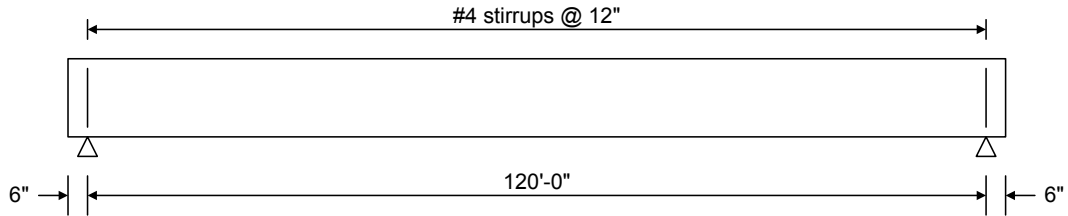
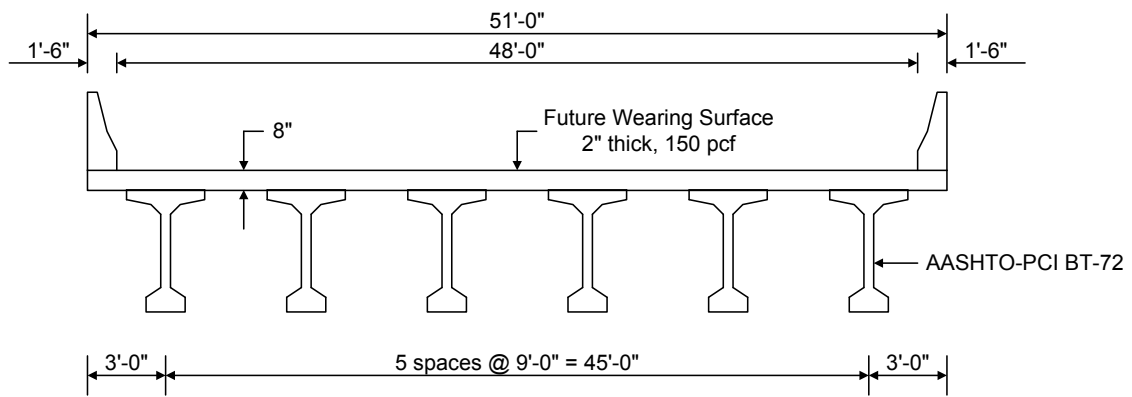


PS1 - Simple Span Prestressed I Beam Example



Elevation



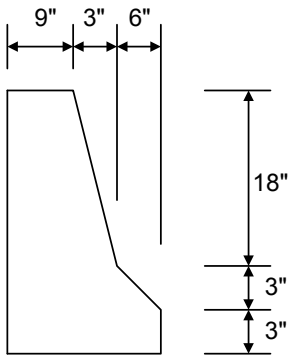
Typical Section

Material Properties

Beam Concrete: $f'c = 6.5$ ksi, $f'ci = 5.5$ ksi

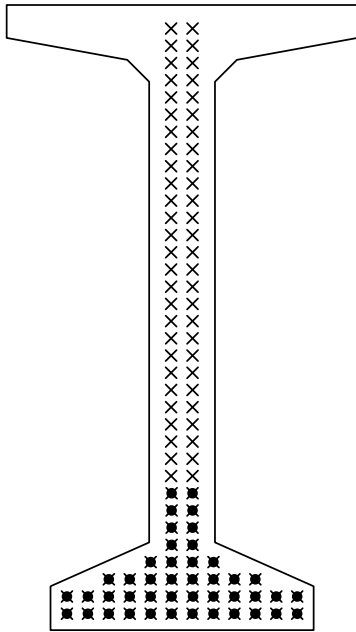
Deck Concrete: $f'c = 4.5$ ksi

Prestressing Strand: 1/2" dia., 7 Wire strand, $F_u = 270$ ksi, Low Relaxation

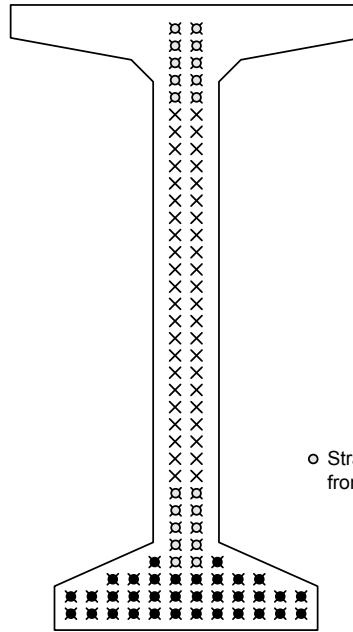


Weight = 300 plf

Parapet Detail



Strand Pattern at Mid-Span



o Strand harped at 48.5' from end of beam


Strand Pattern at End of Beam

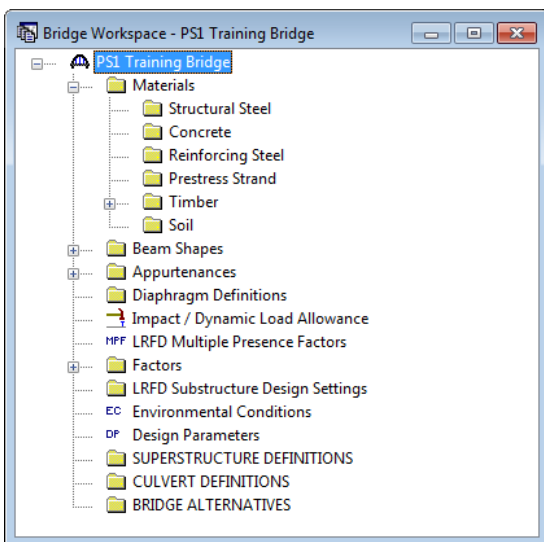
AASHTOWare Bridge Design and Rating Training

PS1 - Simple Span Prestressed I Beam Example (BrD/BrR 6.5)

From the Bridge Explorer create a new bridge and enter the following description data:

Close the window by clicking Ok. This saves the data to memory and closes the window.

To enter the materials to be used by members of the bridge, click on the Materials. The tree with the expanded Materials branch is shown  to expand the tree for below:

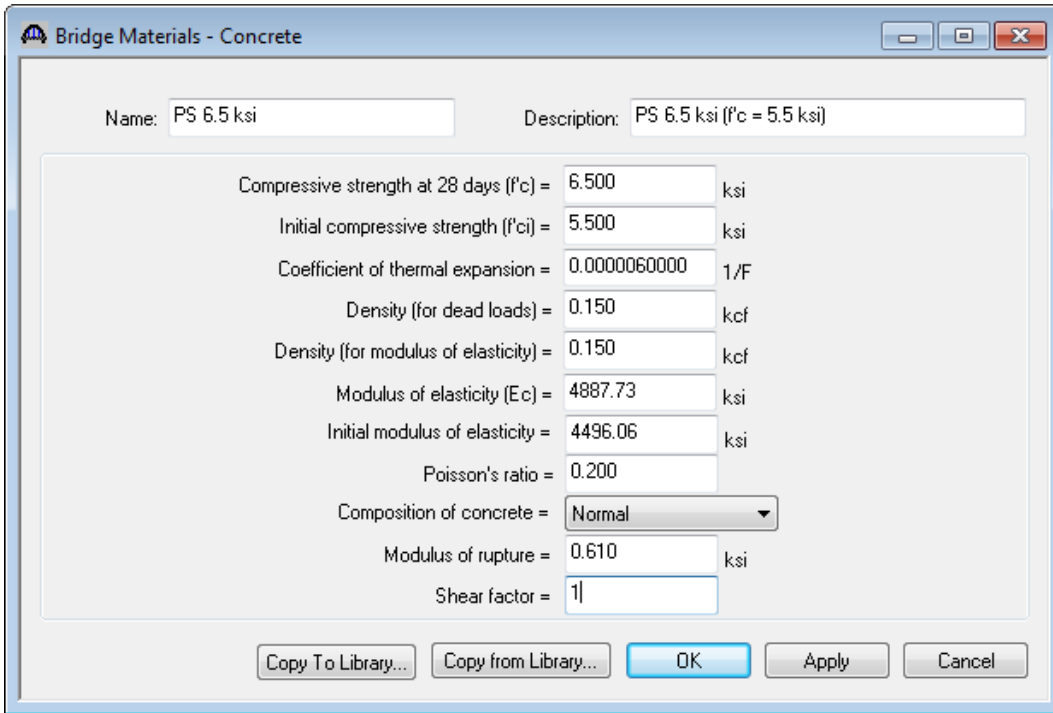


To add a new concrete material click on Concrete in the tree and select File/New from the menu (or right mouse click on Concrete and select New). The window shown below will open.

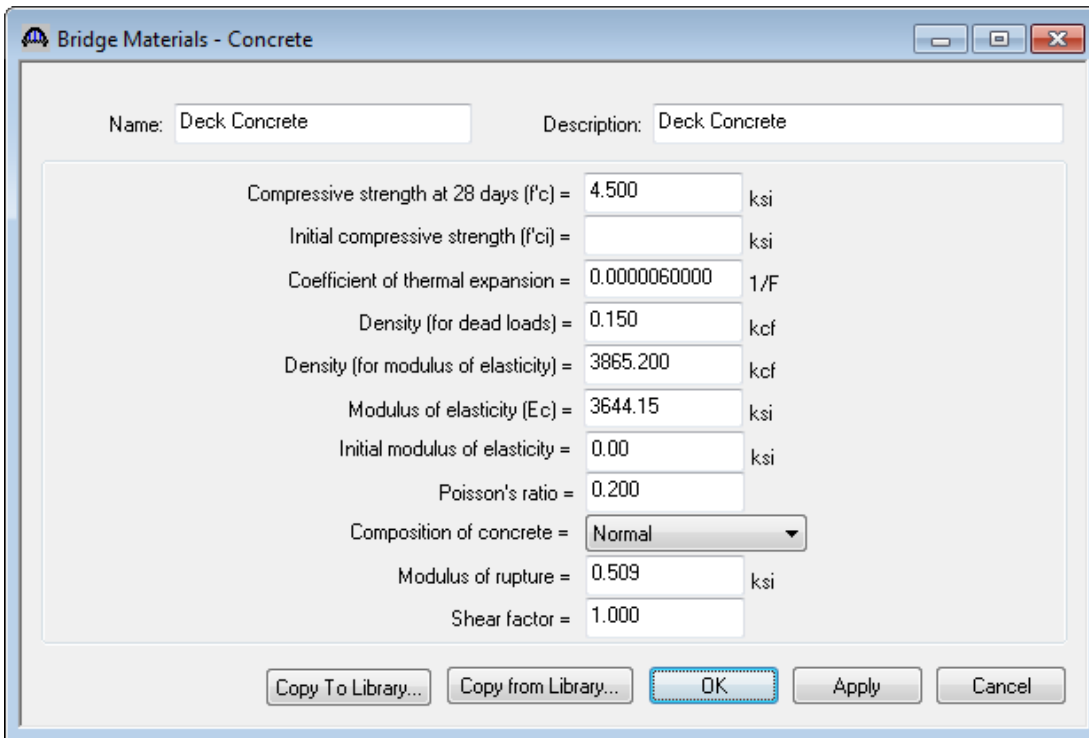
Add the concrete material “PS 6.5 ksi” that was entered into the Library in Exercise 3 by selecting from the Concrete Materials Library by clicking the Copy from Library button. This concrete will be used for the beam concrete in this example.

Name	Description	Library	Units	f _c	f _{ci}	alpha	DL Density	Modulus Density	Modulus of Elasticity	Poisson's Ratio	Modulus of Rupture
Class A	Class A cement concrete	Standard	SI / Me	28.00		0.000	2400.0	2320.00	25426.08	0.200	3.33
Class A (US)	Class A cement concrete	Standard	US Cu	4.000		0.000	0.150	0.145	3644.15	0.200	0.480
Class B	Class B cement concrete	Standard	SI / Me	17.00		0.000	2400.0	2320.00	19811.84	0.200	2.60
Class B (US)	Class B cement concrete	Standard	US Cu	2.400		0.000	0.150	0.145	2822.75	0.200	0.372
Class C	Class C cement concrete	Standard	SI / Me	28.00		0.000	2400.0	2320.00	25426.08	0.200	3.33
Class C (US)	Class C cement concrete	Standard	US Cu	4.000		0.000	0.150	0.145	3644.15	0.200	0.480
PS 6.5 ksi	PS 6.5 ksi (f_c = 5.5 ksi)	Agency	US Cu	6.500	5.500	0.000	0.150	0.150	4887.73	0.200	0.610

Select the PS 6.5 ksi material and click Ok. The selected material properties are copied to the Bridge Materials – Concrete window as shown below.



Click Ok to save the data to memory and close the window. Add a concrete material for the deck, reinforcement material and prestress strand using the same techniques. The windows will look like those shown below:



Bridge Materials - Reinforcing Steel

Name: Description:

Material Properties

Specified yield strength (Fy) = ksi

Modulus of elasticity (Es) = ksi

Ultimate strength (Fu) = ksi

Type

Plain
 Epoxy
 Galvanized
 Other

Bridge Materials - PS Strand

Name: Description:

Strand diameter = in

Strand area = in²

Strand type =

Ultimate tensile strength (Fu) = ksi

Yield strength (Fy) = ksi

Modulus of elasticity (E) = ksi

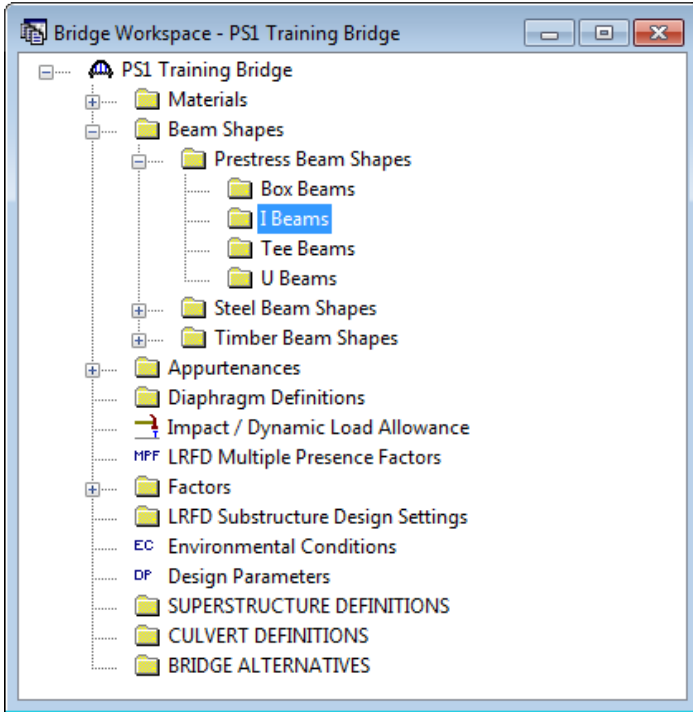
Transfer length (Std) = in

Transfer length (LRFD) = in

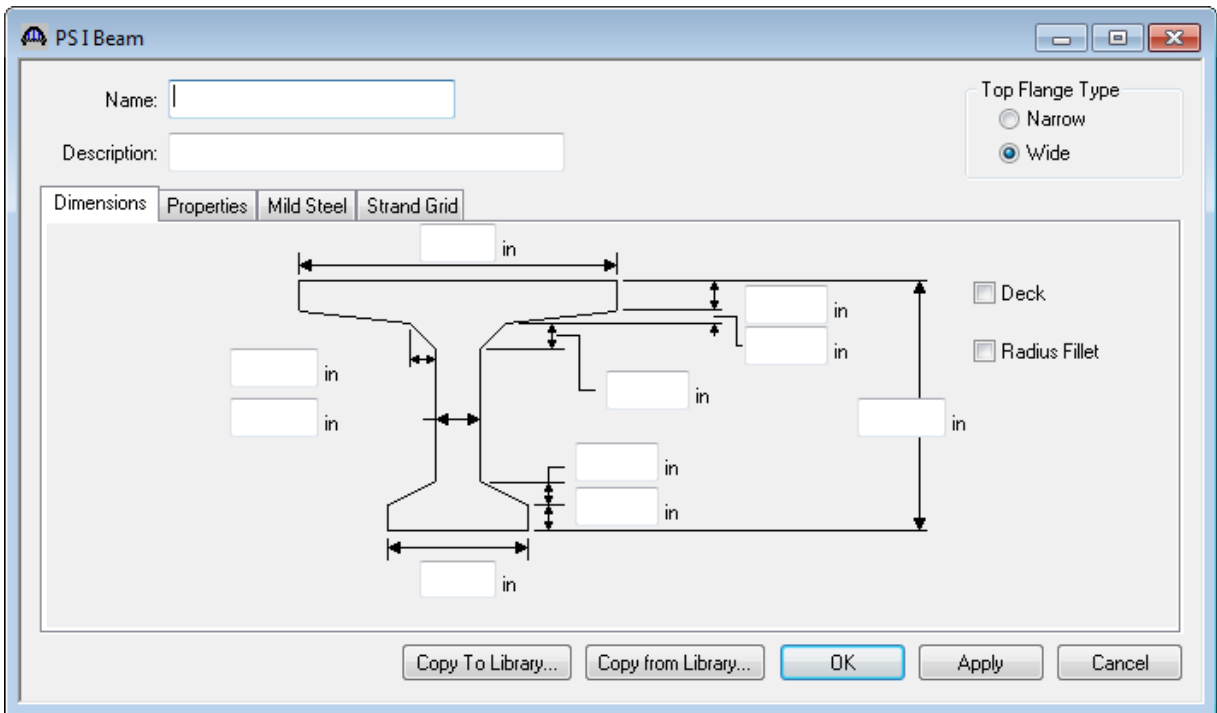
Unit load per length = lb/ft

Epoxy coated

To enter a prestress beam shape to be used in this bridge expand the tree labeled Beam Shapes as shown below:

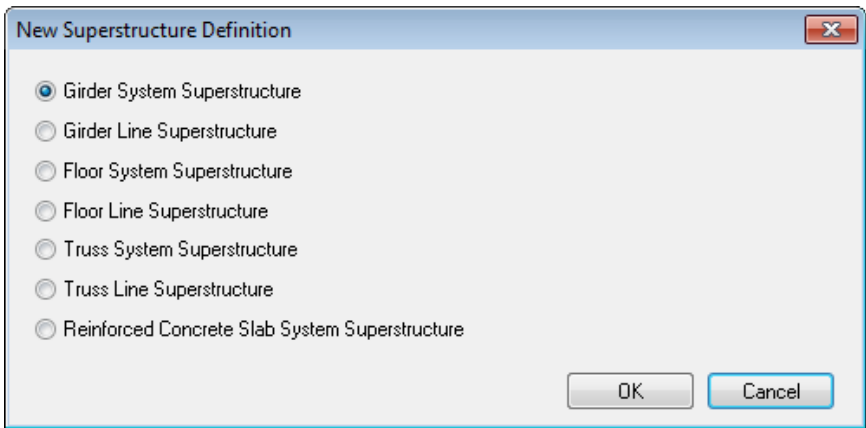


Click on I Beams in the tree and select File/New from the menu (or double click on I Beams in the tree). The window shown below will open.

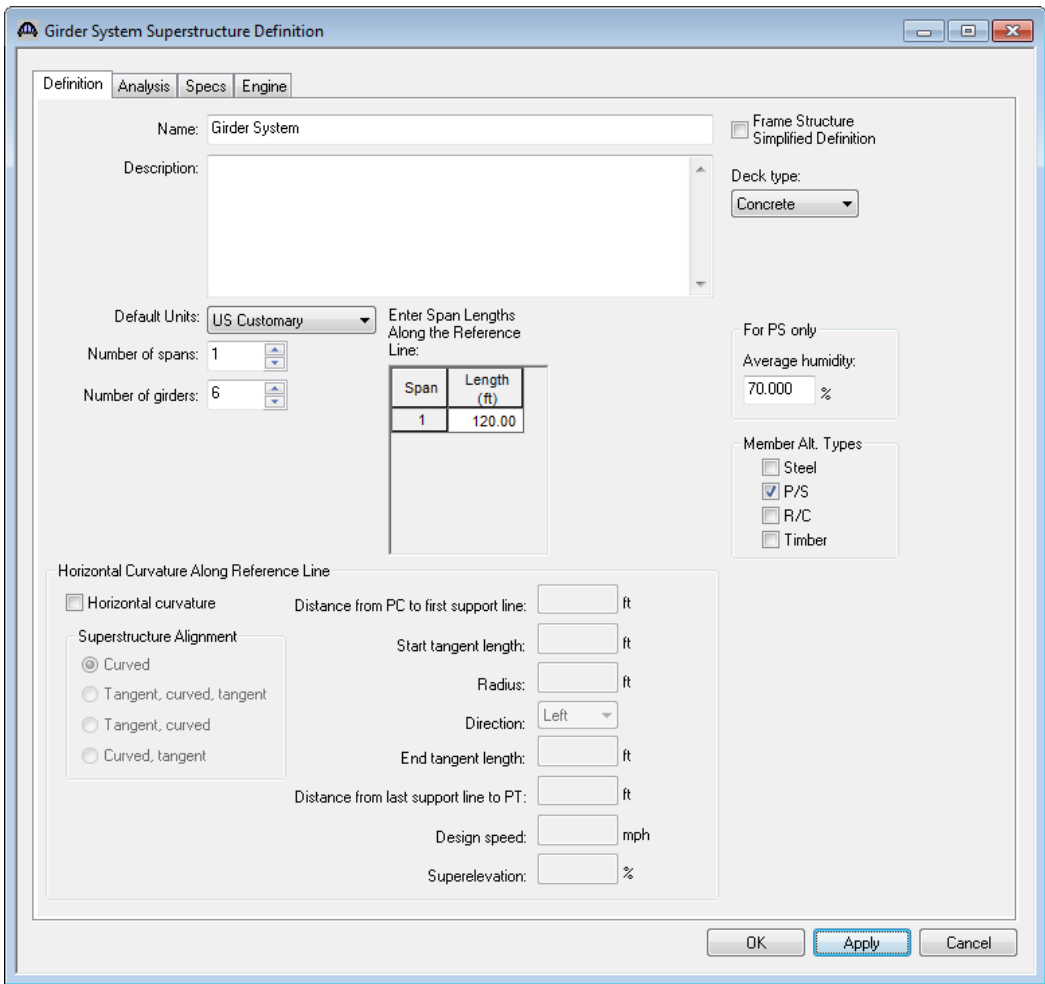


Select the Top Flange Type as Wide and click on the copy from Library button. Select BT-72 (AASHTO-PCI Bulb-Tee BT-72) and click Ok. The beam properties are copied to the I Beam window as shown below.

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

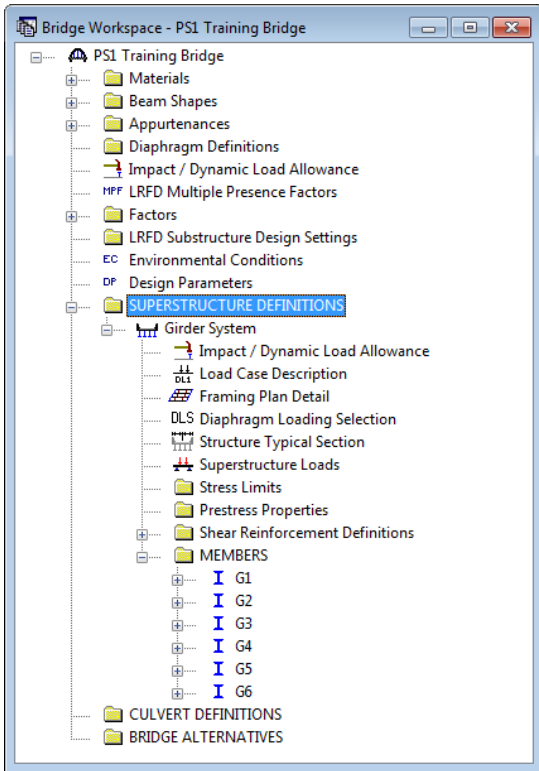


Select Girder System and the Structure Definition window will open. Enter the appropriate data as shown below:



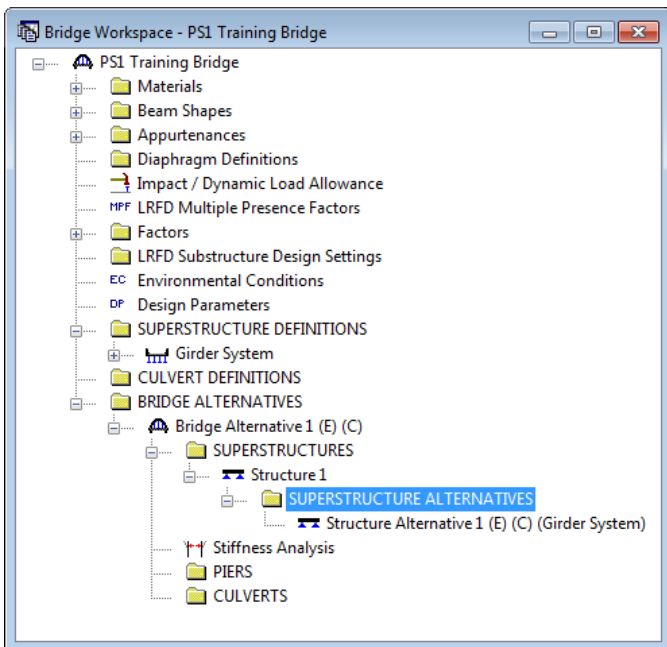
Click on Ok to save the data to memory and close the window.

The partially expanded Bridge Workspace tree is shown below:

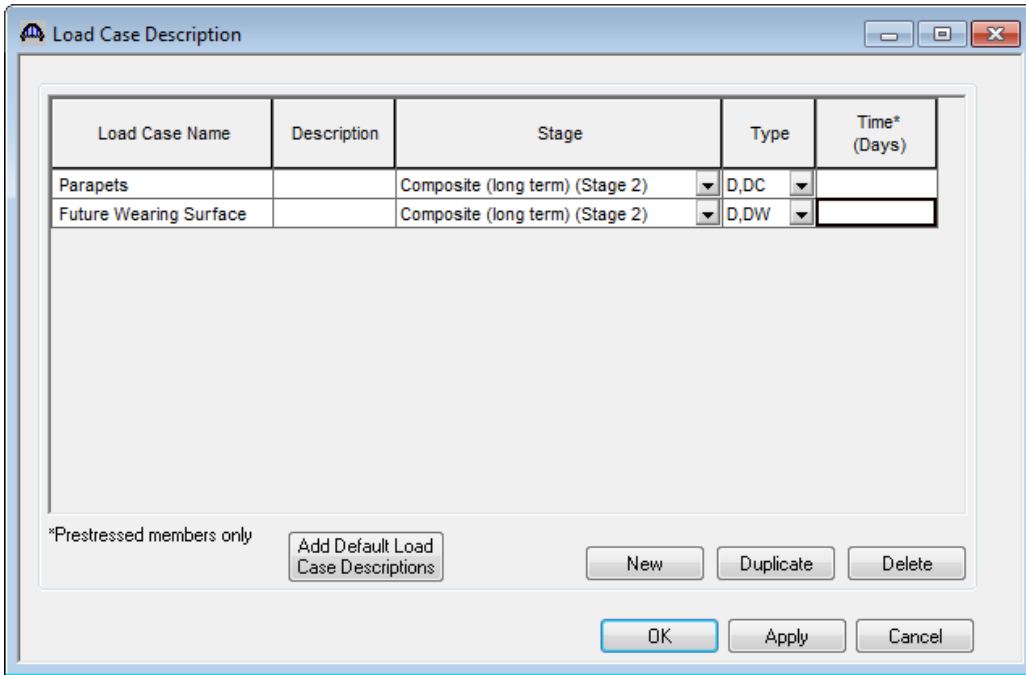


We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative as we did in Example 4a.

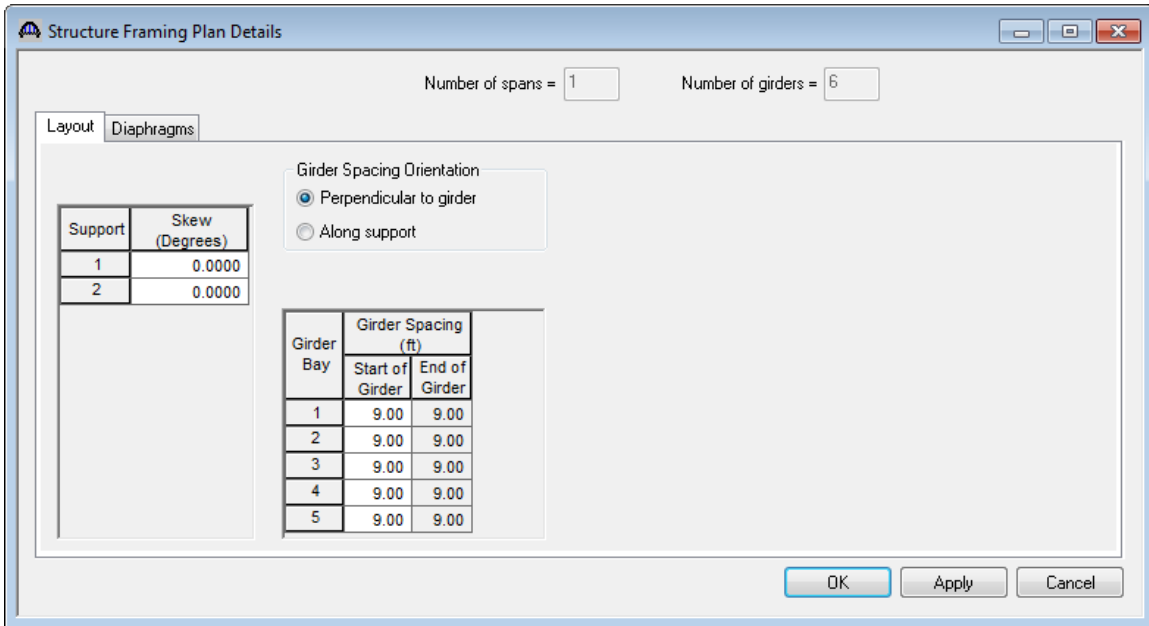
The partially expanded Bridge Workspace tree is shown below:



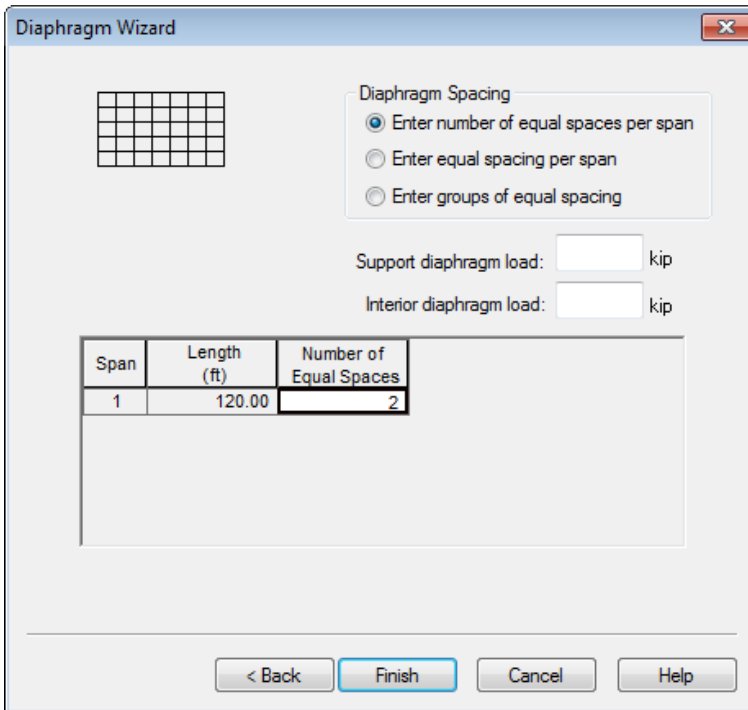
Click Load Case Description to define the dead load cases. The completed Load Case Description window is shown below.



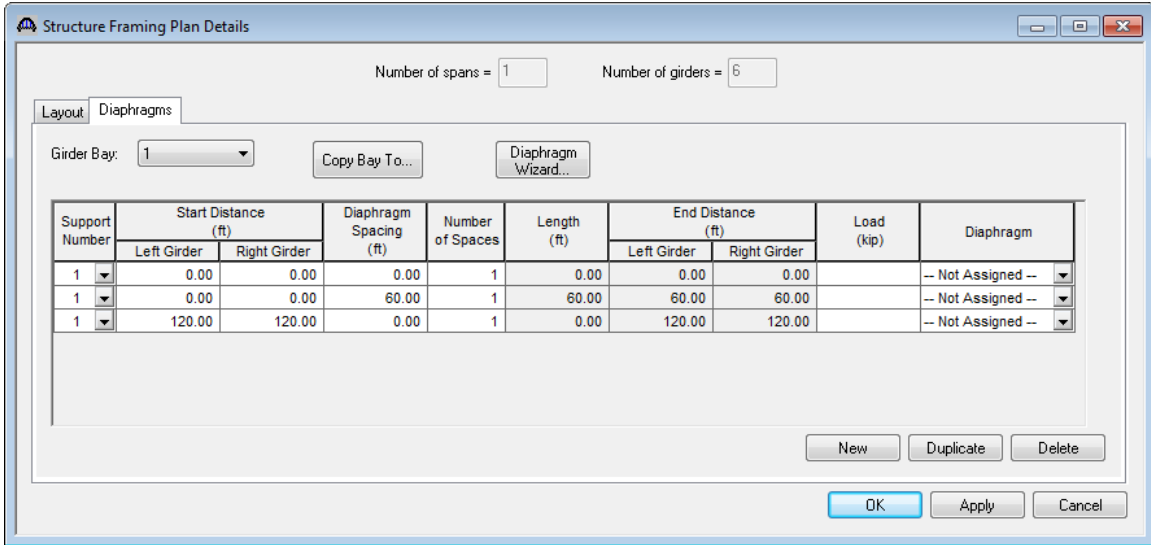
Double-click on Framing Plan Detail to describe the framing plan. Enter the appropriate data as shown below.



Switch to the Diaphragms tab to enter diaphragm spacing. Click the Diaphragm Wizard button to add diaphragms for the entire structure. Select the Framing Plan System and Click the Next button. Enter the following data on the dialog shown below.



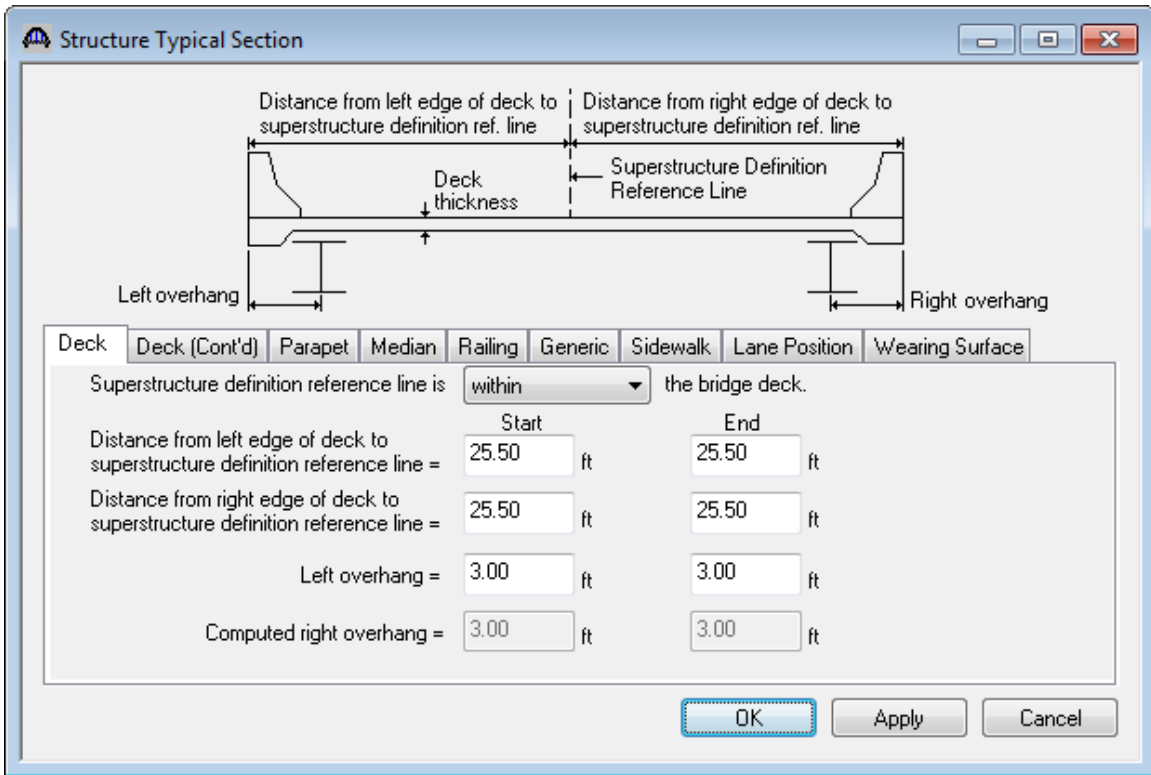
Click the Finish button to add the diaphragms. The Diaphragm Wizard will create diaphragms for all of the girder bays in the structure. The diaphragms created for Girder Bay 1 are shown below:



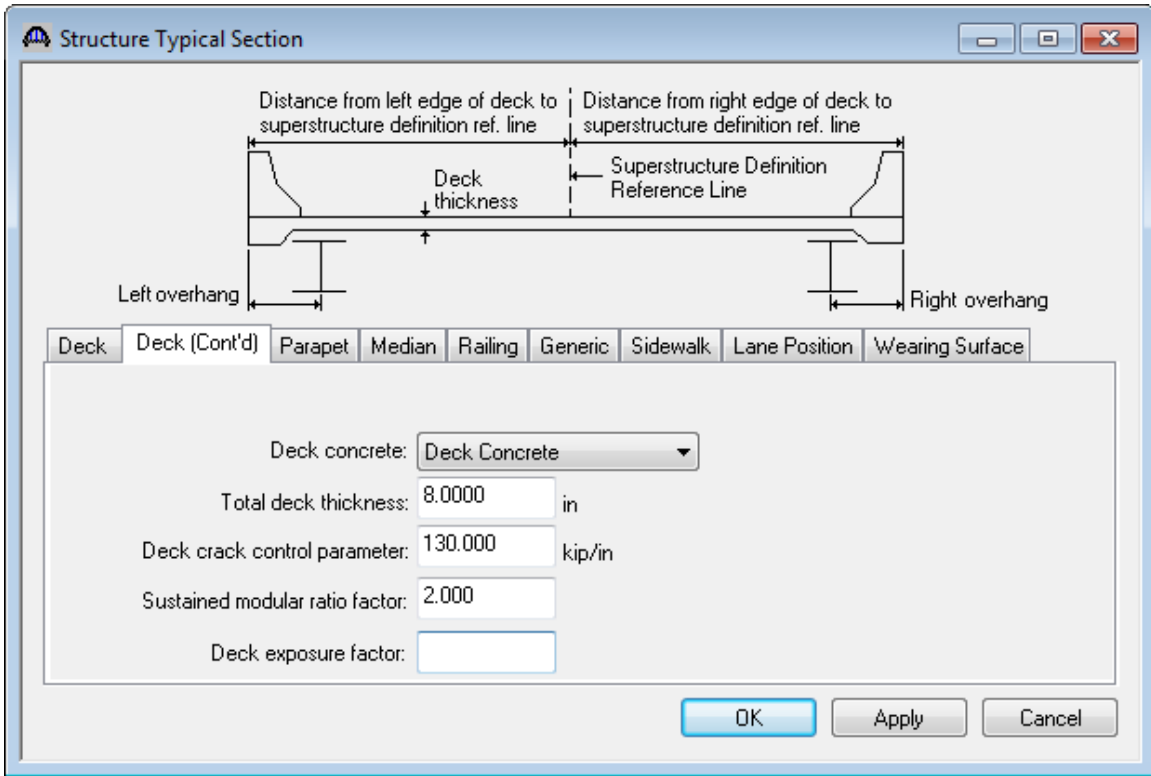
Select Ok to close the window.

Next define the structure typical section by double-clicking on Structure Typical Section in the Bridge Workspace tree. Input the data describing the typical section as shown below.

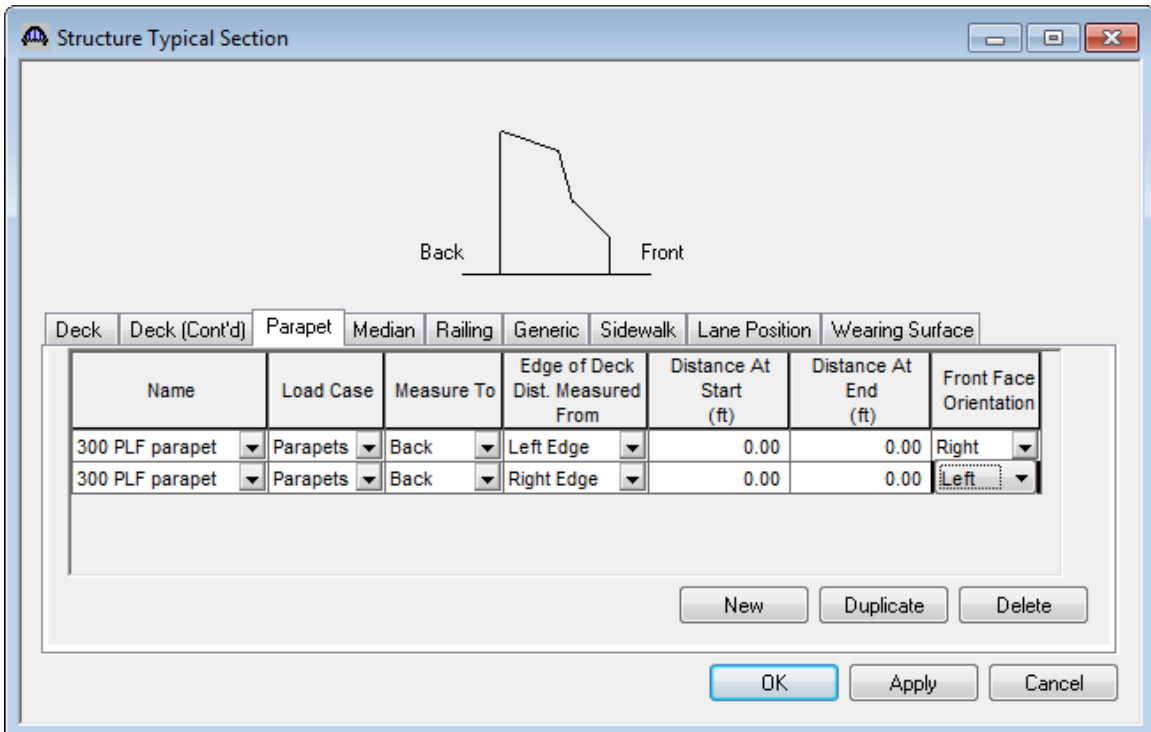
Basic deck geometry:



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 above.

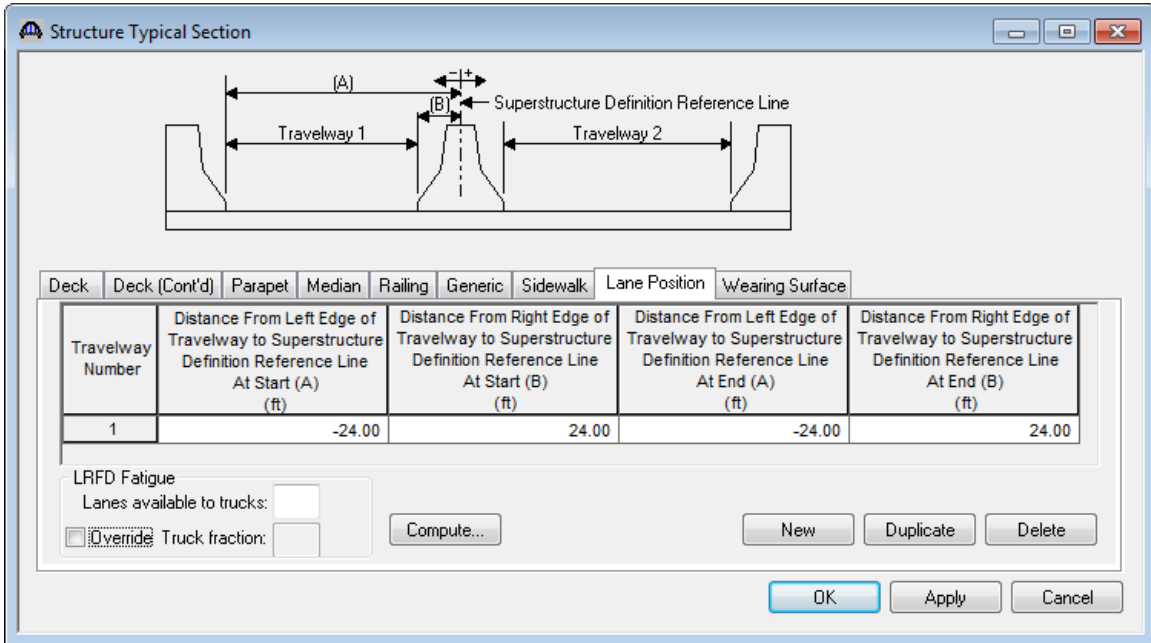


Parapets:
Add two parapets as shown below.



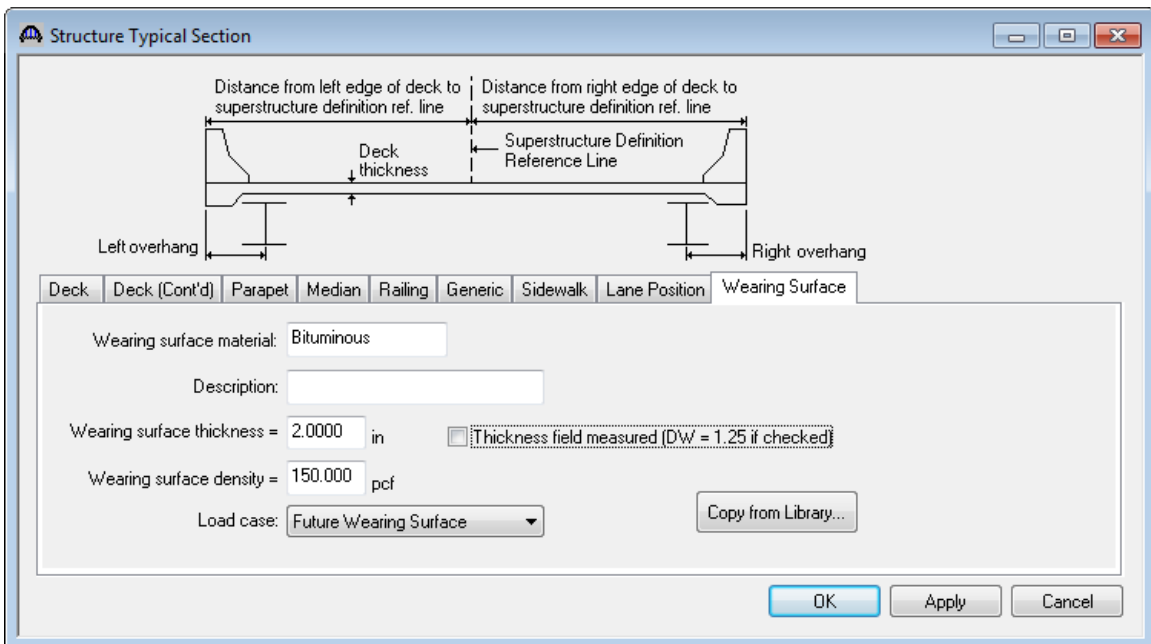
Lane Positions:

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.



Wearing Surface:

Enter the data shown below.



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

Now define a Stress Limit. 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 6.5 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.

Stress Limit Sets - Concrete

Name: 6.5 ksi Concrete Stress Limit

Description: Stress limit for 6.5 ksi concrete used in beam

Concrete Material: PS 6.5 ksi

	LFD	LRFD
Initial allowable compression:	3.300 ksi	3.300 ksi
Initial allowable tension:	0.200 ksi	0.200 ksi
Final allowable compression:	3.900 ksi	3.900 ksi
Final allowable tension:	0.484 ksi	0.484 ksi
Final allowable DL compression:	2.600 ksi	2.925 ksi
Final allowable slab compression:	2.700 ksi	2.700 ksi
Final allowable compression: (LL + 1/2(Pe + DL))	2.600 ksi	2.600 ksi

Buttons: OK, Apply, Cancel

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

Prestress Properties

Name: 1/2" LR AASHTO Loss

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

P/S strand material: 1/2" (7W-270) LR

Loss method: AASHTO Approximate

Jacking stress ratio: 0.750

P/S transfer stress ratio: []

Transfer time: 24.0 Hours

Age at deck placement: 30.00 Days

Final age: 1825.00 Days

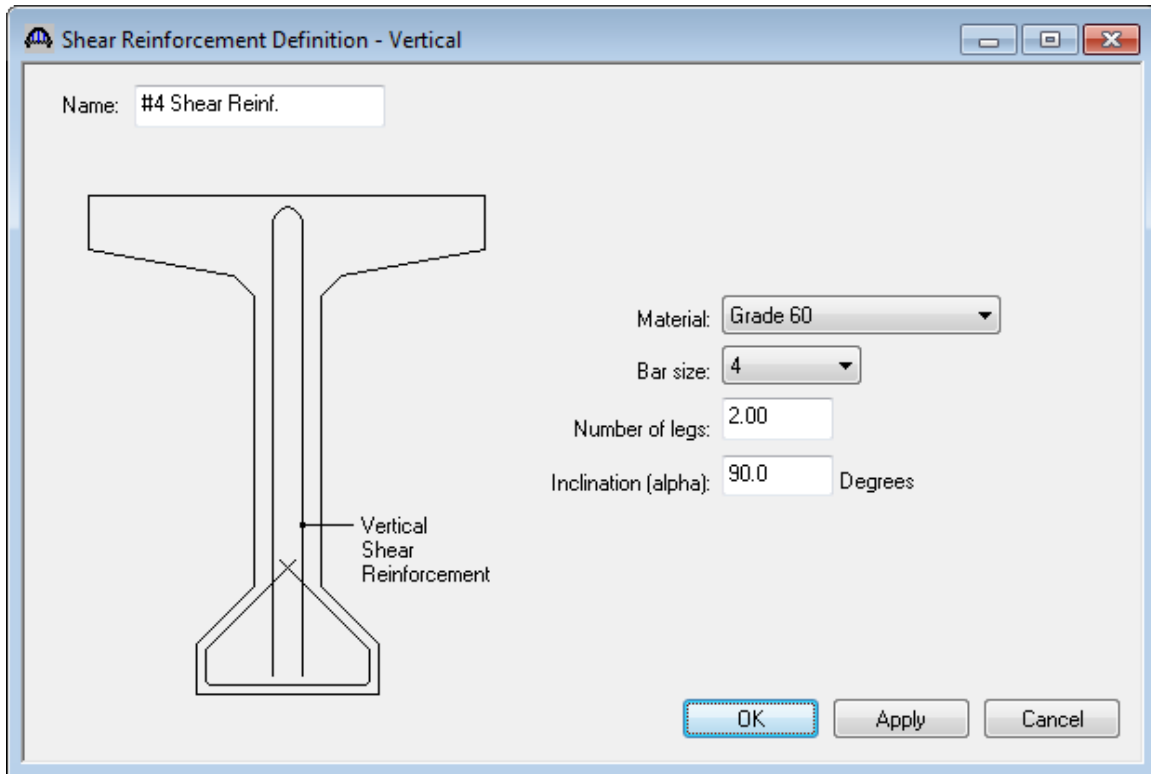
Loss Data - AASHTO

Percentage DL: 0.0 %

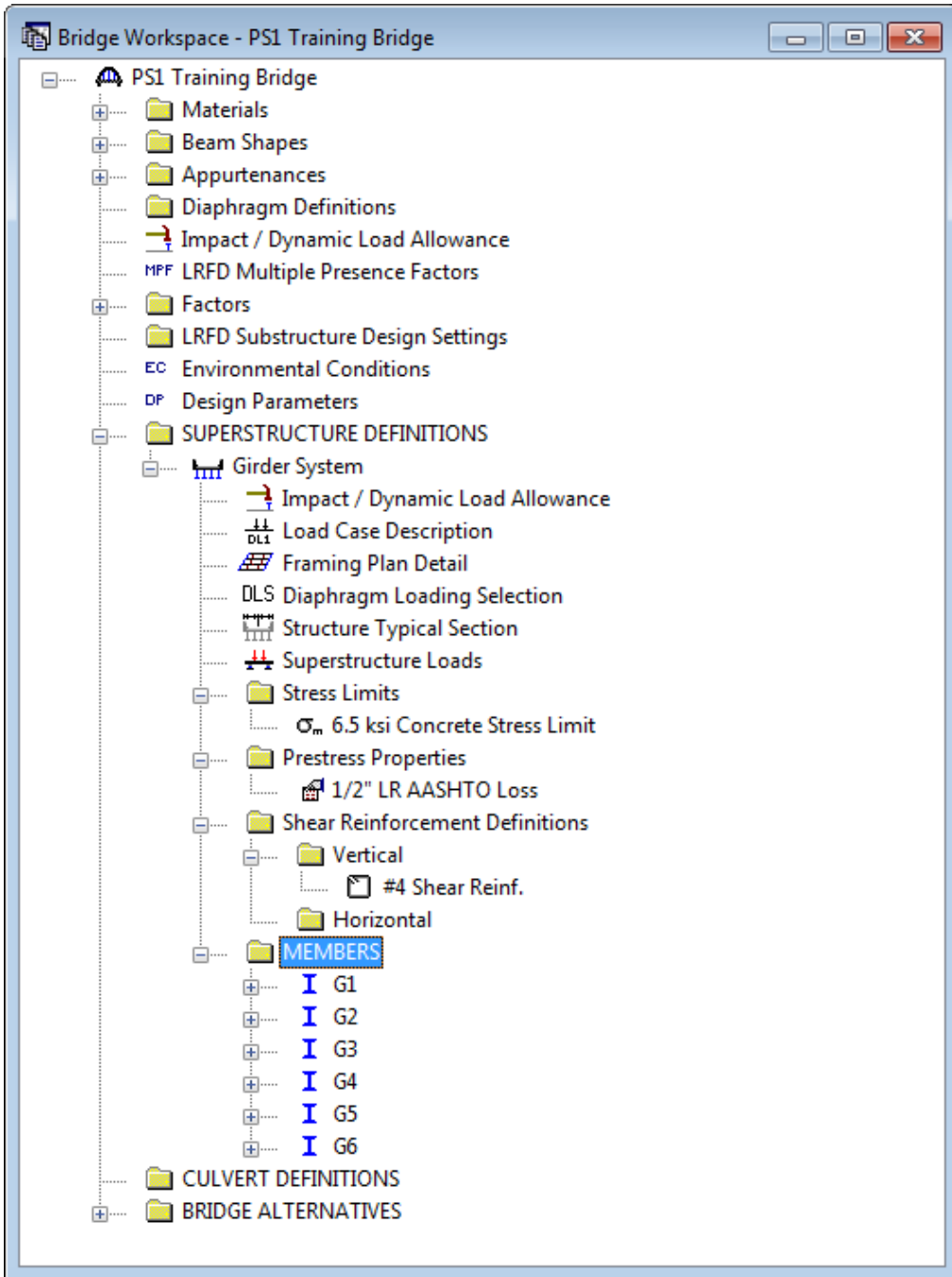
Include elastic gains

OK Apply Cancel

Now define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definitions in the tree). Define the reinforcement as shown below. Click Ok to save to memory and close the window.

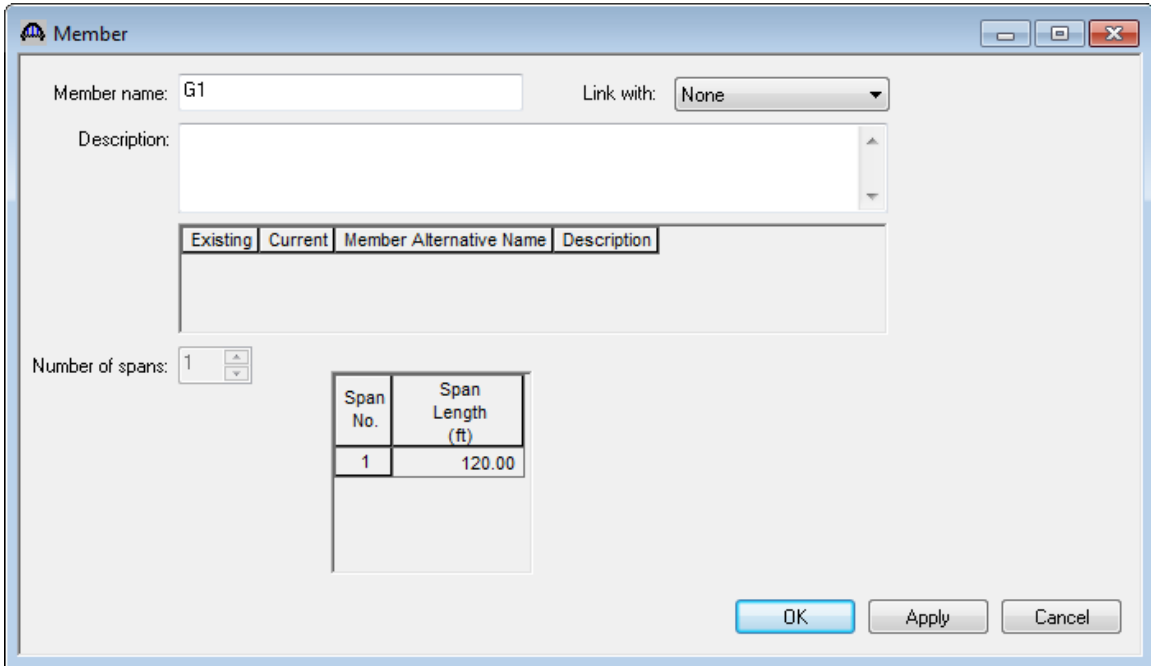


A partially expanded Bridge Workspace is shown below.



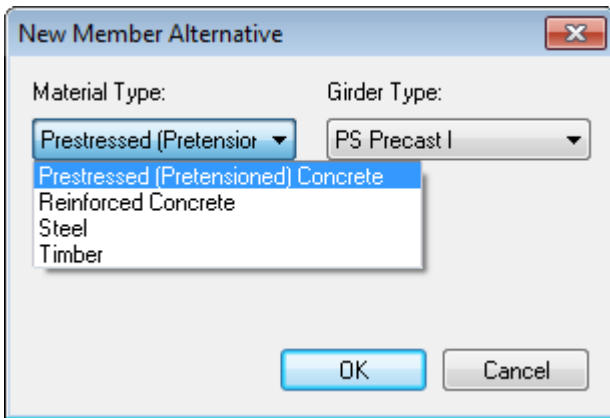
Describing a member:

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.

Member Alternative:

Description | Specs | Factors | Engine | Import | Control Options

Description:

Material Type:

Girder Type:

Default Units:

Girder property input method

Schedule based

Cross-section based

Default rating method:

Additional Self Load

Additional self load = kip/ft

Additional self load = %

Crack control parameter (Z)

Top of beam: kip/in

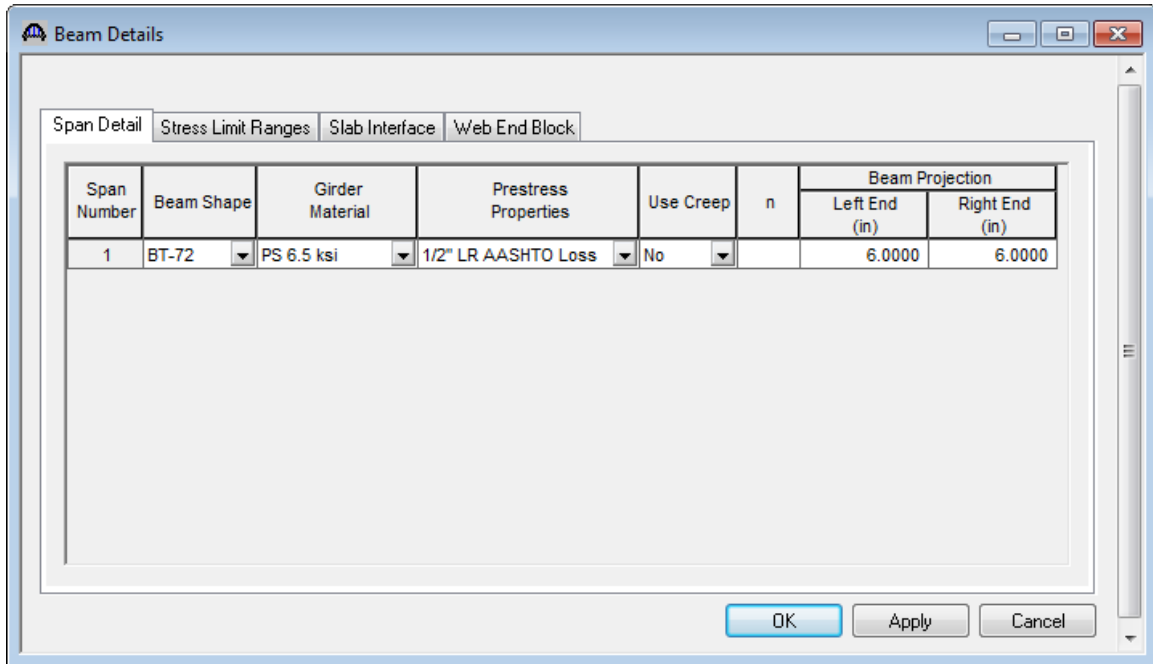
Bottom of beam: kip/in

Exposure factor

Top of beam:

Bottom of beam:

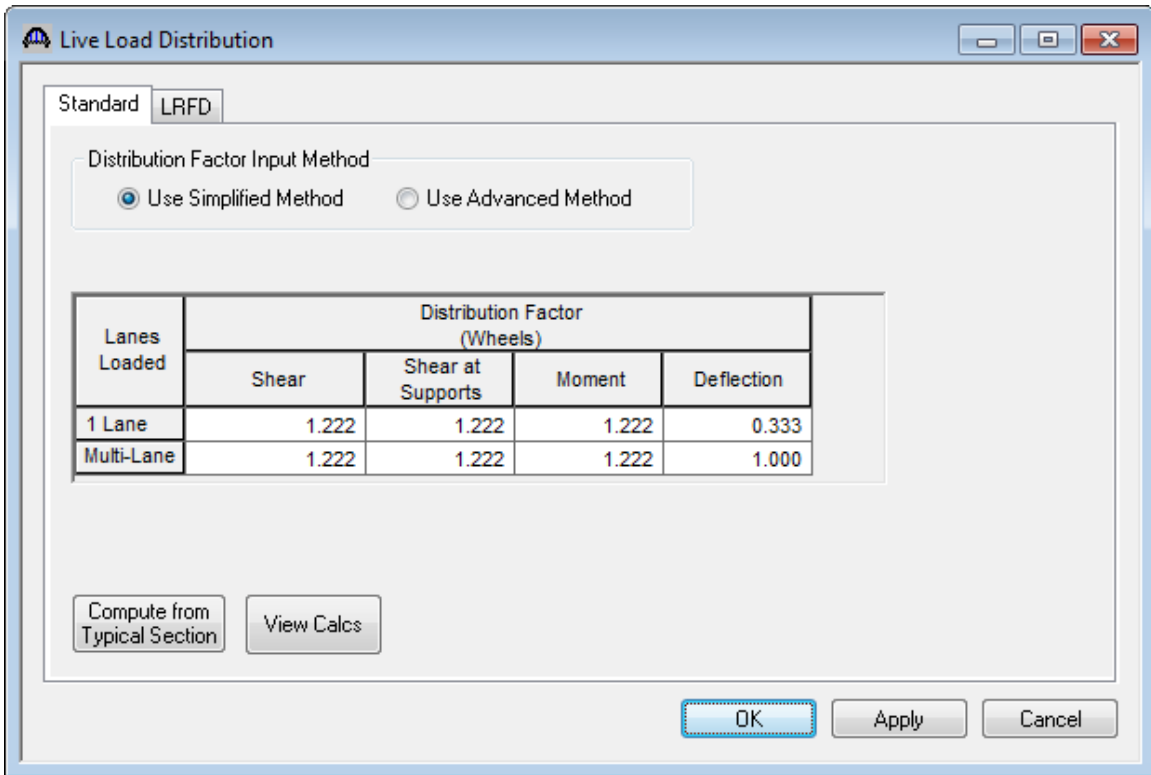
Next describe the beam by double clicking on Beam Details in the tree. The Beam Details windows with the appropriate data are shown below.



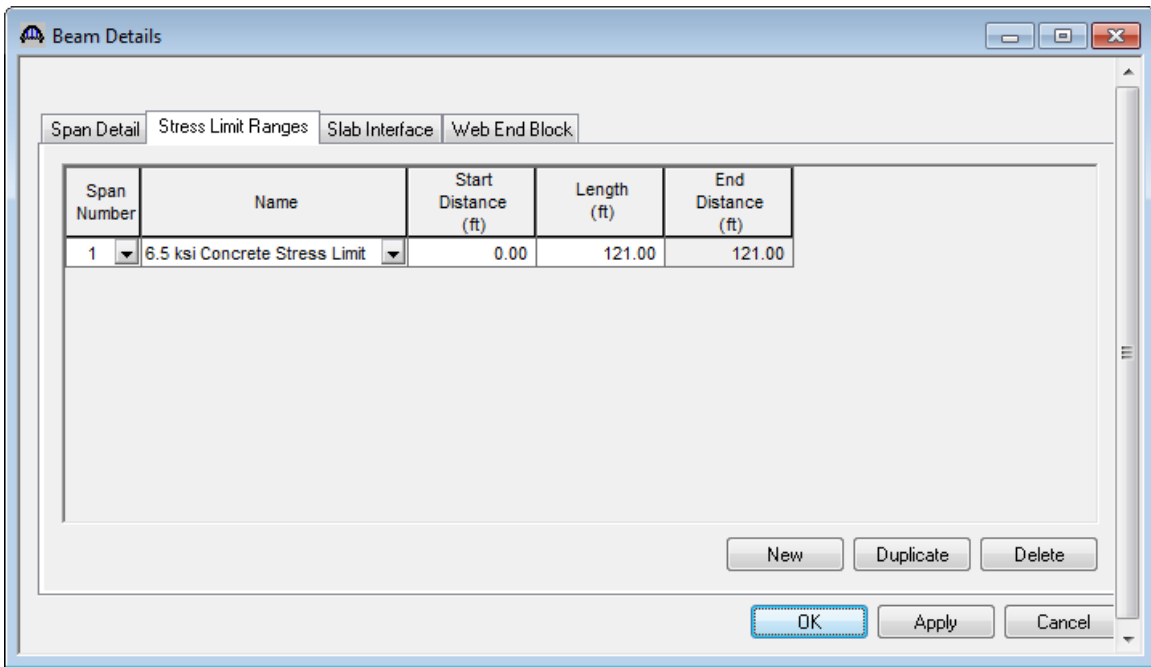
If we try to use the Compute from Typical Section button on the Live Load Distribution – Standard tab to populate the LFD live load distribution factors for this member alternative, we will receive a message that AASHTOWare Bridge Design and Rating cannot calculate the distribution factors because beam shapes are not assigned to adjacent member alternatives. This is due to the fact that AASHTOWare Bridge Design and Rating does not yet know if we have adjacent box beams or spread box beams.

AASHTOWare Bridge Design and Rating uses the beam shape assigned to this member alternative and also the beam shapes assigned to the adjacent member alternatives to determine if we have adjacent or spread box beams. Since we do not have any member alternatives for the adjacent members defined yet in this training example, we will enter the following distribution factors by hand.

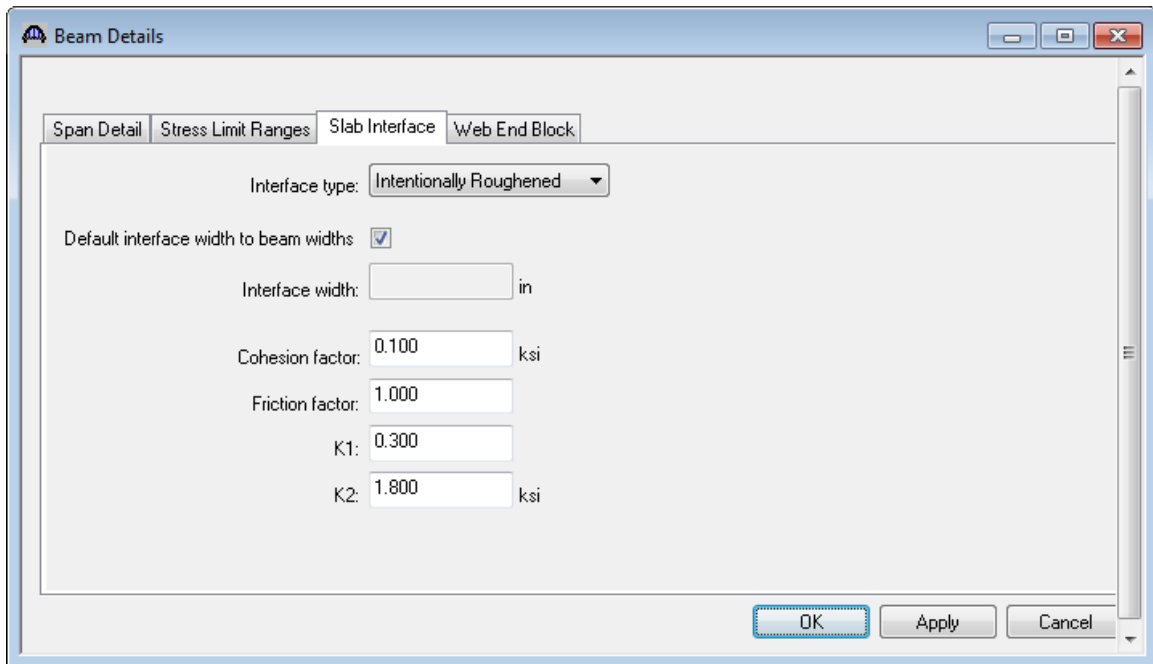
During actual production use of AASHTOWare Bridge Design and Rating you can revisit this window after member alternatives have been created for all members in your superstructure. Then the Compute button will correctly determine if you have adjacent or spread box beams and compute the distribution factors for you.



Go back to the Beam Details Window and complete the remaining information. Note that Stress Limit Ranges are defined over the entire length of the precast beam, including the projections of the beam past the centerline of bearing which were entered on the Span Detail tab.



Enter value in Slab Interface tab as shown below.



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

Expand the tree under Strand Layout and open the Span 1 window. Place the cursor in the schematic view on the right side of the screen. The toolbar buttons in this window will become active. Select the Zoom button to shrink the schematic of the beam shape so that the entire beam is visible. Select the Description Type as Strands in rows and the Strand Configuration Type as Harped. The Mid span radio button will now become active. You can now define the strands that are present at the middle of the span by selecting strands in the right hand schematic. Select the bottom 44 strands in the schematic so that the CG of the strands is 5.82 inches.

The screenshot shows the 'Strand Layout - Span 1' window. On the left is a configuration panel with the following settings:

- Description Type:** P and CGS only, Strands in rows
- Strand Configuration Type:** Straight/Debonded, Harped, Harped and straight debonded
- Symmetry
- Mid span:** Mid span, Left end, Right end

Below these settings is a table for Harp Point Locations:

Harp Point	Distance (ft)	Radius (in)
Left	0.00	0.0000
Right	0.00	0.0000

At the bottom of the configuration panel are buttons for 'OK', 'Apply', and 'Cancel'.

The main area on the right displays a schematic of a T-beam cross-section. The top flange and bottom chord are marked with 'X' symbols, indicating no strands at those positions. The vertical web is marked with 'X' symbols, indicating no strands there either. The bottom chord is marked with solid black circles, indicating the presence of 44 strands. A legend at the bottom right explains the symbols:

- X: No strand at this position at the current section location
- X (with blue dot): No strand at this position at the current location but a strand is harped to this position
- : A strand occupies this position at the current section location
- (with red dot): The strand is debonded at the current section location
- : The strand is debonded between the current section and the mid-span
- (with blue dot): The harped position of a harped strand.
- (with blue dot): The mid-span position of a harped strand.
- (with yellow dot): The mid-span position of one strand and the harped position of another strand.
- (with green dot): Mild steel.

Summary statistics at the bottom of the schematic area:

- Number of strands = 44
- Number of harped strands = 0
- CG of strands (measured from bottom of section) = 5.82 in

Now select the Left end radio button to enter the following harped strand locations at the left end of the precast beam. Place the cursor in the schematic view on the right side of the screen. You can now define the strands that are present at the left end of the span by selecting strands in the right hand schematic. Select the top 10 strands in the schematic so that the CG of the strands is 18.09 inches. Close the window by clicking Ok. This saves the data to memory and closes the window.

Strand Layout - Span 1

100%

Description Type
 P and CGS only Strands in rows

Strand Configuration Type
 Straight/Debonded Symmetry
 Harped
 Harped and straight debonded

Mid span

Left end
 Right end

Harp Point Locations		
Harp Point	Distance (ft)	Radius (in)
Left	48.50	0.000
Right	48.50	0.000

OK Apply Cancel

Notes:
 Strand positions generated by the REVISED method.
 Please refer to Help for a description of this method.

Number of strands = 44
 Number of harped strands = 10
 CG of strands (measured from bottom of section) = 18.09 in

Legend:

- × No strand at this position at the current section location
- ⊗ No strand at this position at the current location but a strand is harped to this position
- A strand occupies this position at the current section location
- The strand is debonded at the current section location
- The strand is debonded between the current section and the mid-span
- The harped position of a harped strand.
- The mid-span position of a harped strand.
- The mid-span position of one strand and the harped position of another strand.
- Mild steel.

Next open the Deck Profile and enter the data describing the structural properties of the deck. The window is shown below.

The screenshot shows the 'Deck Profile' window with the 'Type' set to 'PS Precast I'. The 'Deck Concrete' tab is active, displaying a table with the following data:

Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Start Effective Flange Width (Std) (in)	End Effective Flange Width (Std) (in)	Start Effective Flange Width (LRFD) (in)	End Effective Flange Width (LRFD) (in)	n
Deck Concrete	1	0.00	120.00	120.00	7.5000	90.0000	90.0000	108.0000	108.0000	

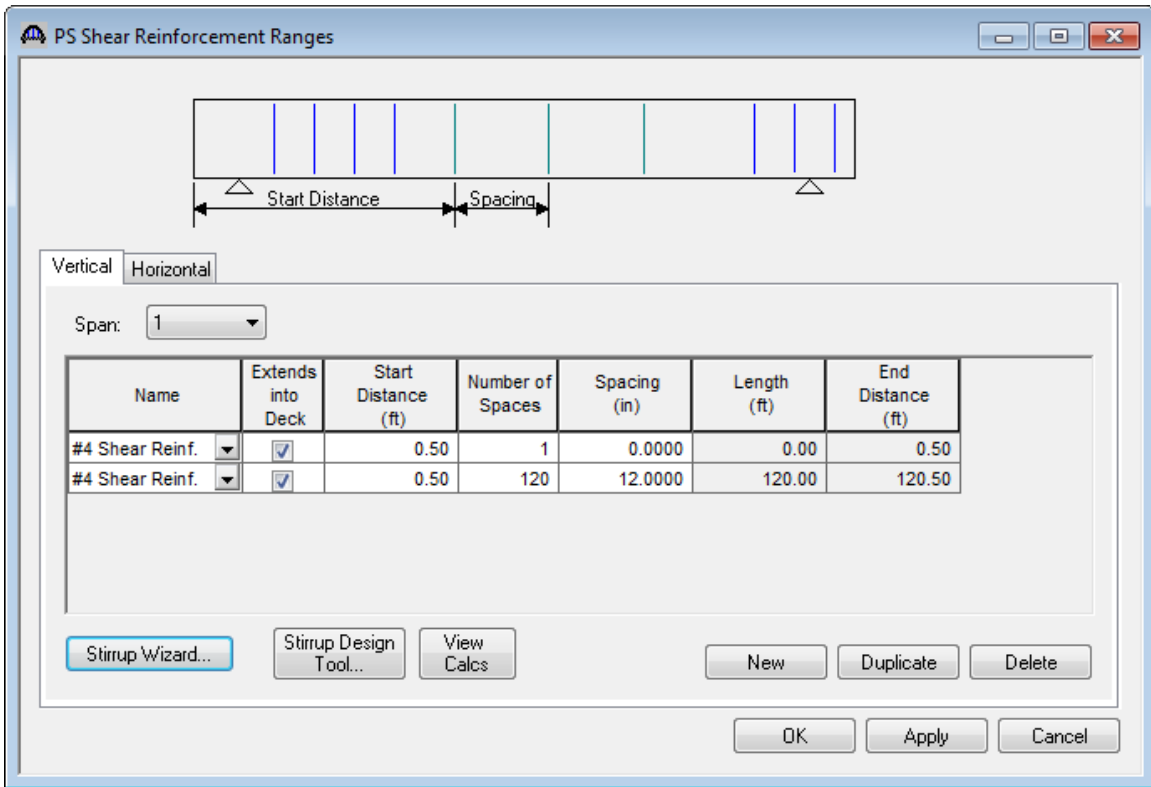
Buttons at the bottom include 'Compute from Typical Section...', 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel'.

No reinforcement is described.

The haunch profile is defined by double clicking on Haunch Profile in the tree. The window is shown below.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Z3 (in)	Z4 (in)	Y1 (in)	Y2 (in)	Y3 (in)
1	0.00	120.00	120.00	0.0000	0.0000	0.0000	0.0000	0.5000	0.5000	0.0000

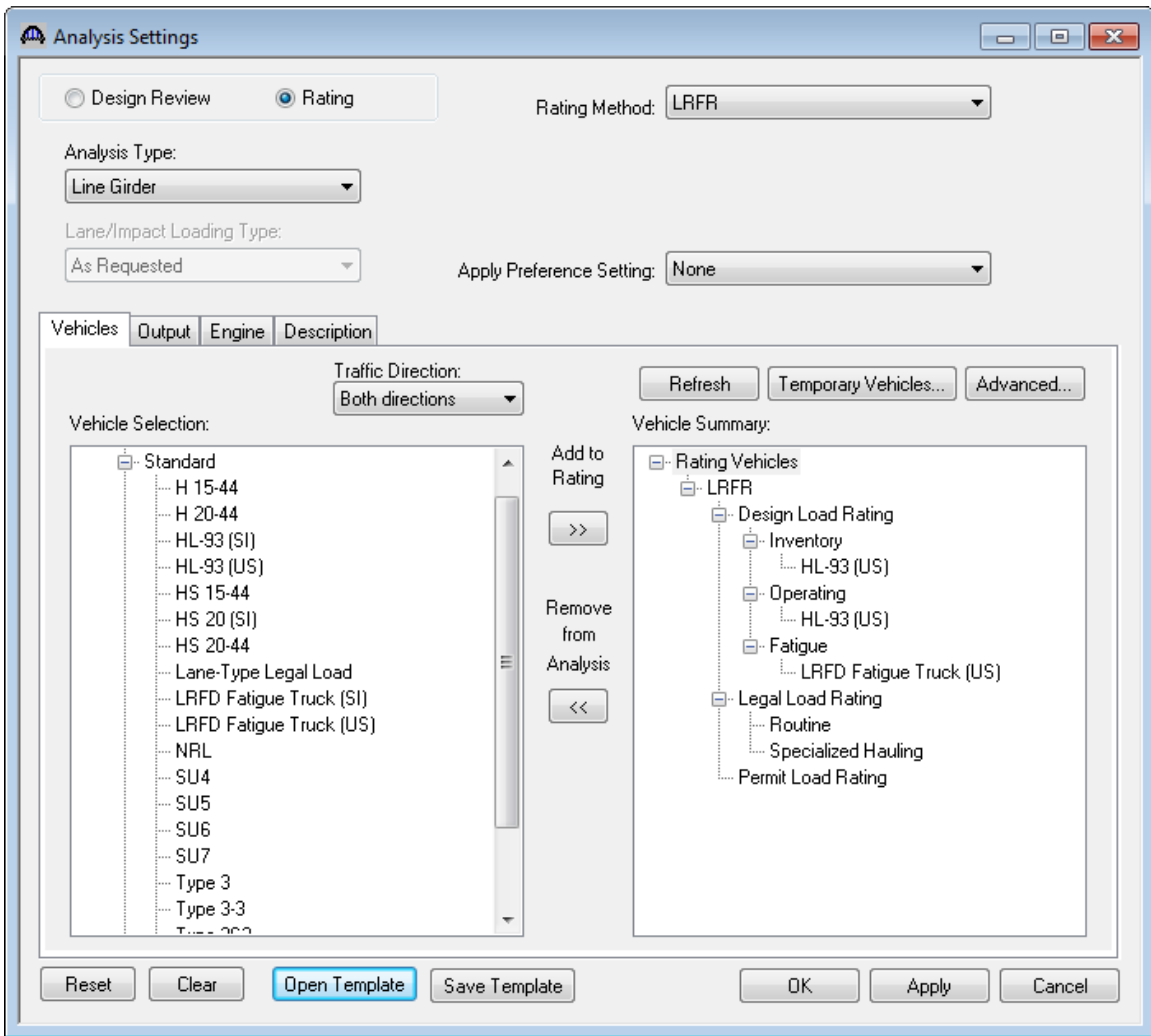
The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on this tab. This indicates composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we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



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

To compute LRFD live load distribution factors the interior girder adjacent to exterior girder must be defined. Copy Precast I Beam Alternative of G1 and paste to G2 as a member alternative. Open Live Load Distribution window, LRFD tab, use Compute from Typical Section button to compute LRFD live load distribution factors.

The member alternative can now be analyzed. To perform LRFR rating, select the View Analysis Settings button on the toolbar to open the window shown below. Click Open Template button and select the LRFR Design Load Rating to be used in the rating and click Ok.

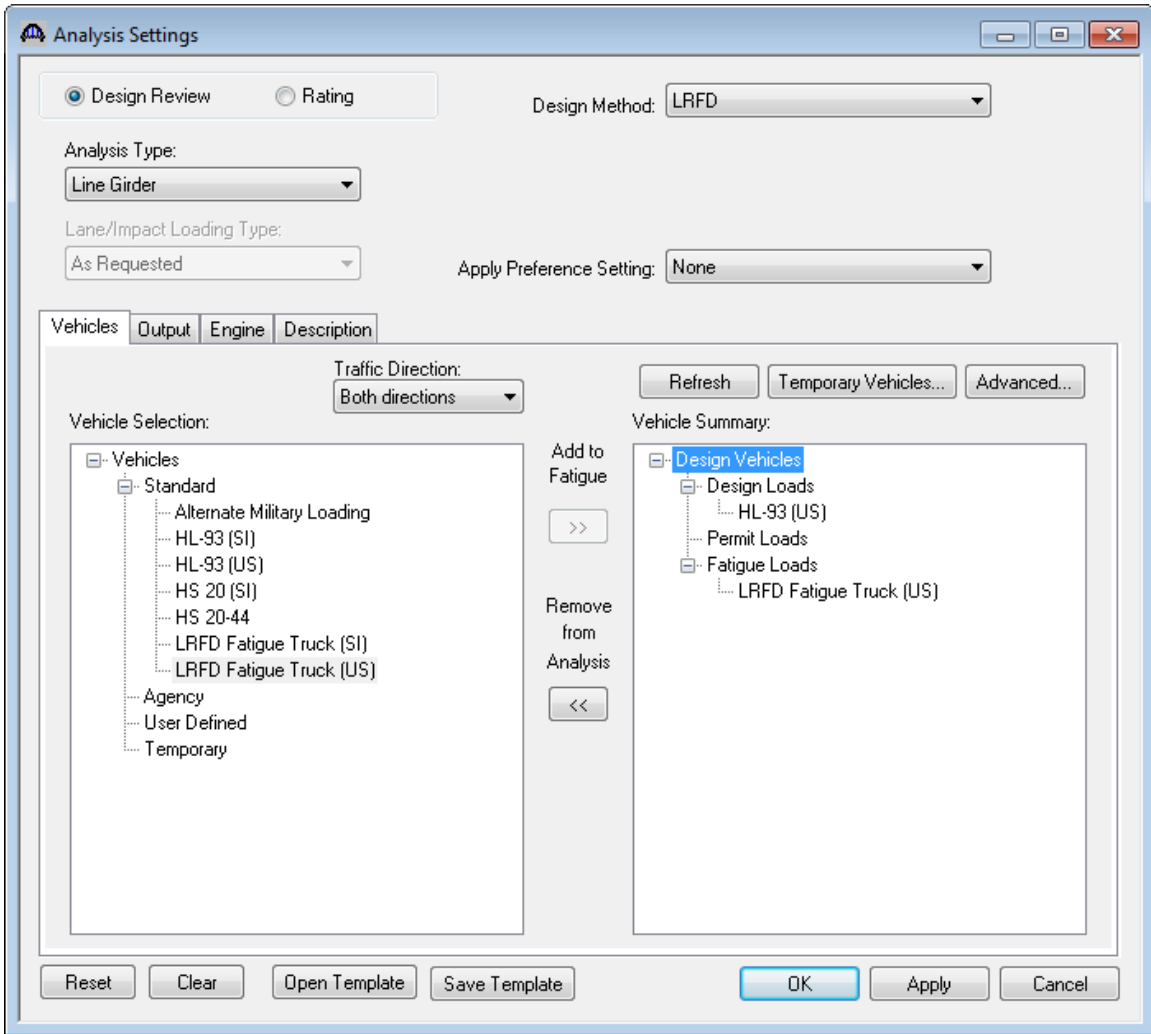



Next click the Analyze button on the toolbar to perform the rating. When the rating is finished you can review the results by clicking the View analysis Report on the toolbar. The window shown below will open.

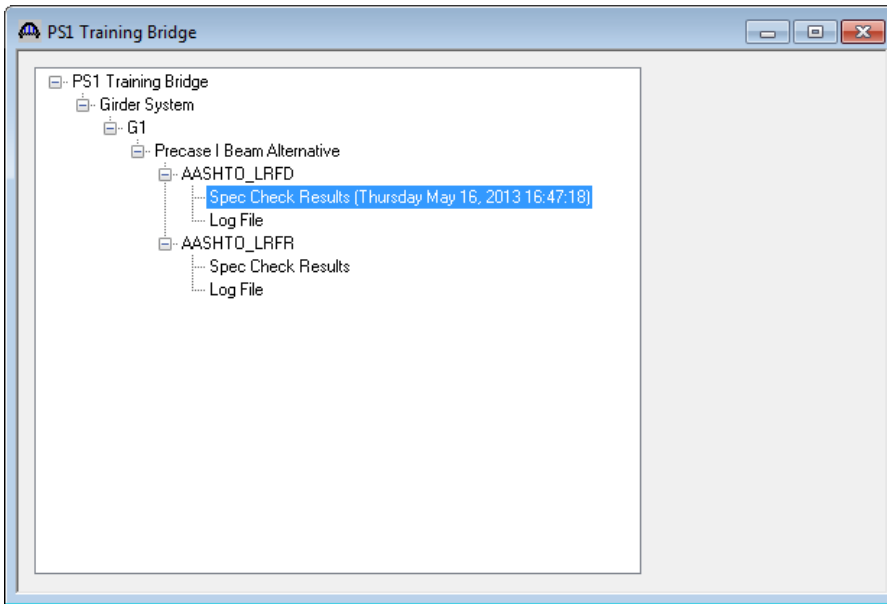
The screenshot shows a software window titled "Analysis Results - Precast I Beam Alternative". At the top, there are three dropdown menus: "Report Type" set to "Rating Results Summary", "Lane/Impact Loading Type" with radio buttons for "As Requested" (selected) and "Detailed", and "Display Format" set to "Multiple rating levels per row". Below these is a table with 15 columns: Live Load, Live Load Type, Rating Method, Inventory Load Rating (Ton), Operating Load Rating (Ton), Legal Load Rating (Ton), Permit Load Rating (Ton), Inventory Rating Factor, Operating Rating Factor, Legal Rating Factor, Permit Rating Factor, Inventory Location (ft), Inventory Location Span-(%), Operating Location (ft), and Operating Location Span-(%). The table contains two rows of data for HL-93 (US) configurations. Below the table is a scroll bar and the text "AASHTO LRFR Engine Version 6.5.0.2001" and "Analysis Preference Setting: None". A "Close" button is in the bottom right corner.

Live Load	Live Load Type	Rating Method	Inventory Load Rating (Ton)	Operating Load Rating (Ton)	Legal Load Rating (Ton)	Permit Load Rating (Ton)	Inventory Rating Factor	Operating Rating Factor	Legal Rating Factor	Permit Rating Factor	Inventory Location (ft)	Inventory Location Span-(%)	Operating Location (ft)	Operating Location Span-(%)
HL-93 (US)	Truck + Lane	LRFR	41.25	62.92			1.146	1.748			60.00	1 - (50.0)	60.00	1 -
HL-93 (US)	Tandem + Lane	LRFR	48.91	74.60			1.358	2.072			60.00	1 - (50.0)	60.00	1 -

An LRFD design review of this girder for HL93 loading can be performed by AASHTO LRFD. To do LRFD design review, enter the Analysis Settings window as shown below:



AASHTO LRFD analysis will generate a spec check results file. Click  on tool bar to open the following window.



To view the spec check results (shown below), double click the Spec Check Results in this window.

Bridge ID : 27
 Bridge : PS1 Training Bridge
 Superstructure Def : Girder System
 Member : G1
 Analysis Preference Setting : None

NBI Structure ID : PS1 Tr. Bridge
 Bridge Alt :
 Member Alt : Precast I Beam Alternative

[AASHTO LRFD Specification, Edition 5, Interim 2010](#)

Specification Check Summary

Article	Status
Initial Stress at Transfer (5.9.4.1.1, 5.9.4.1.2)	Pass
Final Stress due to Permanent and Transient Loads (5.9.4.2.1, 5.9.4.2.2)	Pass
Flexure (5.7.3.2, 5.7.3.3.2)	Pass
Shear (5.8.3.3, 5.8.2.5, 5.8.2.7, 5.8.3.5)	Pass
Deflection (5.7.3.6.2)	Pass

Initial Compression Stress At Transfer of Prestress

Location (ft)	Allowable Stress (ksi)	Actual Stress Top of Beam (ksi)	Actual Stress Bot of Beam (ksi)	Ratio	Code
0.000	-3.30	-0.02	-0.64	5.20	Pass
2.000	-3.30	-0.15	-3.14	1.05	Pass
6.311	-3.30	-0.20	-3.09	1.07	Pass
12.000	-3.30	-0.28	-3.01	1.10	Pass
24.000	-3.30	-0.34	-2.94	1.12	Pass
36.000	-3.30	-0.32	-2.96	1.11	Pass
48.000	-3.30	-0.21	-3.08	1.07	Pass
60.000	-3.30	-0.26	-3.03	1.09	Pass
72.000	-3.30	-0.21	-3.08	1.07	Pass
84.000	-3.30	-0.32	-2.96	1.11	Pass
96.000	-3.30	-0.34	-2.94	1.12	Pass
108.000	-3.30	-0.28	-3.01	1.10	Pass
113.689	-3.30	-0.20	-3.09	1.07	Pass
118.000	-3.30	-0.15	-3.14	1.05	Pass
120.000	-3.30	-0.02	-0.64	5.20	Pass

NR = Spec check not required at this location

Initial Tension Stress At Transfer of Prestress

Location (ft)	Allowable Stress (ksi)	Actual Stress Top of Beam (ksi)	Actual Stress Bot of Beam (ksi)	Ratio	Code
0.000	0.20	-0.02	-0.64	99.00	Pass
2.000	0.20	-0.15	-3.14	99.00	Pass