

AASHTOWare BrD/BrR 6.8.2

Prestress Tutorial 1

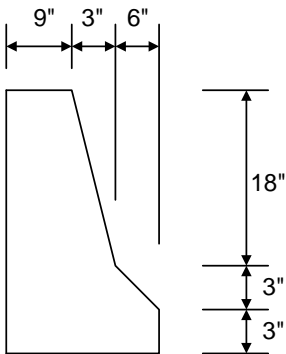
Simple Span Prestressed I Beam Example

Material Properties

Beam Concrete: $f'_c = 6.5$ ksi, $f'_{ci} = 5.5$ ksi

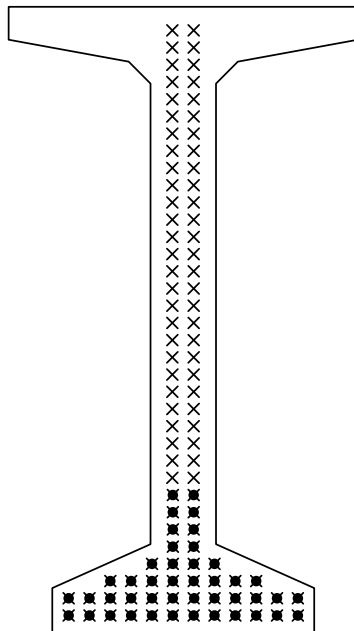
Deck Concrete: $f'_c = 4.5$ ksi

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

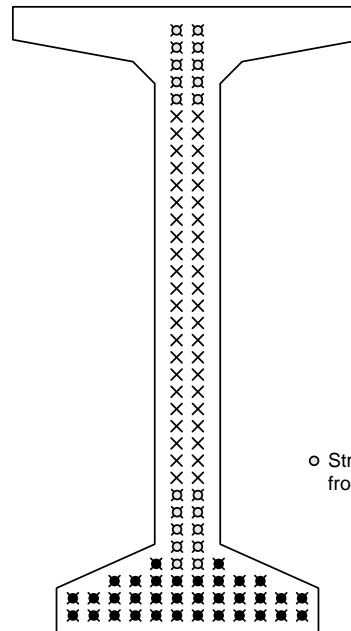


Weight = 300 plf

Parapet Detail



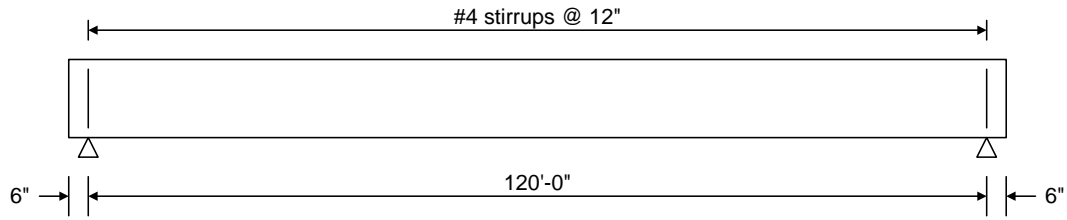
**Strand Pattern at
Mid-Span**



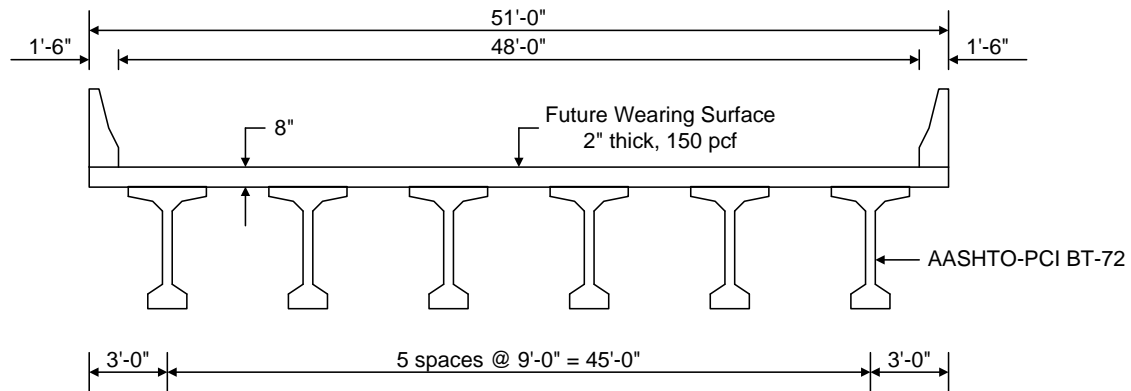
o Strand harped at 48.5'
from end of beam

**Strand Pattern at
End of Beam**

PS1 - Simple Span Prestressed I Beam Example



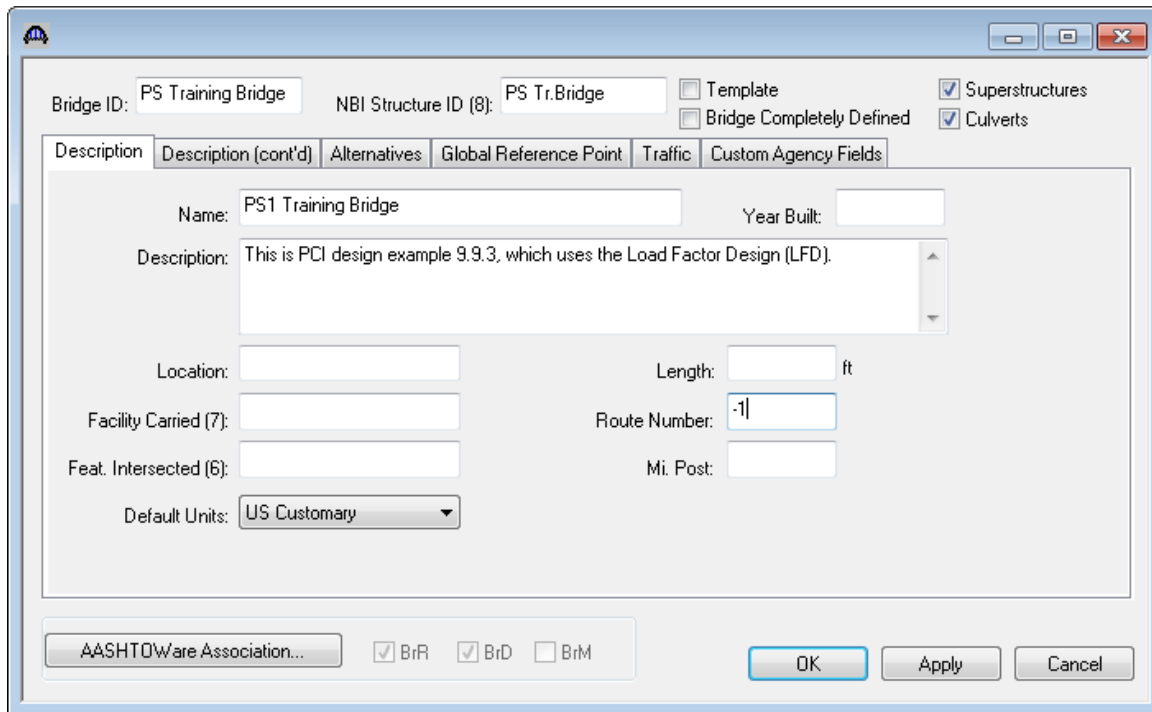
Elevation



Typical Section


PS1 - SimpleSpanPSIBeamExample

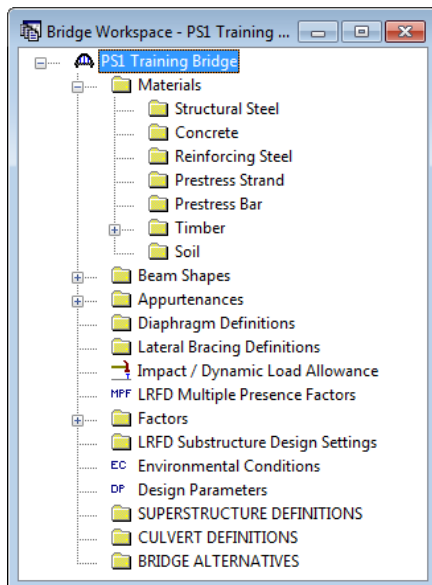
From the Bridge Explorer create a new bridge and enter the following description data:



The screenshot shows the 'Description' tab of the Bridge Explorer window. The 'Bridge ID' is 'PS Training Bridge' and the 'NBI Structure ID (8)' is 'PS Tr.Bridge'. The 'Template' checkbox is unchecked, and 'Bridge Completely Defined' is also unchecked. The 'Superstructures' and 'Culverts' checkboxes are checked. The 'Description' text box contains 'This is PCI design example 9.9.3, which uses the Load Factor Design (LFD)'. The 'Name' is 'PS1 Training Bridge' and the 'Year Built' is empty. The 'Location' is empty, and the 'Length' is empty with a unit of 'ft'. The 'Facility Carried (7)' is empty, and the 'Route Number' is '-1'. The 'Feat. Intersected (6)' is empty, and the 'Mi. Post' is empty. The 'Default Units' are set to 'US Customary'. At the bottom, there is an 'AASHTOWare Association...' button, checkboxes for 'BrR', 'BrD', and 'BrM' (all checked), and 'OK', 'Apply', and 'Cancel' buttons.

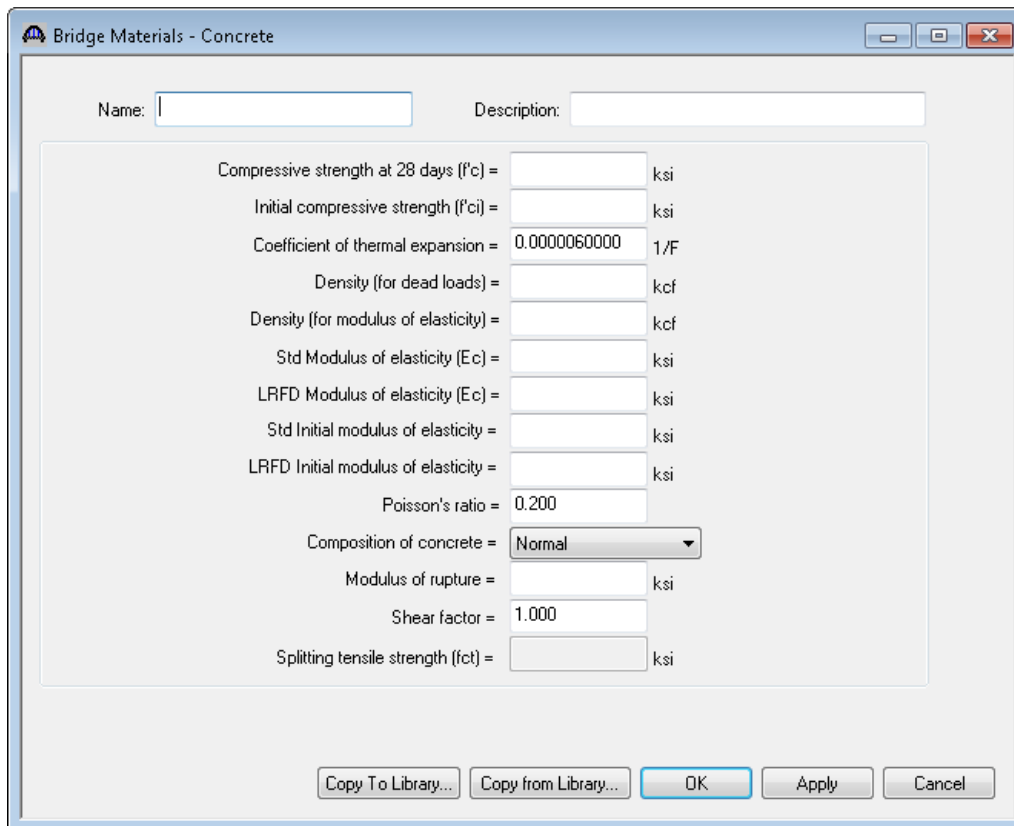
Close the window by clicking Ok. This saves the data to memory and closes the window.

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

PS1 - SimpleSpanPSIBeamExample



Bridge Materials - Concrete

Name: Description:

Compressive strength at 28 days (f'c) = ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 1/F

Density (for dead loads) = kcf

Density (for modulus of elasticity) = kcf

Std Modulus of elasticity (Ec) = ksi

LRFD Modulus of elasticity (Ec) = ksi

Std Initial modulus of elasticity = ksi

LRFD Initial modulus of elasticity = ksi

Poisson's ratio = 0.200

Composition of concrete = Normal

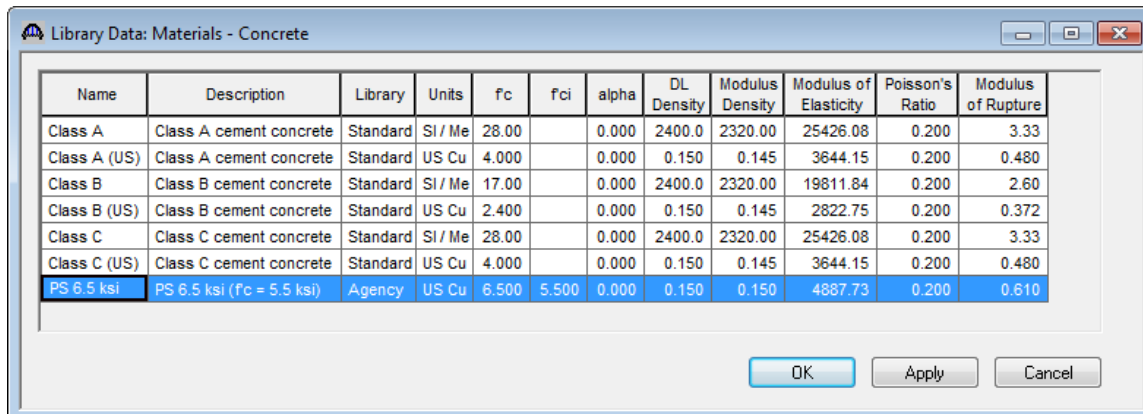
Modulus of rupture = ksi

Shear factor = 1.000

Splitting tensile strength (fct) = ksi

Copy To Library... Copy from Library... OK Apply Cancel

Add the concrete material “PS 6.5 ksi” that was entered into the Library 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.



Library Data: Materials - Concrete

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

OK Apply Cancel

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.

PS1 - SimpleSpanPSIBeamExample

Bridge Materials - Concrete

Name: PS 6.5 ksi Description: PS 6.5 ksi (f'c = 5.5 ksi)

Compressive strength at 28 days (f'c) =	6.500	ksi
Initial compressive strength (f'ci) =	5.500	ksi
Coefficient of thermal expansion =	0.0000060000	1/F
Density (for dead loads) =	0.150	kcf
Density (for modulus of elasticity) =	0.150	kcf
Std Modulus of elasticity (Ec) =	4887.73	ksi
LRFD Modulus of elasticity (Ec) =	5007.55	ksi
Std Initial modulus of elasticity =	4496.06	ksi
LRFD Initial modulus of elasticity =	4738.96	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.61	ksi
Shear factor =	1	
Splitting tensile strength (fct) =		ksi

Copy To Library... Copy from Library... OK Apply Cancel

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

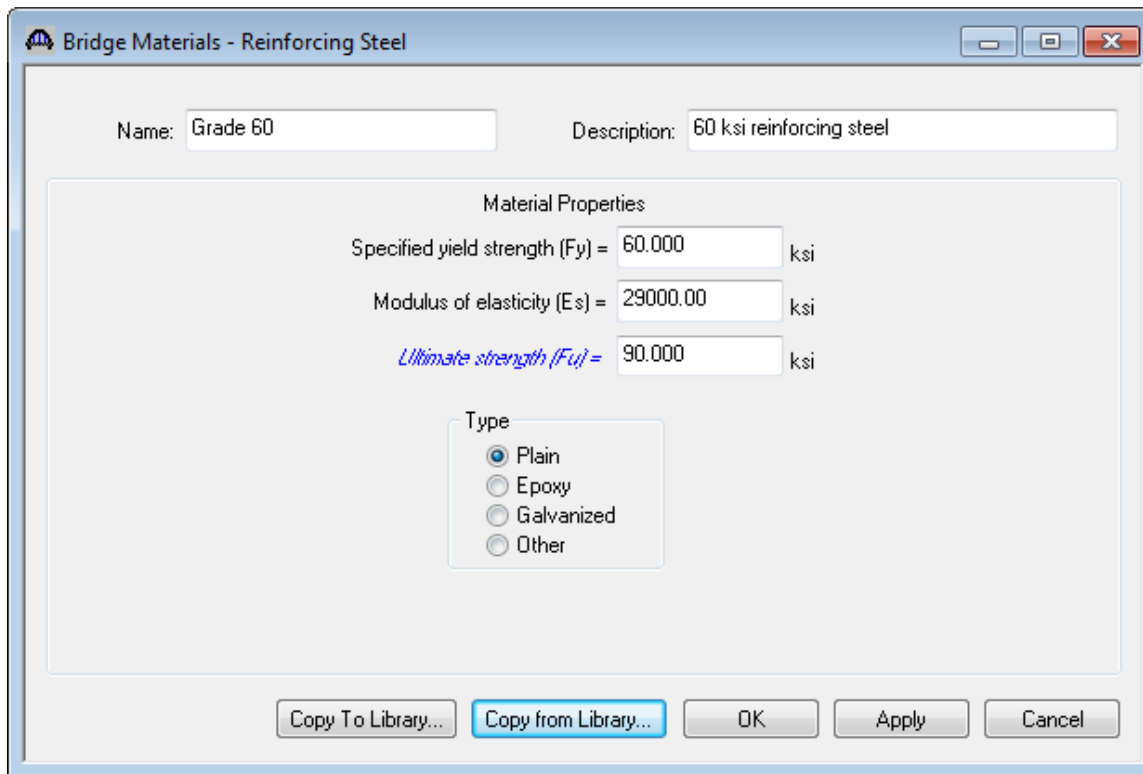
Add a concrete material for the deck, reinforcement material and prestress strand using the same techniques. The windows will look like those shown below:

Bridge Materials - Concrete

Name: Deck Concrete Description: Deck Concrete

Compressive strength at 28 days (f'c) =	4.500	ksi
Initial compressive strength (f'ci) =		ksi
Coefficient of thermal expansion =	0.0000060000	1/F
Density (for dead loads) =	0.150	kcf
Density (for modulus of elasticity) =	0.150	kcf
Std Modulus of elasticity (Ec) =	4066.84	ksi
LRFD Modulus of elasticity (Ec) =	4435.31	ksi
Std Initial modulus of elasticity =	0.00	ksi
LRFD Initial modulus of elasticity =	0.00	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.51	ksi
Shear factor =	1	
Splitting tensile strength (fct) =		ksi

Copy To Library... Copy from Library... OK Apply Cancel



Bridge Materials - Reinforcing Steel

Name: Description:

Material Properties

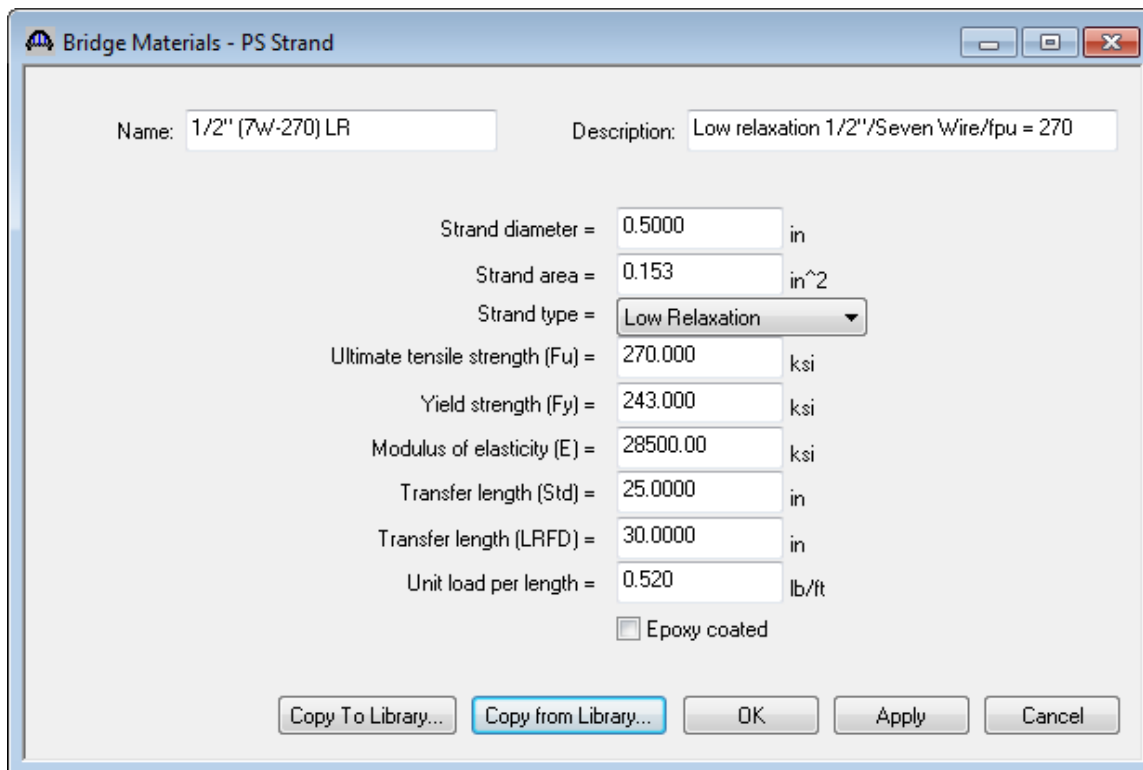
Specified yield strength (F_y) = ksi

Modulus of elasticity (E_s) = ksi

Ultimate strength (F_u) = ksi

Type

☒ Plain
☐ Epoxy
☐ Galvanized
☐ Other



Bridge Materials - PS Strand

Name: Description:

Strand diameter = in

Strand area = in²

Strand type =

Ultimate tensile strength (F_u) = ksi

Yield strength (F_y) = ksi

Modulus of elasticity (E) = ksi

Transfer length (Std) = in

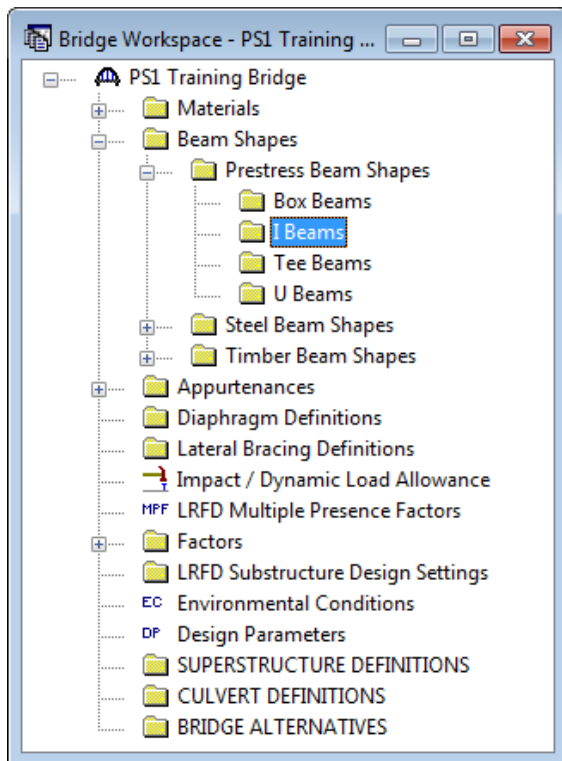
Transfer length (LRFD) = in

Unit load per length = lb/ft

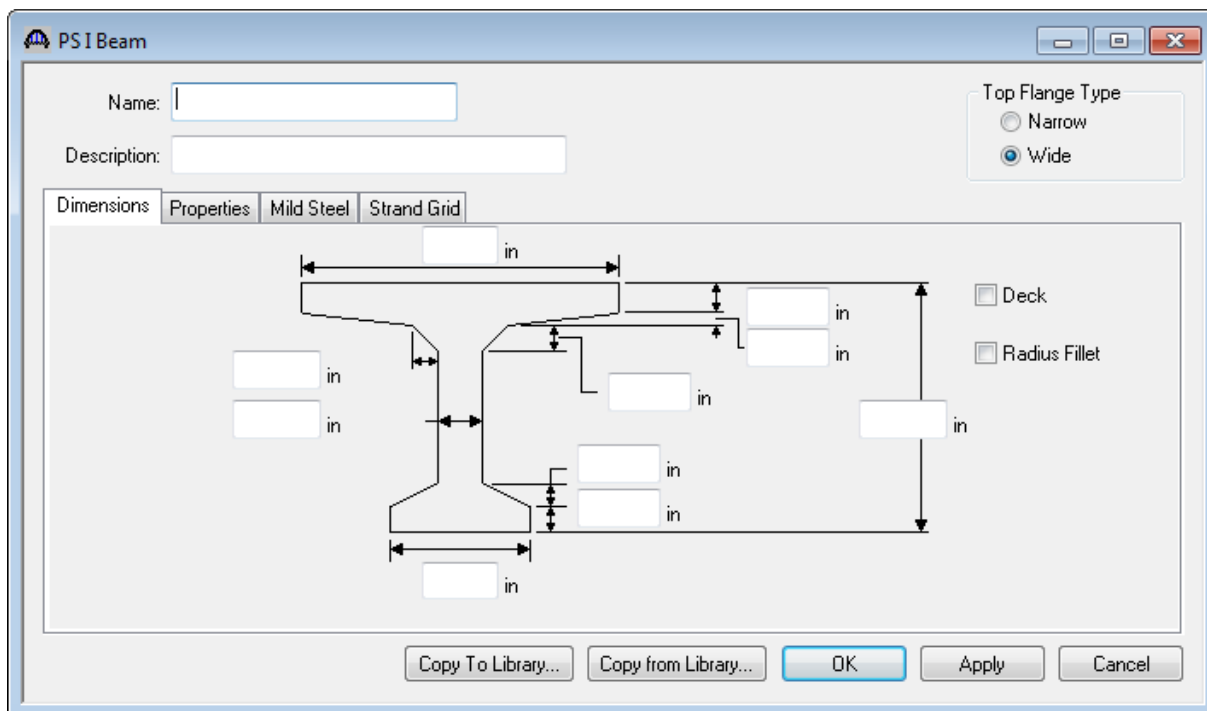
☐ Epoxy coated

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

PS1 - SimpleSpanPSIBeamExample

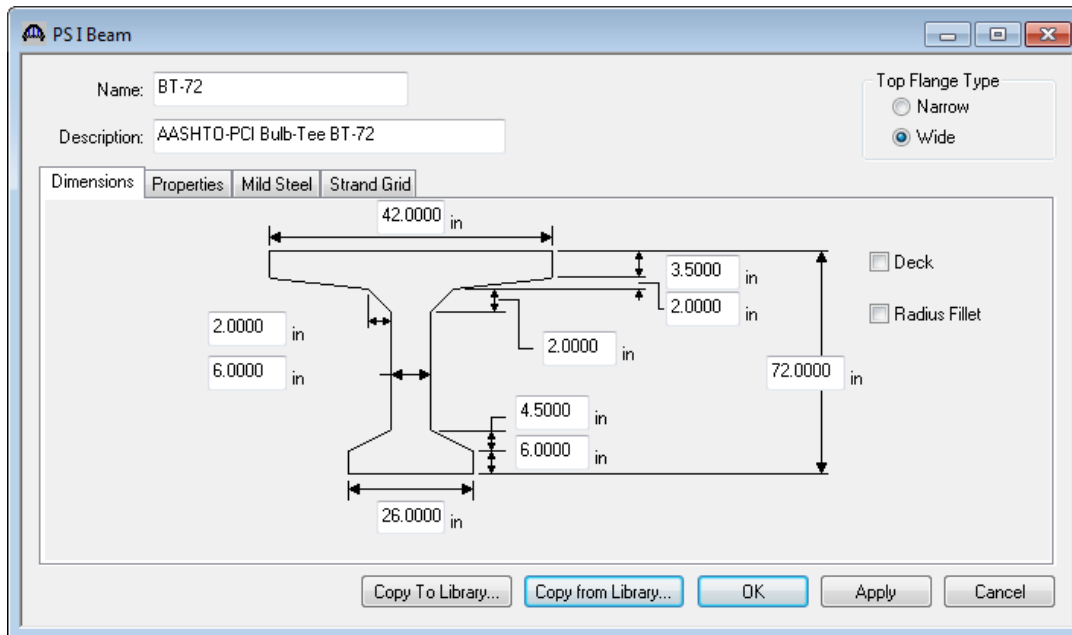


Click on I Beams in the tree and select File/New from the menu (or double click on I Beams in the tree). The window shown below will open.

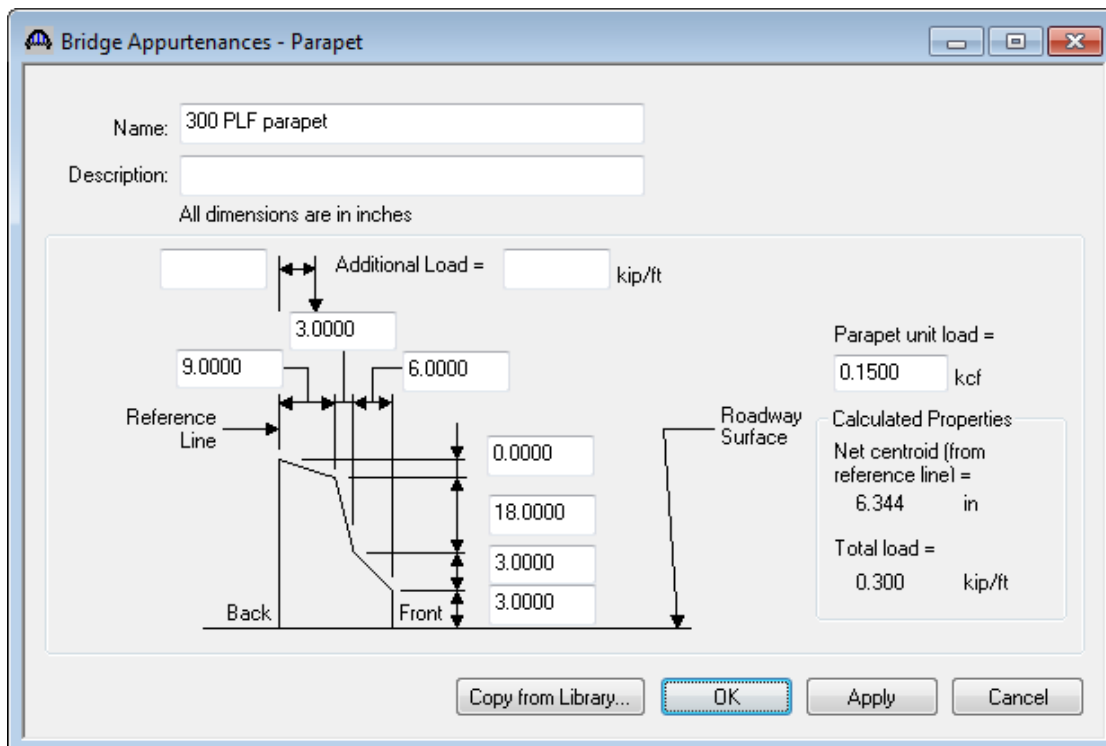


PS1 - SimpleSpanPSIBeamExample

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.



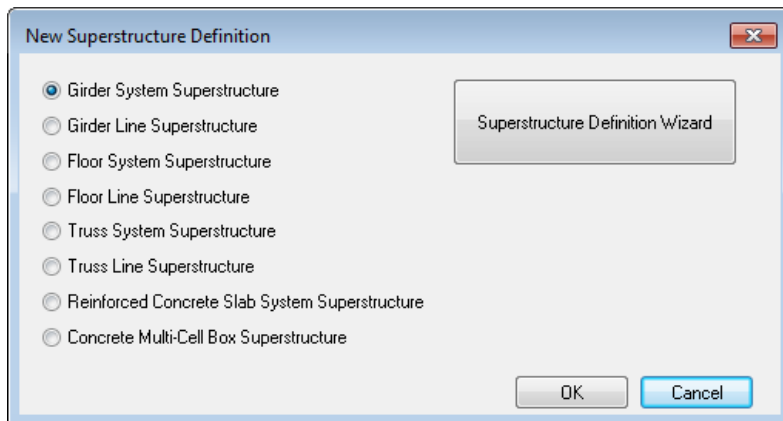
To enter the appurtenances to be used within the bridge expand the tree branch labeled Appurtenances. To define a parapet double click on Parapet in the tree and input the parapet dimensions as shown below. Click Ok to save the data to memory and close the window.



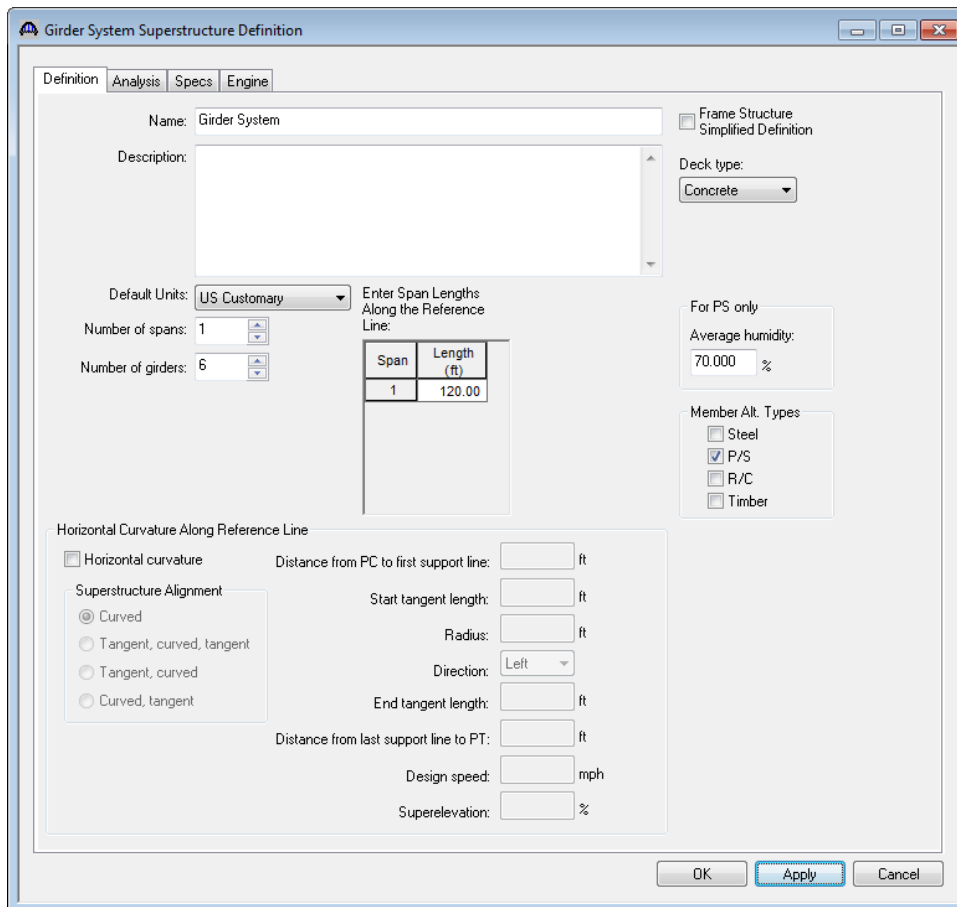
PS1 - SimpleSpanPSIBeamExample

The default impact factors, standard LRFD and LFD factors will be used as they were in Tutorial STL1 so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

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:



The "Girder System Superstructure Definition" window is shown with the "Definition" tab selected. The "Name" field is "Girder System". The "Description" field is empty. The "Default Units" are set to "US Customary". The "Number of spans" is 1 and the "Number of girders" is 6. The "Enter Span Lengths Along the Reference Line:" table shows one span with a length of 120.00 ft.

Span	Length (ft)
1	120.00

The "Deck type" is set to "Concrete". The "Frame Structure Simplified Definition" checkbox is unchecked. The "For PS only" section shows "Average humidity" set to 70.000 %.

The "Member Alt. Types" section shows checkboxes for Steel, P/S (checked), R/C, and Timber.

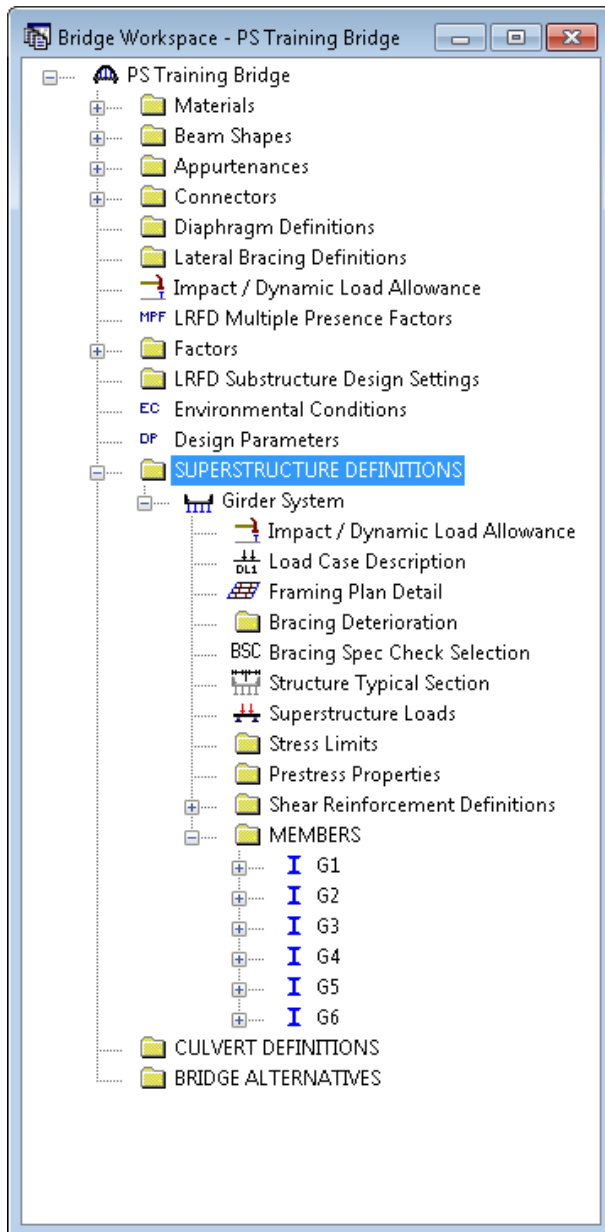
The "Horizontal Curvature Along Reference Line" section has the "Horizontal curvature" checkbox unchecked. The "Superstructure Alignment" section has the "Curved" radio button selected. The "Distance from PC to first support line:" is 0 ft, "Start tangent length:" is 0 ft, "Radius:" is 0 ft, "Direction:" is "Left", "End tangent length:" is 0 ft, "Distance from last support line to PT:" is 0 ft, "Design speed:" is 0 mph, and "Superelevation:" is 0 %.

Buttons at the bottom include "OK", "Apply", and "Cancel".

PS1 - SimpleSpanPSIBeamExample

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

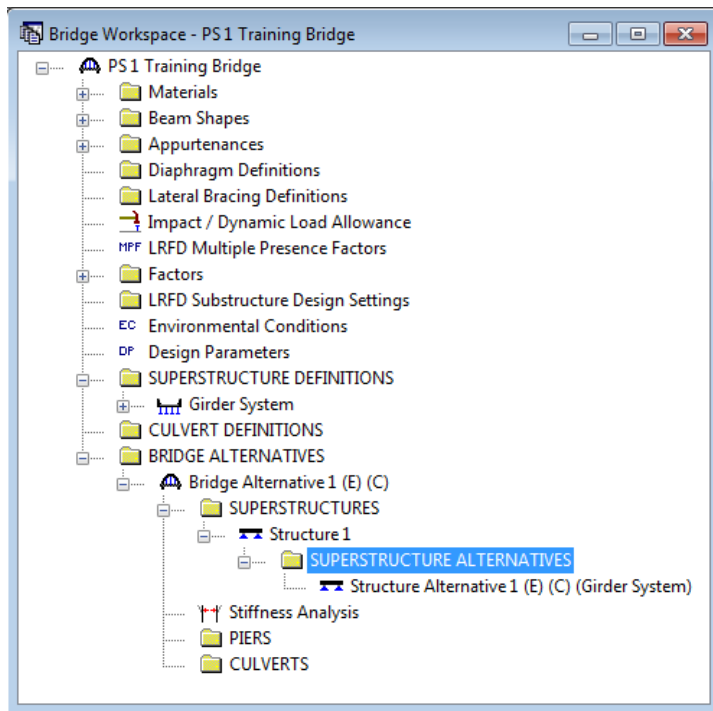
The partially expanded Bridge Workspace tree is shown below:



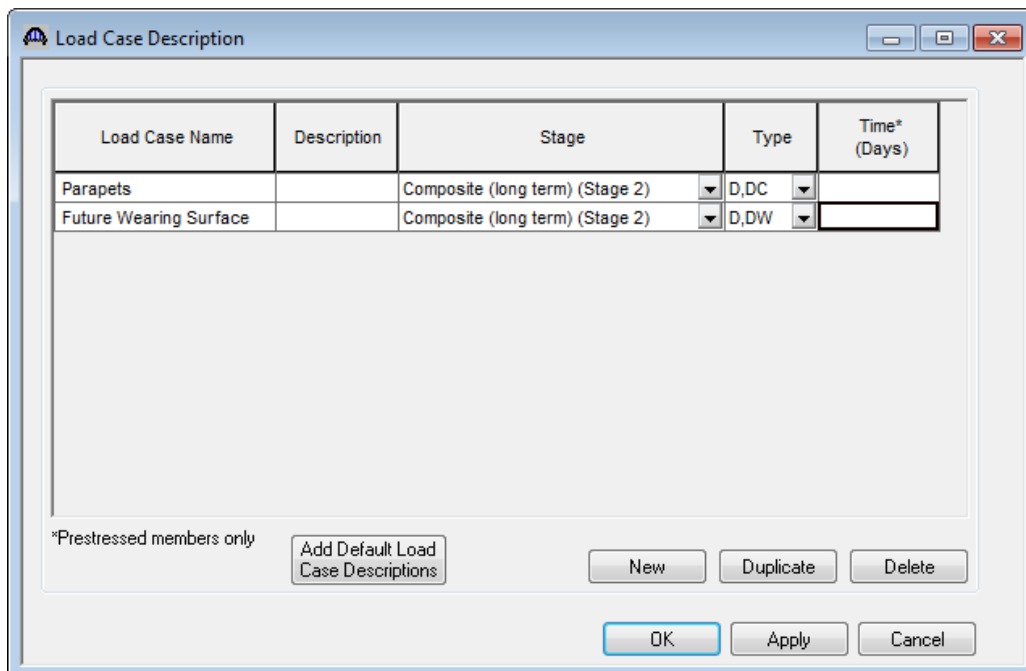
We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative as we did in tutorial STL1.

The partially expanded Bridge Workspace tree is shown below:

PS1 - SimpleSpanPSIBeamExample

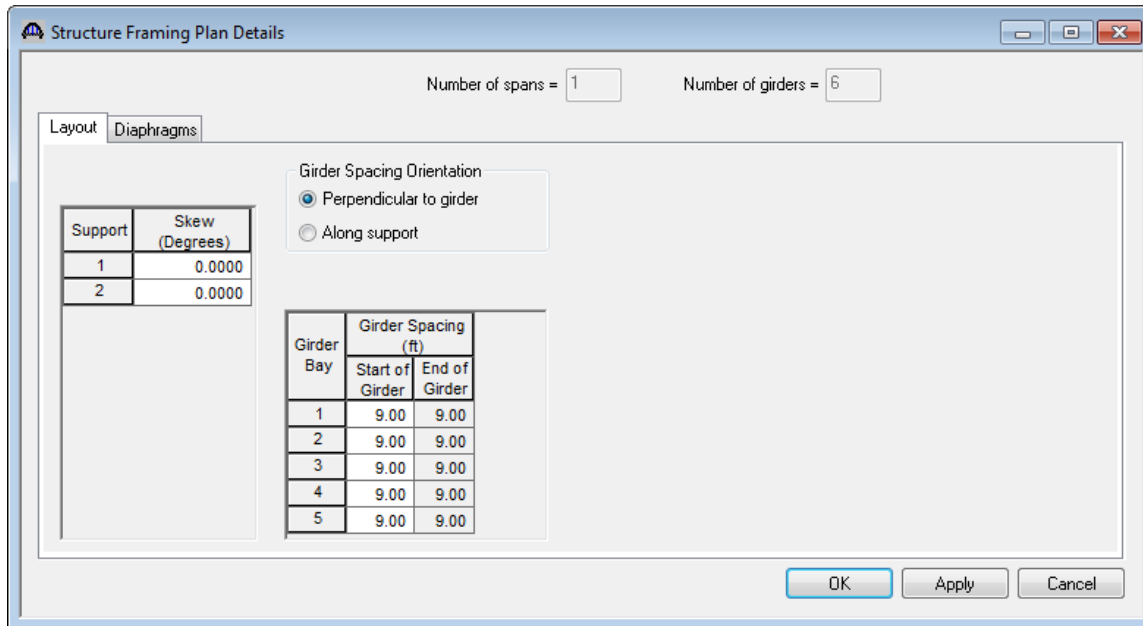


Click Load Case Description to define the dead load cases. The completed Load Case Description window is shown below.



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

PS1 - SimpleSpanPSIBeamExample



Structure Framing Plan Details

Number of spans = 1 Number of girders = 6

Layout Diaphragms

Girder Spacing Orientation

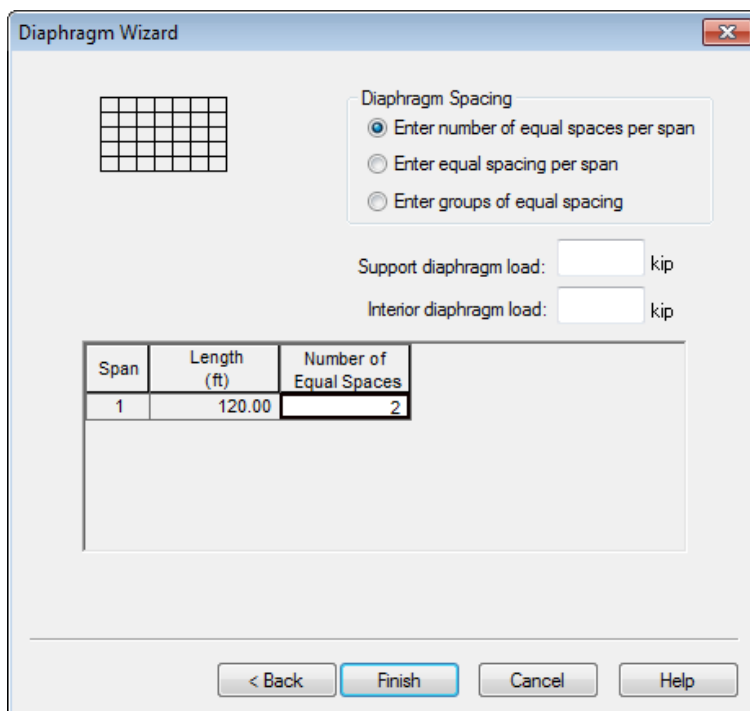
- ☒ Perpendicular to girder
- ☐ Along support

Support	Skew (Degrees)
1	0.0000
2	0.0000

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

OK Apply Cancel

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.



Diaphragm Wizard

Diaphragm Spacing

- ☒ Enter number of equal spaces per span
- ☐ Enter equal spacing per span
- ☐ Enter groups of equal spacing

Support diaphragm load: kip

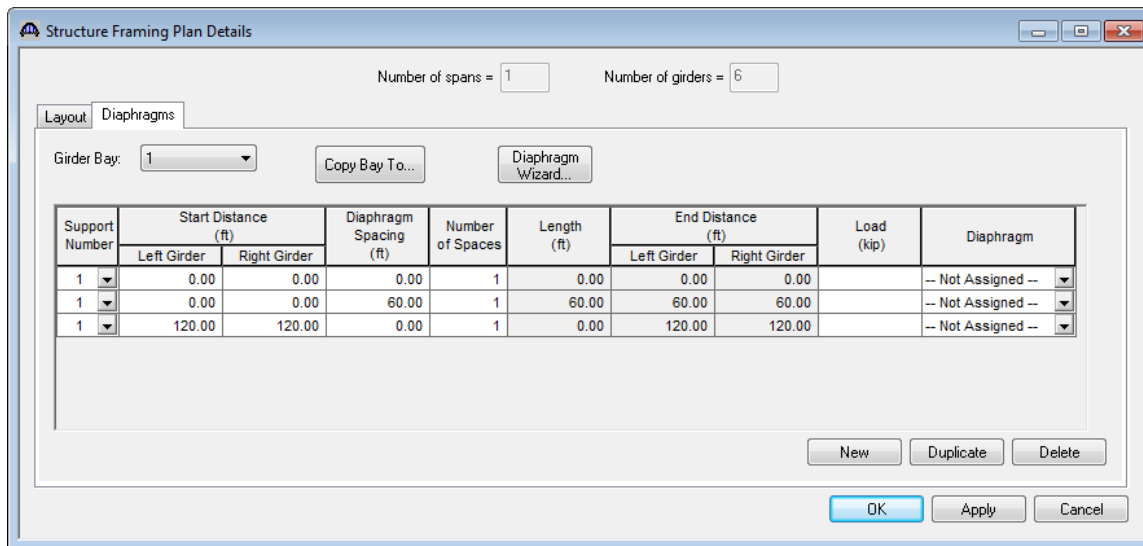
Interior diaphragm load: kip

Span	Length (ft)	Number of Equal Spaces
1	120.00	2

< Back Finish Cancel Help

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:

PS1 - SimpleSpanPSIBeamExample



Structure Framing Plan Details

Number of spans = 1 Number of girders = 6

Layout: Diaphragms

Girder Bay: 1 Copy Bay To... Diaphragm Wizard...

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)	Diaphragm
	Left Girder	Right Girder				Left Girder	Right Girder		
1	0.00	0.00	0.00	1	0.00	0.00	0.00		-- Not Assigned --
1	0.00	0.00	60.00	1	60.00	60.00	60.00		-- Not Assigned --
1	120.00	120.00	0.00	1	0.00	120.00	120.00		-- Not Assigned --

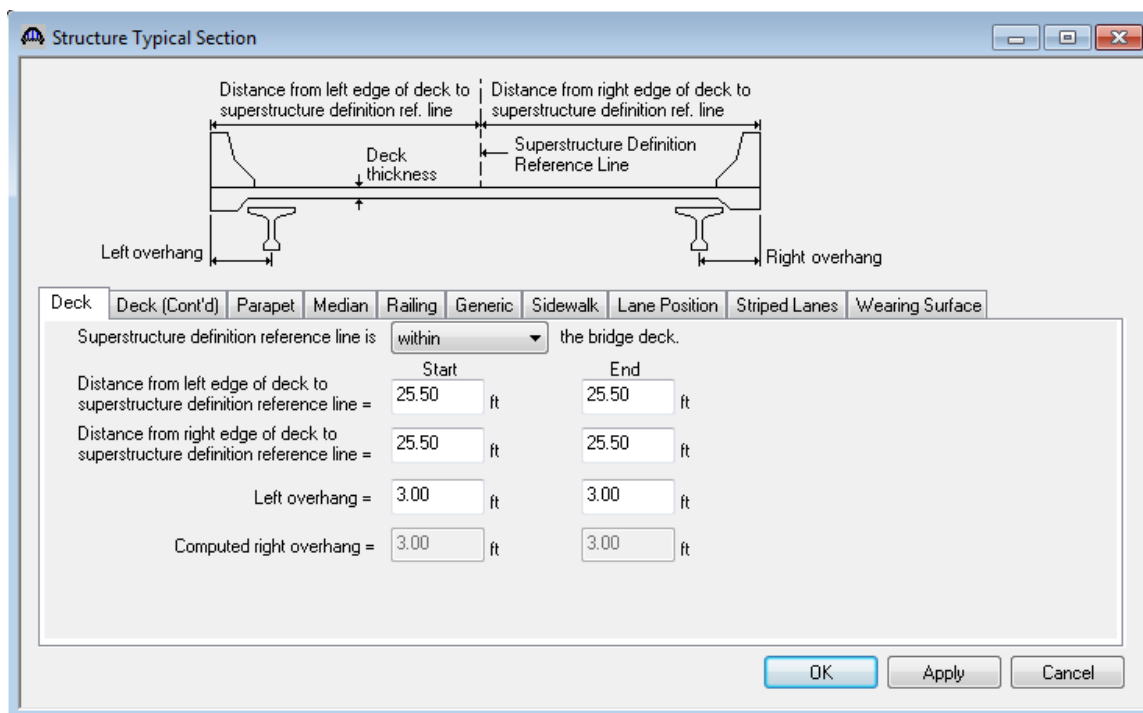
New Duplicate Delete

OK Apply Cancel

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:



Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line Distance from right edge of deck to superstructure definition ref. line

Deck thickness Superstructure Definition Reference Line

Left overhang Right overhang

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

Superstructure definition reference line is within the bridge deck.

Start End

Distance from left edge of deck to superstructure definition reference line = 25.50 ft 25.50 ft

Distance from right edge of deck to superstructure definition reference line = 25.50 ft 25.50 ft

Left overhang = 3.00 ft 3.00 ft

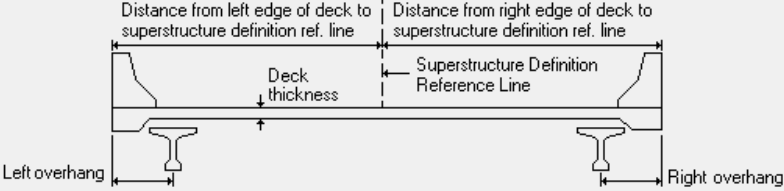
Computed right overhang = 3.00 ft 3.00 ft

OK Apply Cancel

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

PS1 - SimpleSpanPSIBeamExample

Structure Typical Section



Distance from left edge of deck to superstructure definition ref. line

Distance from right edge of deck to superstructure definition ref. line

Deck thickness

Superstructure Definition Reference Line

Left overhang

Right overhang

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

Deck concrete: Deck Concrete

Total deck thickness: 8.0000 in

Load case: Engine Assigned

Deck crack control parameter: 130.000 kip/in

Sustained modular ratio factor: 3.000

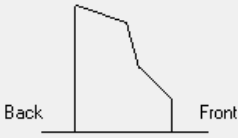
Deck exposure factor:

OK Apply Cancel

Parapets:

Add two parapets as shown below.

Structure Typical Section



Back Front

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

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

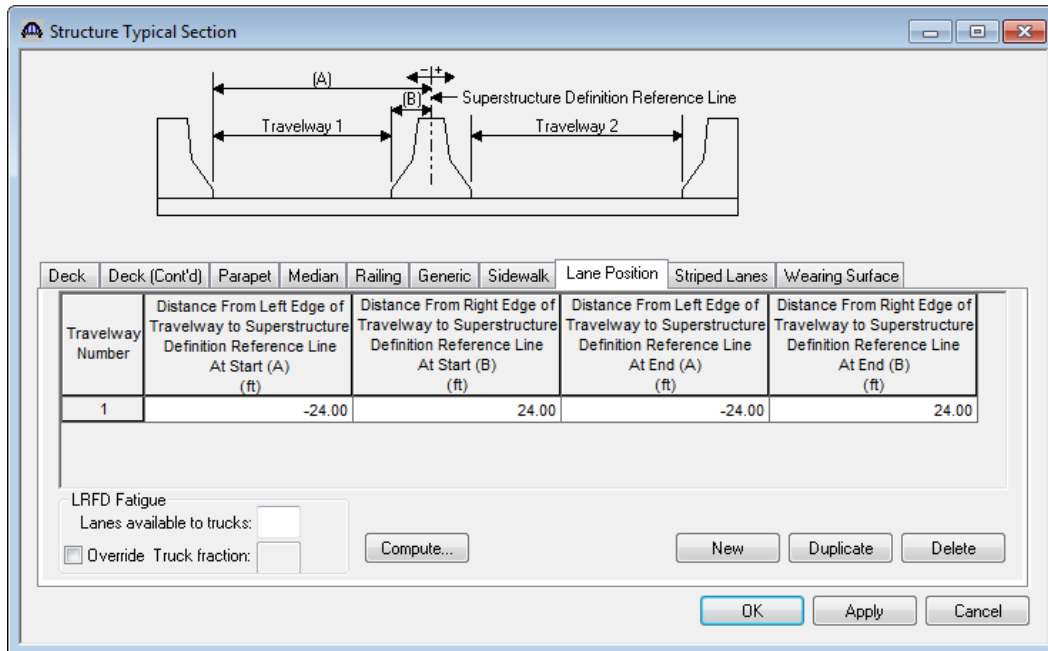
New Duplicate Delete

OK Apply Cancel

PS1 - SimpleSpanPSIBeamExample

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.



The dialog box shows a cross-section of a bridge with two travelways. The Superstructure Definition Reference Line is centered. Travelway 1 is on the left and Travelway 2 is on the right. Dimensions (A) and (B) are indicated for the travelway widths.

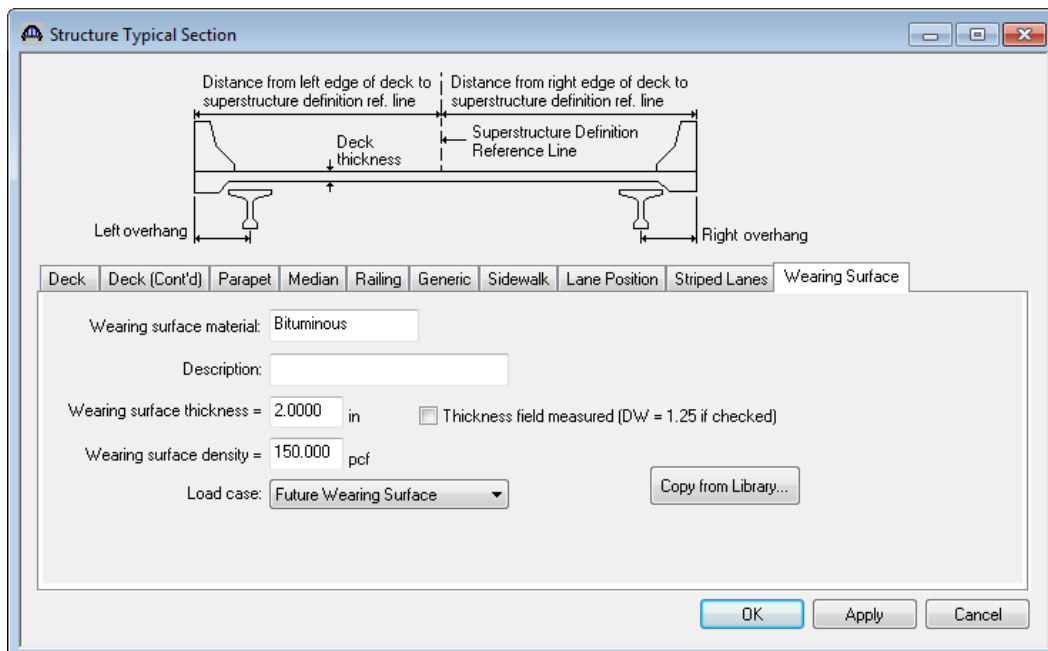
Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-24.00	24.00	-24.00	24.00

LRFD Fatigue
Lanes available to trucks:
☐ Override Truck fraction:

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

Wearing Surface:

Enter the data shown below.



The dialog box shows a cross-section of a bridge with two travelways. The Superstructure Definition Reference Line is centered. Dimensions for Left overhang, Deck thickness, and Right overhang are indicated. The Wearing Surface tab is selected.

Wearing surface material: Bituminous
Description:
Wearing surface thickness = 2.0000 in ☐ Thickness field measured (DW = 1.25 if checked)
Wearing surface density = 150.000 pcf
Load case: Future Wearing Surface

Buttons: OK, Apply, Cancel

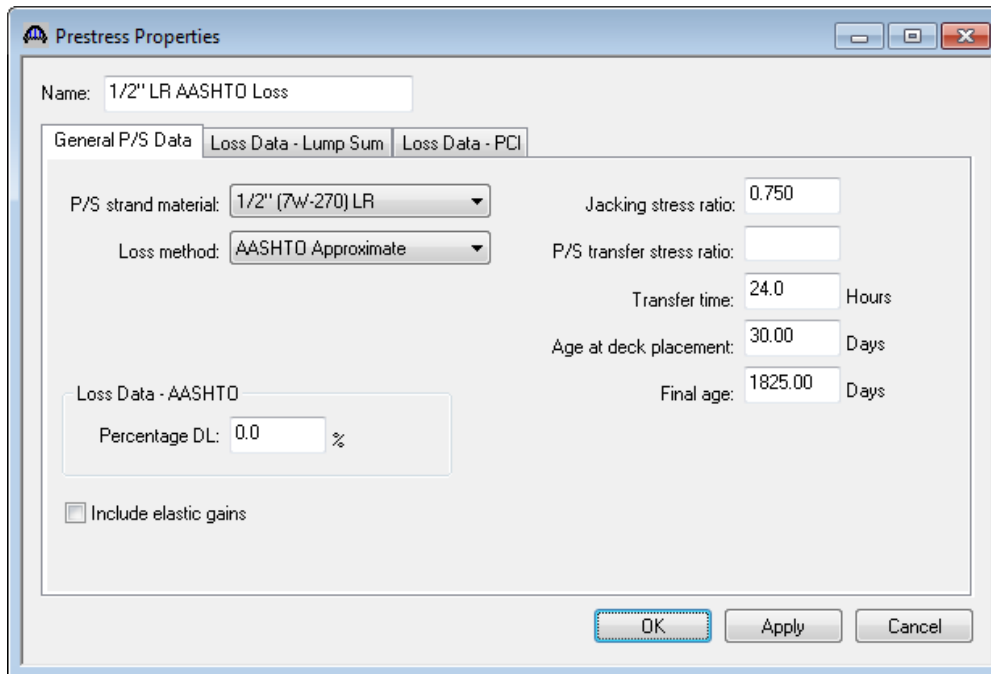
PS1 - SimpleSpanPSIBeamExample

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.

	LFD	LRFD
Initial allowable compression:	3.300 ksi	3.575 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:	2.400 ksi	
Final allowable compression: (LL + 1/2(Pe + DL))	2.600 ksi	2.6 ksi

Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. 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.

PS1 - SimpleSpanPSIBeamExample

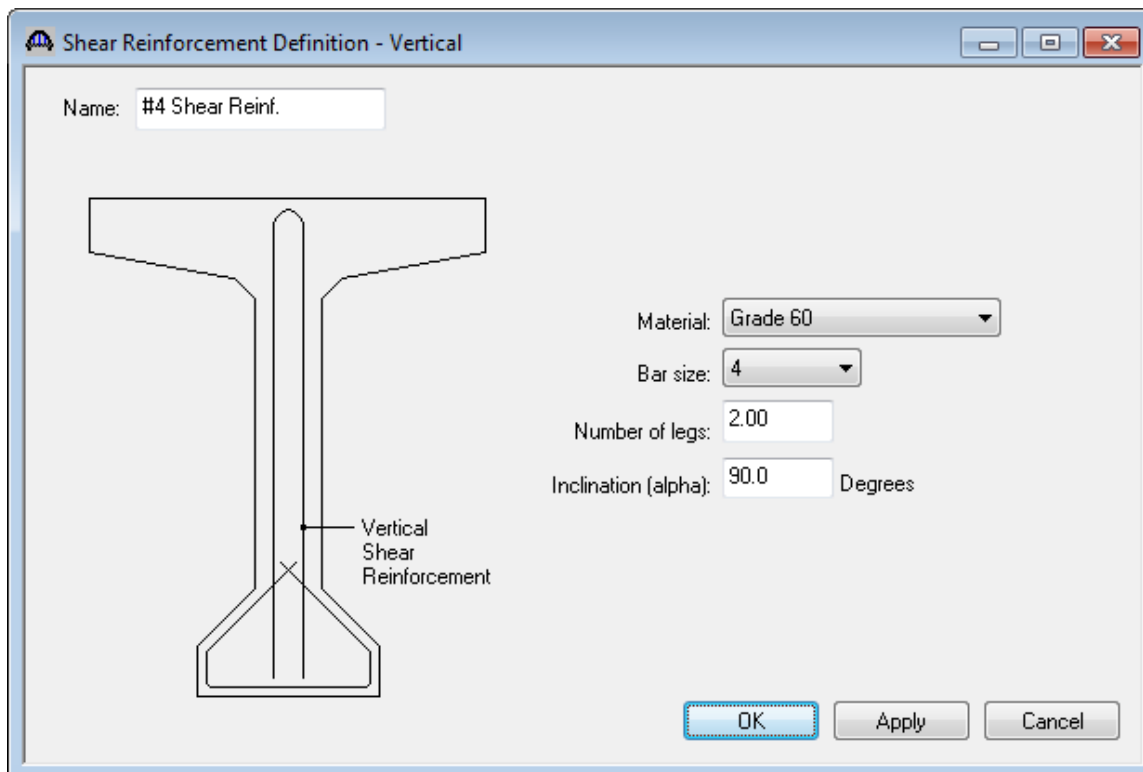


The Prestress Properties dialog box is shown with the following settings:

- Name: 1/2" LR AASHTO Loss
- General P/S Data tab is selected.
- P/S strand material: 1/2" (7W-270) LR
- Loss method: AASHTO Approximate
- Jacking stress ratio: 0.750
- P/S transfer stress ratio: (empty)
- Transfer time: 24.0 Hours
- Age at deck placement: 30.00 Days
- Final age: 1825.00 Days
- Loss Data - AASHTO section: Percentage DL: 0.0 %
- Include elastic gains: ☐

Buttons: 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.



The Shear Reinforcement Definition - Vertical dialog box is shown with the following settings:

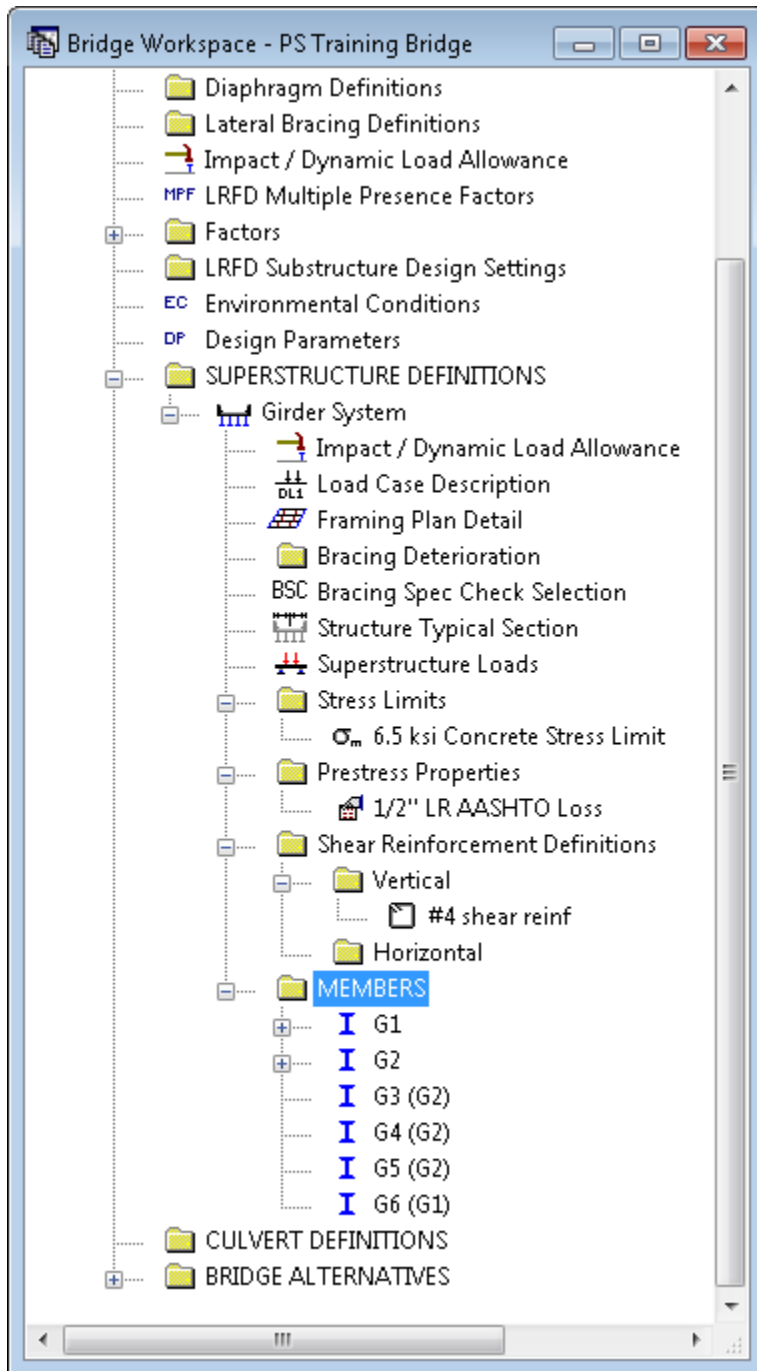
- Name: #4 Shear Reinf.
- Material: Grade 60
- Bar size: 4
- Number of legs: 2.00
- Inclination (alpha): 90.0 Degrees

A diagram of a T-beam cross-section is shown on the left, with a label "Vertical Shear Reinforcement" pointing to the vertical bars in the stem.

Buttons: OK, Apply, Cancel

PS1 - SimpleSpanPSIBeamExample

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.

Member name: Link with:

Description:

Existing	Current	Member Alternative Name	Description

Number of spans:

Span No.	Span Length (ft)
1	120.00

OK Apply Cancel

Defining a Member Alternative:

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

New Member Alternative

Material Type:

- Prestressed (Pretensioned) Concrete
- Reinforced Concrete
- Steel
- Timber

Girder Type:

- PS Precast Box
- PS Precast I
- PS Precast Tee
- PS Precast U

OK Cancel

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

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

Member Alternative:

Description | 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:

Self Load

Load case:

Additional self load = kip/ft

Additional self load = %

Crack control parameter (Z)

Top of beam: kip/in

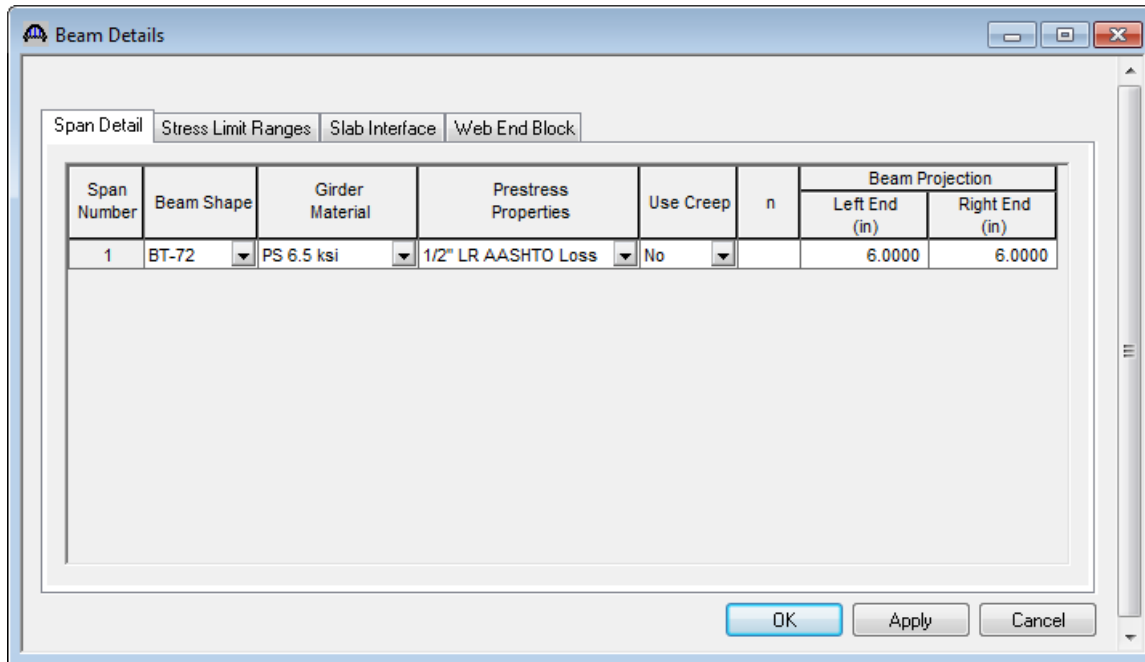
Bottom of beam: kip/in

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.



Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	BT-72	PS 6.5 ksi	1/2" LR AASHTO Loss	No		6.0000	6.0000

OK Apply Cancel

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.

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 compute distribution factor. If adjacent members have not been entered, it will assume they are the same. 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 compute the distribution factors for you.

Live Load Distribution

Standard **LRFD**

Distribution Factor Input Method

☒ Use Simplified Method ☐ Use Advanced Method

☐ Allow distribution factors to be used to compute effects of permit loads with routine traffic

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.222	1.222	1.222	0.333
Multi-Lane	1.222	1.222	1.222	1.000

Compute from Typical Section... View Calcs

OK Apply Cancel

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.

Beam Details

Span Detail **Stress Limit Ranges** Slab Interface Web End Block

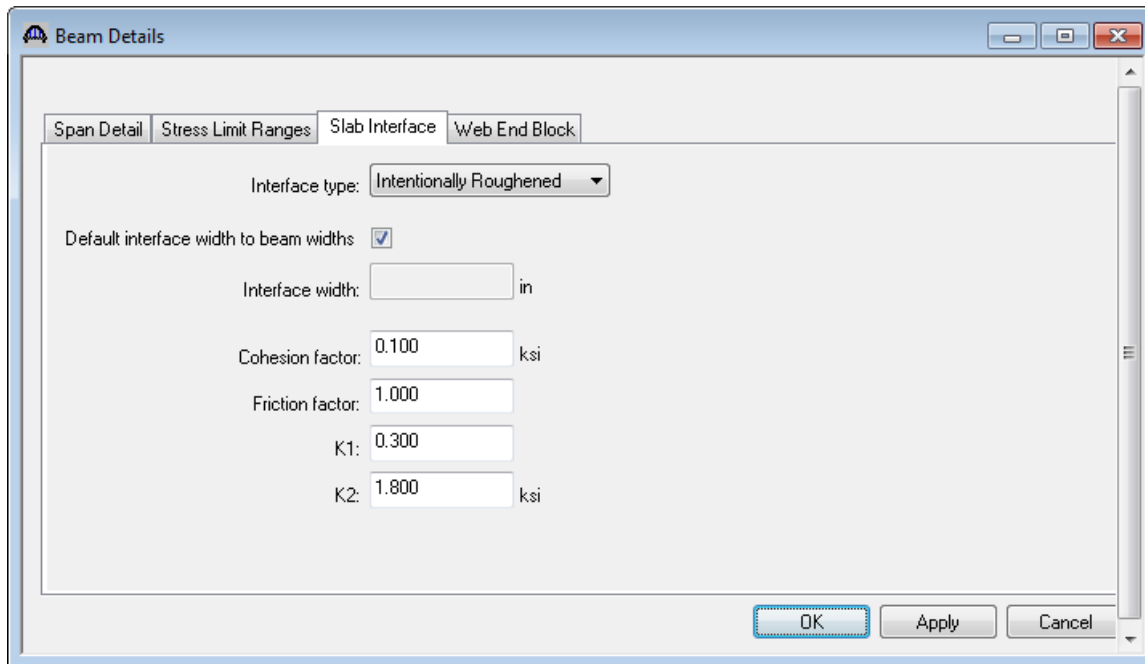
Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	6.5 ksi Concrete Stress Limit	0.00	121.00	121.00

New Duplicate Delete

OK Apply Cancel

PS1 - SimpleSpanPSIBeamExample

Enter value in Slab Interface tab as shown below.



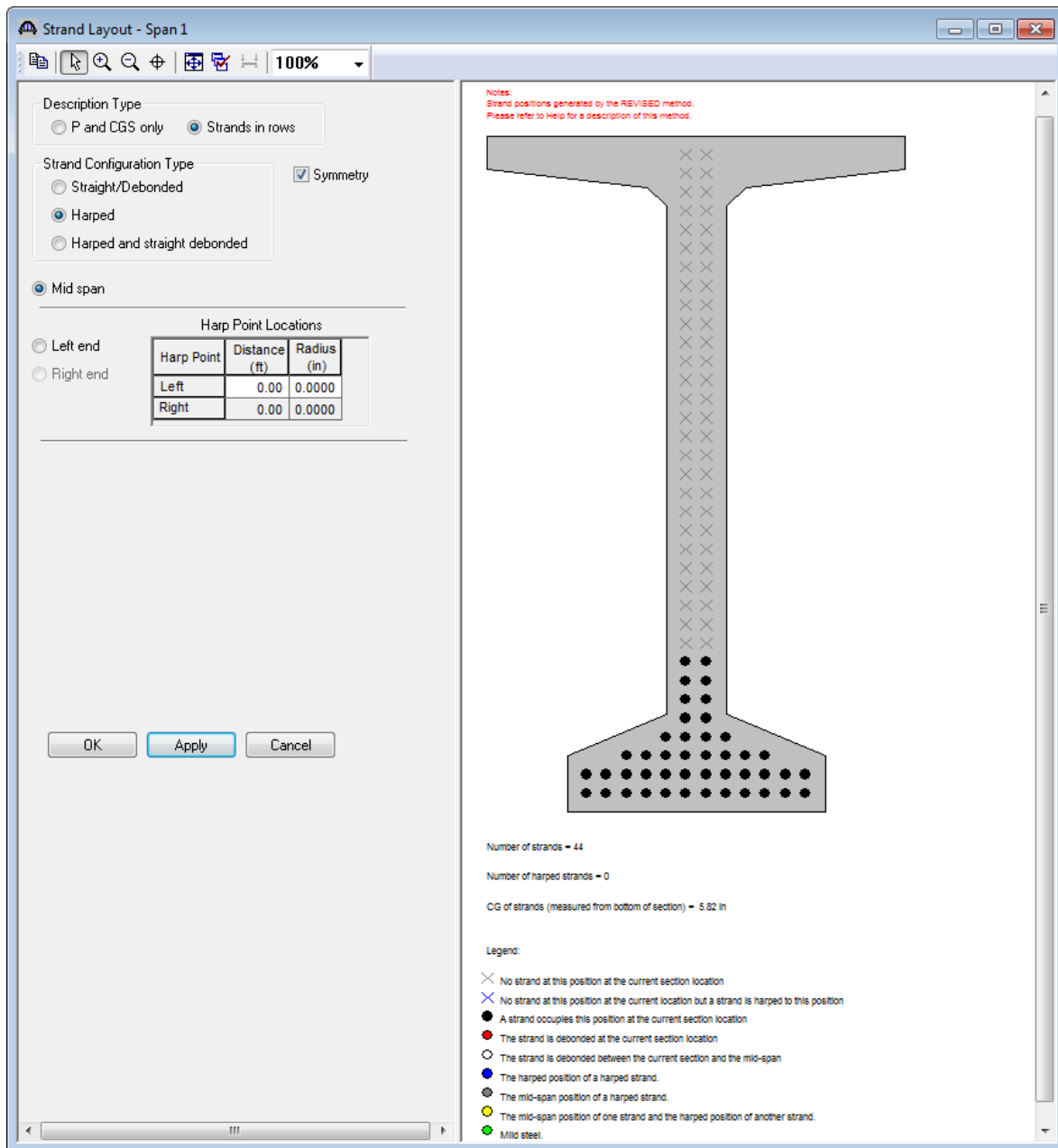
The screenshot shows the 'Beam Details' dialog box with the 'Slab Interface' tab selected. The 'Interface type' is set to 'Intentionally Roughened'. The 'Default interface width to beam widths' checkbox is checked. The 'Interface width' is set to an empty text box followed by 'in'. The 'Cohesion factor' is set to '0.100' ksi. The 'Friction factor' is set to '1.000'. 'K1' is set to '0.300' and 'K2' is set to '1.800' ksi. The 'OK', 'Apply', and 'Cancel' buttons are at the bottom right.

Parameter	Value	Unit
Interface type	Intentionally Roughened	
Default interface width to beam widths	<input checked="" type="checkbox"/>	
Interface width		in
Cohesion factor	0.100	ksi
Friction factor	1.000	
K1	0.300	
K2	1.800	ksi

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

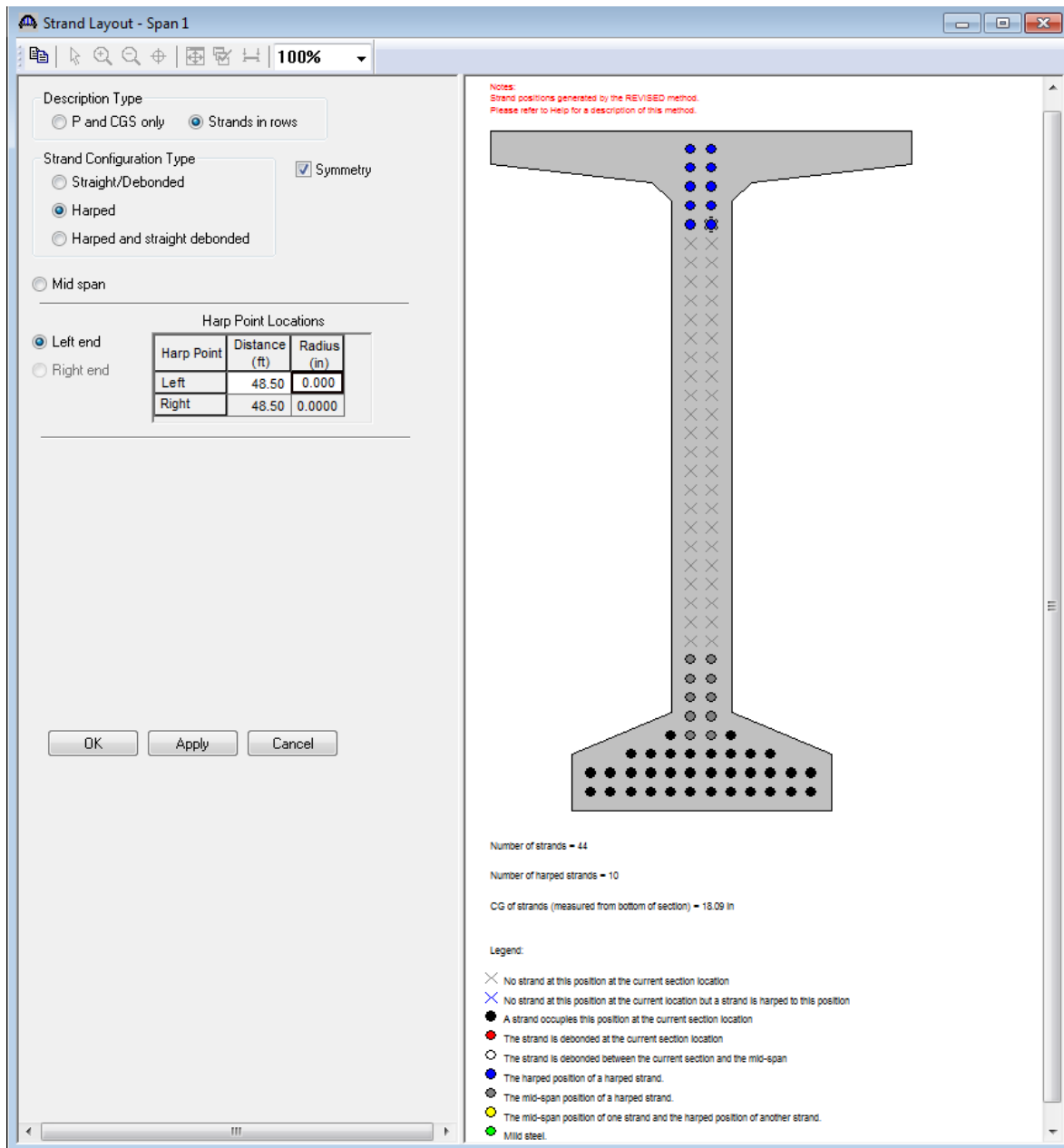
Expand the tree under Strand Layout and open the Span 1 window. Place the cursor in the schematic view on the right side of the screen. The toolbar buttons in this window will become active. Select the Zoom button to shrink the schematic of the beam shape so that the entire beam is visible.

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.



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 strand locations in the right hand schematic. Select the top 10 strand locations 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.

PS1 - SimpleSpanPSIBeamExample



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

PS1 - SimpleSpanPSIBeamExample

Deck Profile

Type: PS Precast I

Deck Concrete Reinforcement

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	

Compute from Typical Section...

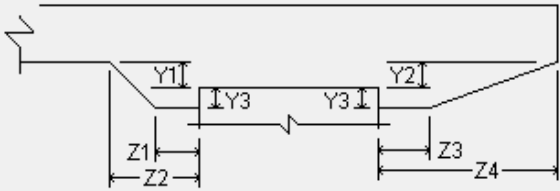
New Duplicate Delete

OK Apply Cancel

No reinforcement is described.

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

PS Haunch Profile



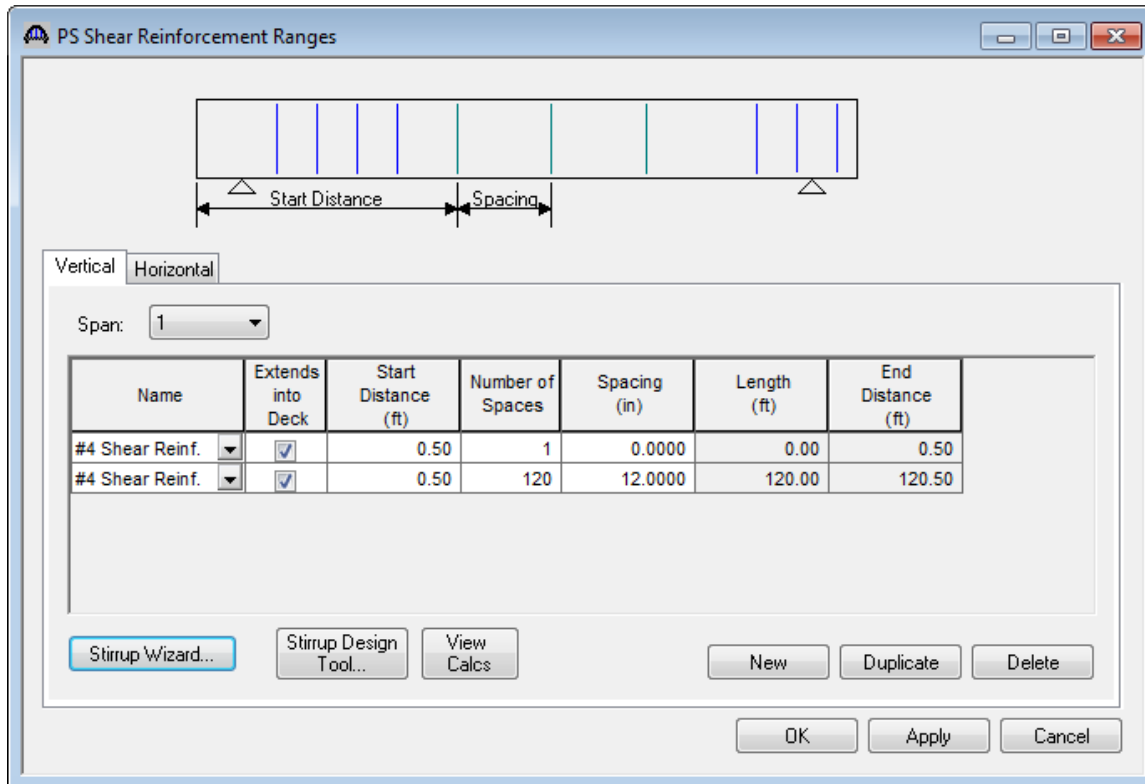
Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Z3 (in)	Z4 (in)	Y1 (in)	Y2 (in)	Y3 (in)
1	0.00	120.00	120.00	0.0000	0.0000	0.0000	0.0000	0.5000	0.5000	0.0000

New Duplicate Delete

OK Apply Cancel

PS1 - SimpleSpanPSIBeamExample

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 dialog box titled "PS Shear Reinforcement Ranges" features a graphical representation of a beam with vertical reinforcement lines. Below the diagram, the "Vertical" tab is selected, showing a "Span:" dropdown set to "1". A table lists the reinforcement details for two spans. The first span has a start distance of 0.50 ft, 1 space, and a spacing of 0.0000 in. The second span has a start distance of 0.50 ft, 120 spaces, and a spacing of 12.0000 in. The table also indicates that the reinforcement extends into the deck. At the bottom, there are buttons for "Stirrup Wizard...", "Stirrup Design Tool...", "View Calcs", "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

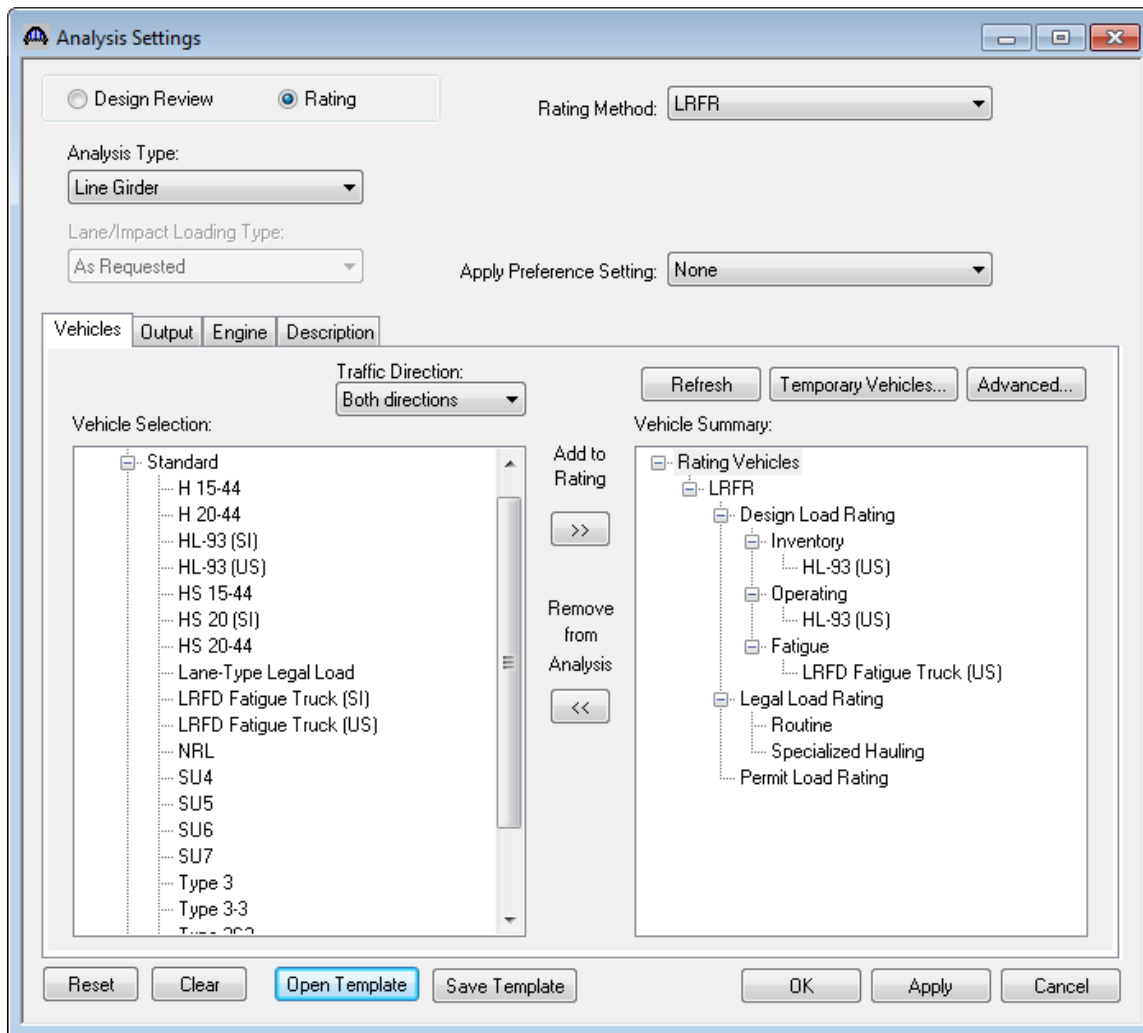
Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Shear Reinf.	<input checked="" type="checkbox"/>	0.50	1	0.0000	0.00	0.50
#4 Shear Reinf.	<input checked="" type="checkbox"/>	0.50	120	12.0000	120.00	120.50

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.

PS1 - SimpleSpanPSIBeamExample



Analysis Settings

☐ Design Review ☒ Rating Rating Method: LRFR

Analysis Type: Line Girder

Lane/Impact Loading Type: As Requested Apply Preference Setting: None

Vehicles Output Engine Description

Traffic Direction: Both directions

Vehicle Selection:

- Standard
 - H 15-44
 - H 20-44
 - HL-93 (SI)
 - HL-93 (US)
 - HS 15-44
 - HS 20 (SI)
 - HS 20-44
 - Lane-Type Legal Load
 - LRFD Fatigue Truck (SI)
 - LRFD Fatigue Truck (US)
 - NRL
 - SU4
 - SU5
 - SU6
 - SU7
 - Type 3
 - Type 3-3

Add to Rating >>

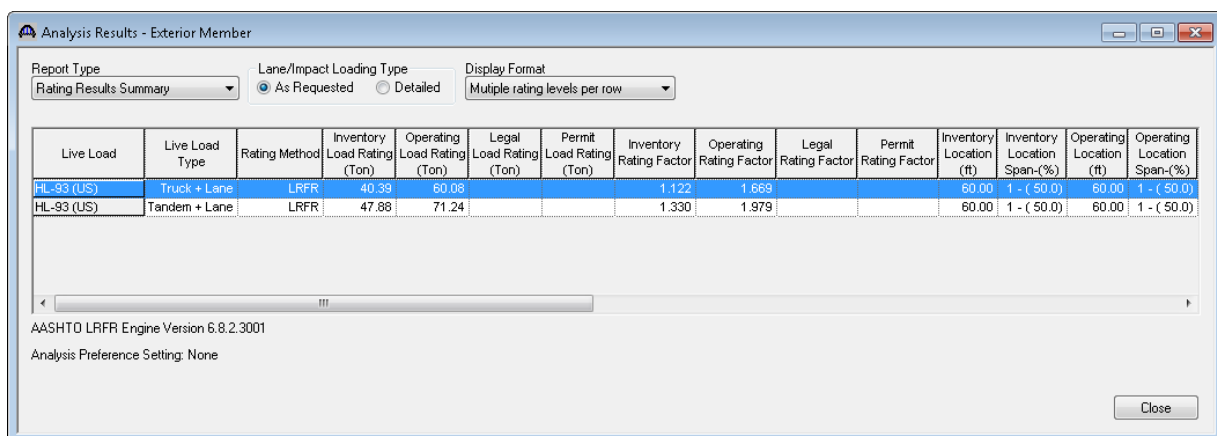
Remove from Analysis <<

Vehicle Summary:

- Rating Vehicles
 - LRFR
 - Design Load Rating
 - Inventory
 - HL-93 (US)
 - Operating
 - HL-93 (US)
 - Fatigue
 - LRFD Fatigue Truck (US)
 - Legal Load Rating
 - Routine
 - Specialized Hauling
 - Permit Load Rating

Reset Clear **Open Template** Save Template OK Apply Cancel

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.



Analysis Results - Exterior Member

Report Type: Rating Results Summary Lane/Impact Loading Type: As Requested Display Format: Multiple rating levels per row

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	40.39	60.08			1.122	1.669			60.00	1 - (.50.0)	60.00	1 - (.50.0)
HL-93 (US)	Tandem + Lane	LRFR	47.68	71.24			1.330	1.979			60.00	1 - (.50.0)	60.00	1 - (.50.0)


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Analysis Preference Setting: None

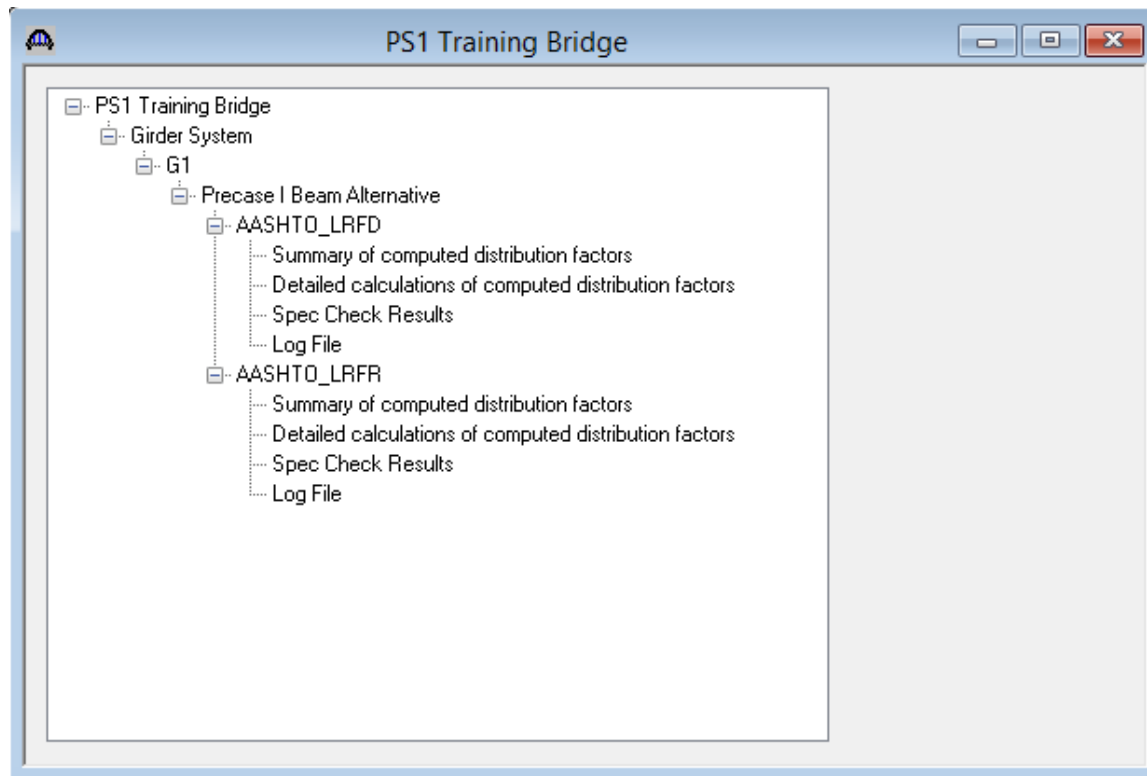
Close

PS1 - SimpleSpanPSIBeamExample

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.

PS1 - SimpleSpanPSIBeamExample



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

Bridge ID : 31
 Bridge : PS 1 Training Bridge
 Superstructure Def : Girder System
 Member : G1
 Analysis Preference Setting : None

NBI Structure ID : PS 1 Tr Bridge
 Bridge Alt :
 Member Alt : Precast I Beam Alternative

[AASHTO LRFD Specification, Edition 7, Interim 2015](#)

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
6.318	-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
113.682	-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