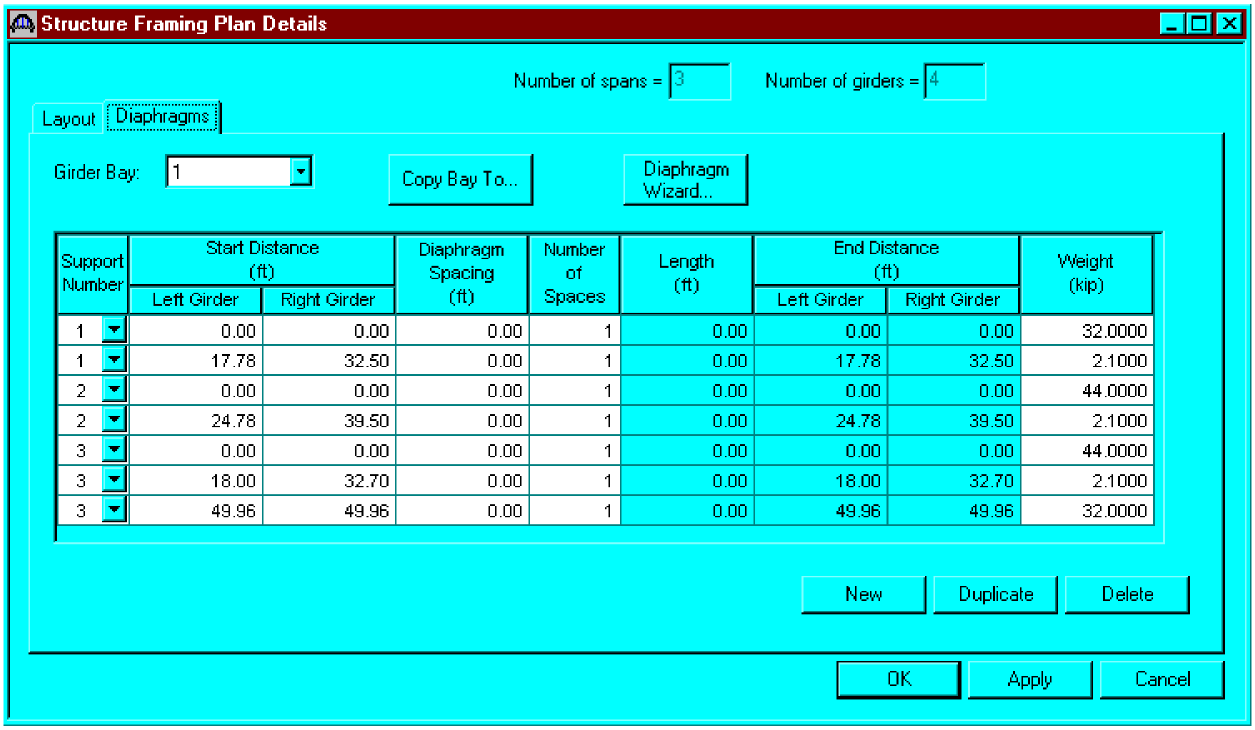
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed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



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

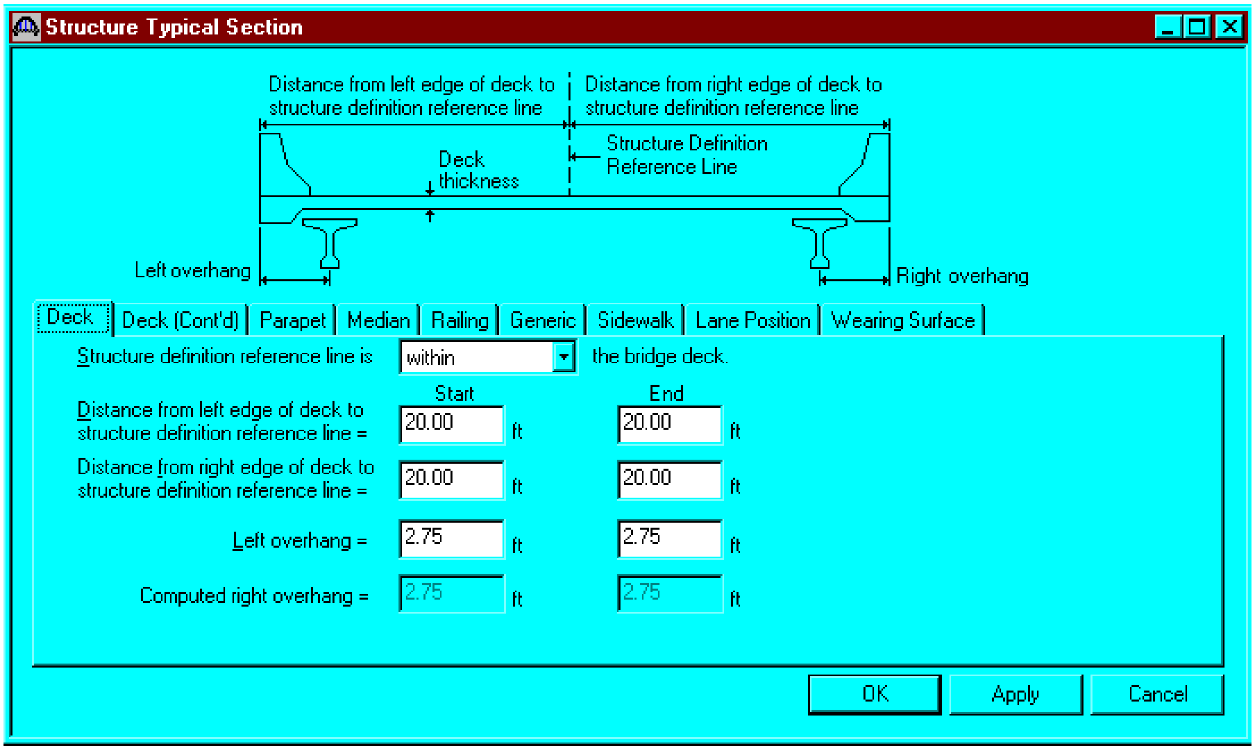


If the bridge has diaphragms, switch to the Diaphragms tab and enter the appropriate data. Click OK to save to memory and close the window.

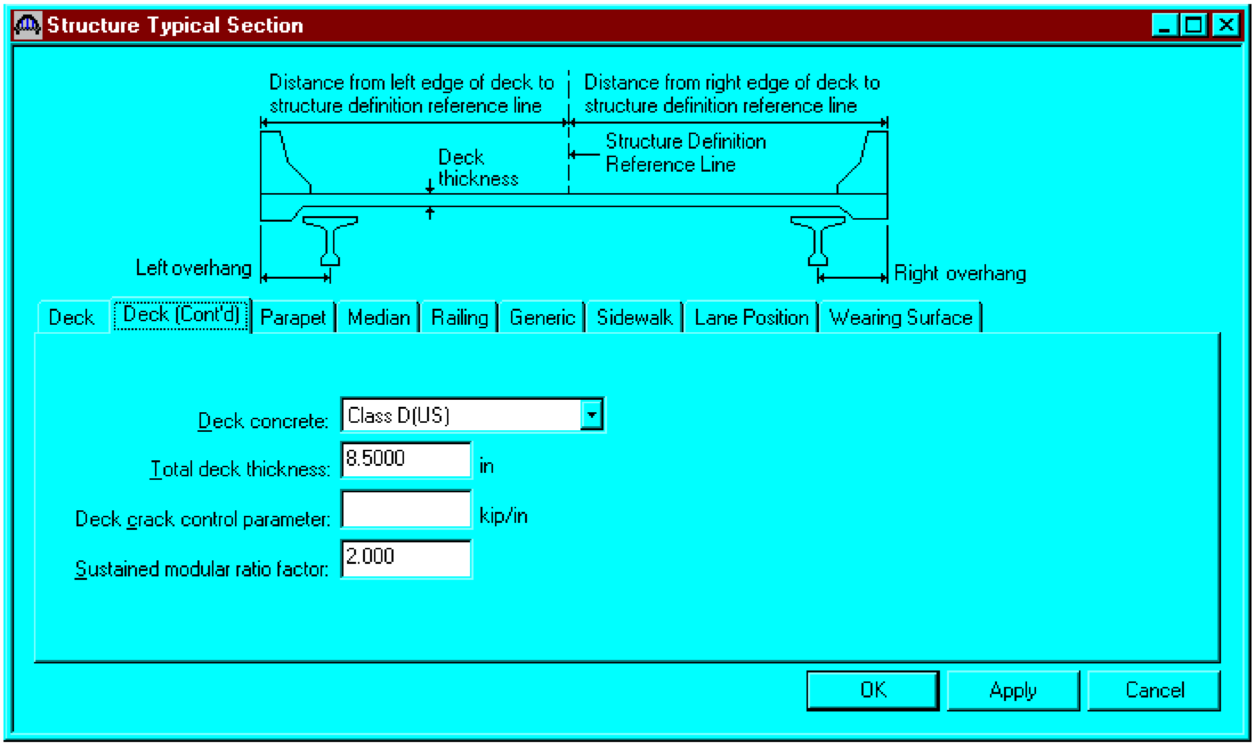


Support Number	Start Distance (ft) Left Girder	Start Distance (ft) Right Girder	Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft) Left Girder	End Distance (ft) Right Girder	Weight (kip)
1	0.00	0.00	0.00	1	0.00	0.00	0.00	32.0000
1	17.78	32.50	0.00	1	0.00	17.78	32.50	2.1000
2	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
2	24.78	39.50	0.00	1	0.00	24.78	39.50	2.1000
3	0.00	0.00	0.00	1	0.00	0.00	0.00	44.0000
3	18.00	32.70	0.00	1	0.00	18.00	32.70	2.1000
3	49.96	49.96	0.00	1	0.00	49.96	49.96	32.0000

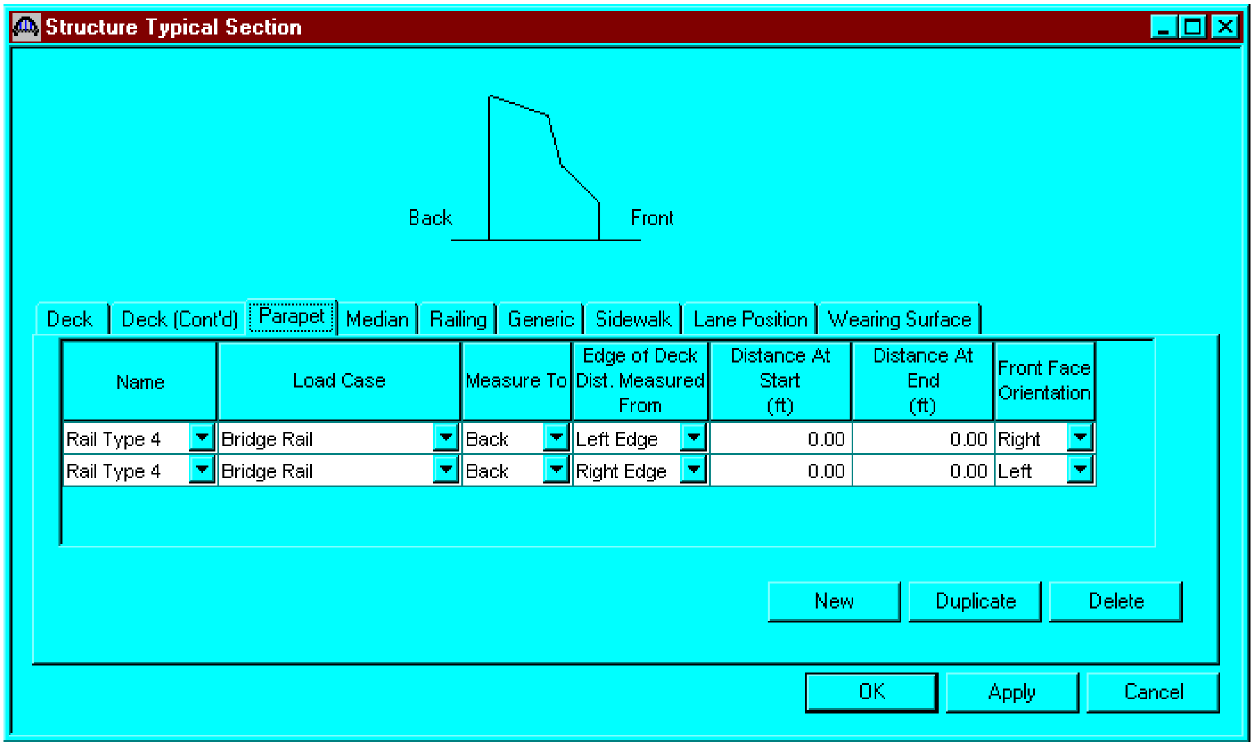
Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.



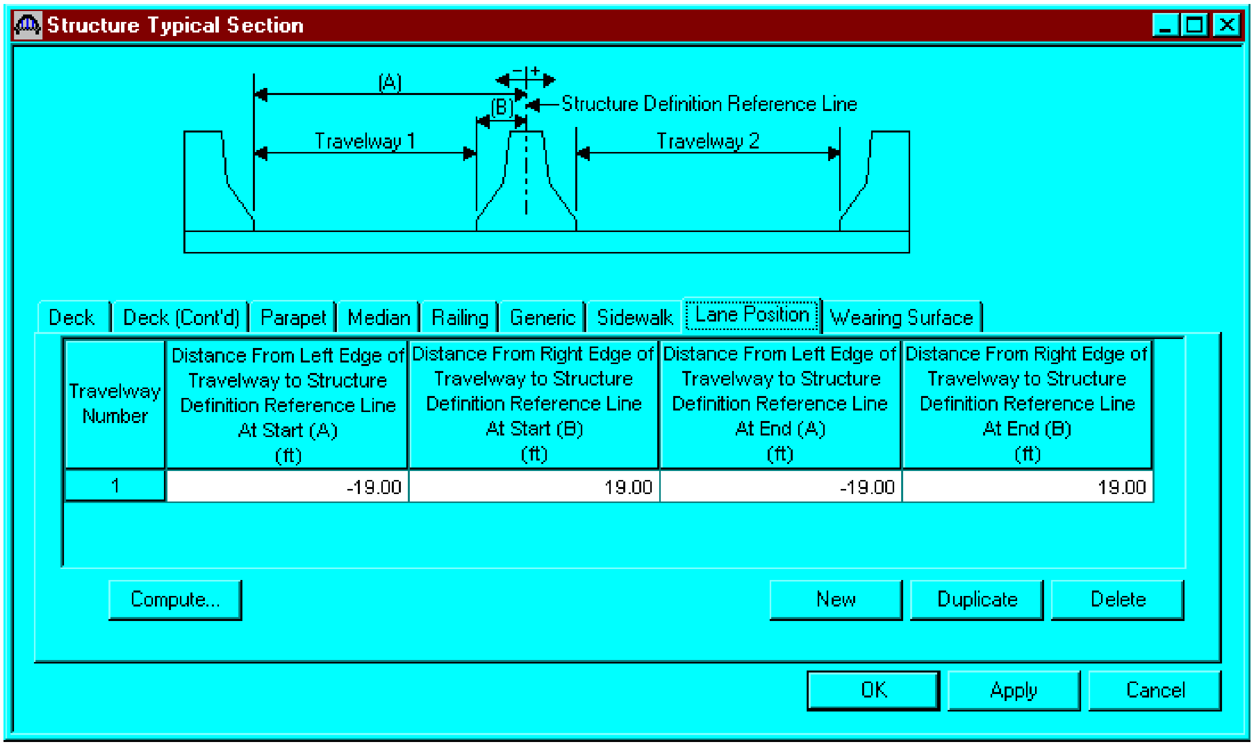
The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously.



Parapets:
Add two parapets as shown below.

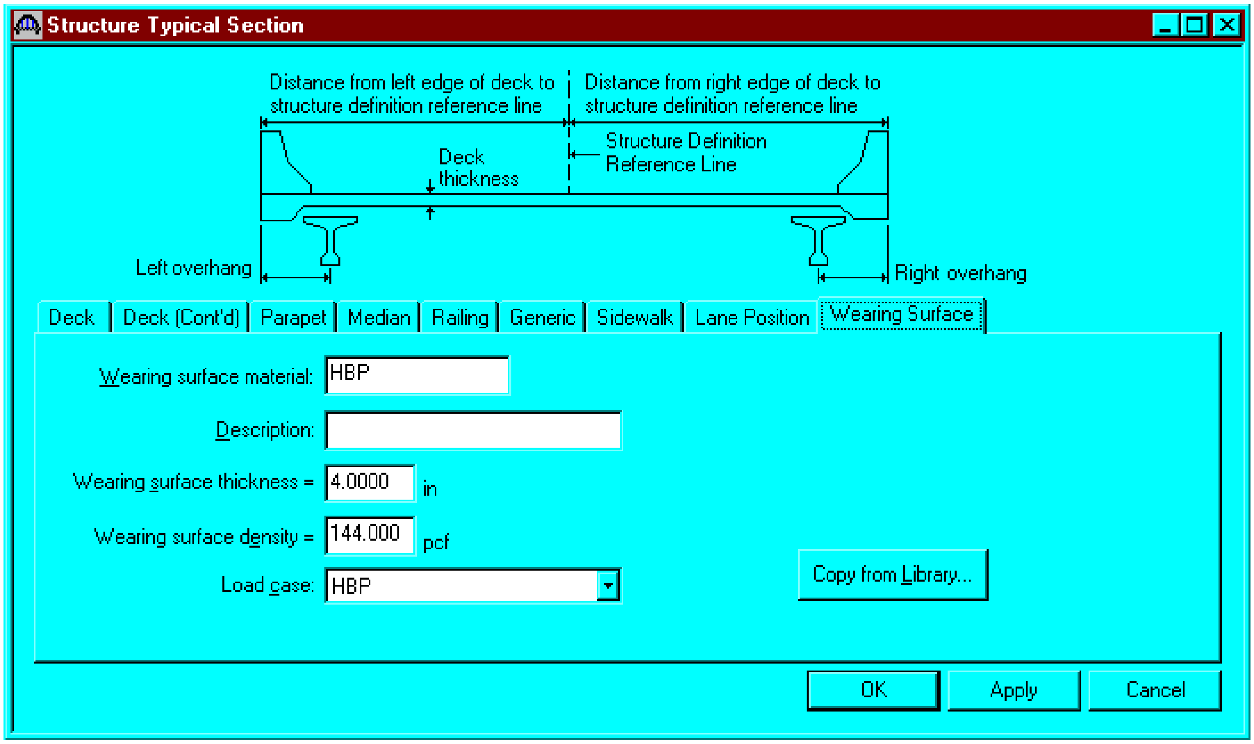


Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.

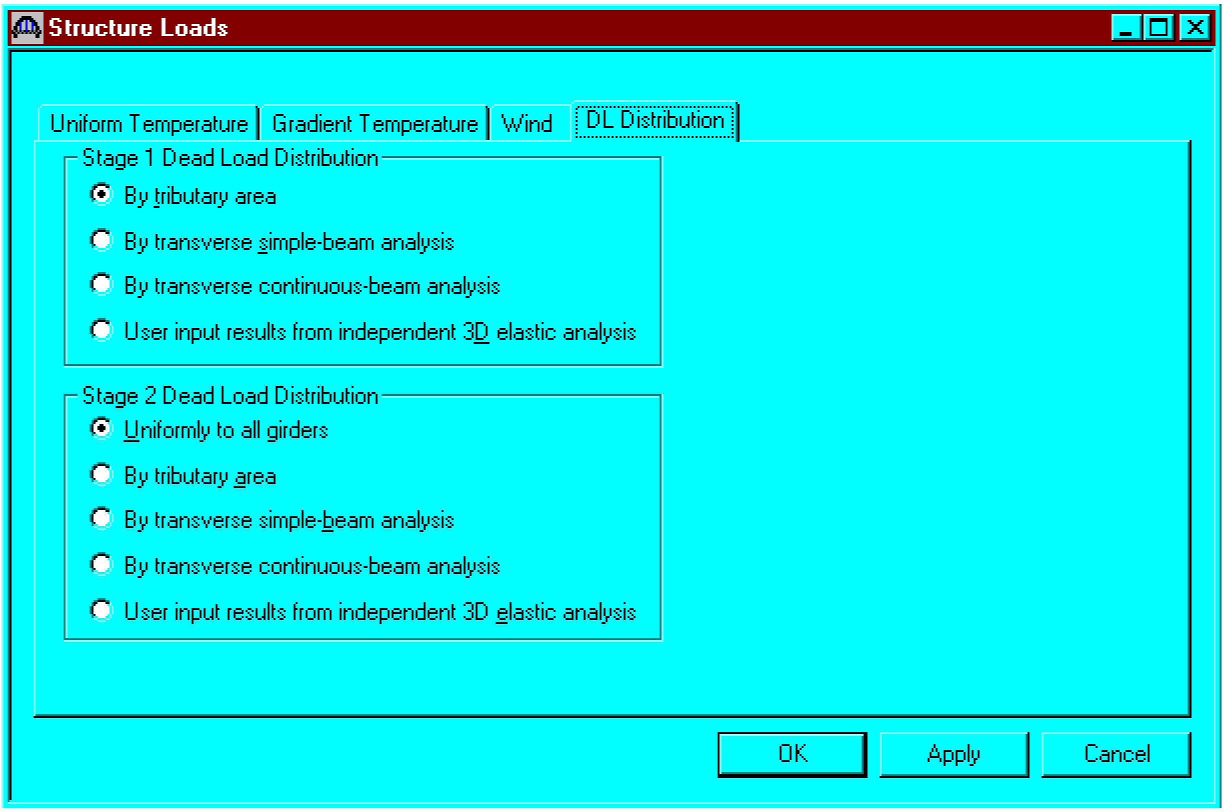


Travelway Number	Distance From Left Edge of Travelway to Structure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Structure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Structure Definition Reference Line At End (A) (ft)	Distance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

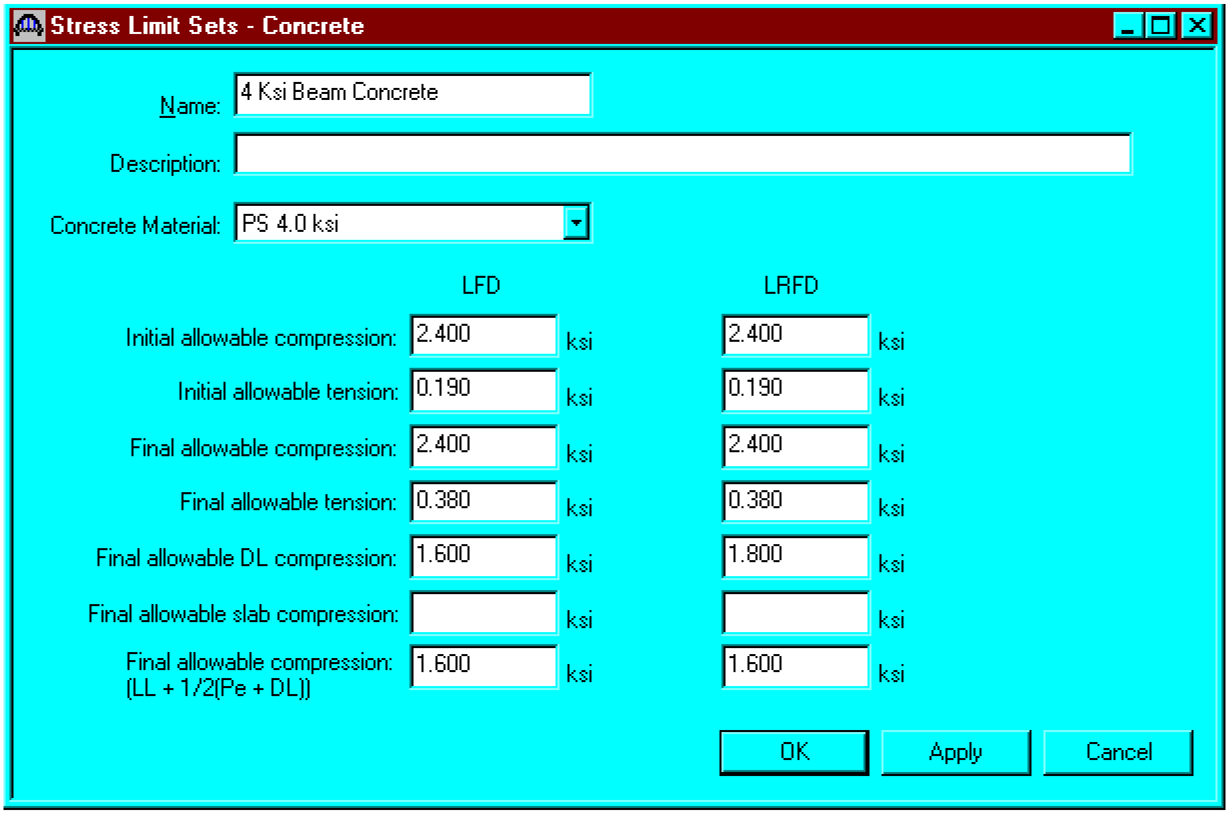
Enter the following wearing surface information on the Wearing Surface tab.



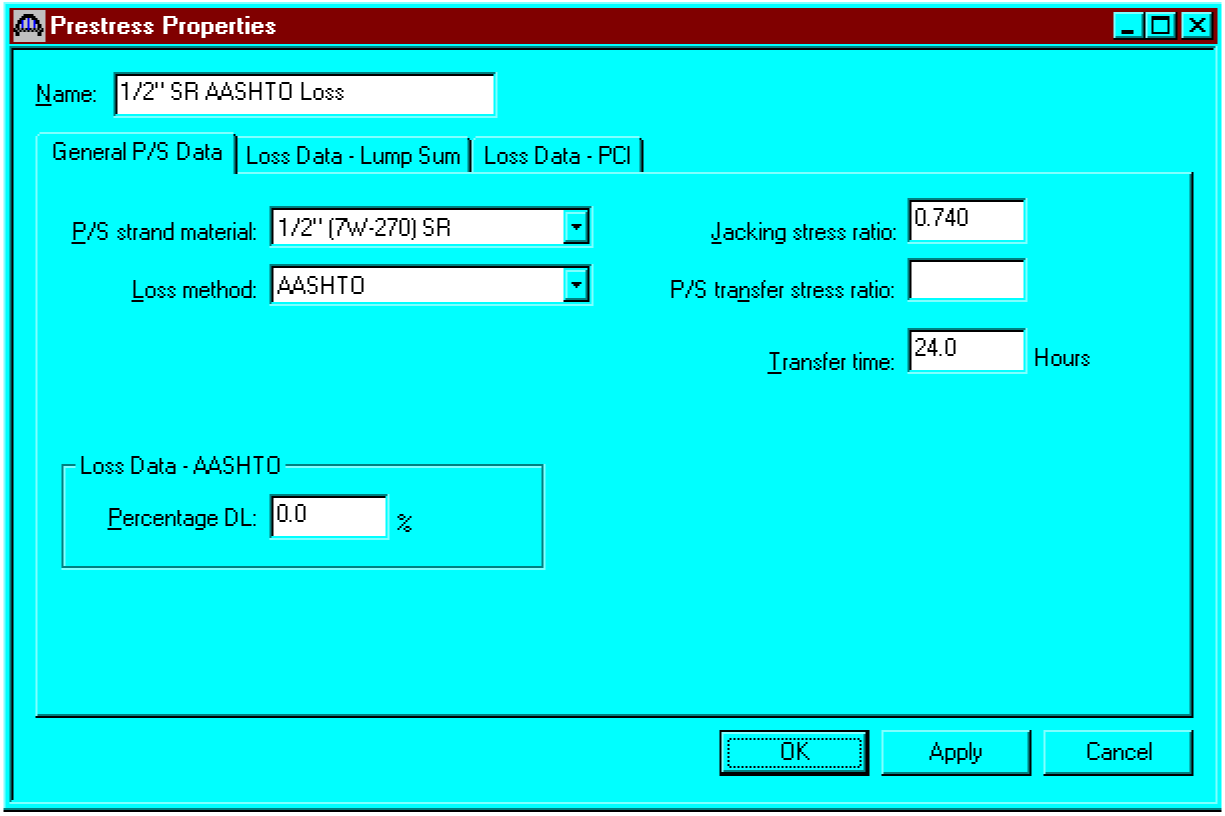
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



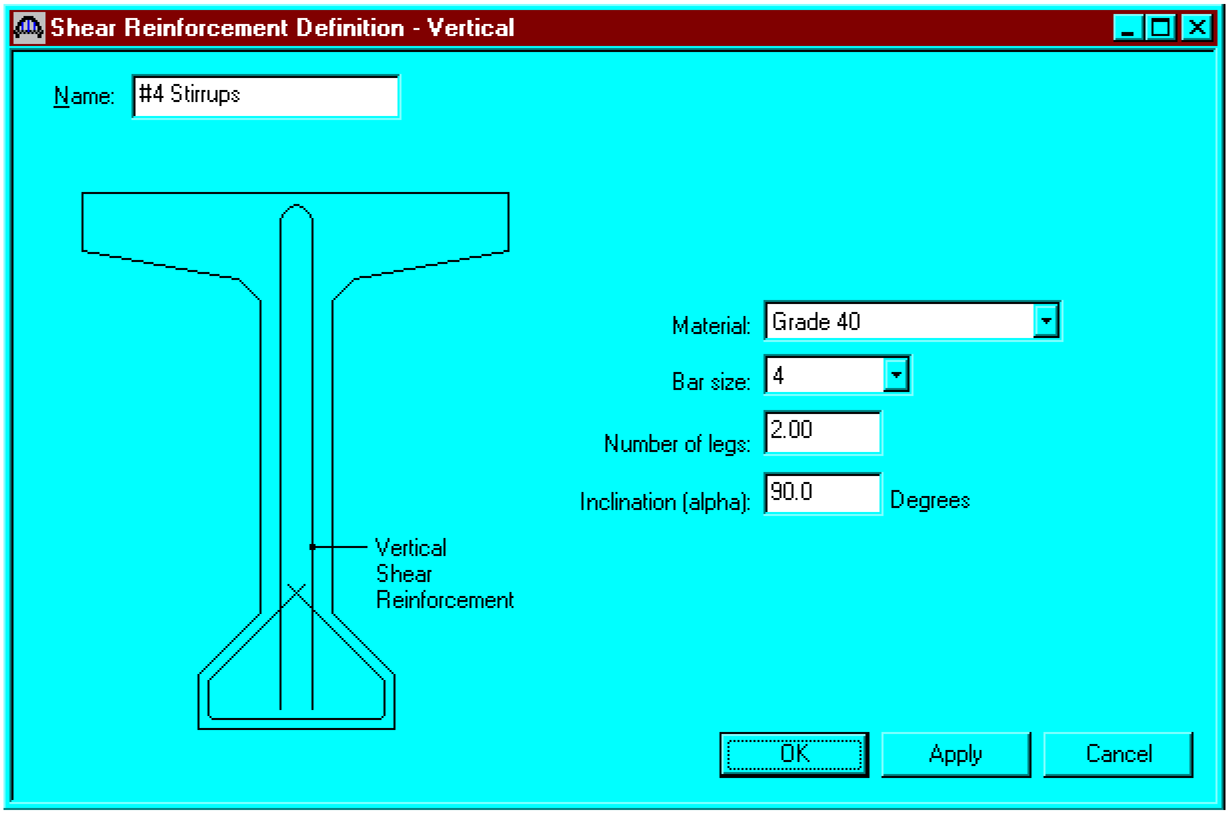
A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “PS 4.0 ksi” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications.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



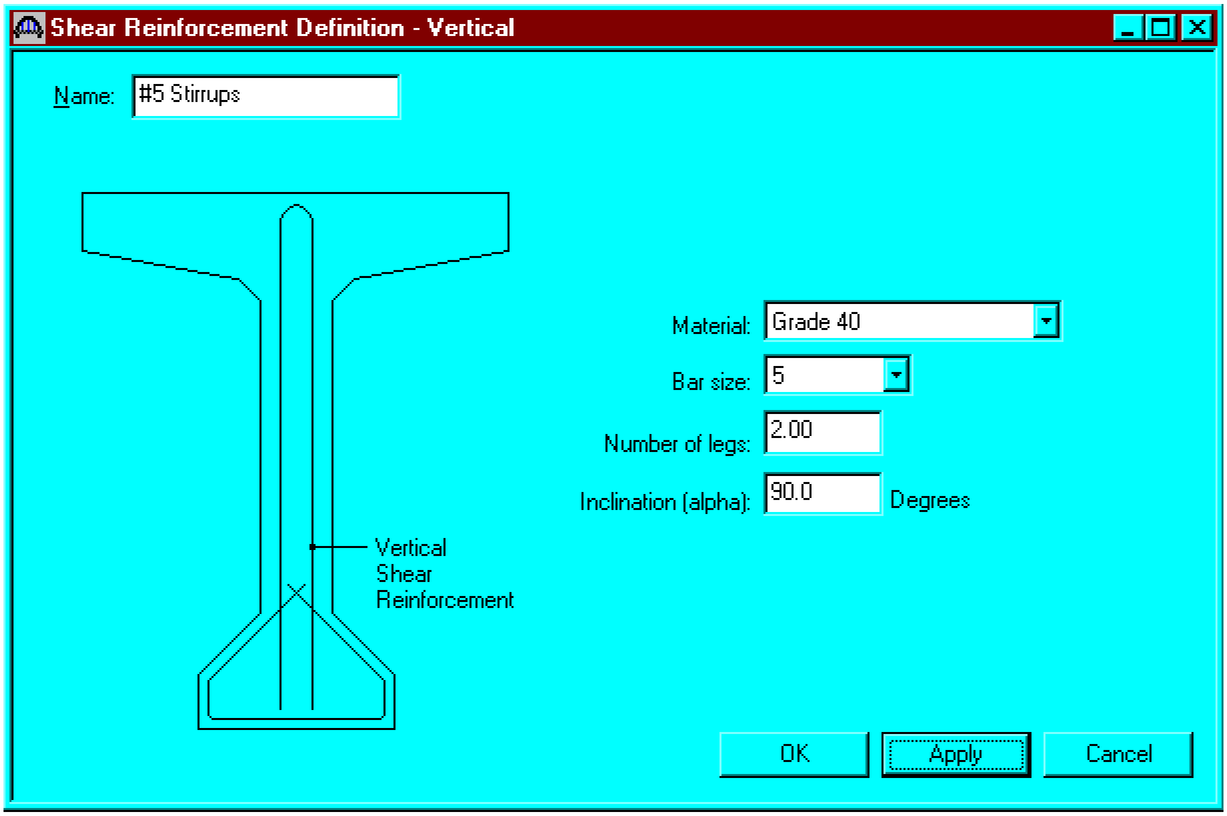
Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the “General P/S Data” tab is required.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



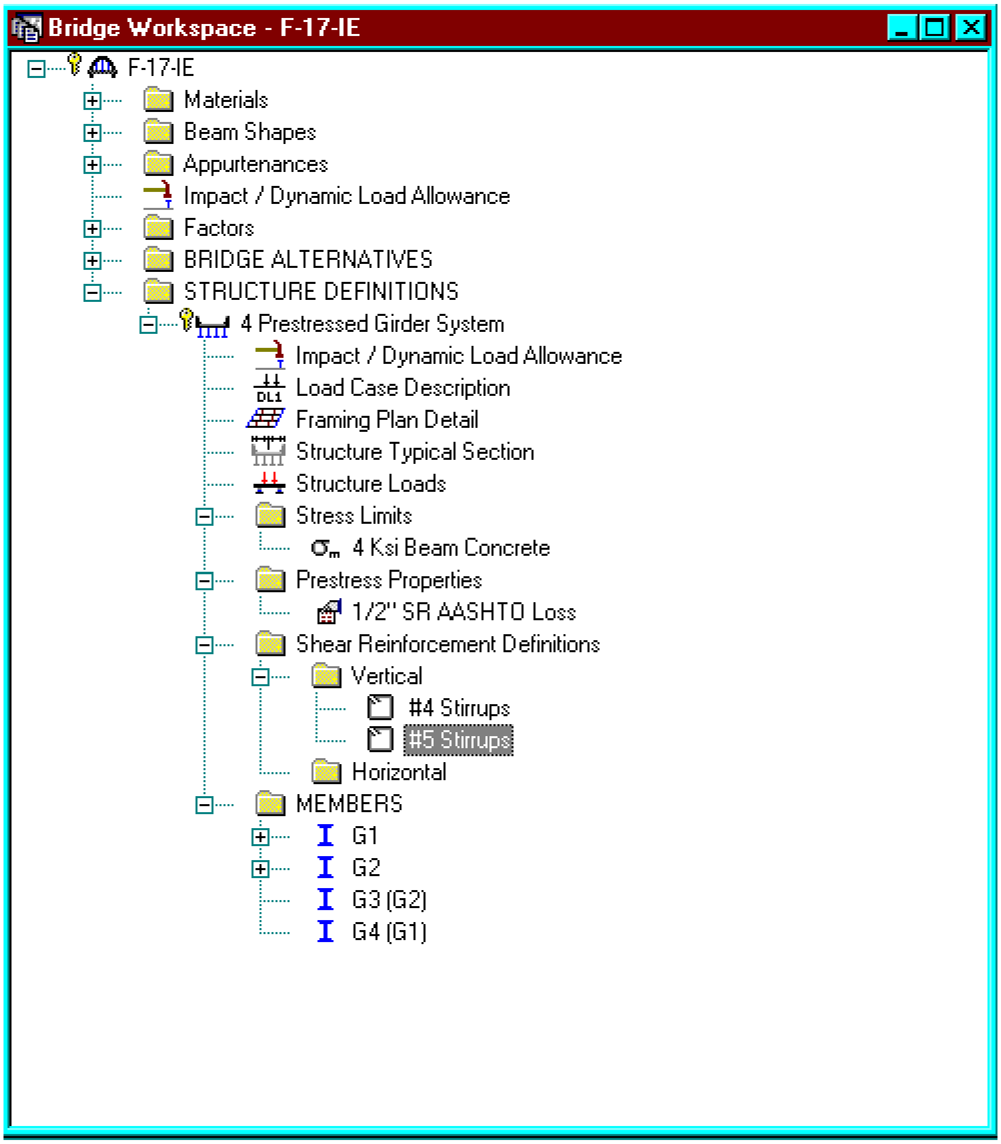
Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



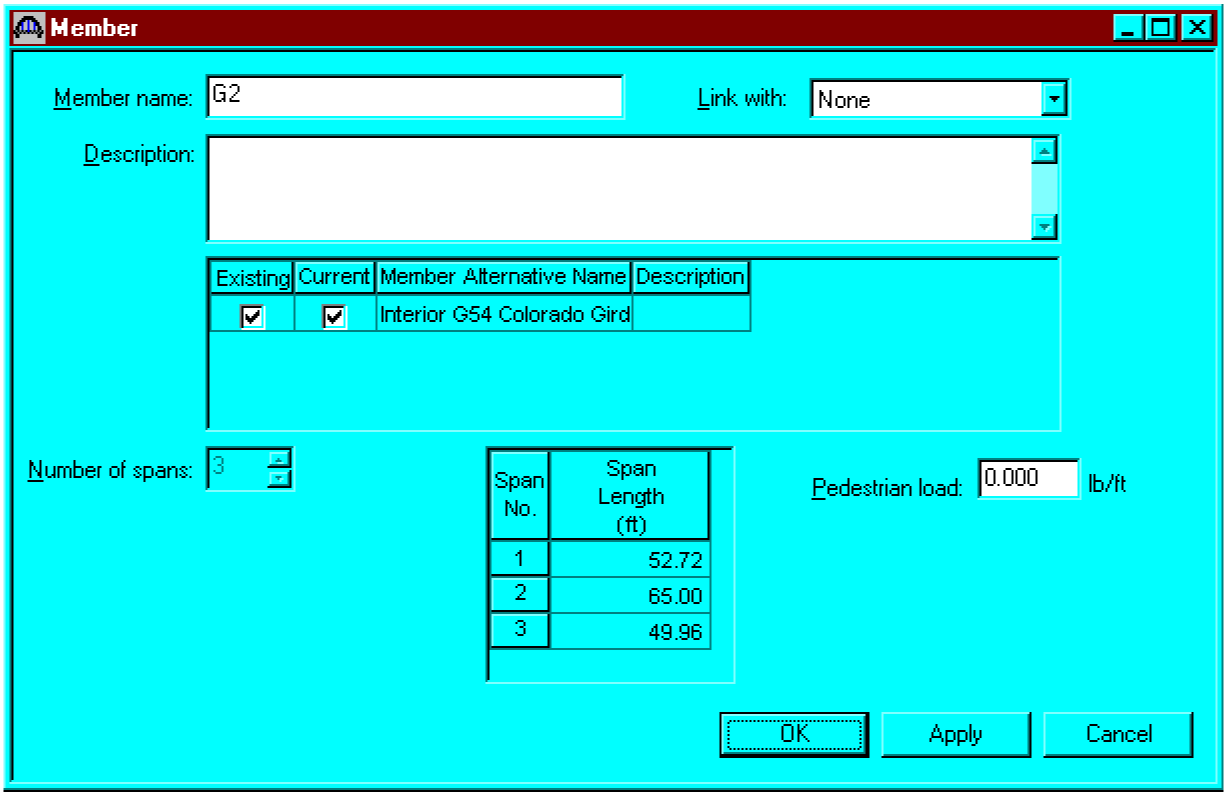
Using the same techniques, define another vertical Shear Reinforcement Definition.



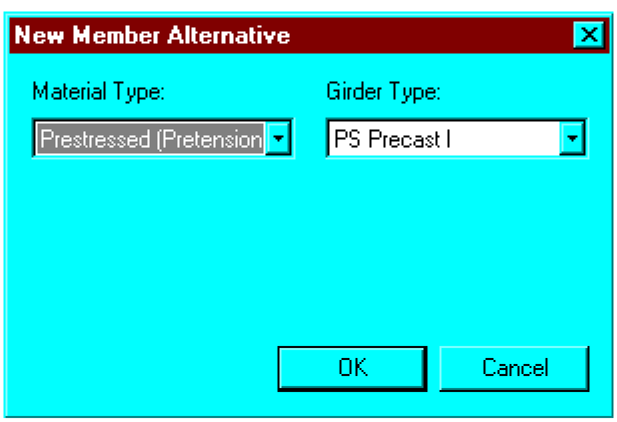
The partially expanded Bridge Workspace tree is shown below:



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

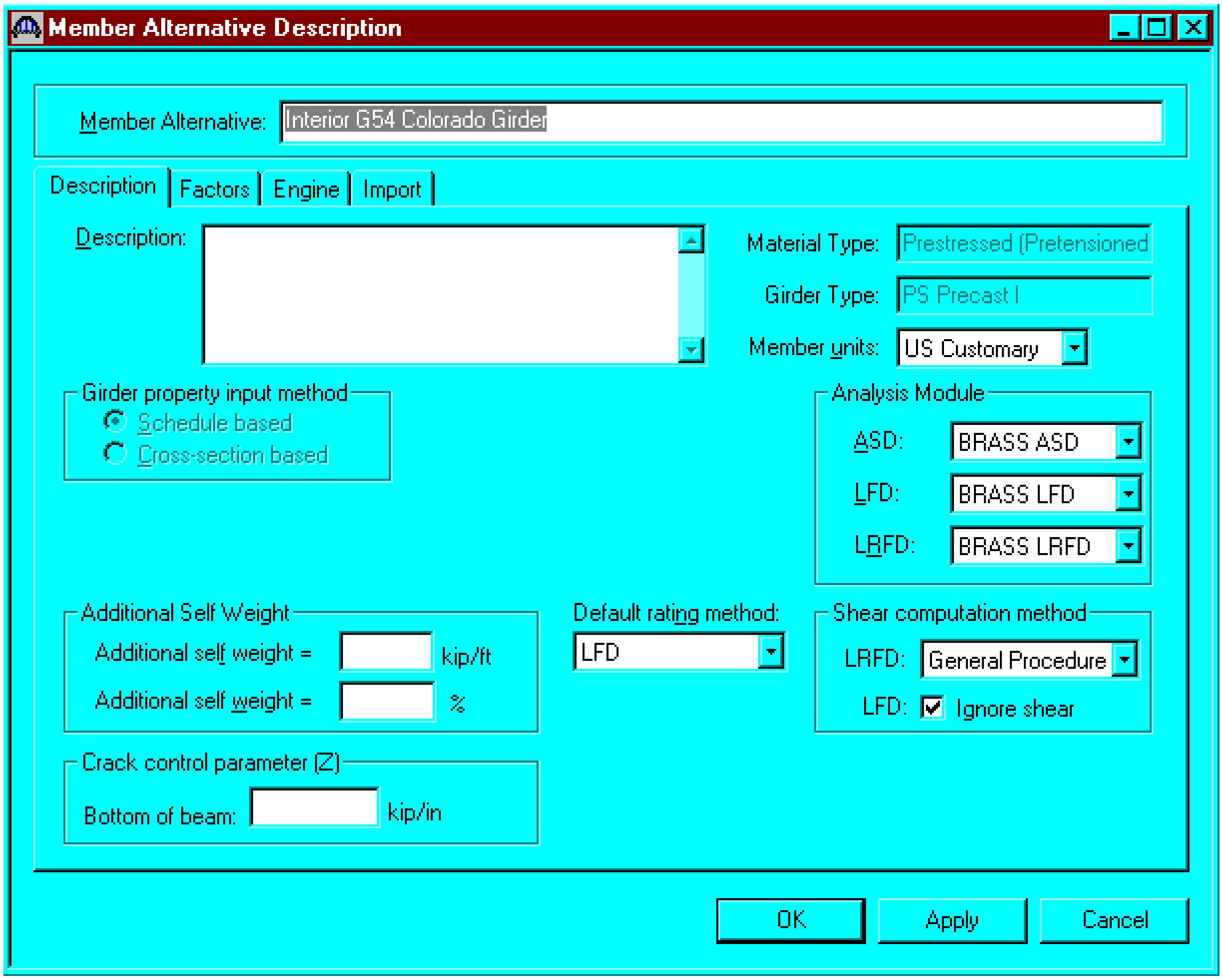


Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

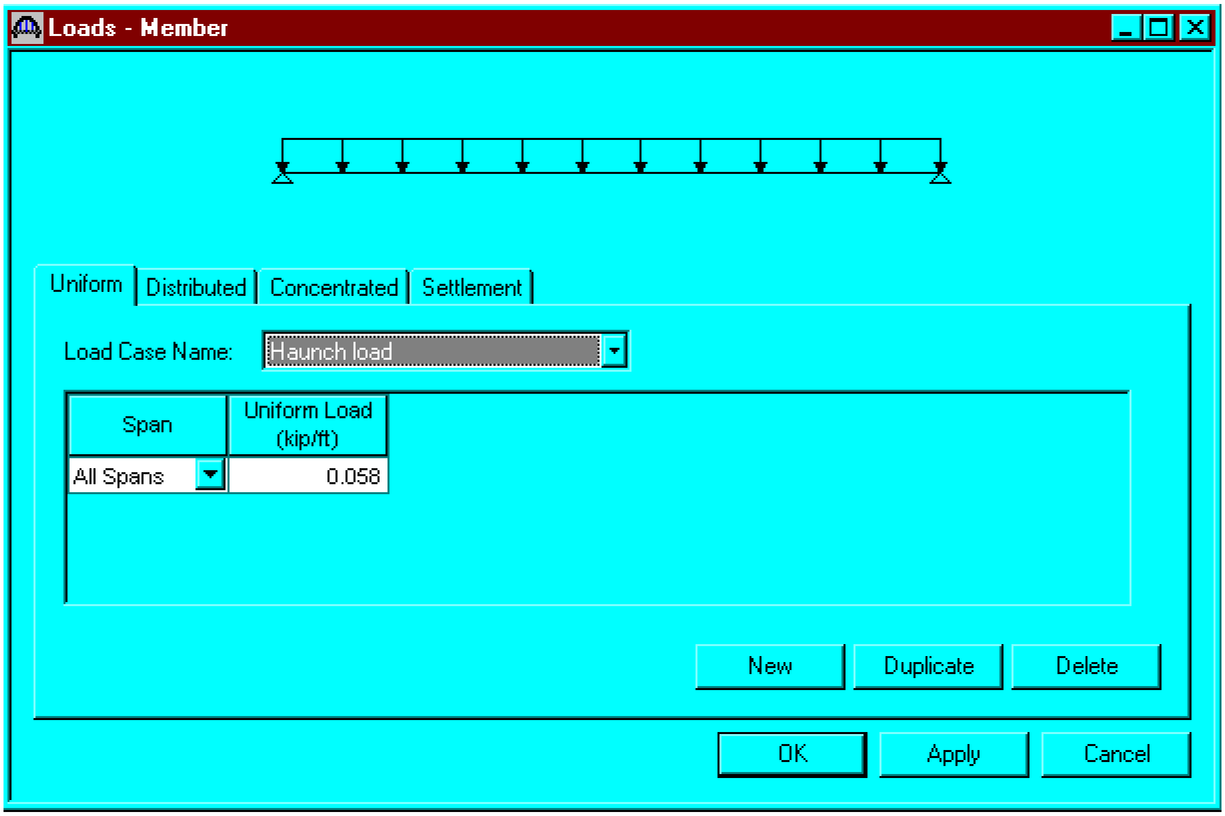


Click OK to close the dialog and create a new member alternative.

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



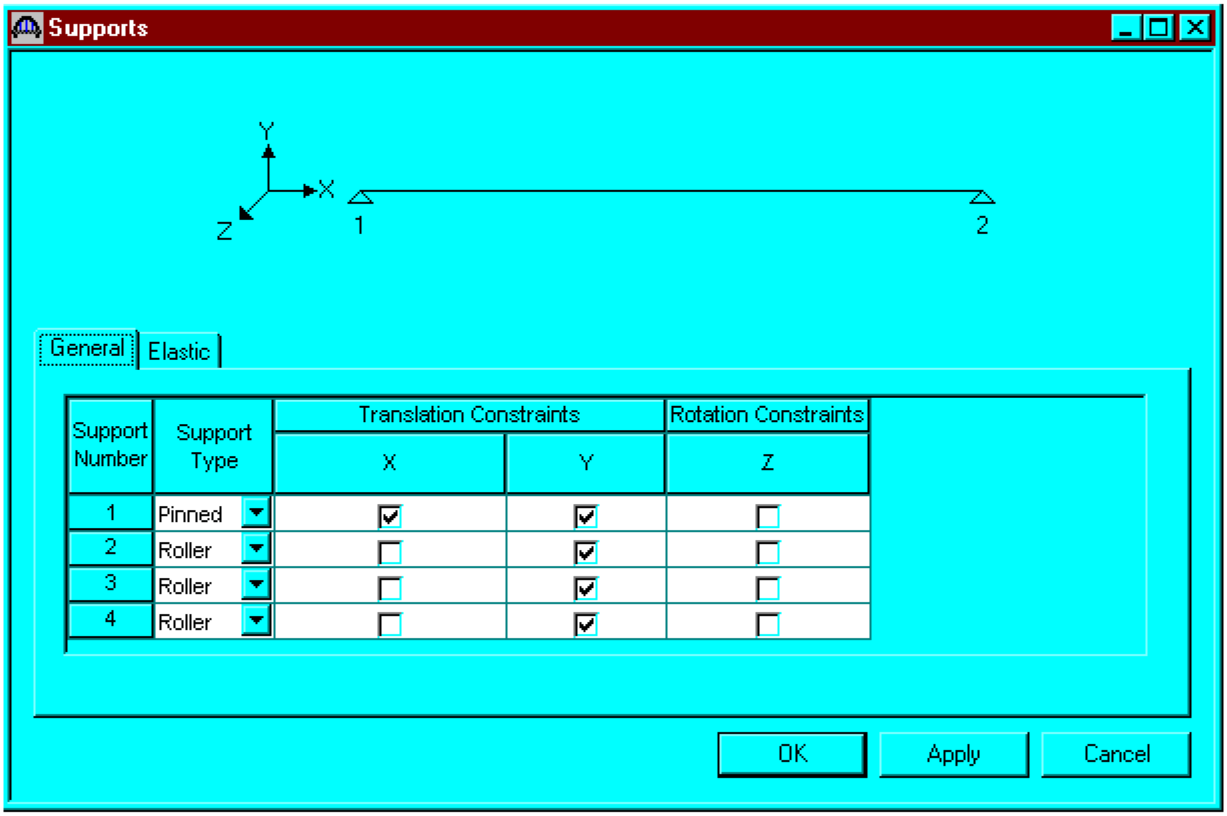
Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to haunch not included in the section properties calculation is entered here.



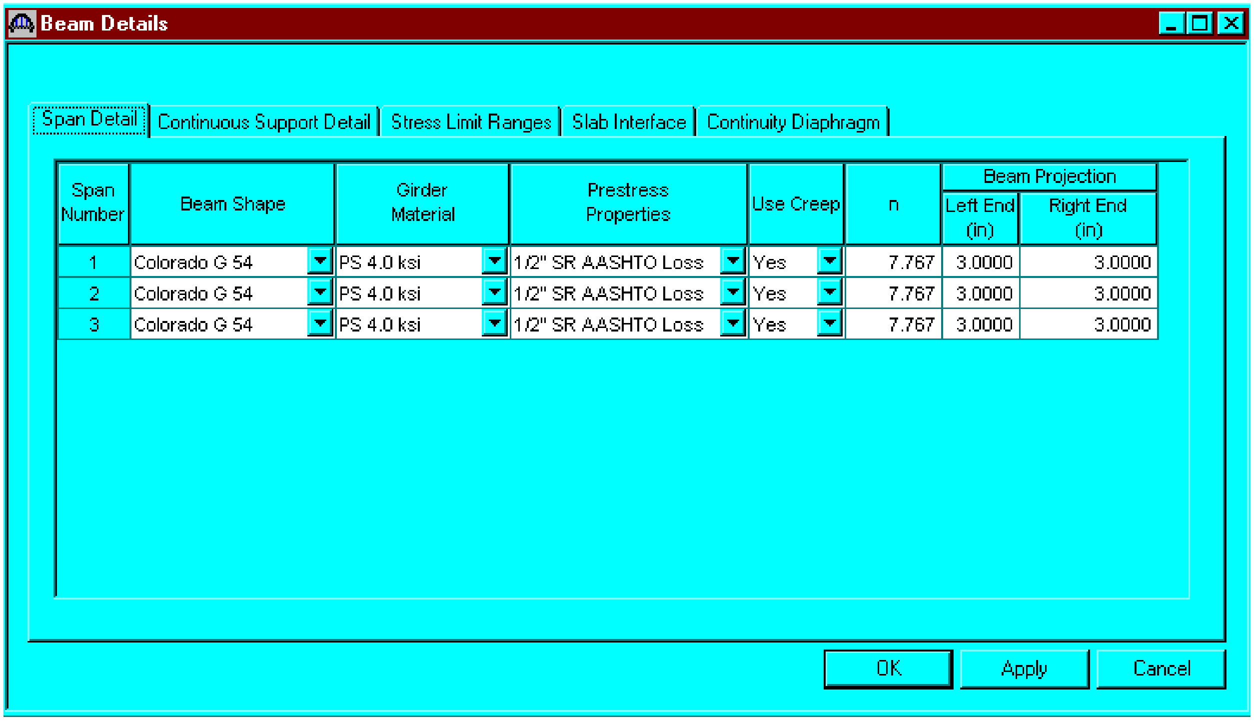
Calculated average haunch = 2.0”
Haunch used for section properties = 0.0”

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

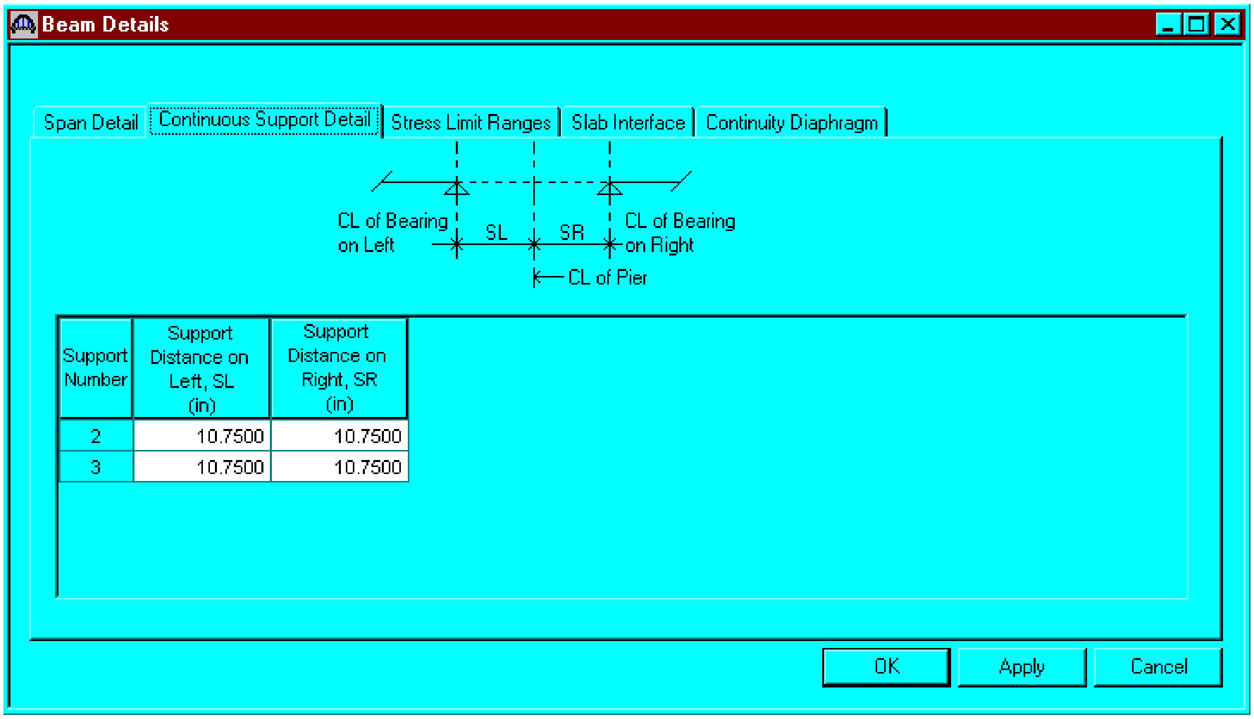
Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



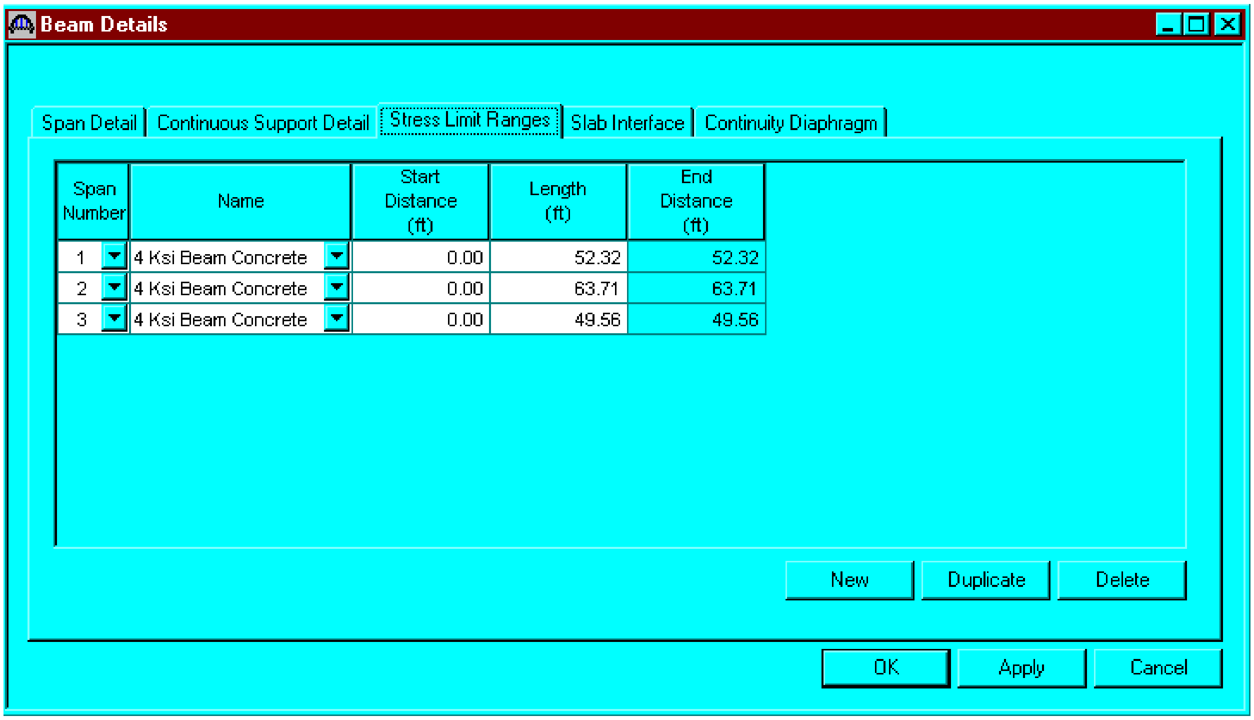
The Compute from Typical Section button on the Live Load Distribution window to calculate the distribution factors cannot be used until we have selected the beam shape in the Beam Details window. At this point, Virtis/Opis does not know if we have spread or adjacent beams. We will select the beam shape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



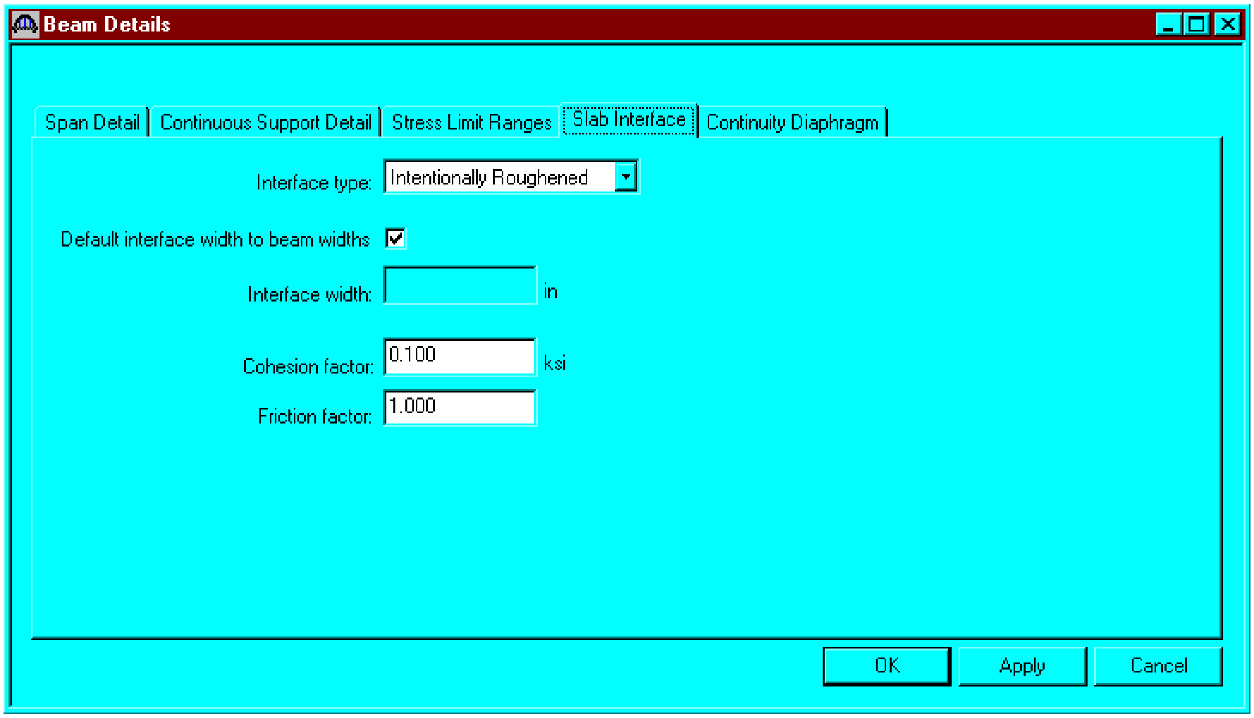
The Continuous Support Detail tab is only shown for a multi-span structure. The following data describes the distances from the centerlines of bearing to the centerlines of the piers.



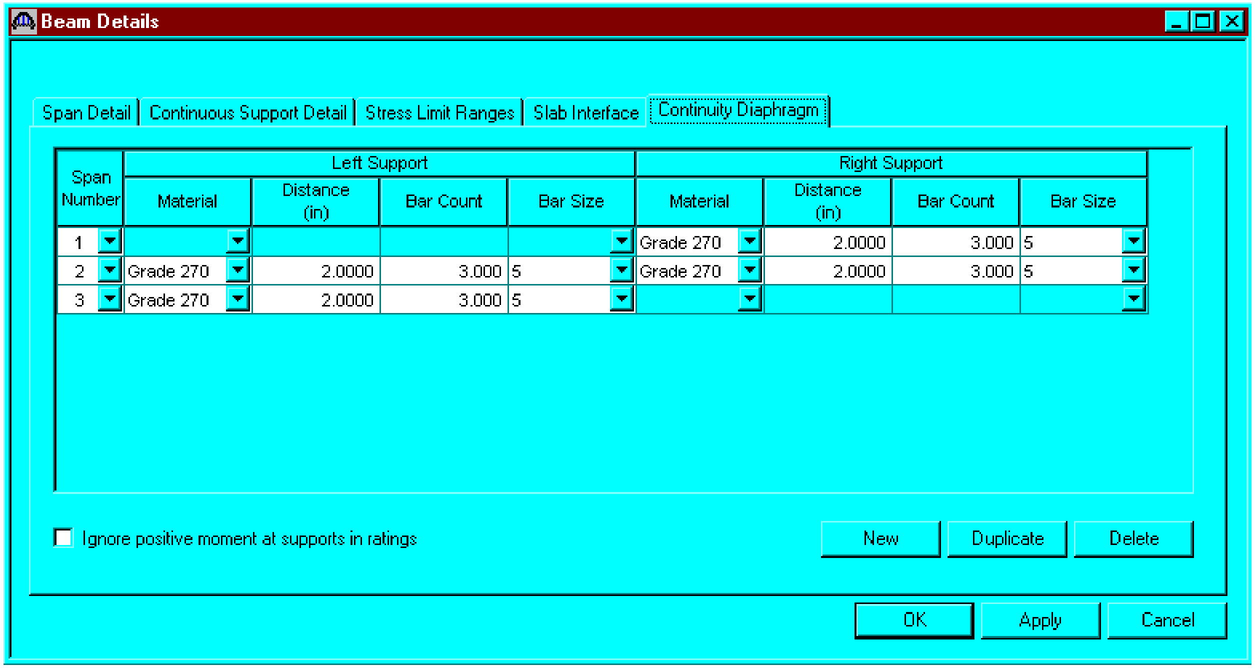
Note that the Stress Limit Ranges are defined over the entire length of the precast beam.



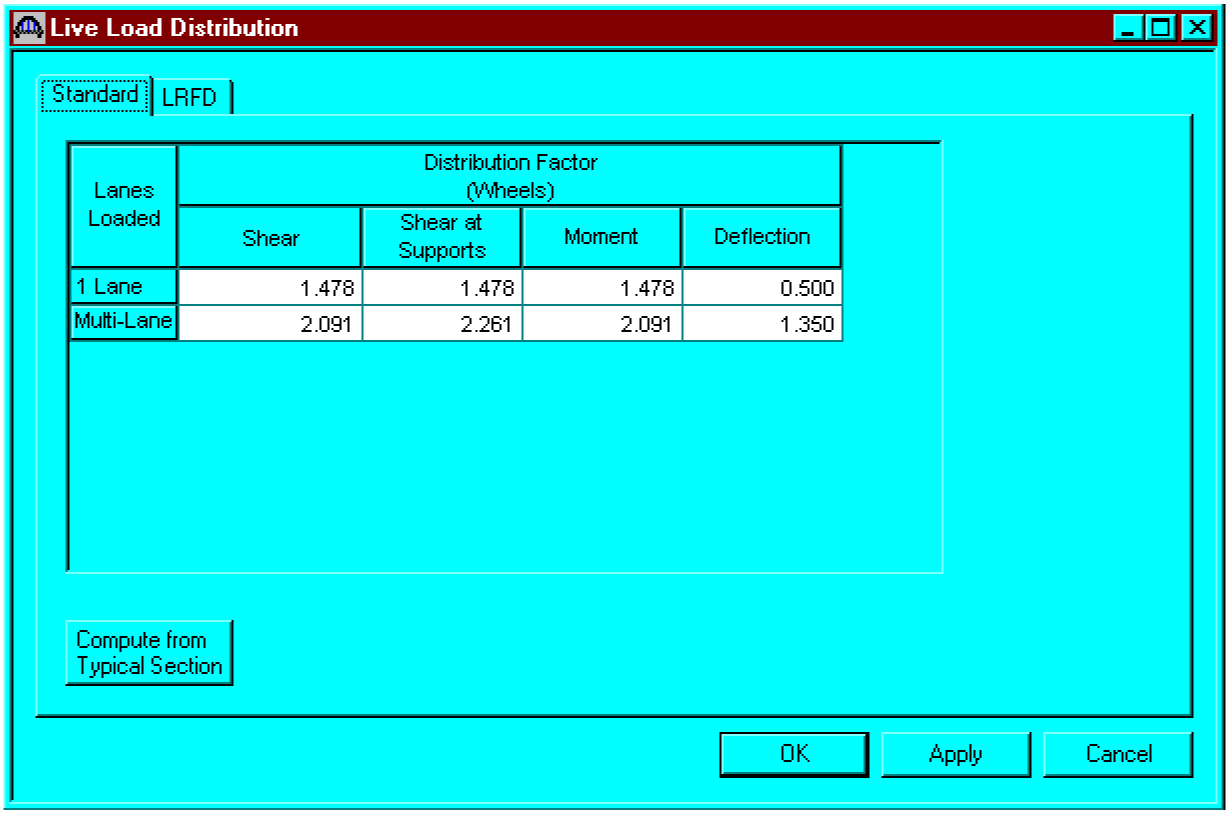
The defaults on the Slab Interface tab are shown below and are acceptable.



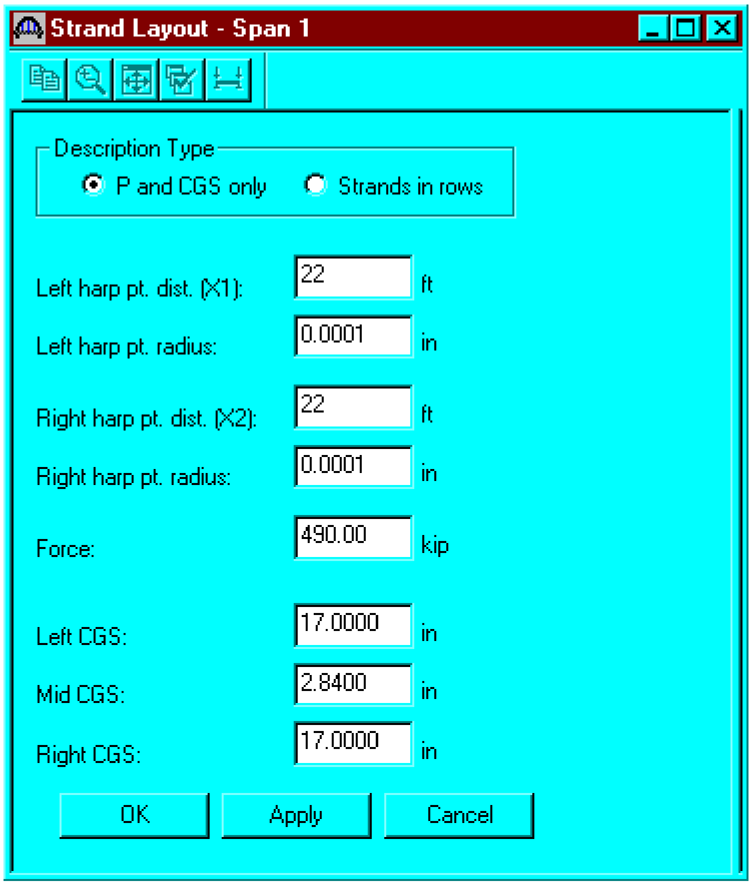
The Continuity Diaphragm tab is only displayed for multi-span structures. The data on this tab defines the cast-in-place diaphragms used to make the structure continuous for live load. Press F1 while on this tab to view the continuity diaphragm help topic describing the use of this information.



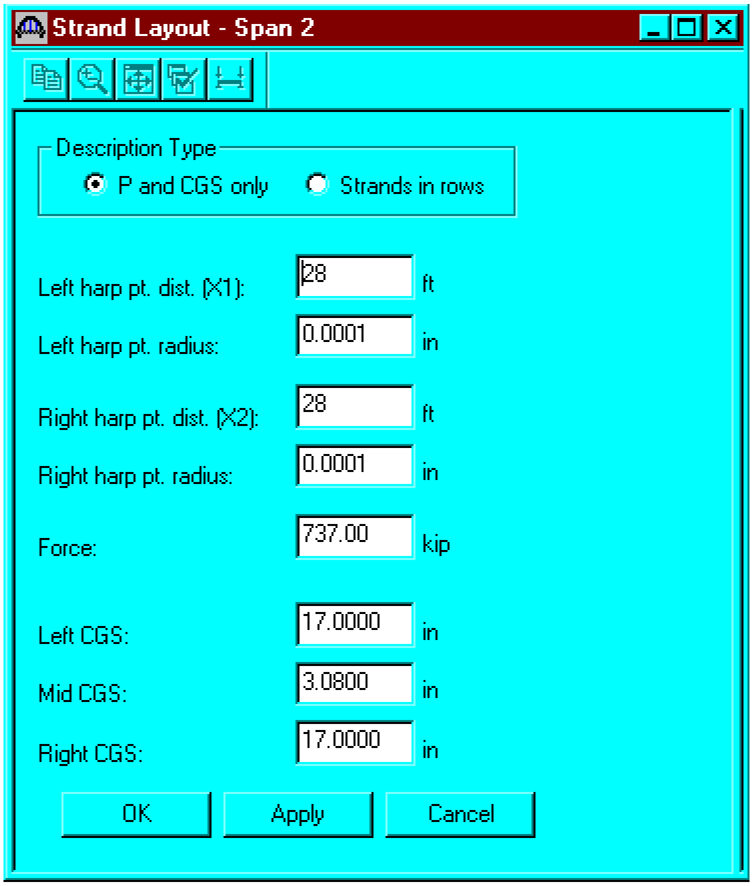
Now double click on Live Load Distribution in the tree to enter the live load distribution factors. Click the Compute from Typical Section button to compute the live load distribution factors. The distribution factors are computed based on the AASHTO Specifications, Articles 3.23 and 3.28. Click Apply and then OK to save data to memory and close the window.



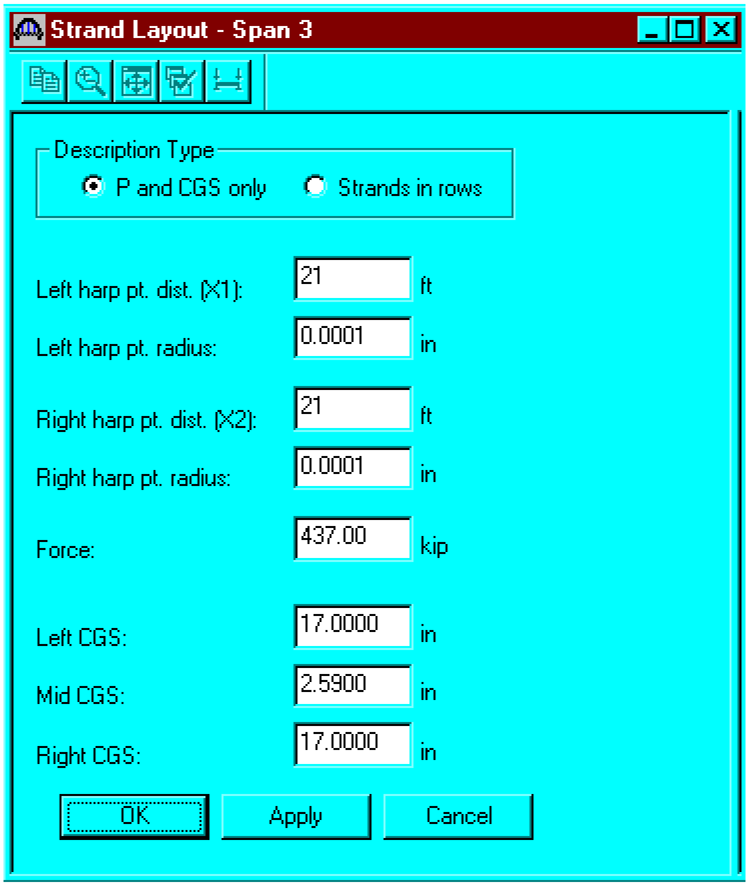
Expand the tree under Strand Layout and open the Span 1 window. This window allows you to define a prestress strand layout for a prestressed concrete beam span. Prestress strand layout can be described either by the actual strand locations or the prestress force (jacking force) and eccentricity (center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



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

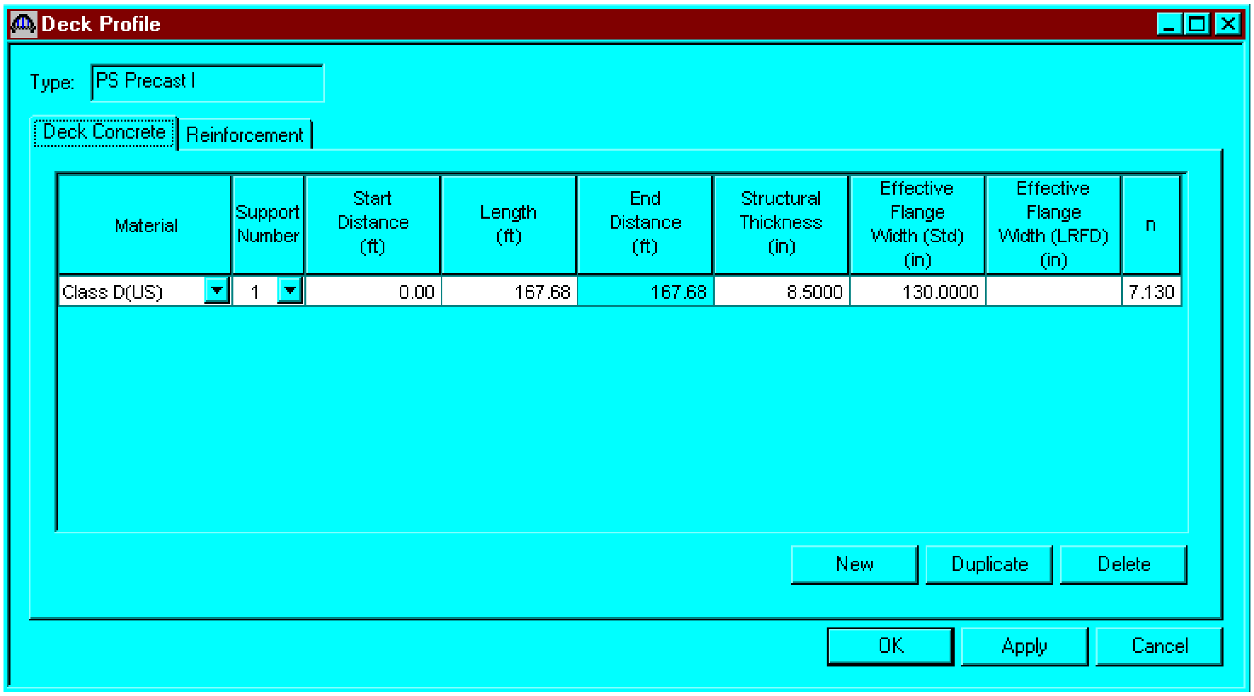


Strand Layout - Span 2
Description Type
P and CGS only
Strands in rows
Left harp pt. dist. (X1):
28
ft
Left harp pt. radius:
0.0001
in
Right harp pt. dist. (X2):
28
ft
Right harp pt. radius:
0.0001
in
Force:
737.00
kip
Left CGS:
17.0000
in
Mid CGS:
3.0800
in
Right CGS:
17.0000
in
OK
Apply
Cancel

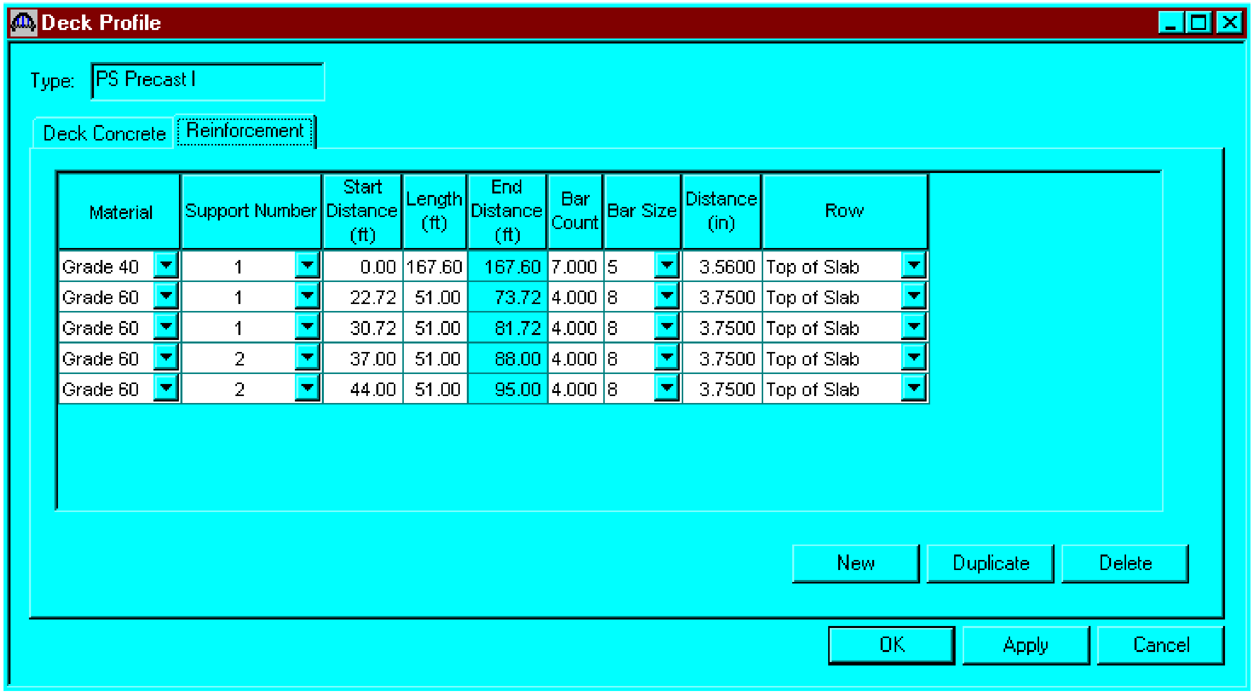


Strand Layout - Span 3
Description Type
P and CGS only
Strands in rows
Left harp pt. dist. (X1): 21 ft
Left harp pt. radius: 0.0001 in
Right harp pt. dist. (X2): 21 ft
Right harp pt. radius: 0.0001 in
Force: 437.00 kip
Left CGS: 17.0000 in
Mid CGS: 2.5900 in
Right CGS: 17.0000 in
OK
Apply
Cancel

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



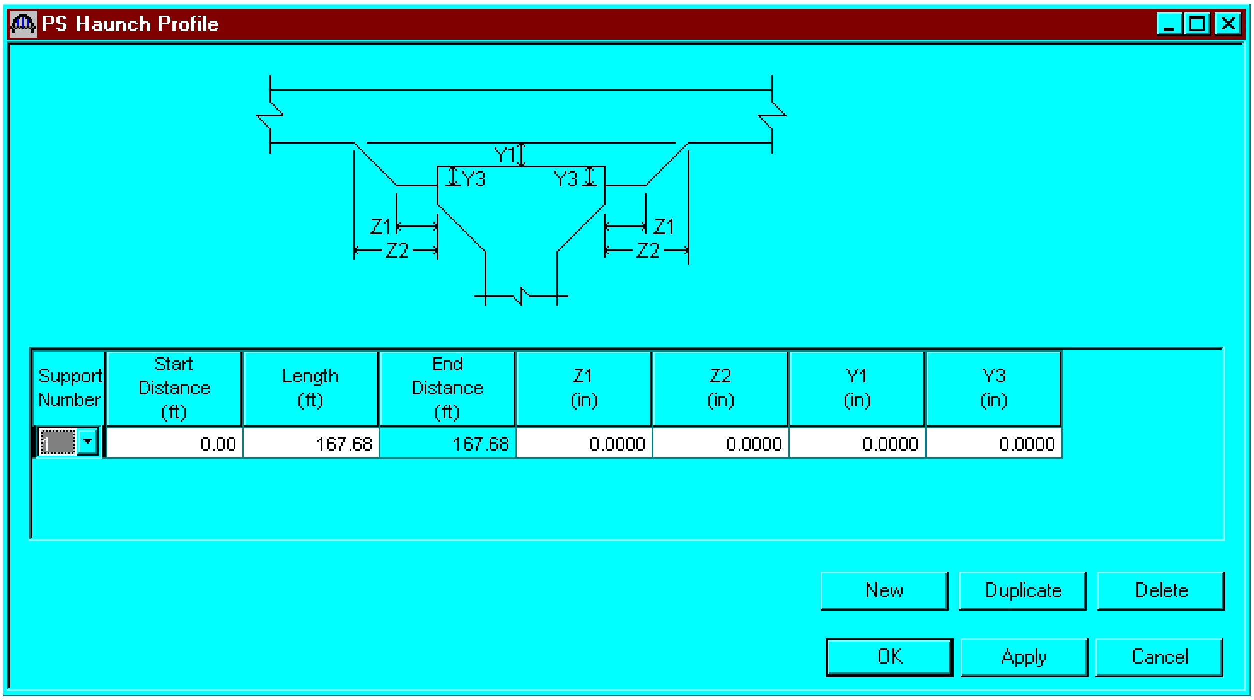
The deck reinforcement in the negative moment regions is described as follows.



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

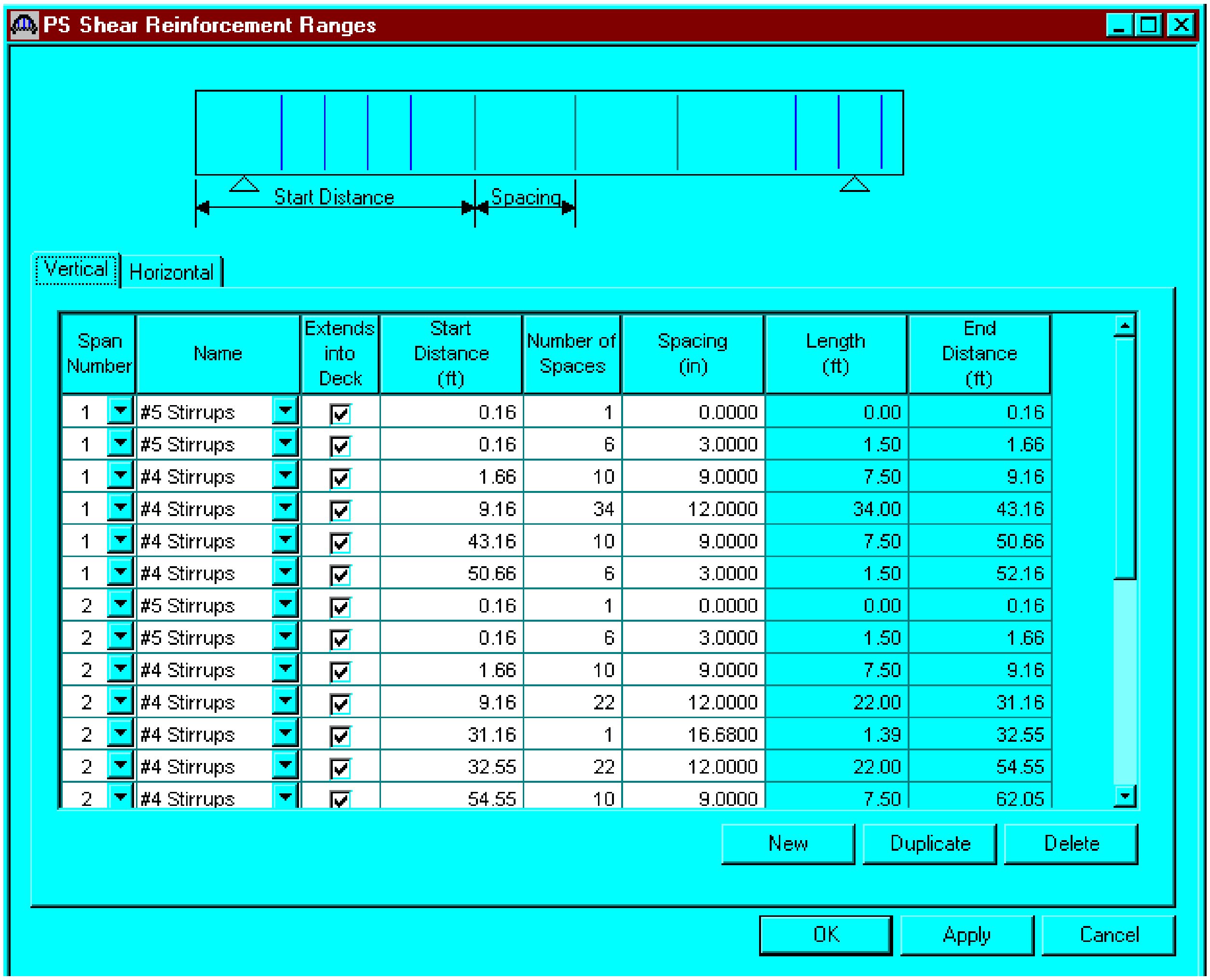
Note: Only the top layer of the slab’s distribution reinforcement is used in the analysis.

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



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

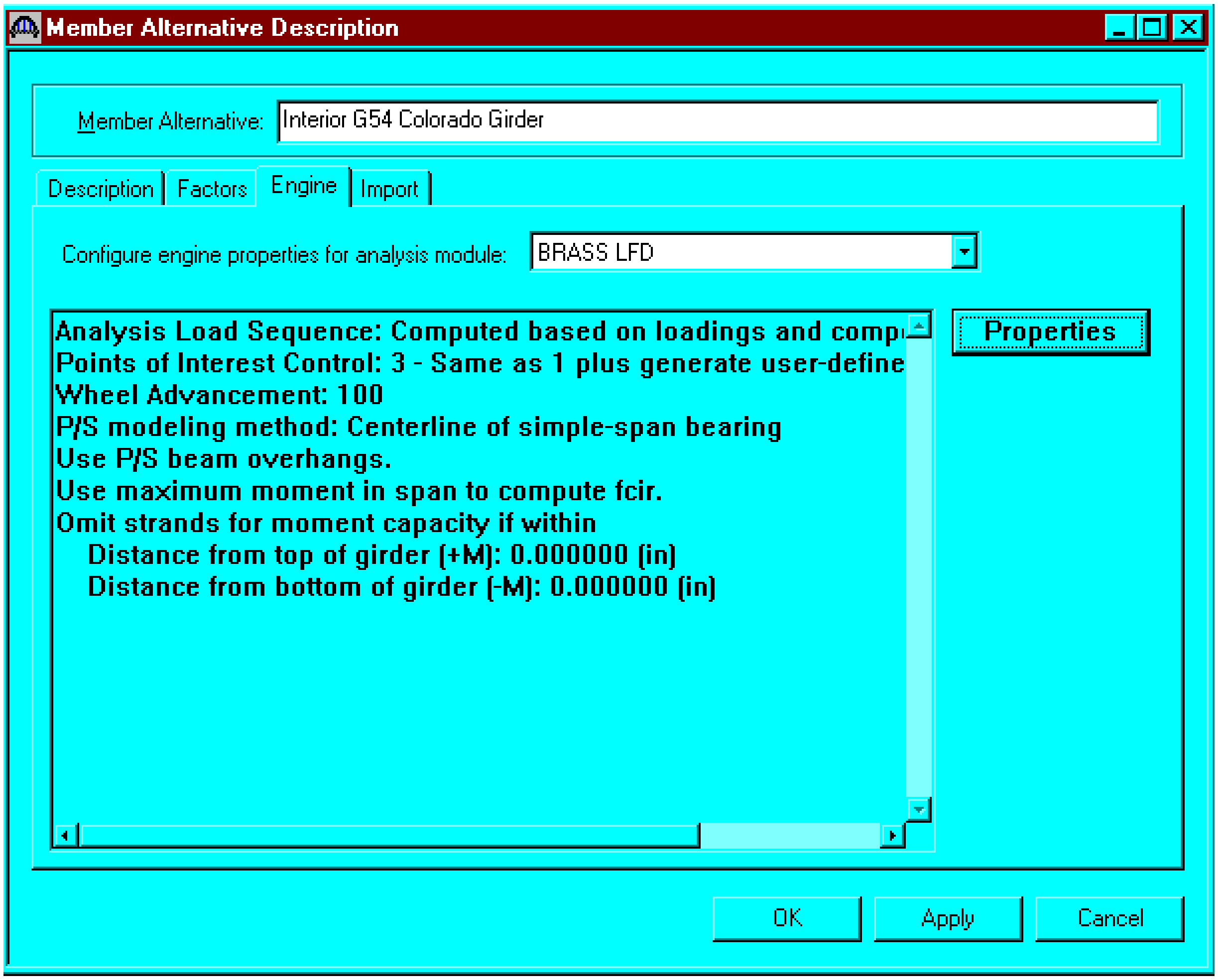
The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This ensures composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we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



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

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

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



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

Analysis Results - Interior G54 Colorado Girder

Report Type

Rating Results Summary

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

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

Close

Analysis Results - Interior G54 Colorado Girder

Report Type

Rating Results Summary

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

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

Close

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

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Rated using Asphalt thickness: 102 mm (4 in) ☒ Colorado legal loads ☐ Interstate legal loads	Structure # F-17-IE State highway # 470 Batch I.D. Structure type CPGC Parallel structure #

Structural member	INTERIOR GIRDER G 54	SLAB		
	Metric tons (Tons)			
Inventory	43.6 (48)	34.5 (38)	( )	( )
Operating	73.6 (81)	57.3 (63)	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	96.3 (106)	( )	( )	( )

____ Metric tons (____) Tons	____ Metric tons (____) Tons	____ Metric tons (____) Tons

Comments

Control Member: Deck; Rated for 4" HBP
Load Capacity: 63.0 Tons
Girder: Only Interior Girder Rated; Haunch not included in the section properties calculations;
G 54 Girders; Rated for 2" HBP

Color Code: White

Project No: I 25 - 2(153)

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used   CDOT Form #1187a 1/98

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

Use average web = 6.0”
Girder flange = ½(Total flange width) = ½(86.0) = 43.0”
4x4 ~ W4xW4 WWF, assumed shear reinforcing: #3 single leg bar @ 12” c/c
Dead Load:

Intermediate Diaphragm = 0.150 kip/diaphragm
½(diaphragm) = 0.075 kip

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

Distribution Factors:

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

K = √ (1+μ)*I/J= √ (1+0.2)*(90584)/(12345)=2.96

C = K*(W/L) = 2.96*(72/59.5) = 3.58 > K   ∴ C = K = 2.96

NL = 6 Lanes Assumed   L = 59.5’

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

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

S/D = (43/12)/(6.898/2) = 1.039 Wheel Lines

NL = 1 Lane

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

S/D = (43/12)/(10.733/2) = 0.668 Wheel Lines

- **AASHTO Standard Specifications, Table 3.23.1**

Assumed full depth rigid diaphragm.

Distribution Factor = S/6 = (7.167/2)/6 = 0.597 (Multi Lanes)

Distribution Factor = 0.547   (Single Lane)

- **LDFAC Program**

Assumed 8” poured in place composite deck.

Distribution Factor = 0.673   (Multi Lanes)

Distribution Factor = 0.542   (Single Lane)

LDFAC Version 1.0 (Release Version)

Dbl_Tee

Geometry Data:

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

Live Load Generator Data

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

Point-of-Interest Data

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

Beam and Slab Data:

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

Girder Spacing Values [in]

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

LDFAC Version 1.0 - Release Version
Out-of-Limits Results for Formula Are Marked With an Asterisk *

1 - Span Straight Beam & Slab Bridge with HS20TR Load

Multi-Lane Load Distribution Results

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

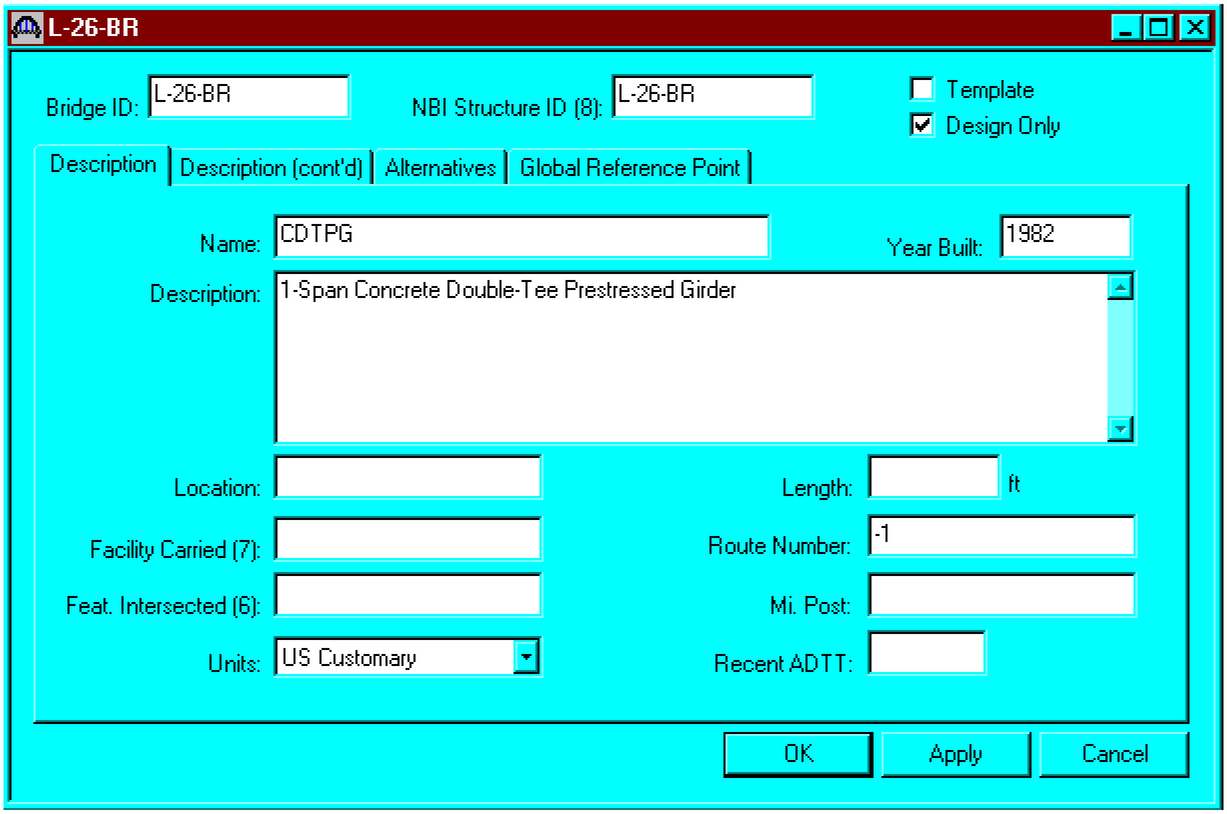
LDFAC Version 1.0 - Release Version
Out-of-Limits Results for Formula Are Marked With an Asterisk *

1 - Span Straight Beam & Slab Bridge with HS20TR Load

Single-Lane Load Distribution Results

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

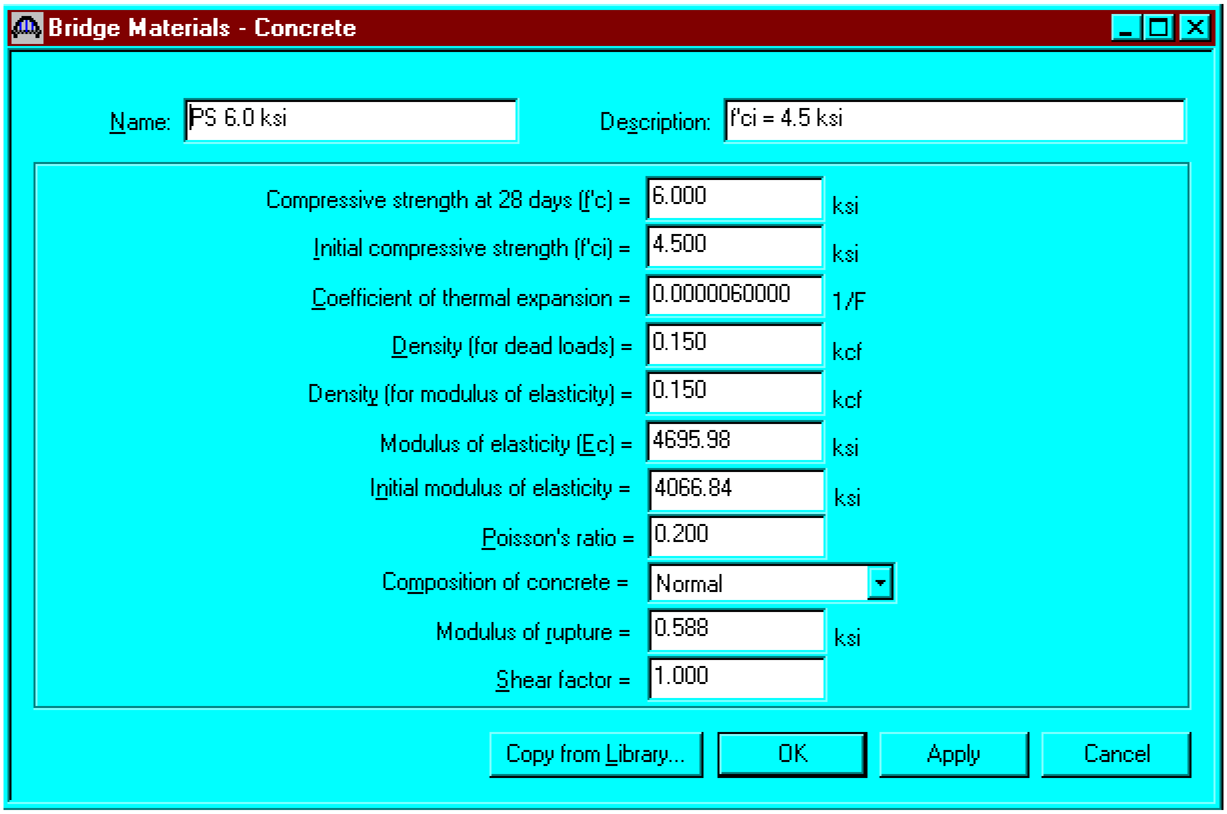
From the bridge explorer, create a new bridge and enter the following information.



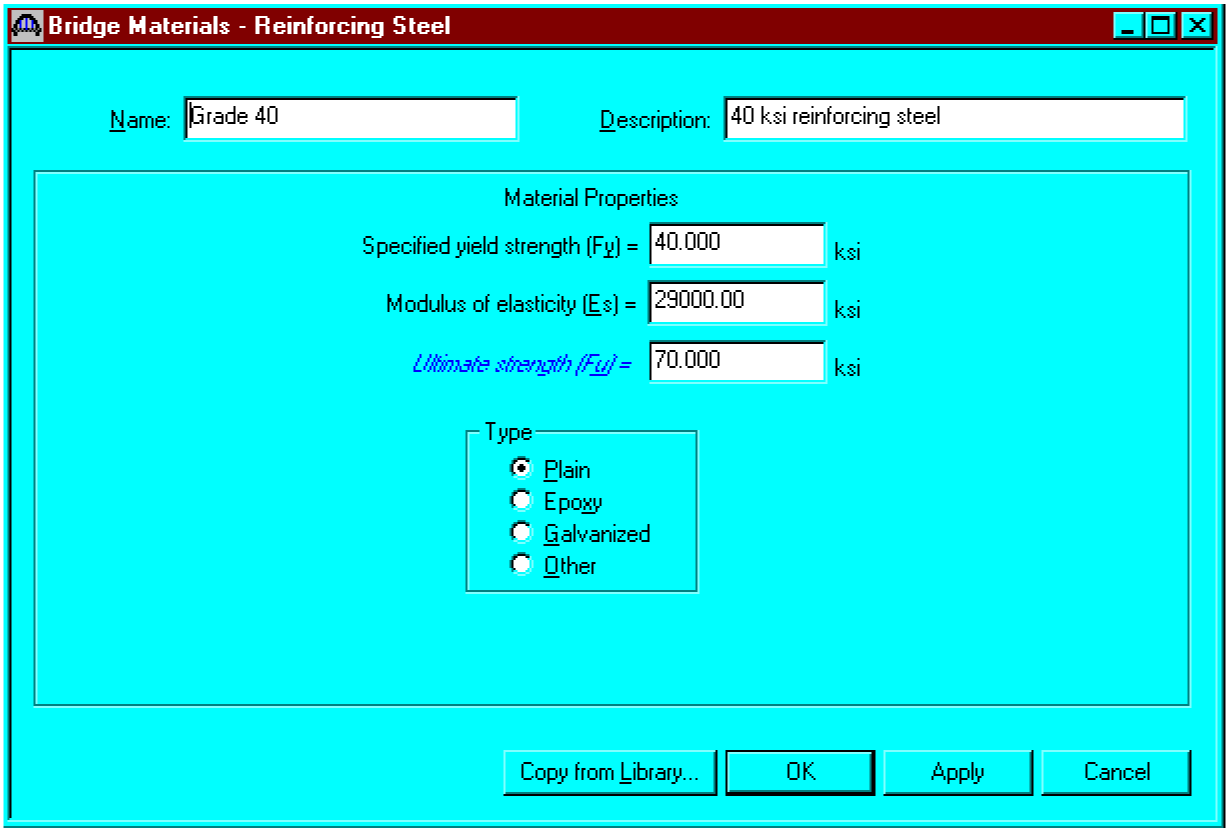
Click OK. This saves the data to memory and closes the window.

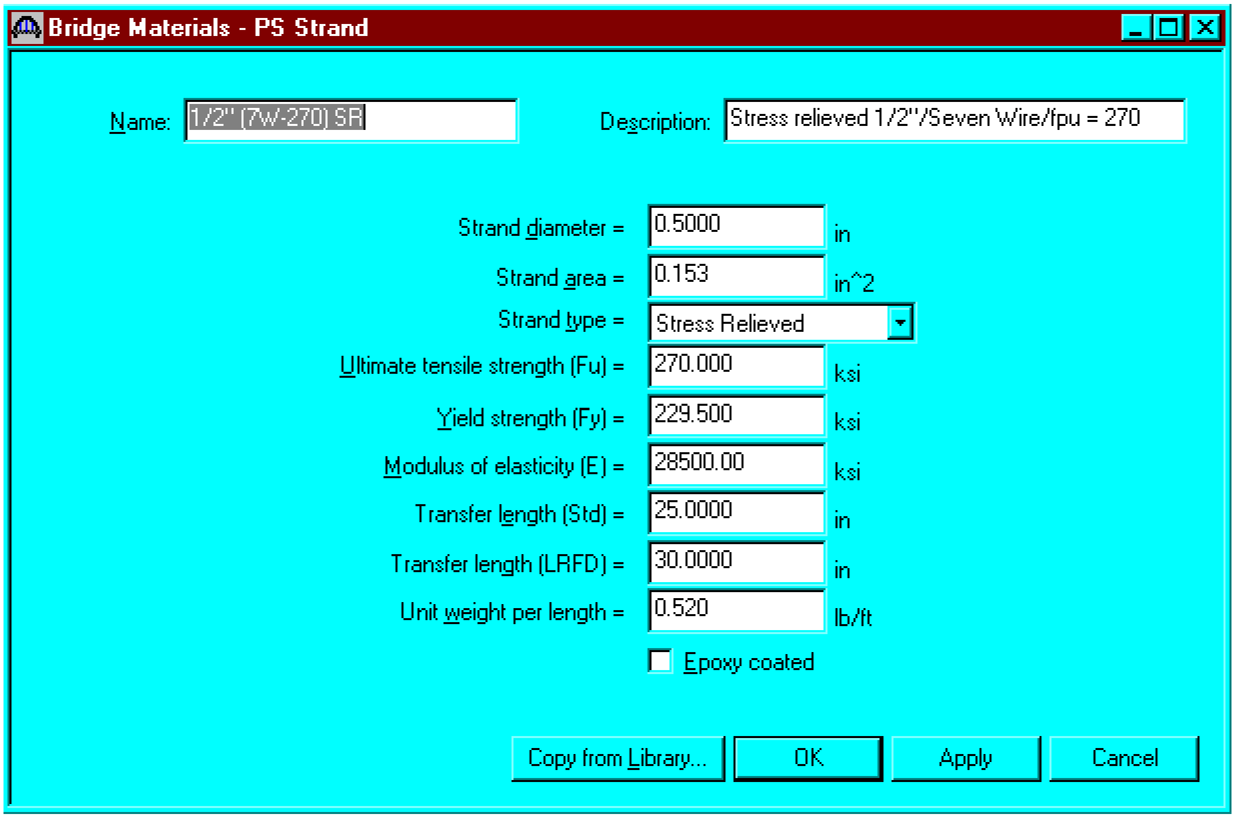
NOTE: Since Virtis uses a common/shared database; it is required that users of this program create a folder from the bridge explorer window **(EXAMPLE: MY FOLDER OR YOUR LAST NAME)** before creating the model for a new structure.

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



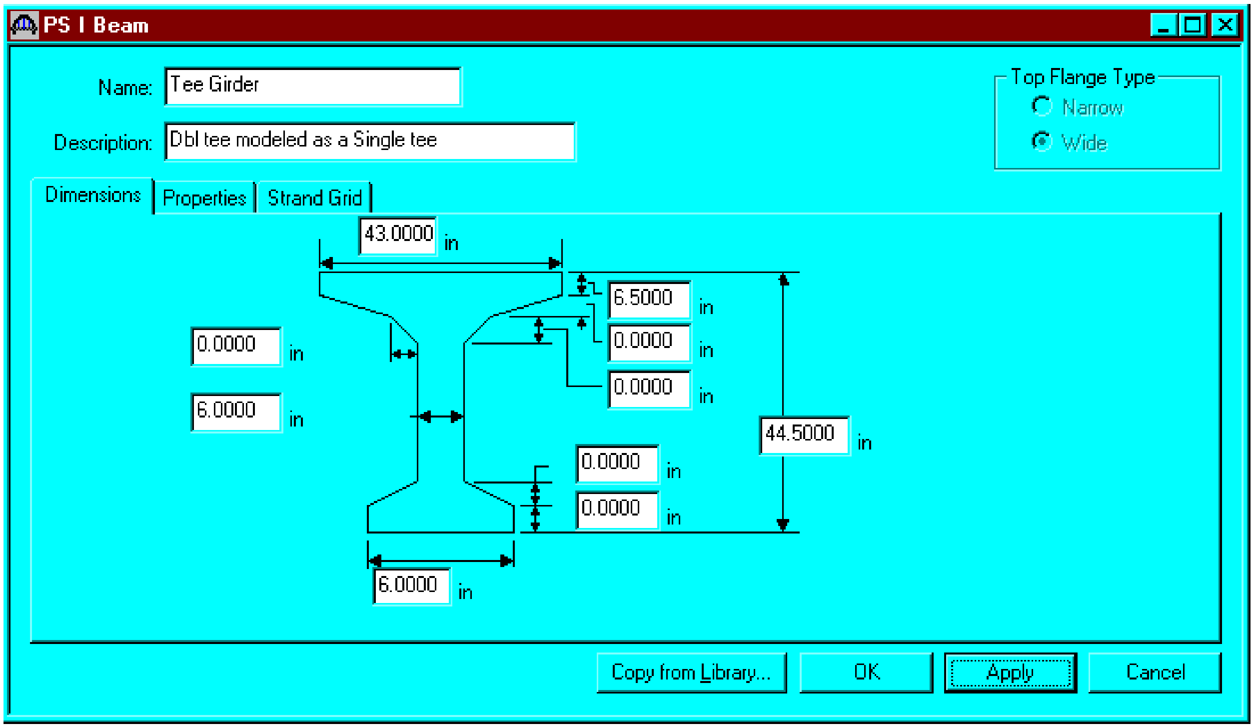
Using the same techniques, create the following Reinforcing Steel Materials and Prestress Strands Materials. The windows are shown in the following pages.





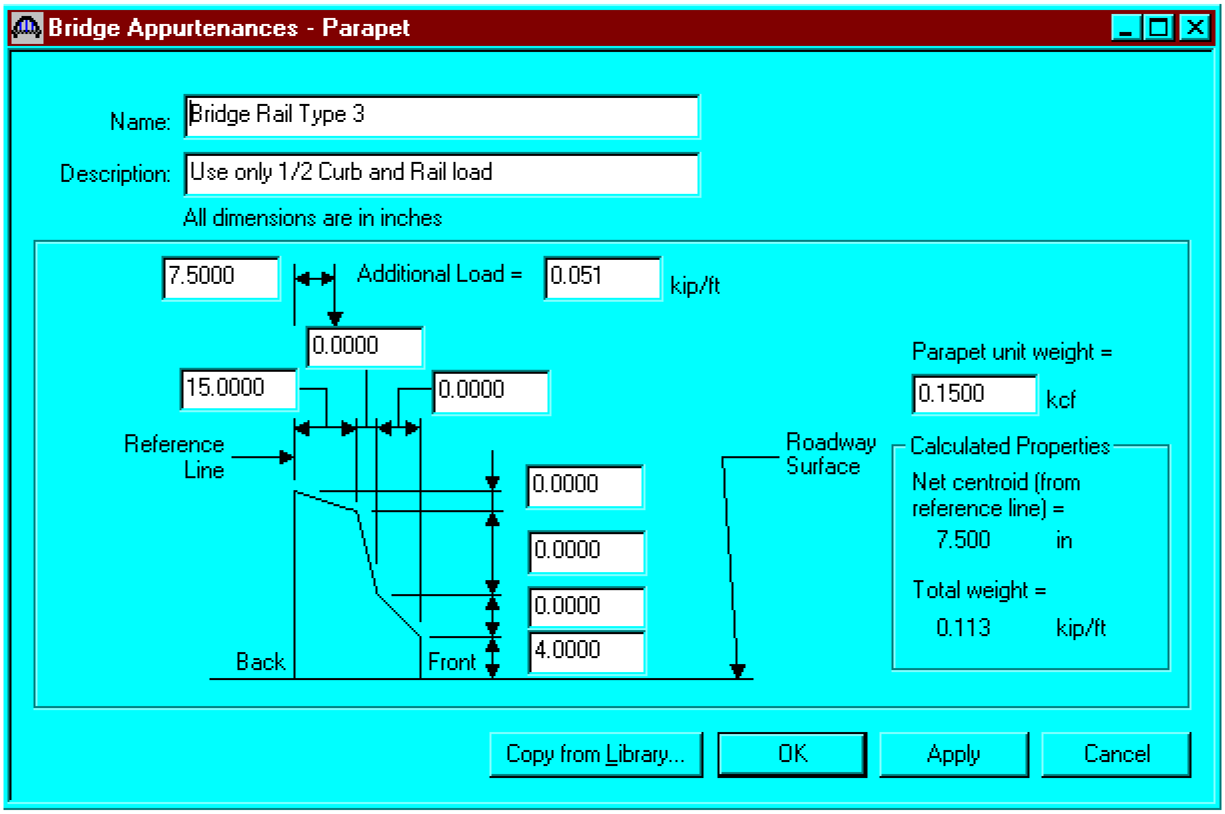
Bridge Materials - PS Strand
Name: 1/2" (7W-270) SR
Description: Stress relieved 1/2"/Seven Wire/fpu = 270
Strand diameter = 0.5000 in
Strand area = 0.153 in^2
Strand type = Stress Relieved
Ultimate tensile strength (Fu) = 270.000 ksi
Yield strength (Fy) = 229.500 ksi
Modulus of elasticity (E) = 28500.00 ksi
Transfer length (Std) = 25.0000 in
Transfer length (LRFD) = 30.0000 in
Unit weight per length = 0.520 lb/ft
Epoxy coated
Copy from Library...
OK
Apply
Cancel

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



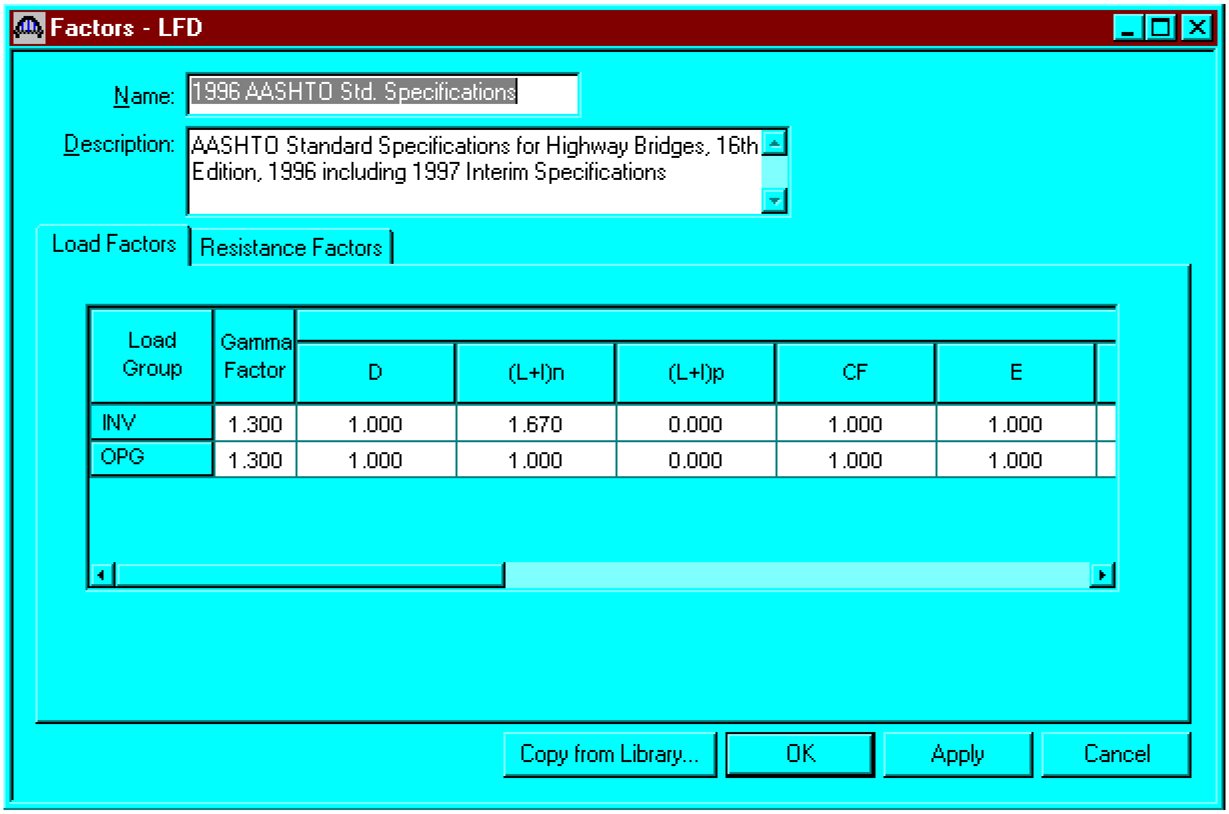
Click OK to save the data to memory and close the window.

To enter the appurtenances to be used within the bridge, expand the explorer tree labeled Appurtenances. Right mouse click on Parapet in the tree, select New and fill in the data for the Bridge Rail Type 3 (Note: Since the girder is modeled as a single-Tee, use only ½ the curb and rail load). Click OK to save the data to memory and close the window.

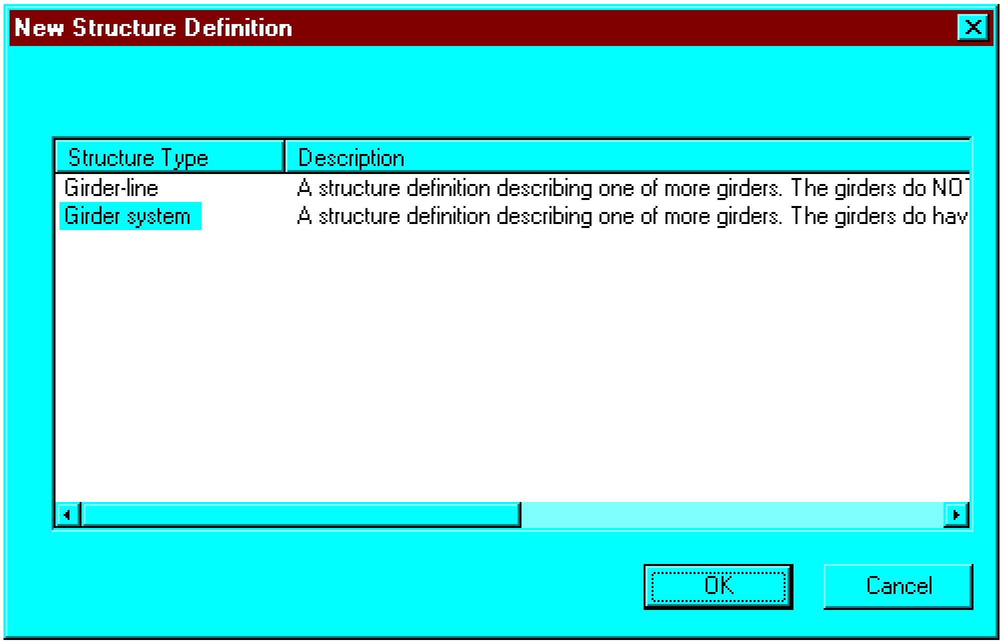


The default impact factors and the standard LFD factors will be used, so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

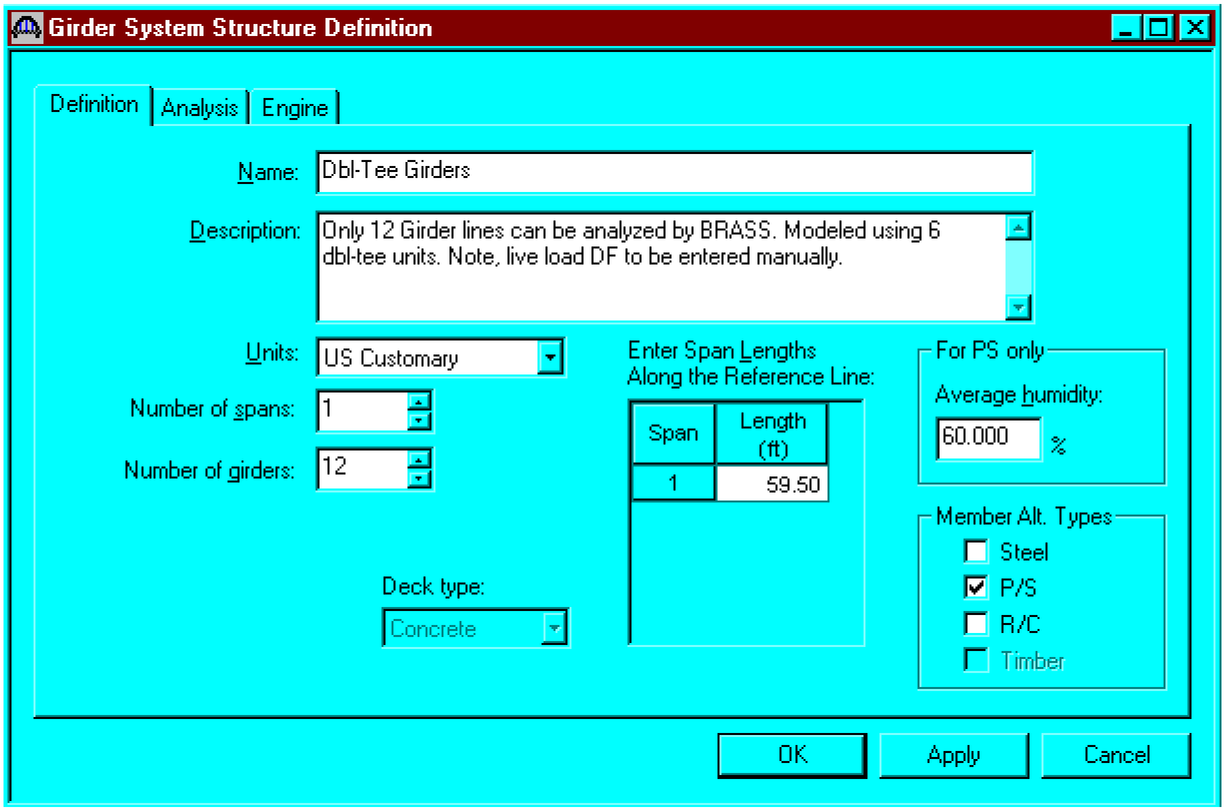
This window shows the LFD load factors.



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.

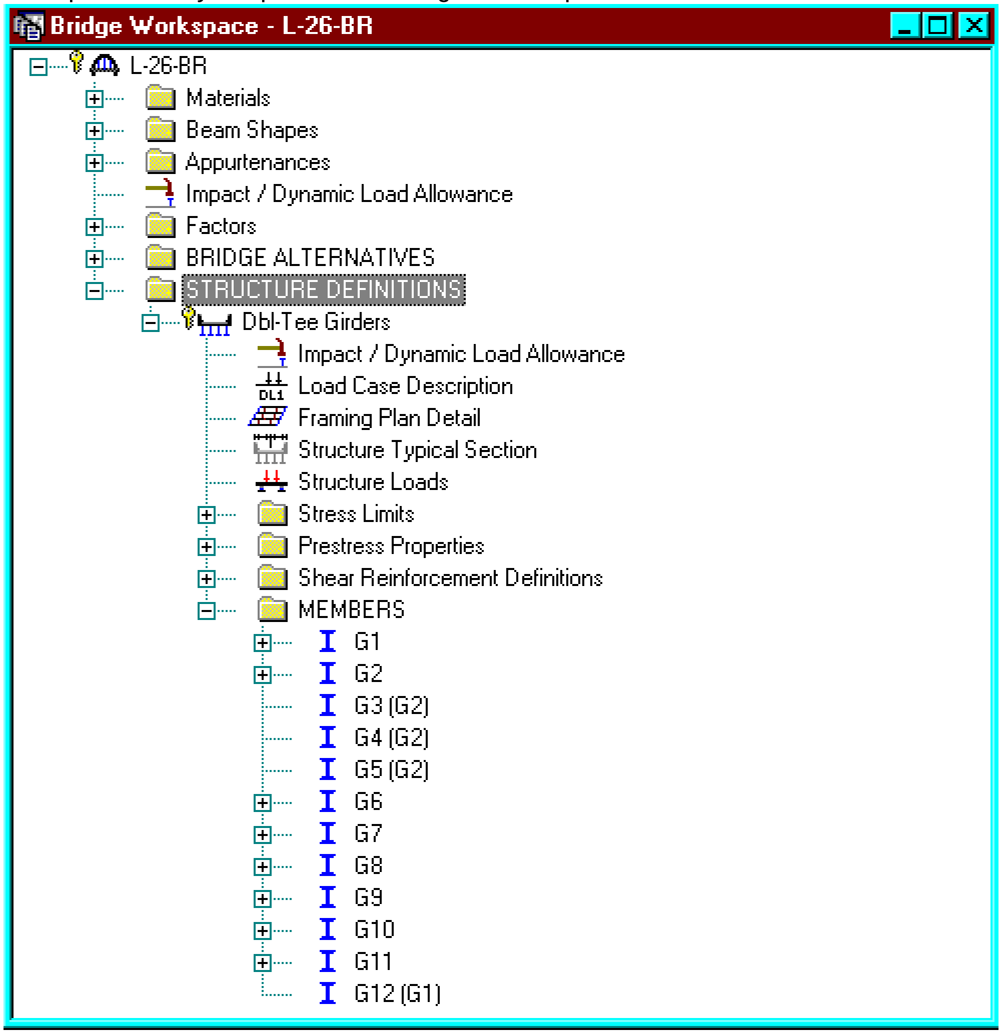


Select Girder System and the following Structure Definition window will open. Enter the appropriate data as shown below. Press F1 while on this tab to view the help topic describing the use of this information.



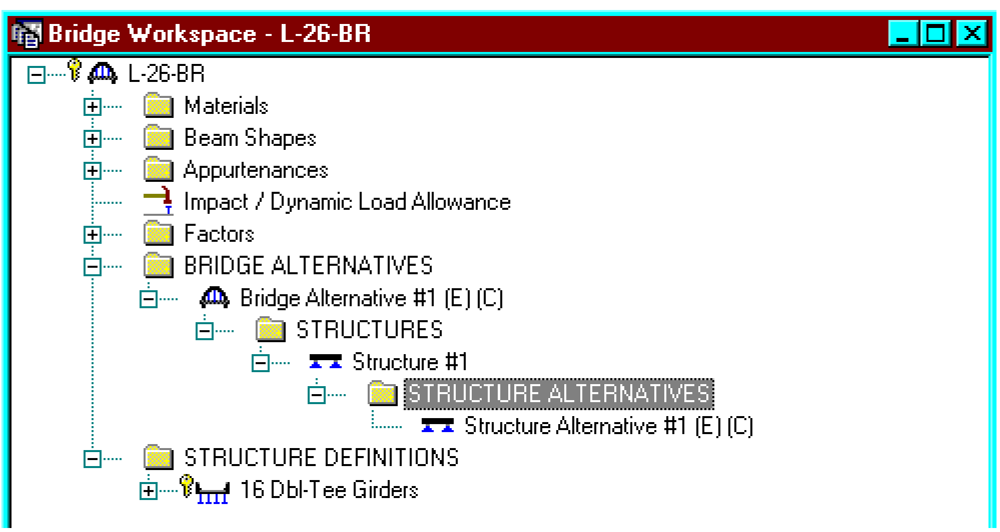
Span length for a simple span prestressed girder structure shall be per Section 9A-2 IV.

The partially expanded Bridge Workspace tree is shown below:

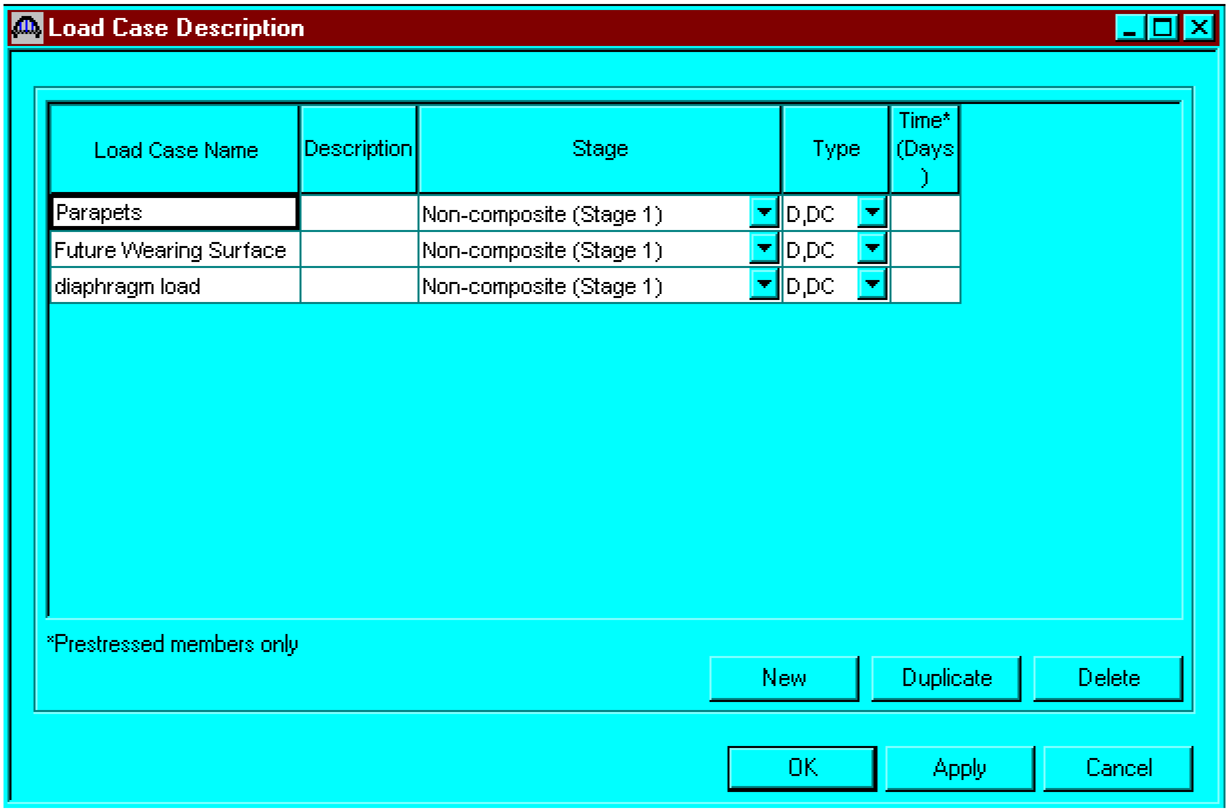


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative.

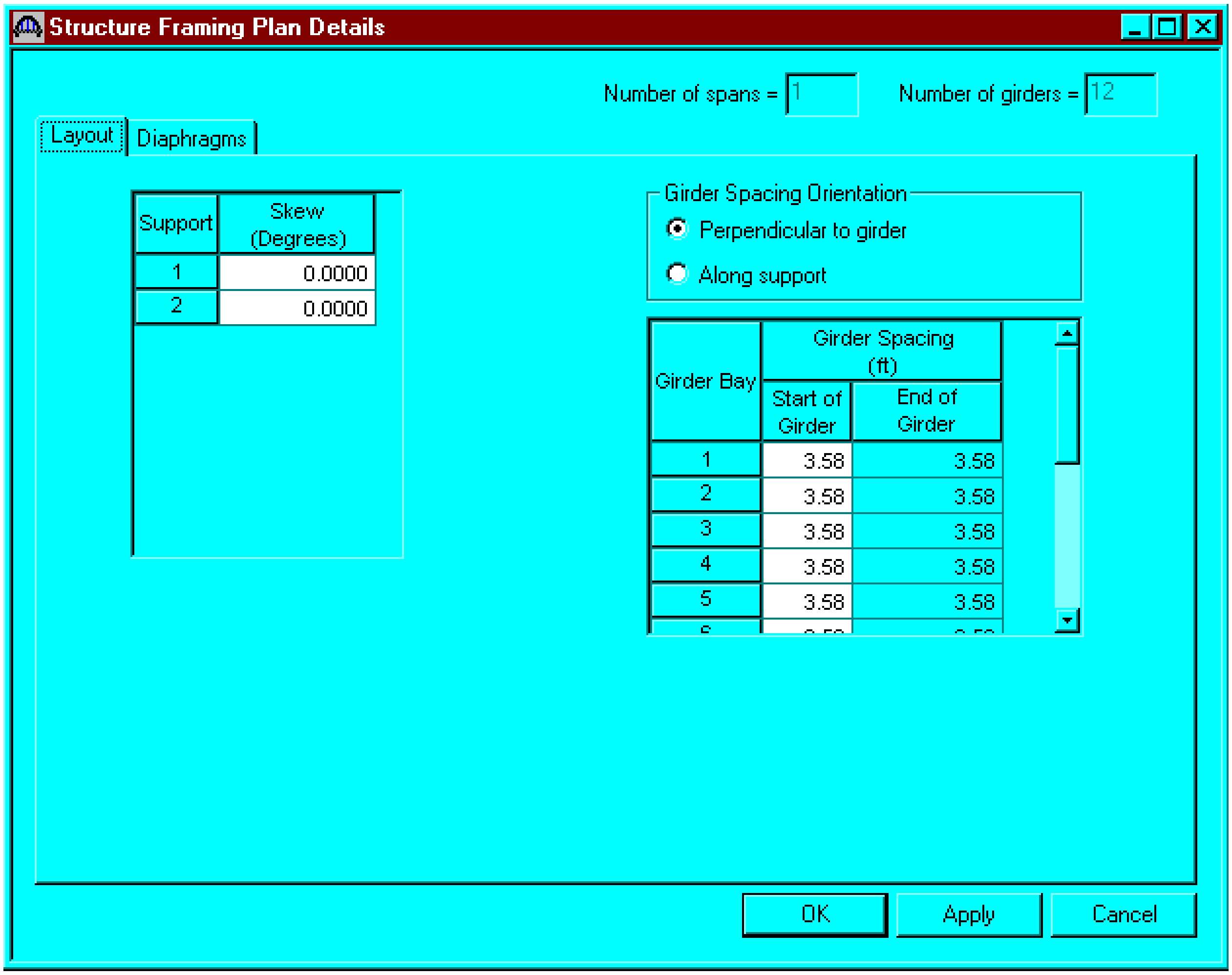
The partially expanded Bridge Workspace tree is shown below:



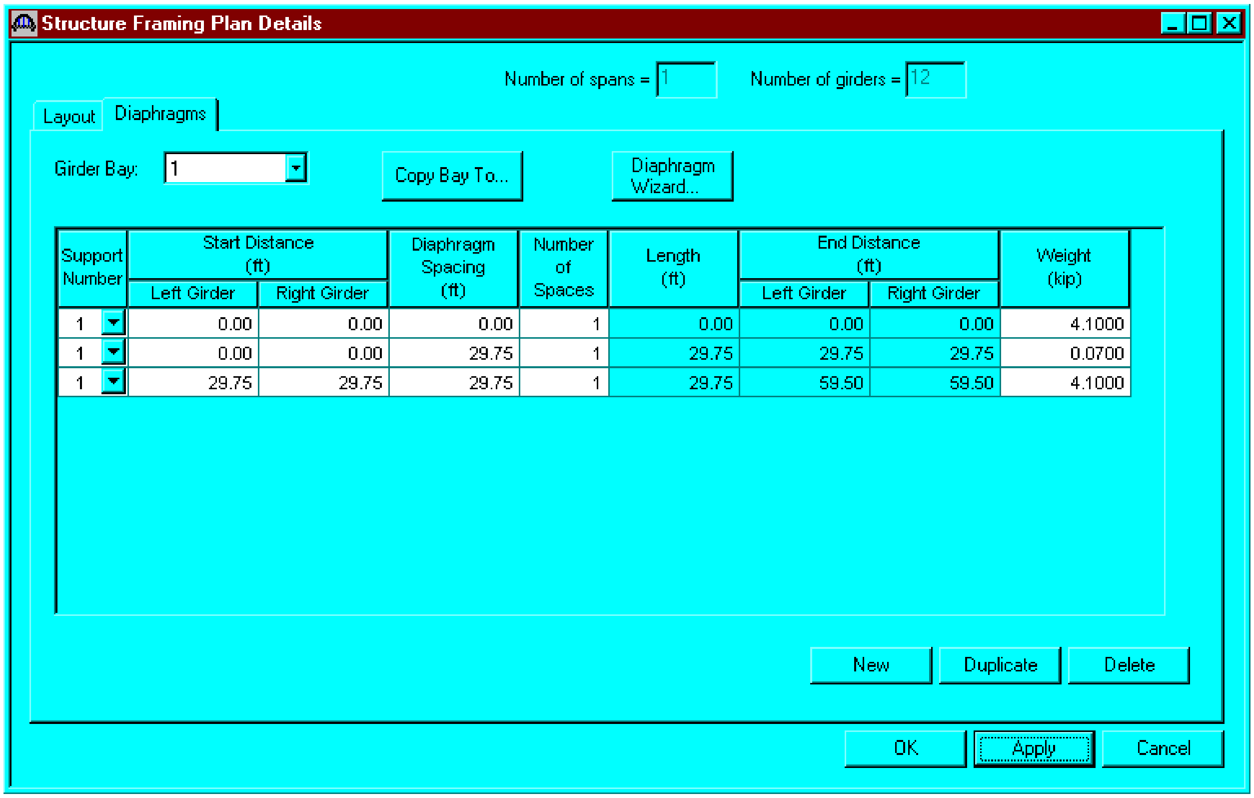
Click Load Case Description to define the dead load cases. The load types are presented in a single row separated by a comma. The first type applies to the LFD design and the second type applies to the LRFD design and it corresponds with the load types presented in the AASHTO Specifications. The completed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



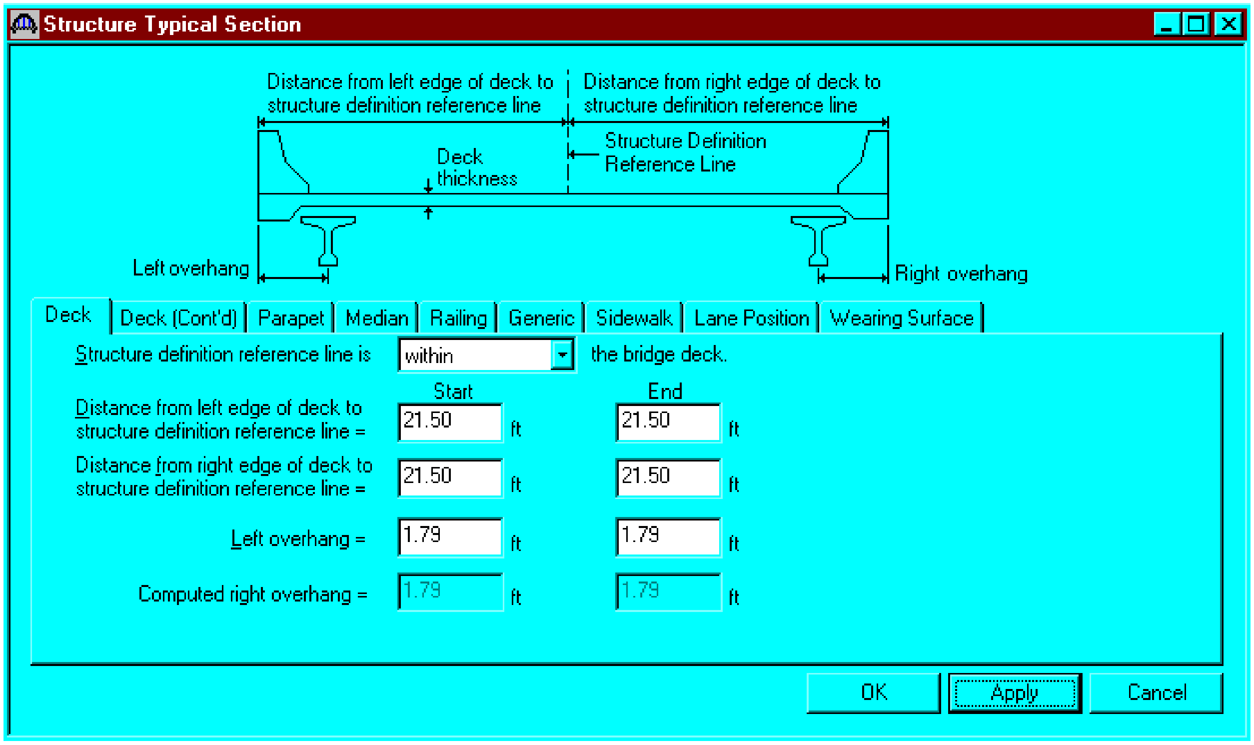
Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data to describe the framing plan.



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.

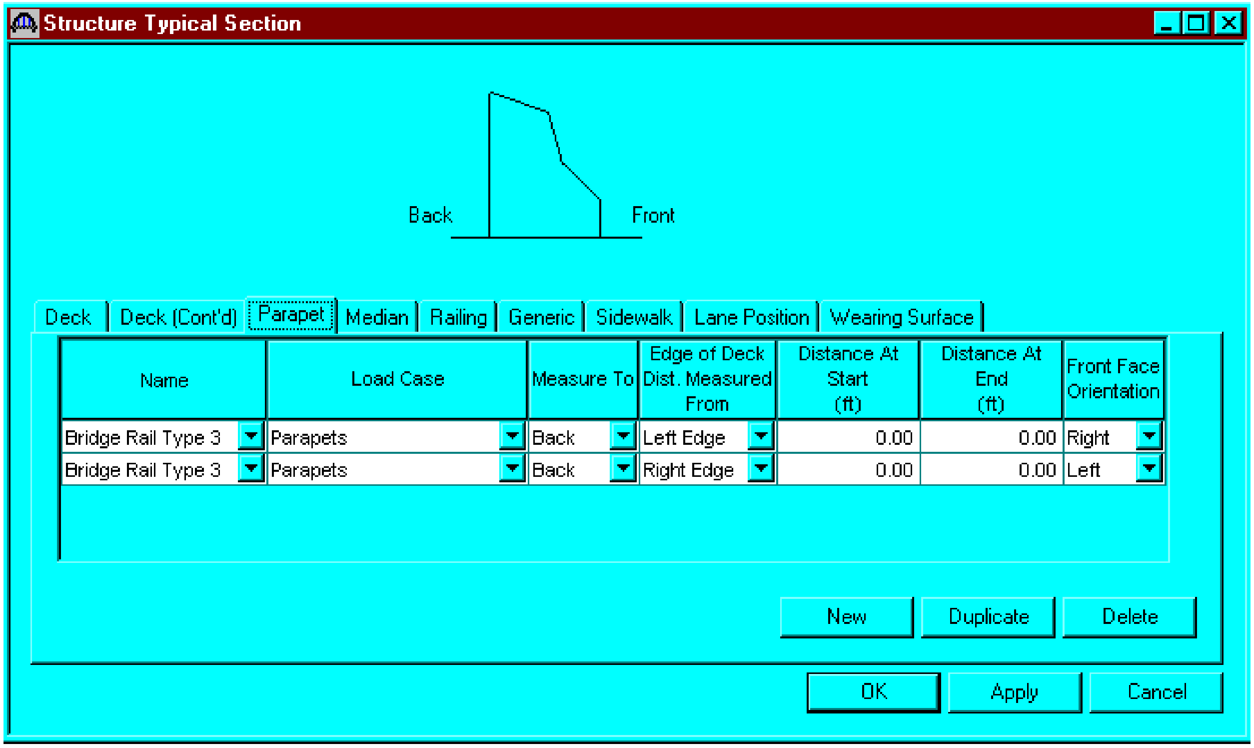


Double click on Structure Typical Section in the Bridge Workspace tree to define the structure typical section. Input the data describing the typical section as shown below.

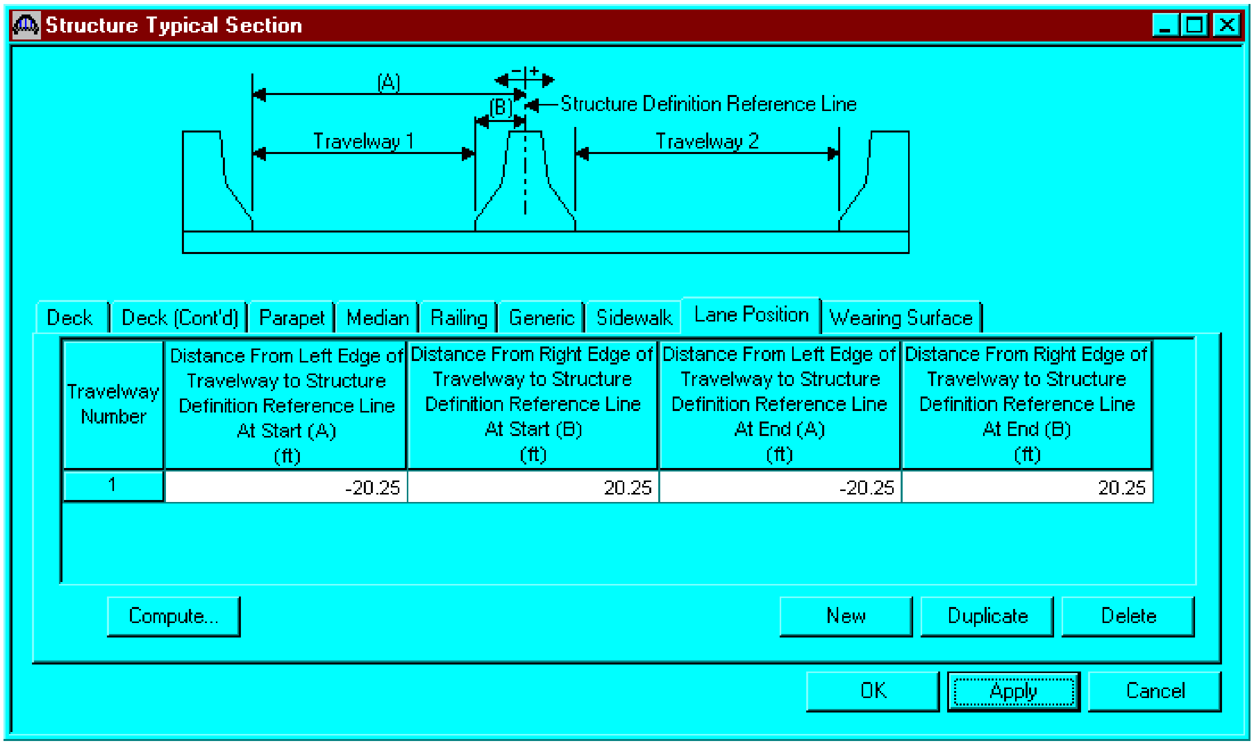


The Deck(Cont'd) tab is used to enter information about the deck concrete and thickness. This structure does not have a concrete deck, so leave the information on this tab blank.

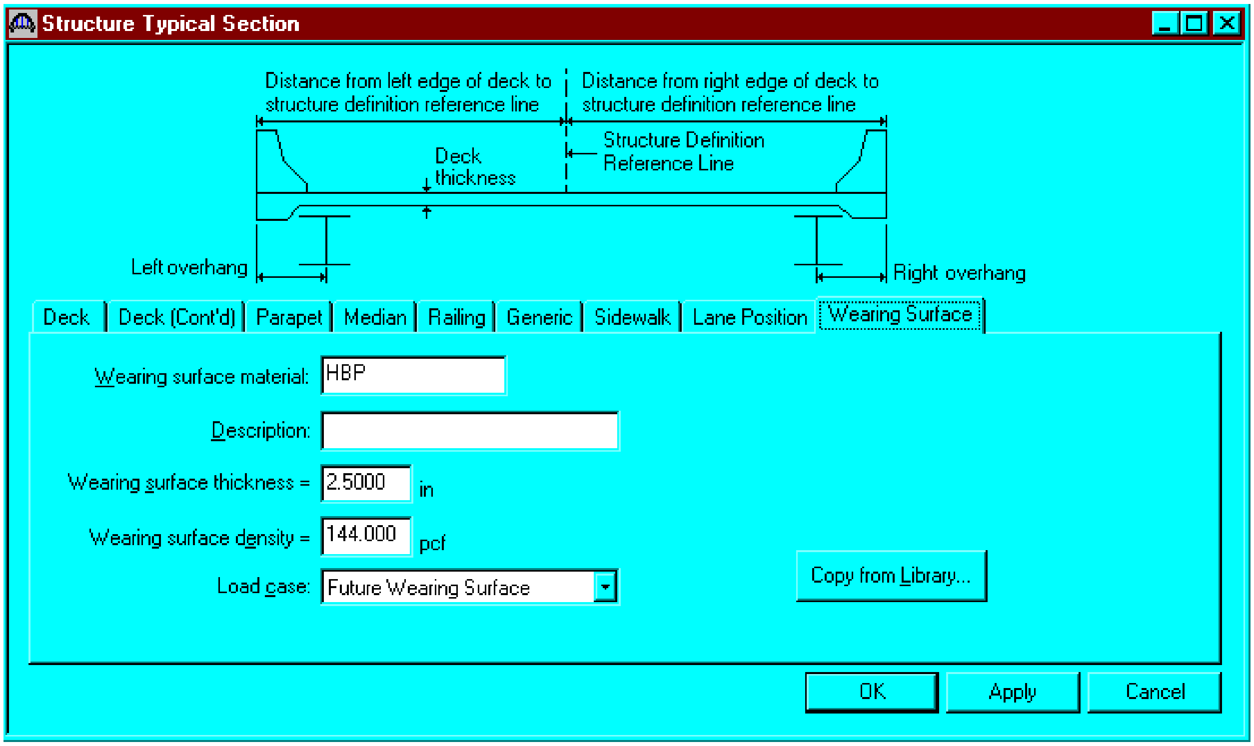
Parapets:
Add two parapets as shown below.



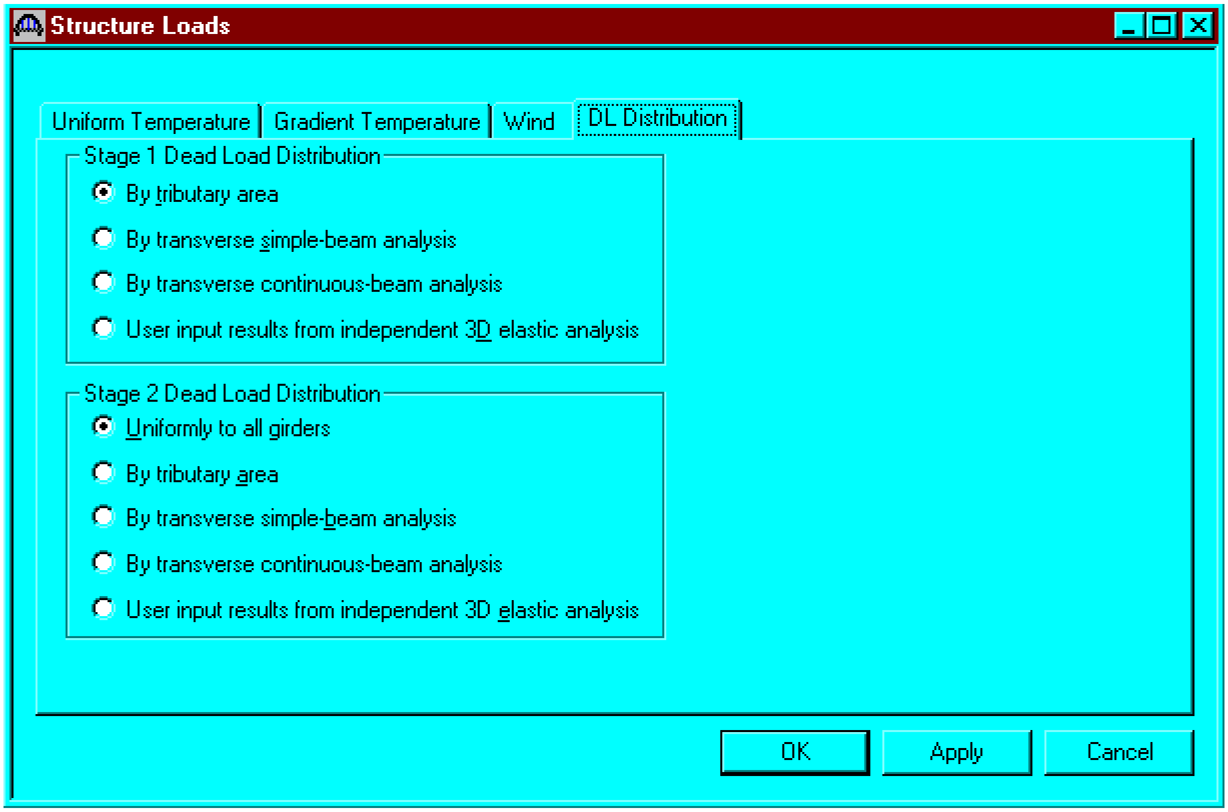
Lane Positions:
Select the lane position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click apply to accept the computed values. The Lane Position tab is populated as shown below.



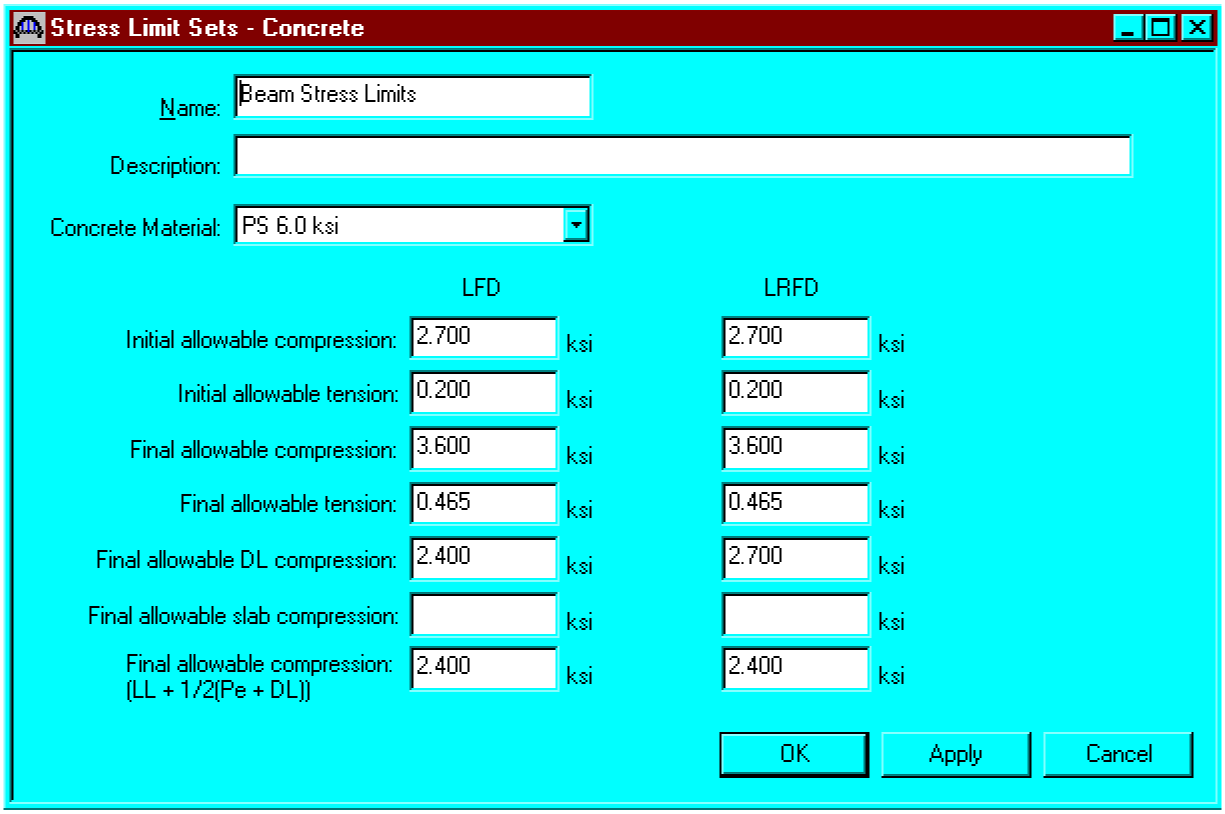
Enter the following wearing surface information on the Wearing Surface tab.



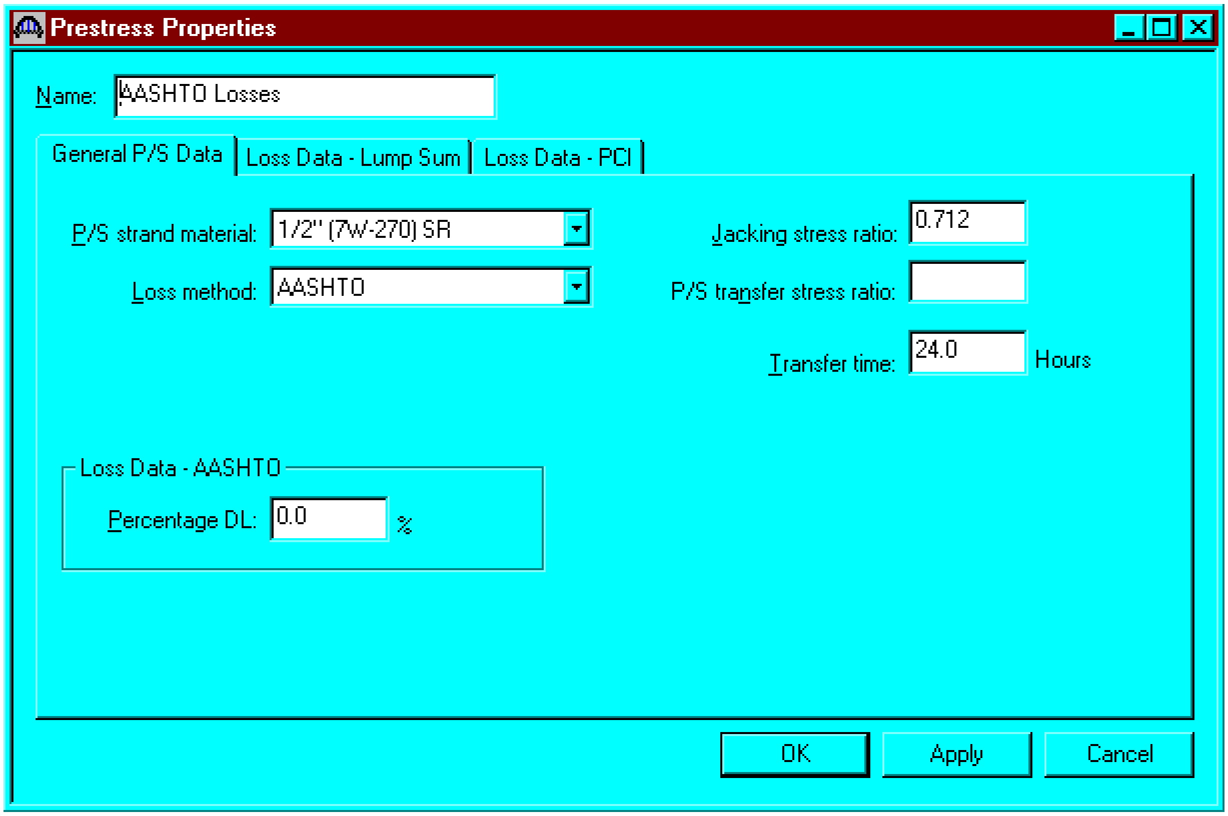
Double click on the Structure Loads tree item to define the DL Distribution. Select the required DL Distribution. Click OK to save this information to memory and close the window.



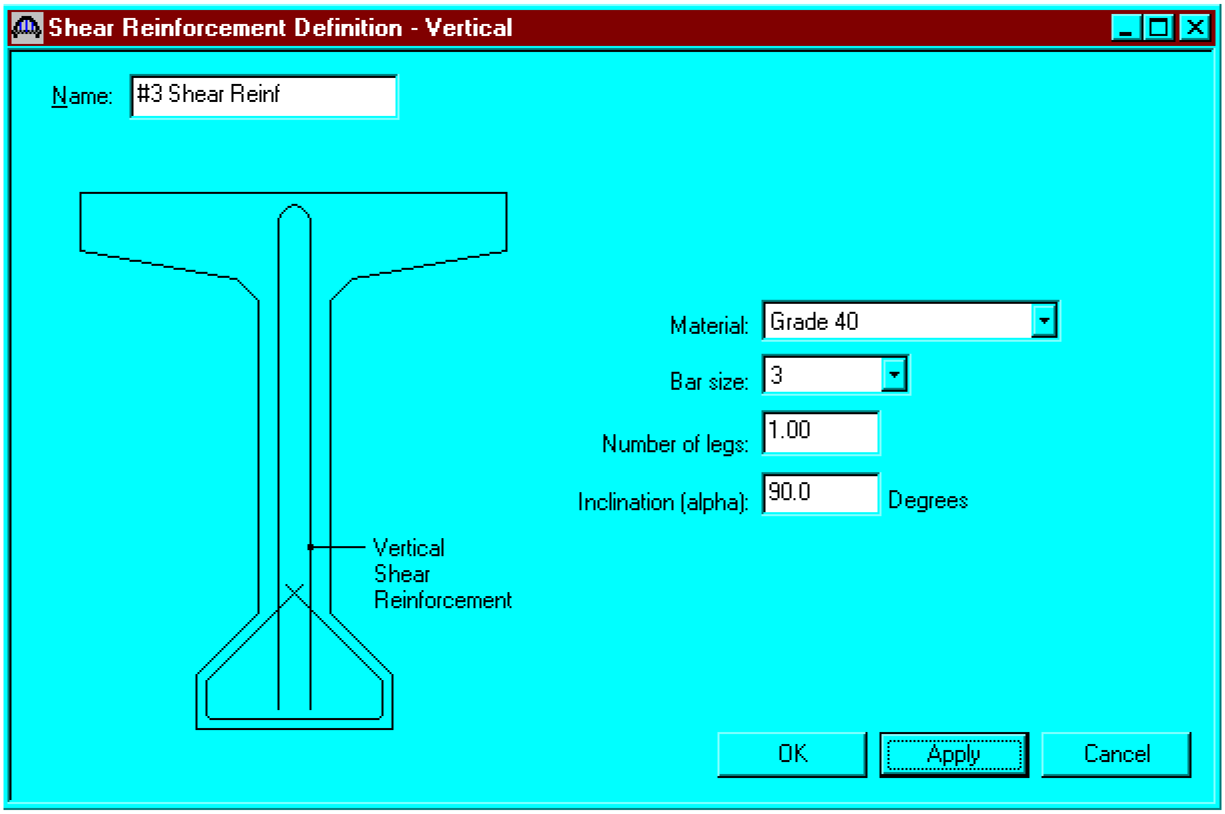
A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “PS 6.0 ksi” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications.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



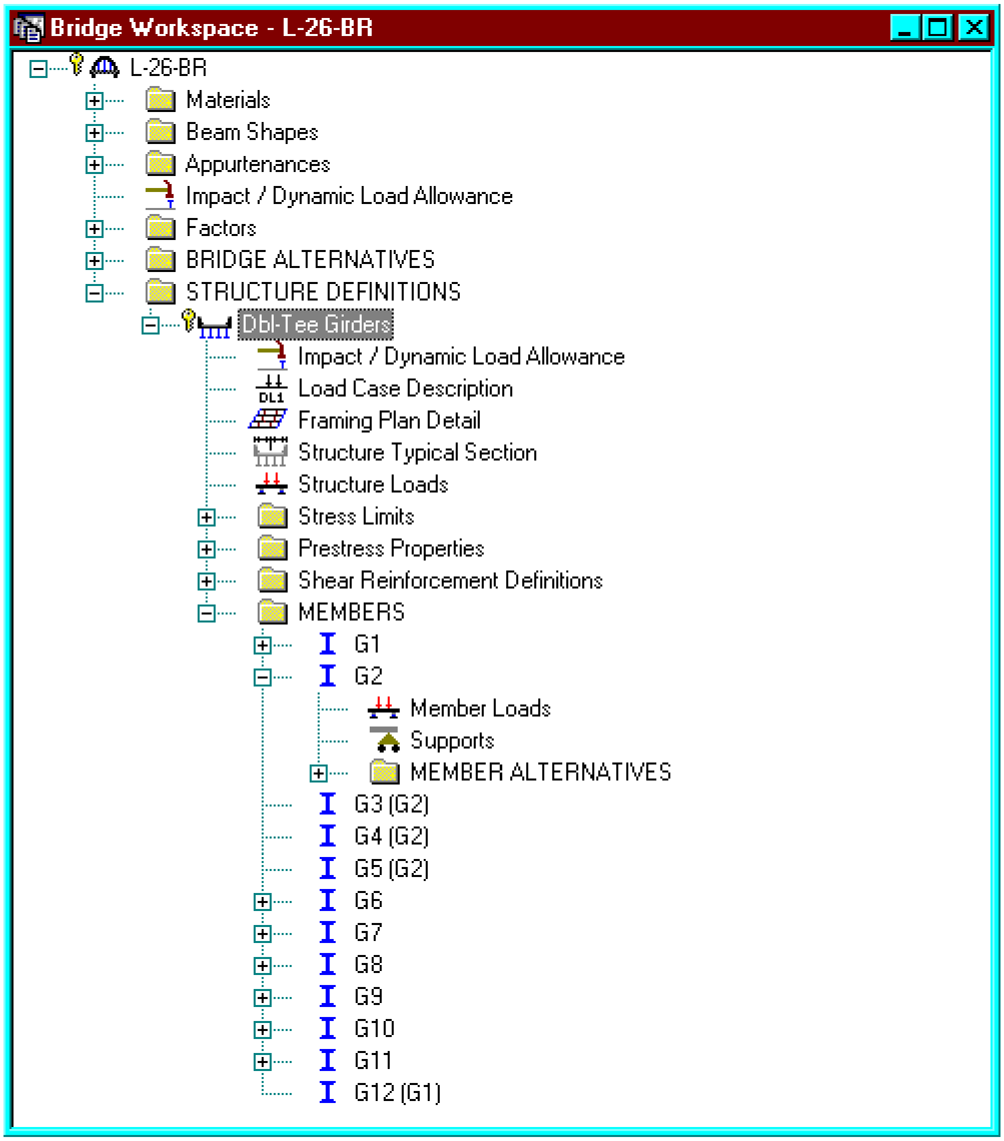
Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. Since we are using the AASHTO method to compute losses, only information in the “General P/S Data” tab is required.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



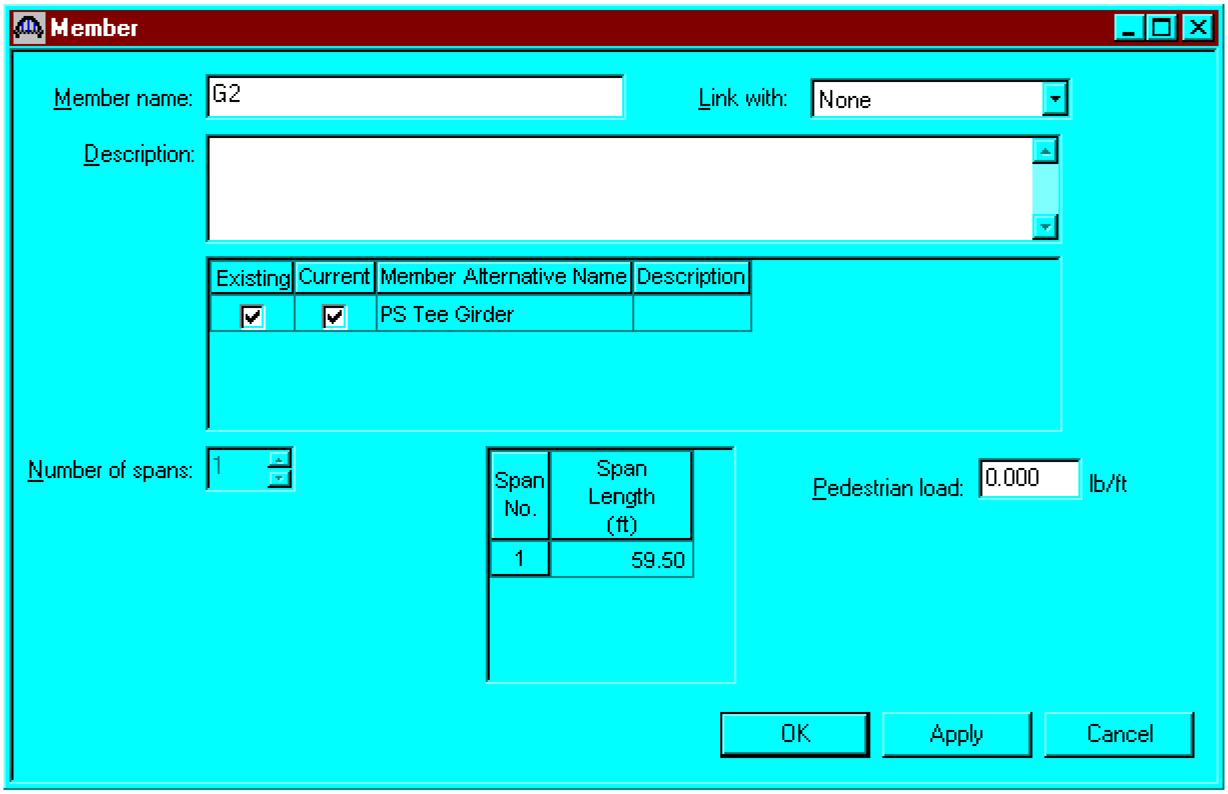
Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definition in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only. Click OK to save to memory and close the window.



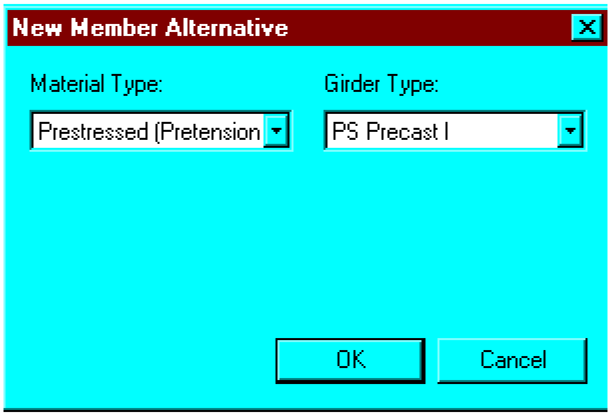
The partially expanded Bridge Workspace tree is shown below:



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.

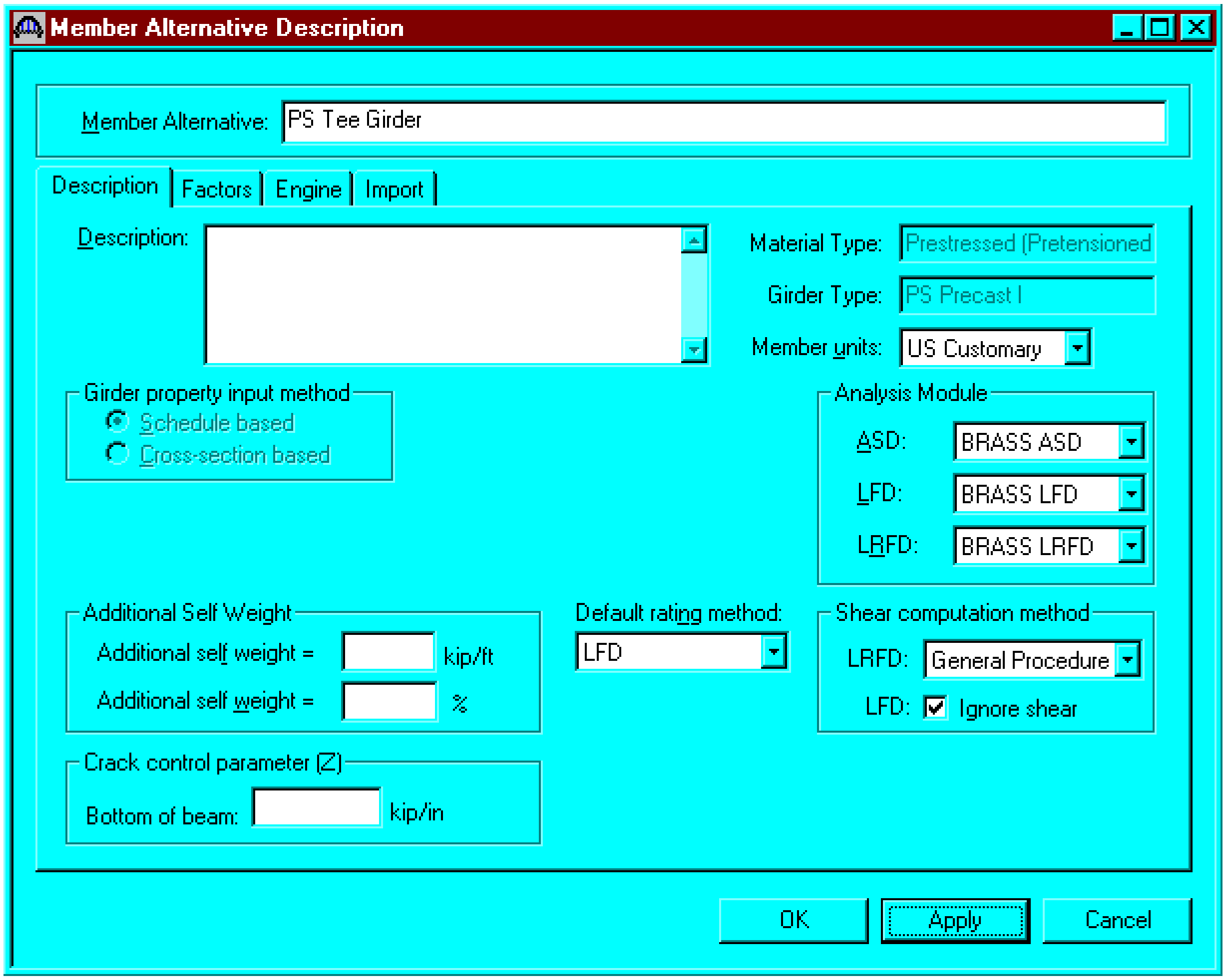


Defining a Member Alternative:
Double click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

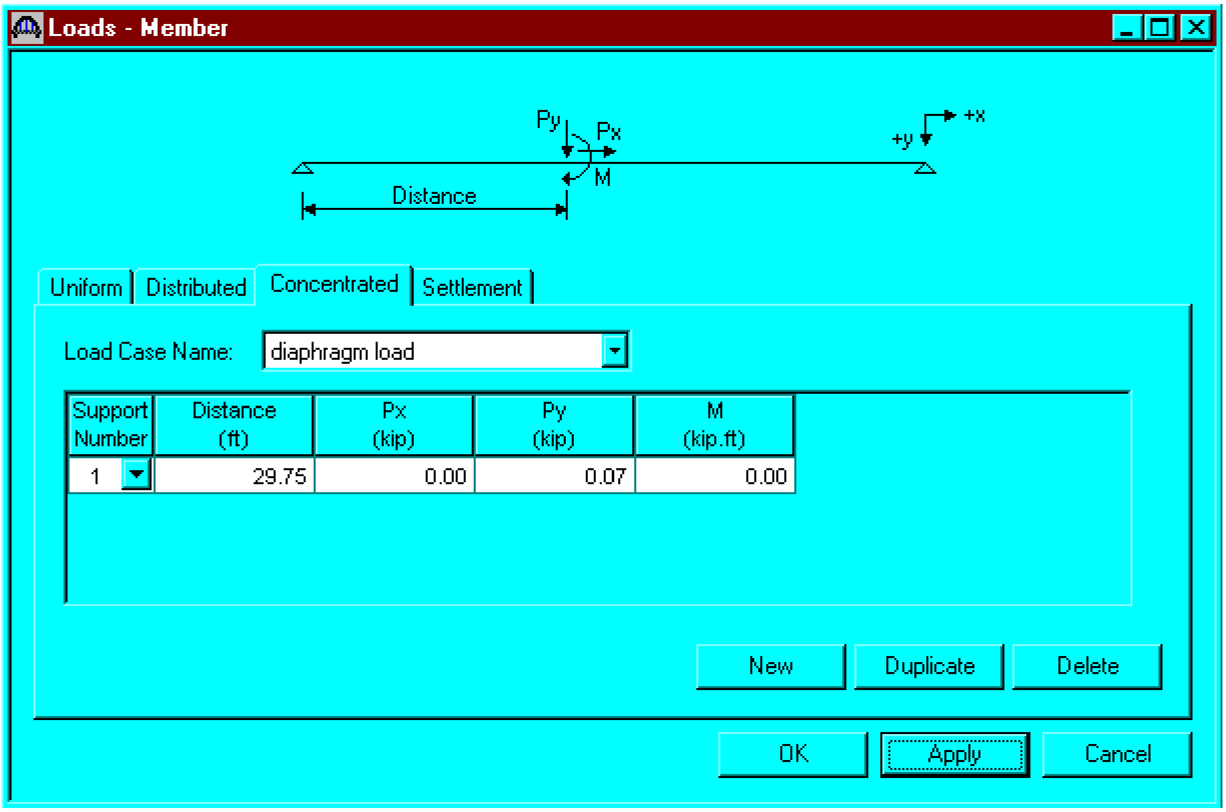


Click OK to close the dialog and create a new member alternative.

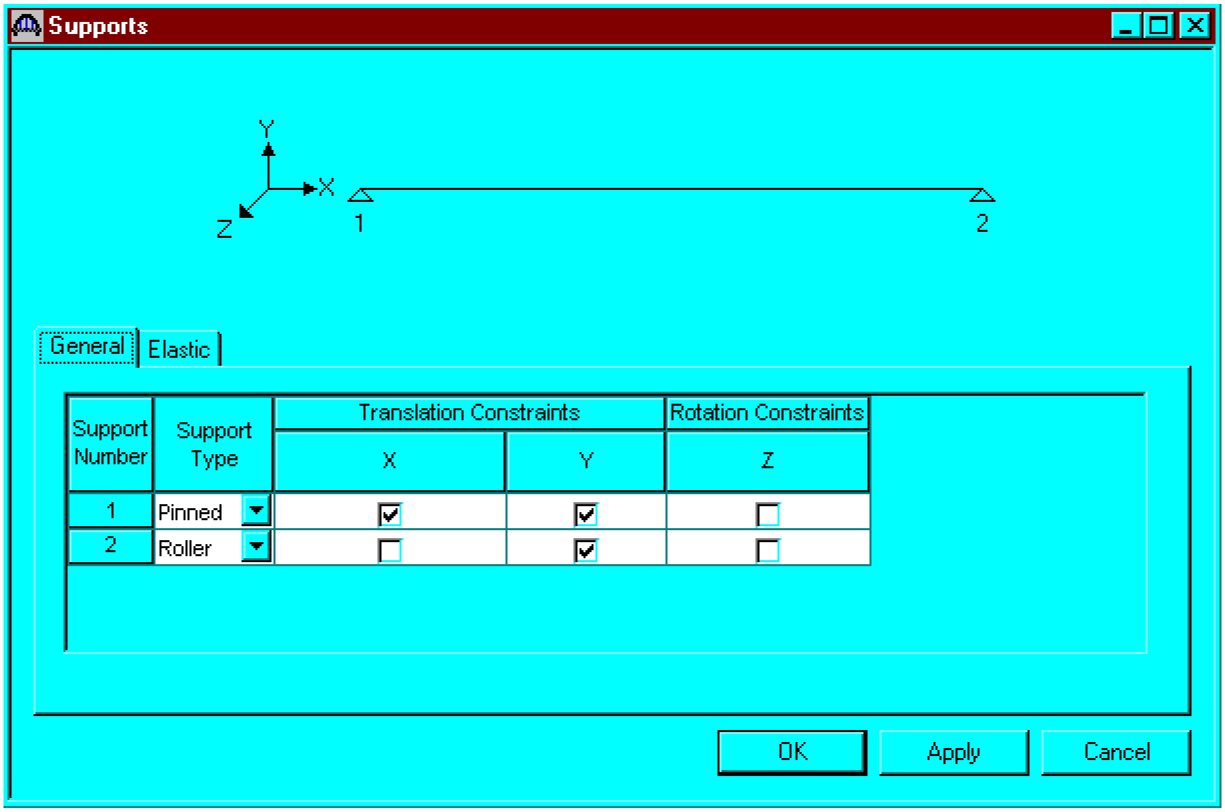
The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam.



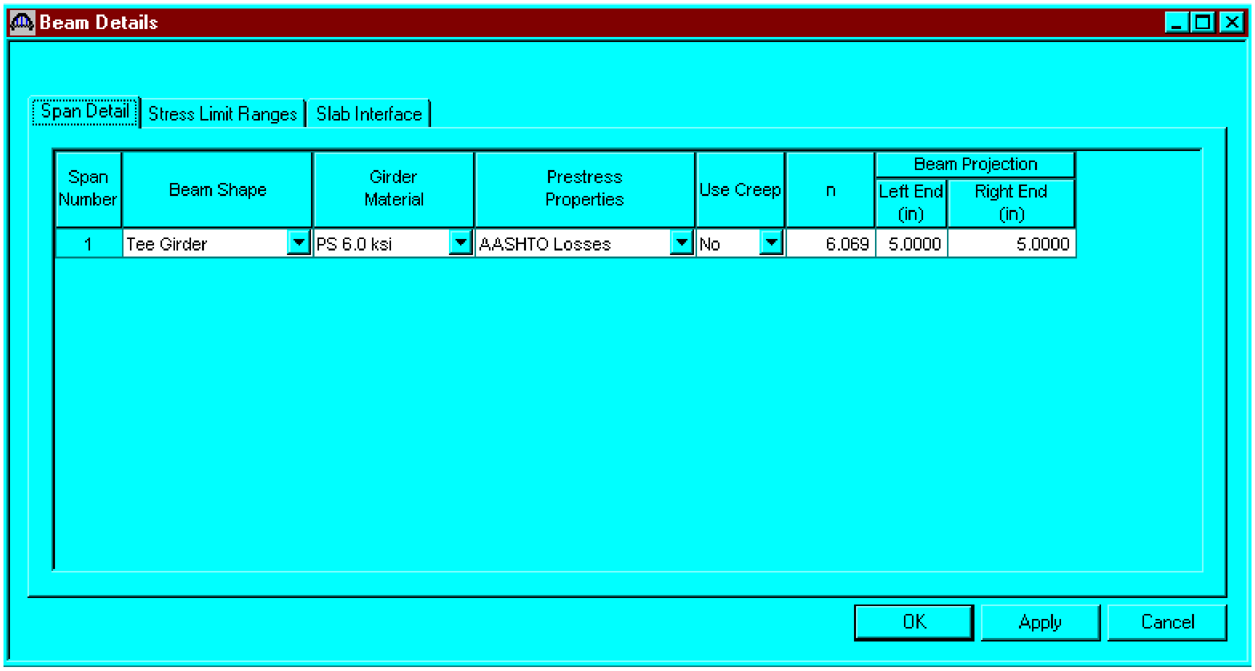
Double click on Member Loads to define other girder dead loads not calculated by the program automatically. Dead load due to intermediate diaphragm located at centerline of the girder is entered here.



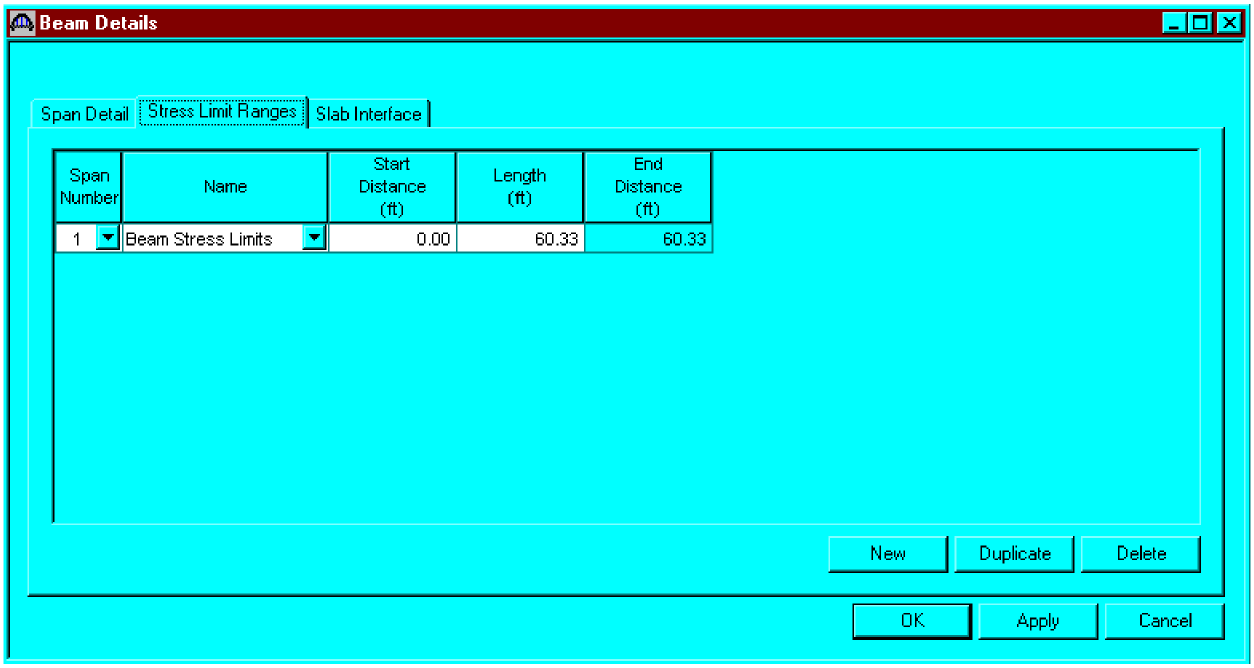
Double click on Supports to define support constraints for the girder. Enter the following support constraints. Click OK to save data to memory and close the window.



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



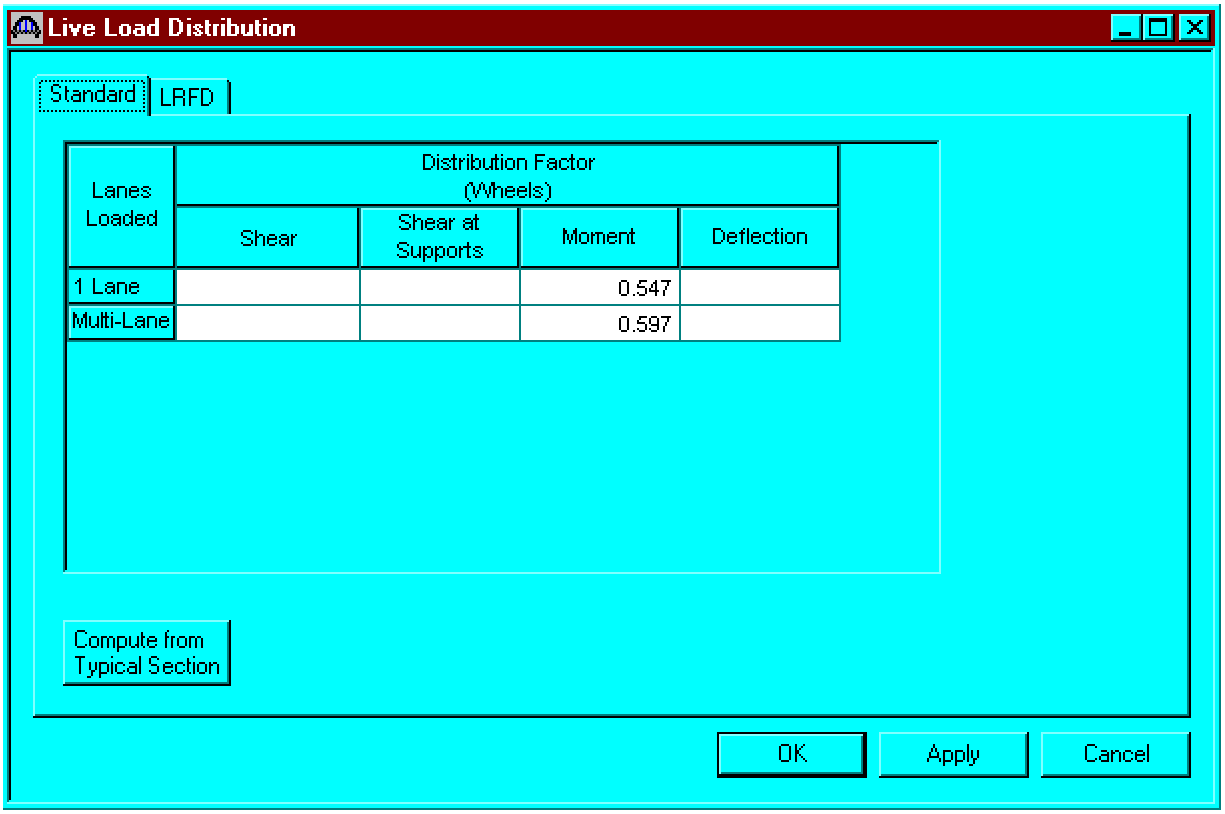
Note that the Stress Limit Ranges are defined over the entire length of the precast beam.



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

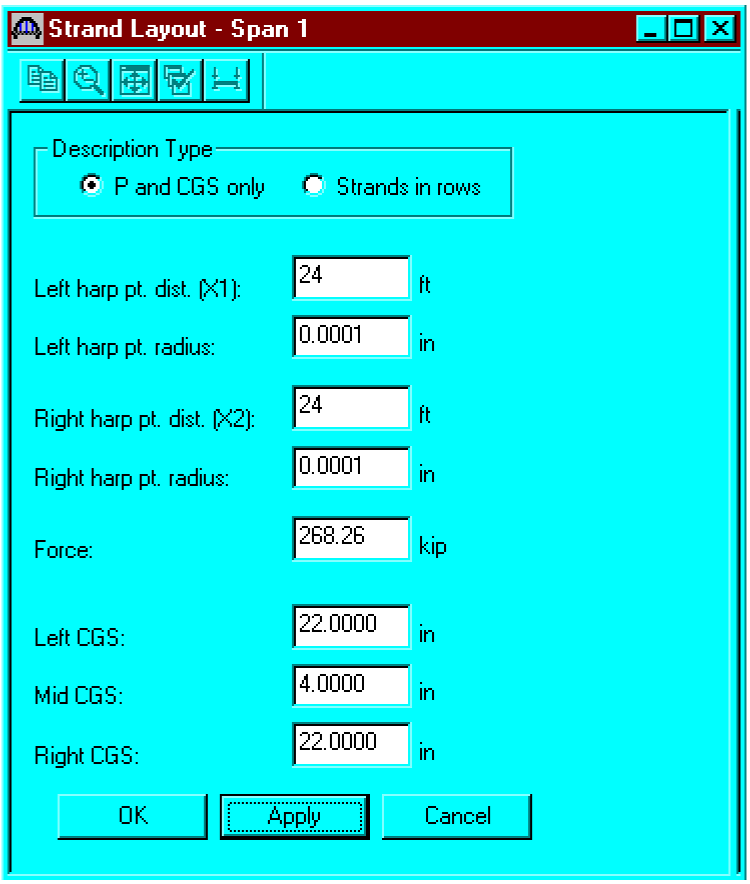
Click OK to save the Beam Details data to memory and close the window.

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



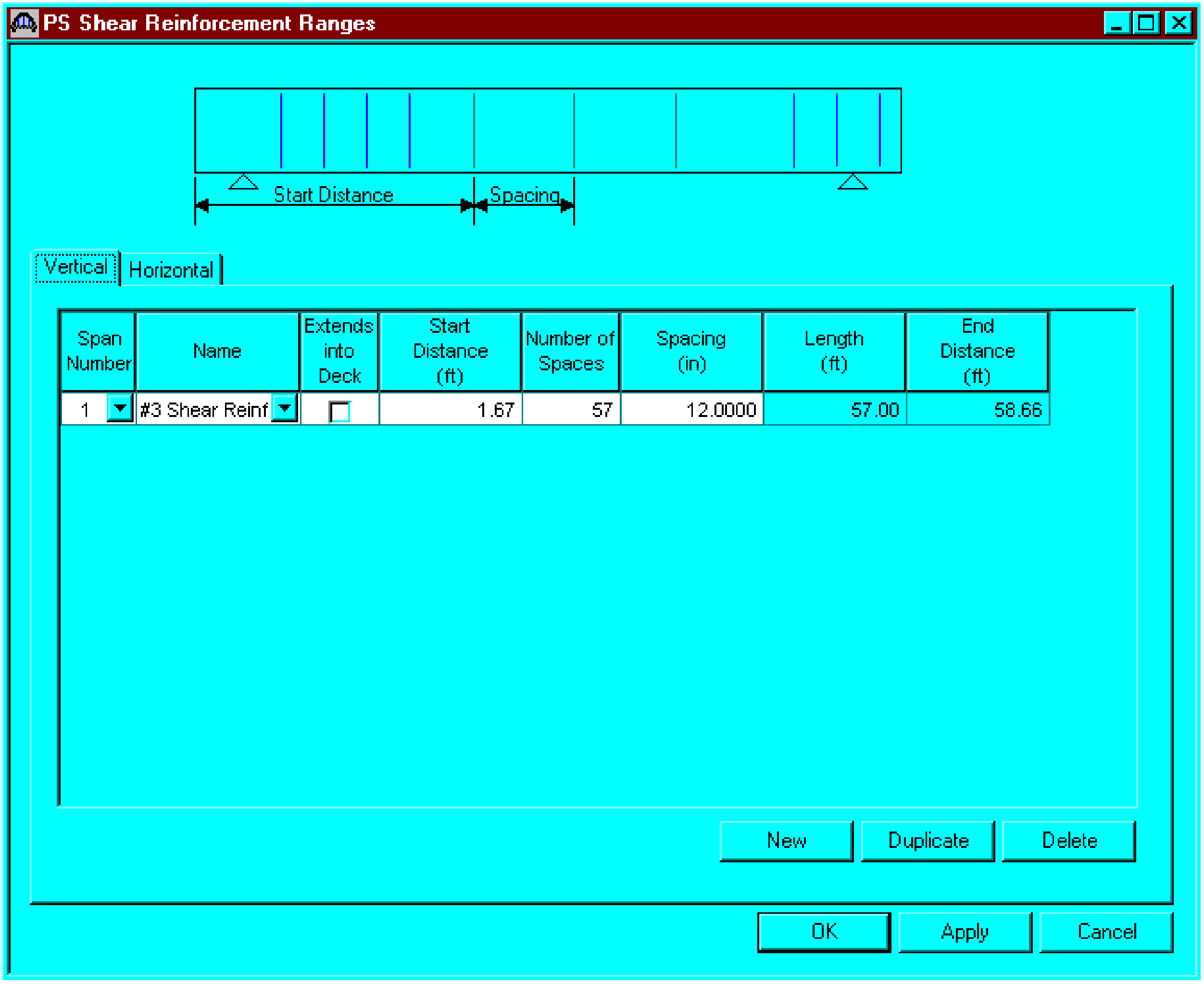
Note: The AASHTO live load distribution factor for concrete T-Girder used in the analysis.

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



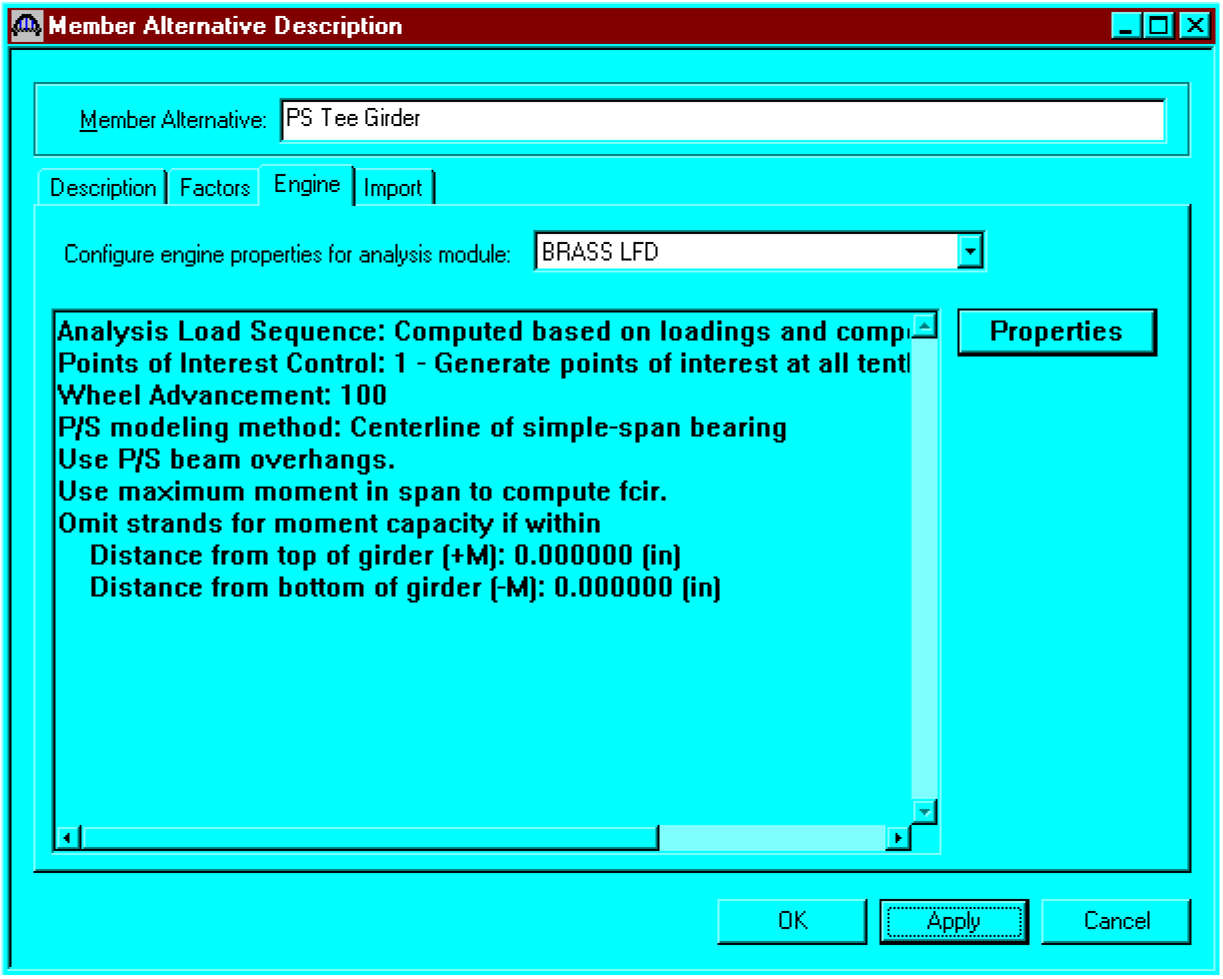
Since this structure does not have a cast in place deck, the Deck Profile and the Haunch Profile information is not required.

The Shear Reinforcement Ranges are entered as described below.



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

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



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

Analysis Results - PS Tee Girder

Report Type

Rating Results Summary

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

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

Close

Analysis Results - PS Tee Girder

Report Type

Rating Results Summary

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

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

Close

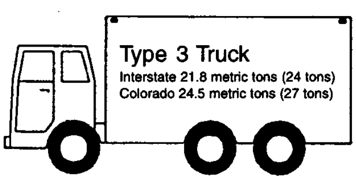
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

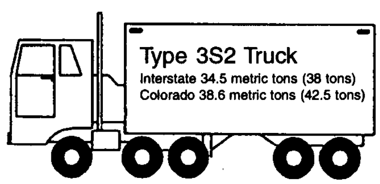
Structure #	L-26-BR
State highway #	50
Batch I.D.	
Structure type	CDTPG
Parallel structure #	

Rated using
Asphalt thickness: 51 mm (2 in.)
☒ Colorado legal loads
☐ Interstate legal loads

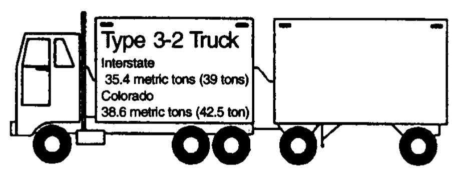
Structural member	INTERIOR GIRDER DBL-TEE			
	Metric tons (Tons)			
Inventory	26.4 (29)	( )	( )	( )
Operating	46.4 (51)	( )	( )	( )
Type 3 truck	( )	( )	( )	( )
Type 3S2 truck	( )	( )	( )	( )
Type 3-2 truck	( )	( )	( )	( )
Permit truck	78.2 (86)	( )	( )	( )



______ Metric tons (______ Tons)



______ Metric tons (______ Tons)



______ Metric tons (______ Tons)

Comments

Load Capacity: 51 Tons
Girder: Only Interior Girder Rated

Color Code: Orange

Project No: FC 050 - 5(16)

Rated by	Date	Checked by	Date

Previous editions are obsolete and may not be used