

AASHTOWare BrD 6.8

BrR and BrD Tutorial

PS6 – Skewed, Simple Span Prestressed I Beam Example

BrR and BrD Training

PS6 – Skewed, Simple Span Prestressed I Beam Example

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

PS6TrainingBridge

Bridge ID: PS6TrainingBridge NBI Structure ID (8): PS6TrainingBrid Template Superstructures
 Bridge Completely Defined Culverts

Description Description (cont'd) Alternatives Global Reference Point Traffic Custom Agency Fields

Name: Skewed PS I Beam Bridge Year Built:

Description:

Location: Length: ft

Facility Carried (7): Route Number:

Feat. Intersected (6): Mi. Post:

Default Units: US Customary

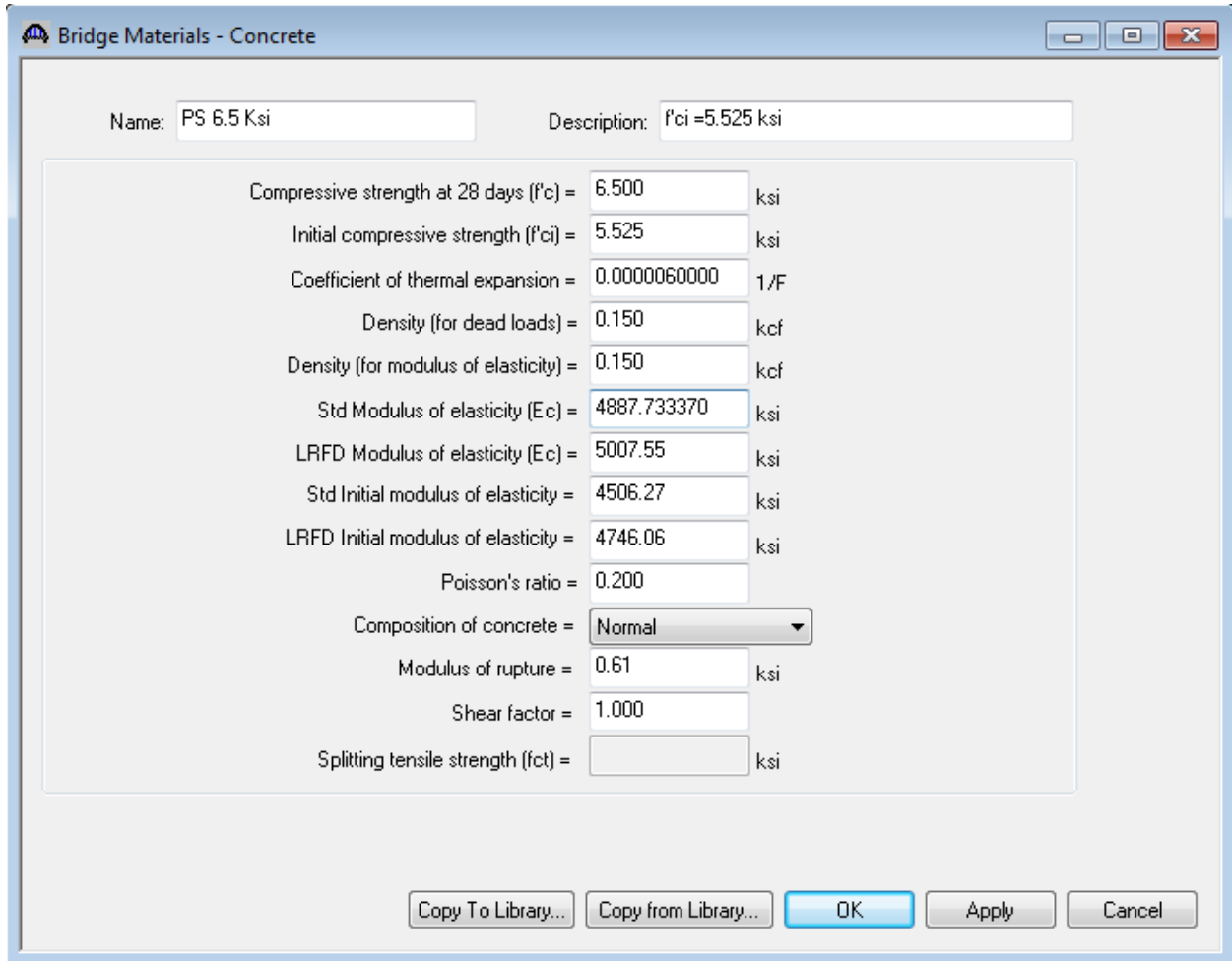
AASHTOWare Association... BrR BrD BrM

OK Apply Cancel

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

PS6 – Skewed, Simple Span Prestressed I Beam Example

To enter the materials to be used by members of the bridge, click on the **+** to expand the tree for Materials. 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). Fill in the data for the beam concrete material as shown below:



The screenshot shows a software window titled "Bridge Materials - Concrete". It contains several input fields for defining material properties. The "Name" field is set to "PS 6.5 Ksi" and the "Description" field is set to "f'ci =5.525 ksi". The main area contains the following properties and values:

Property	Value	Unit
Compressive strength at 28 days (f'c) =	6.500	ksi
Initial compressive strength (f'ci) =	5.525	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) =	4887.733370	ksi
LRFD Modulus of elasticity (Ec) =	5007.55	ksi
Std Initial modulus of elasticity =	4506.27	ksi
LRFD Initial modulus of elasticity =	4746.06	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.61	ksi
Shear factor =	1.000	
Splitting tensile strength (fct) =		ksi

At the bottom of the window, there are five buttons: "Copy To Library...", "Copy from Library...", "OK", "Apply", and "Cancel".

PS6 – Skewed, Simple Span Prestressed I Beam Example

Add a concrete material for the deck by entering the following data. Add a reinforcement material and prestress strand using the Copy from Library techniques. The windows will look like those shown below:

Bridge Materials - Concrete

Name: Deck Concrete Description:

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) = 0.145 kcf

Std Modulus of elasticity (Ec) = 3865.20 ksi

LRFD Modulus of elasticity (Ec) = 4144.55 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 = 1.000

Splitting tensile strength (fct) = ksi

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

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Bridge Materials - Reinforcing Steel

Name: Grade 60 Description: 60 ksi reinforcing steel

Material Properties

Specified yield strength (F_y) = 60.000 ksi

Modulus of elasticity (E_s) = 29000.00 ksi

Ultimate strength (F_u) = 90.000 ksi

Type

- Plain
- Epoxy
- Galvanized
- Other

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

Bridge Materials - PS Strand

Name: 1/2" (7W-270) LR Description: Low relaxation 1/2"/Seven Wire/fpu = 270

Strand diameter = 0.5000 in

Strand area = 0.153 in²

Strand type = Low Relaxation

Ultimate tensile strength (F_u) = 270.000 ksi

Yield strength (F_y) = 243.000 ksi

Modulus of elasticity (E) = 28500.00 ksi

Transfer length (Std) = 25.0000 in

Transfer length (LRFD) = 30.0000 in

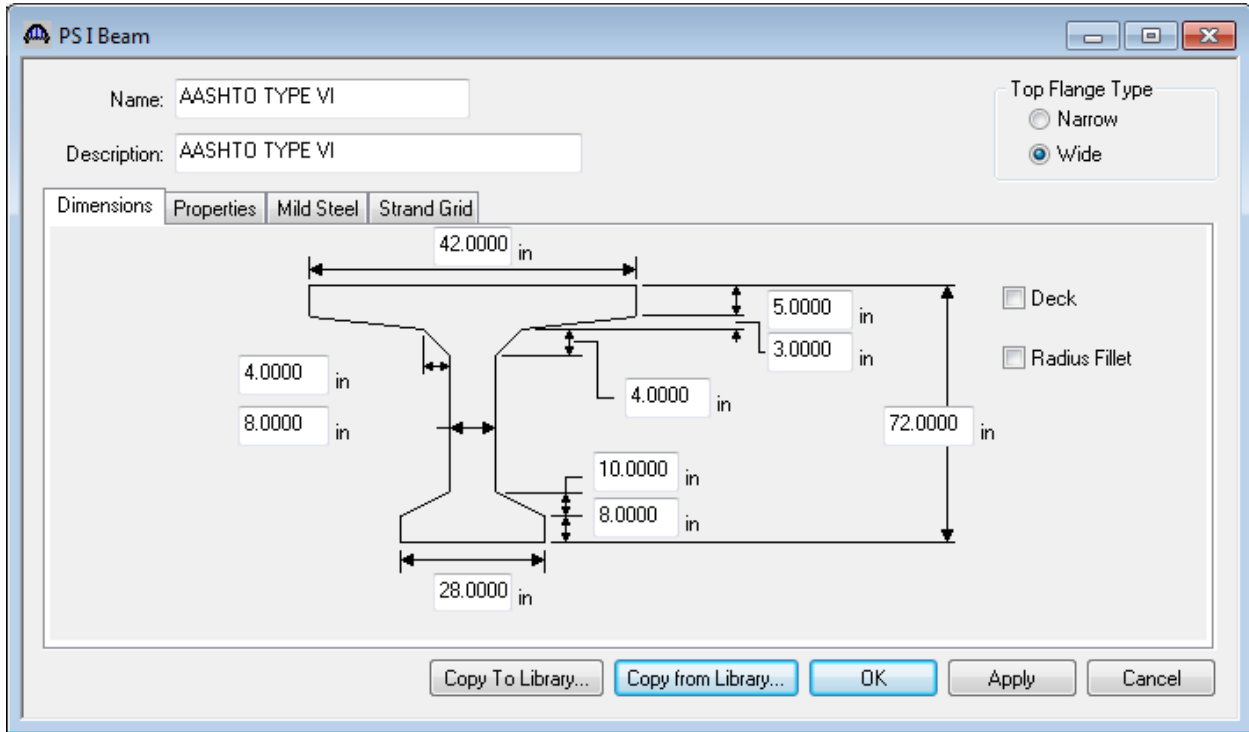
Unit load per length = 0.520 lb/ft

Epoxy coated

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

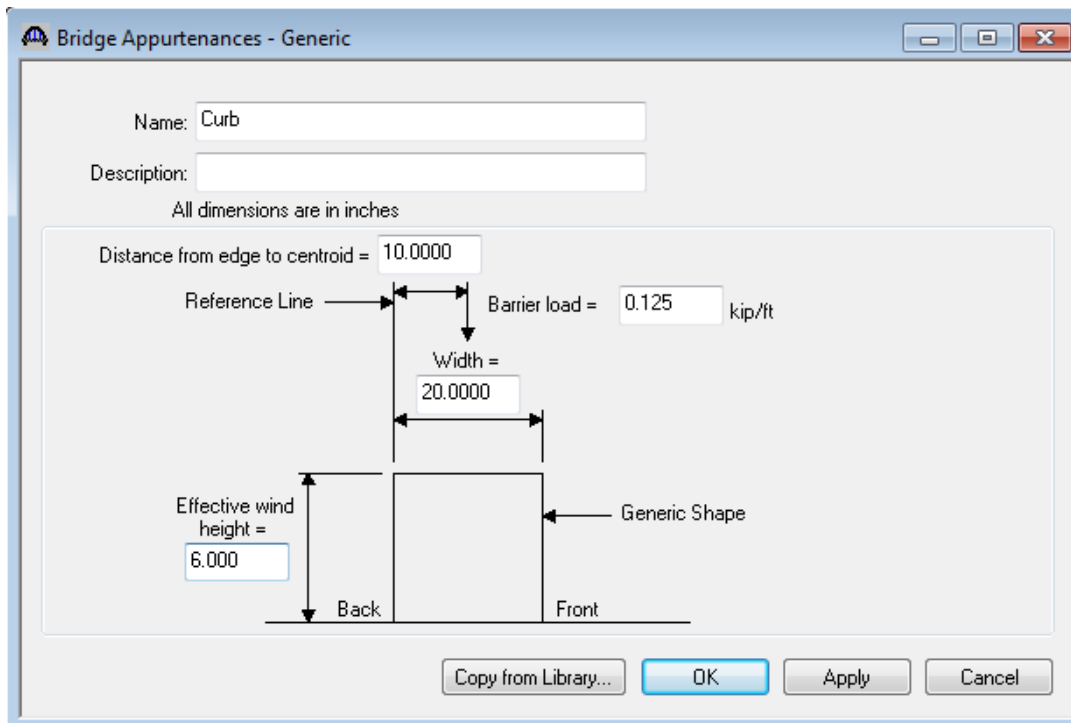
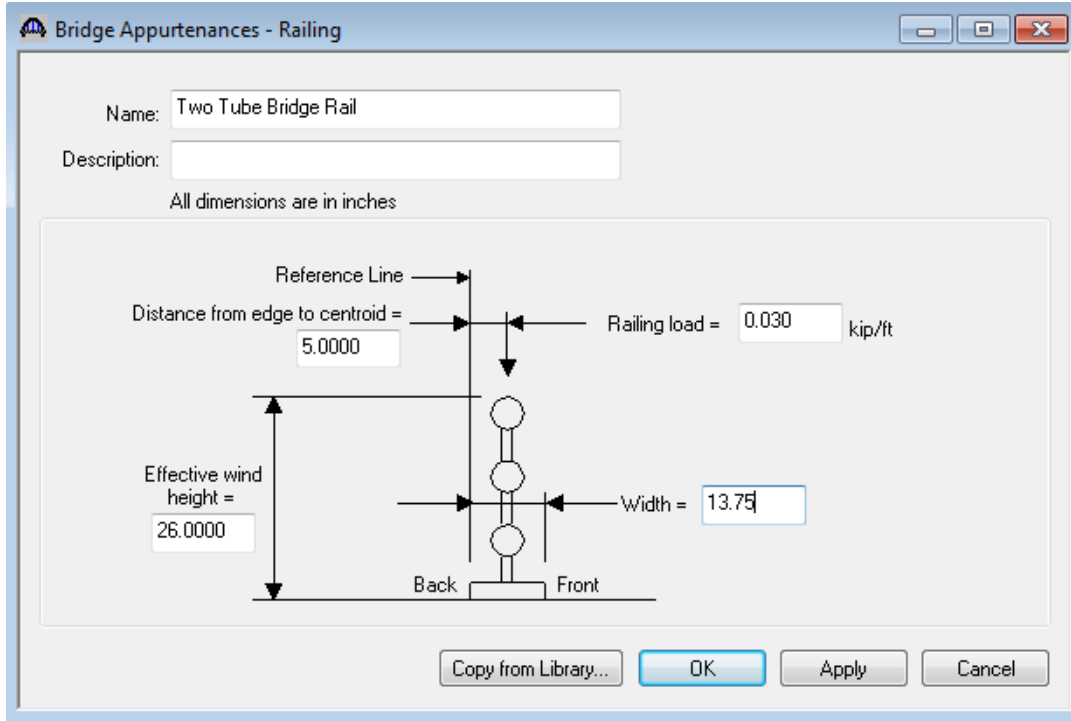
PS6 – Skewed, Simple Span Prestressed I Beam Example

To enter a prestress beam shape to be used in this bridge expand the tree item labeled Beam Shapes. Click on I-Beams in the tree and select File/New from the menu (or double click on I Beams in the tree). Select the Top Flange Type as Wide and click on the Copy from Library button. Select AASHTO Type VI and click Ok. The beam properties are copied to the I Beam window as shown below.



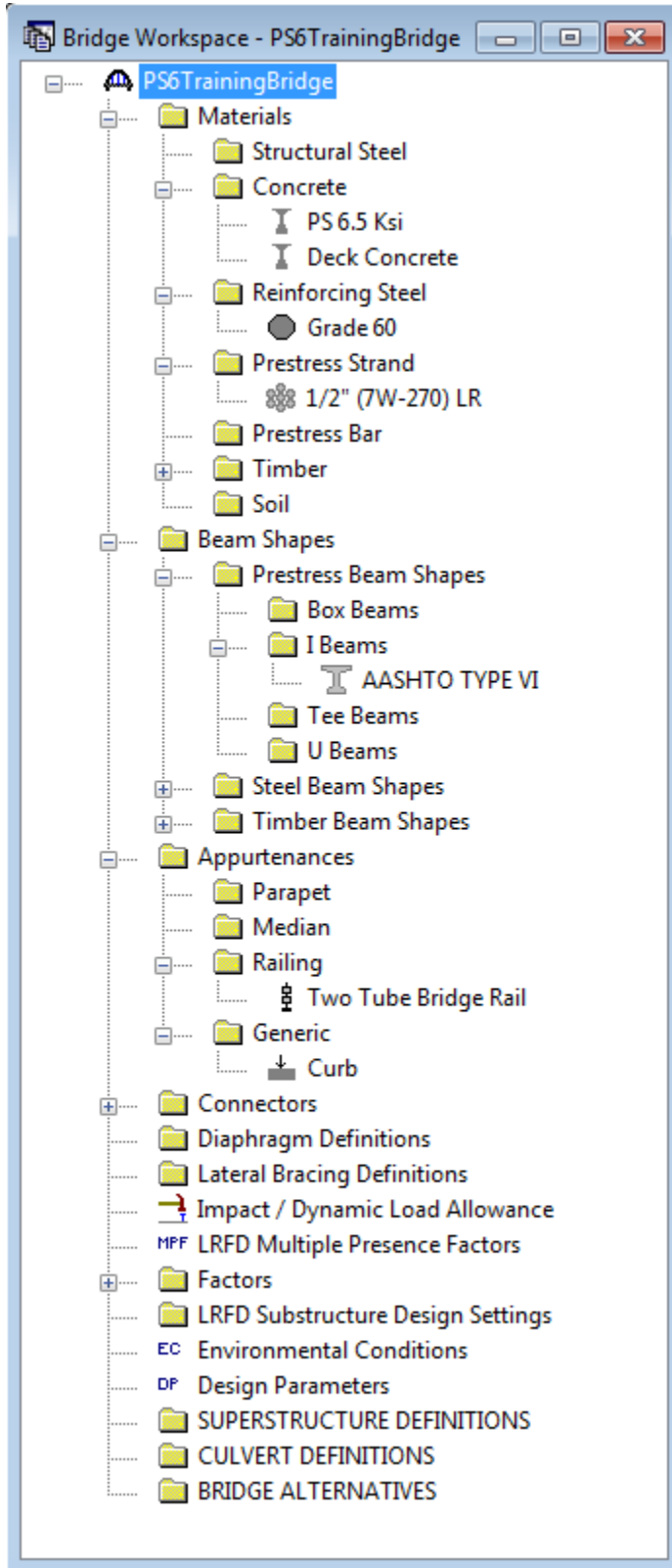
PS6 – Skewed, Simple Span Prestressed I Beam Example

To enter the appurtenances to be used within the bridge expand the tree branch labeled Appurtenances. This bridge has a steel railing mounted on top of a concrete curb. Define a Railing appurtenance to model the steel railing and a Generic appurtenance to model the concrete curb. The completed windows are shown below:



PS6 – Skewed, Simple Span Prestressed I Beam Example

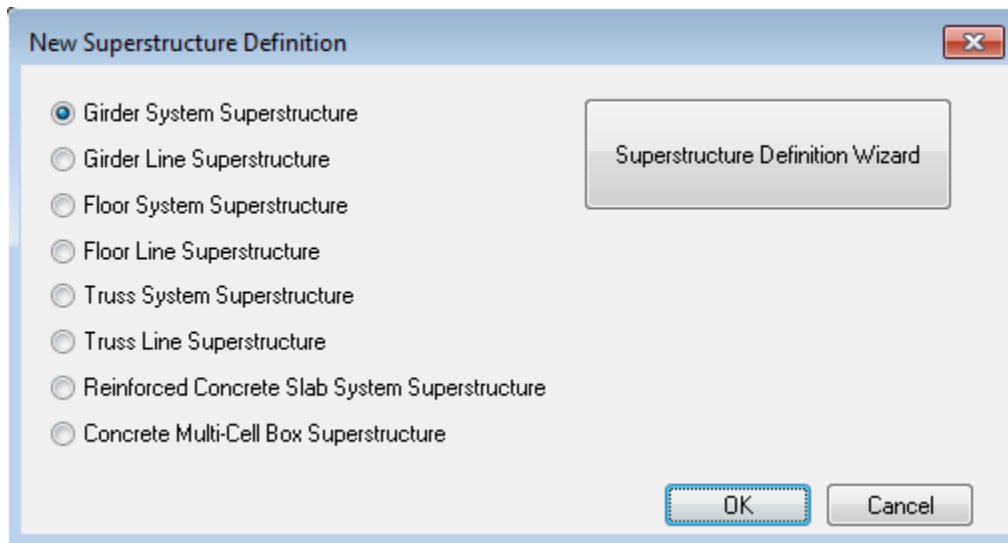
The Bridge Workspace is shown below:



PS6 – Skewed, Simple Span Prestressed I Beam Example

The default impact factors, standard LRFD and LFD factors will be used 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.



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

Girder System Superstructure Definition

Definition | Analysis | Specs | Engine

Name: 1 Span, 5 Girder System

Description:

Default Units: US Customary

Number of spans: 1

Number of girders: 5

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	121.75

Frame Structure Simplified Definition:

Deck type: Concrete

For PS only

Average humidity: 70.0 %

Member Alt. Types

Steel

P/S

R/C

Timber

Horizontal Curvature Along Reference Line

Horizontal curvature

Distance from PC to first support line: _____ ft

Start tangent length: _____ ft

Radius: _____ ft

Direction: Left

End tangent length: _____ ft

Distance from last support line to PT: _____ ft

Design speed: _____ mph

Superelevation: _____ %

Superstructure Alignment

Curved

Tangent, curved, tangent

Tangent, curved

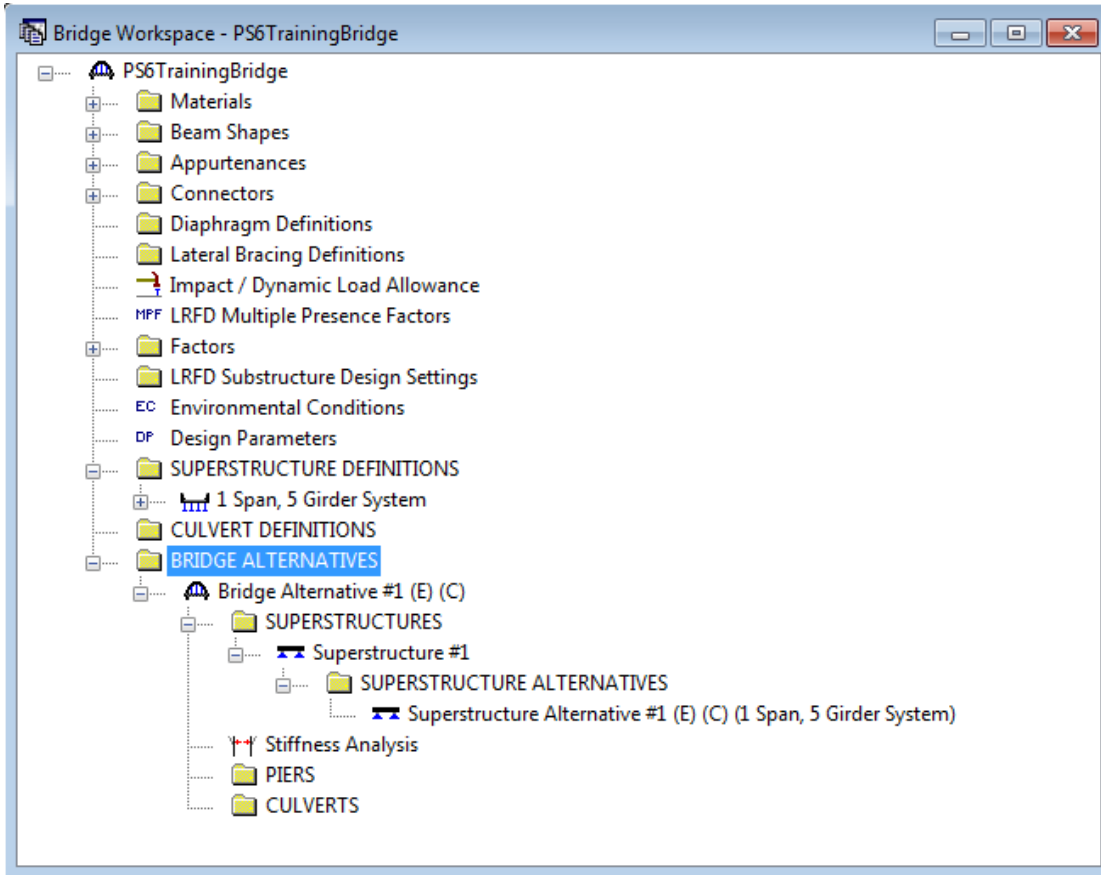
Curved, tangent

OK Apply Cancel

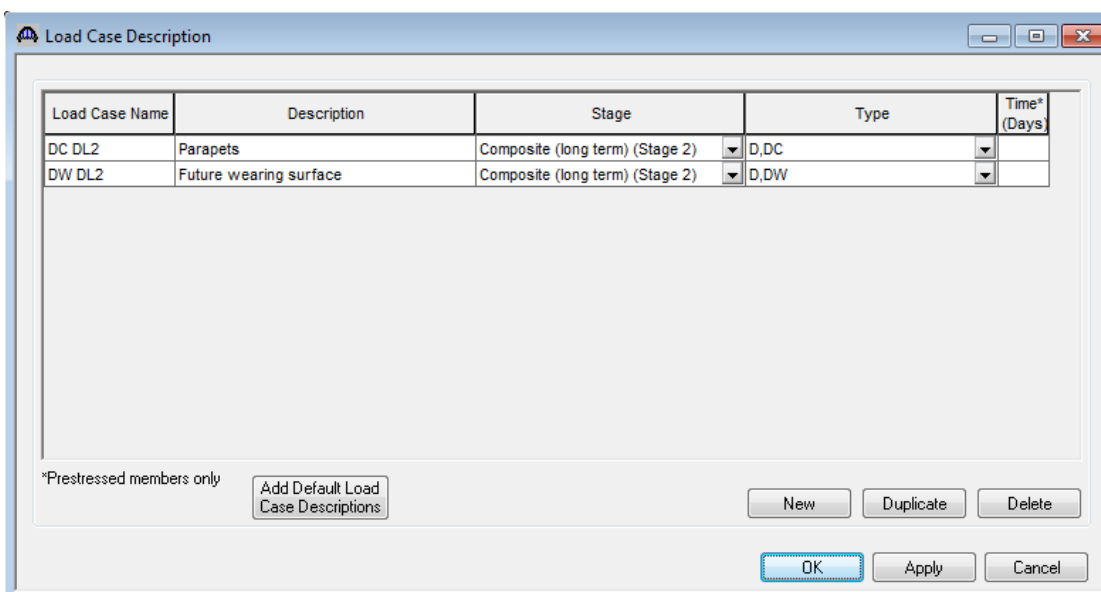
Click on Ok to save the data to memory and close the window.

PS6 – Skewed, Simple Span Prestressed I Beam Example

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Superstructure, and a new Superstructure Alternative. The partially expanded Bridge Workspace tree is shown below:

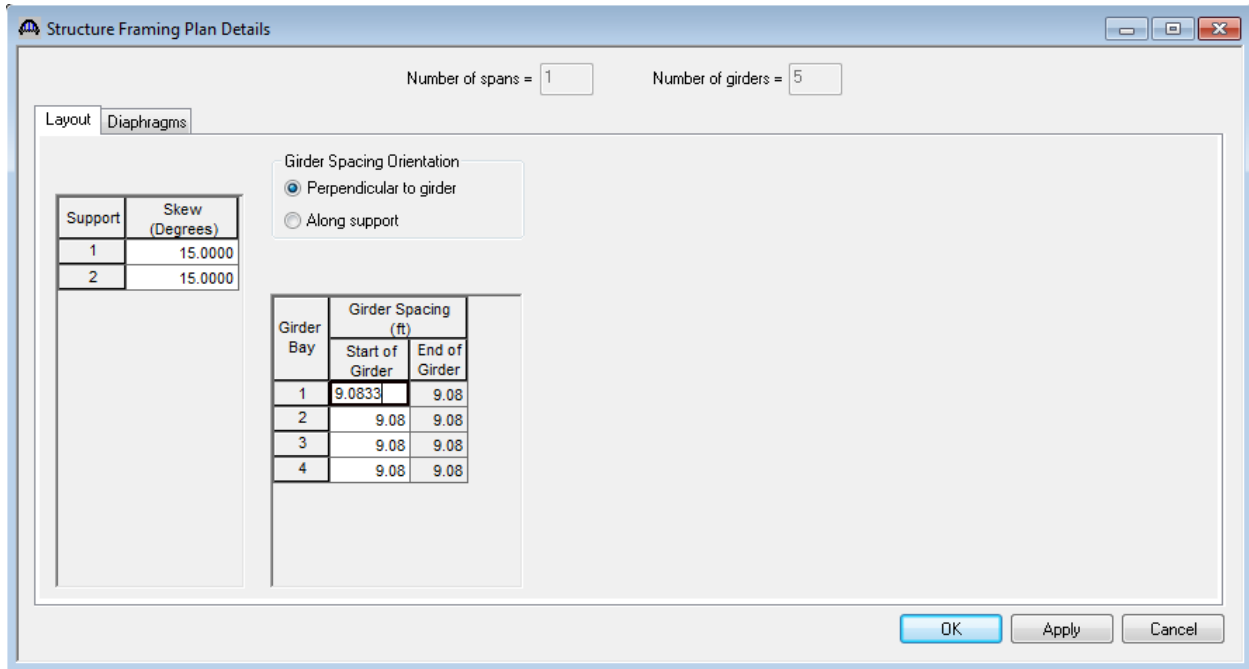


Click Load Case Description to define the dead load cases. The completed Load Case Description window is shown below.



PS6 – Skewed, Simple Span Prestressed I Beam Example

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



The dialog box "Structure Framing Plan Details" has a title bar with standard window controls. At the top, it shows "Number of spans = 1" and "Number of girders = 5". Below this are two tabs: "Layout" and "Diaphragms", with "Diaphragms" selected. The main area contains a "Girder Spacing Orientation" section with two radio buttons: "Perpendicular to girder" (selected) and "Along support". To the left is a table with two columns: "Support" and "Skew (Degrees)".

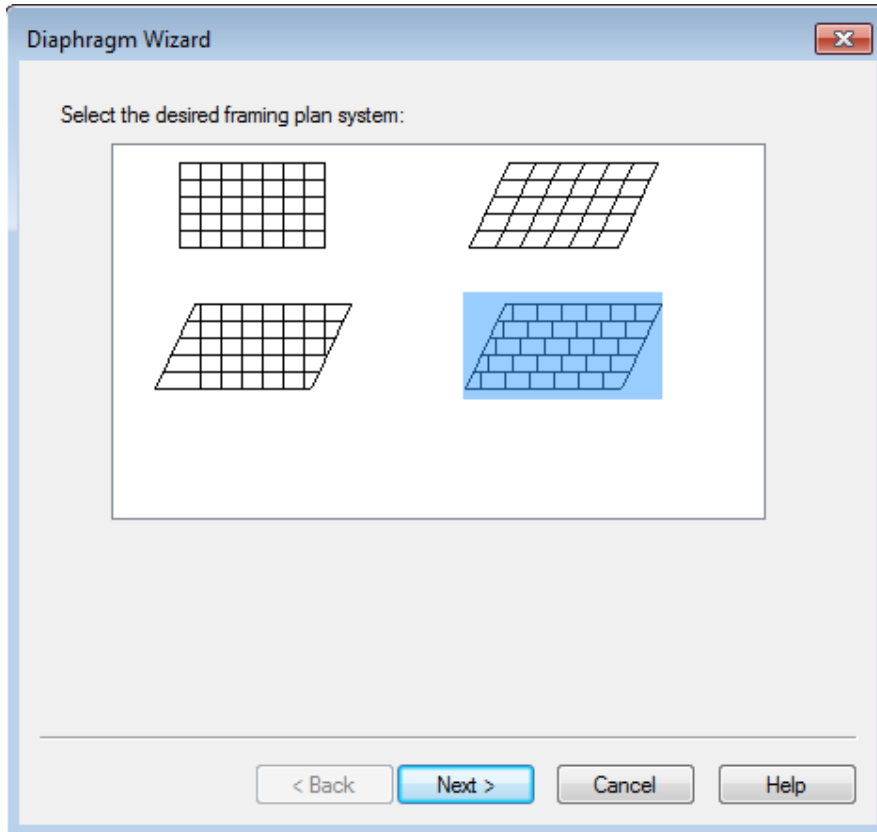
Support	Skew (Degrees)
1	15.0000
2	15.0000

To the right of the orientation section is another table with three columns: "Girder Bay", "Start of Girder", and "End of Girder".

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	9.0833	9.08
2	9.08	9.08
3	9.08	9.08
4	9.08	9.08

At the bottom right are three buttons: "OK", "Apply", and "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.



The "Diaphragm Wizard" dialog box has a title bar with a close button. The main area contains the text "Select the desired framing plan system:" followed by four grid diagrams. The first is a standard rectangular grid. The second is a skewed rectangular grid. The third is a trapezoidal grid. The fourth is a skewed trapezoidal grid, which is highlighted with a blue border. At the bottom are four buttons: "< Back", "Next >" (highlighted), "Cancel", and "Help".

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Enter the following data on the dialog shown below.

The Diaphragm Wizard dialog box includes a diagram of a skewed grid with dimensions D and S. The Diaphragm Spacing section has three options: 'Enter equal spacing per span' (selected), 'Enter groups of equal spacing', and 'Interior diaphragm along skew' (unchecked). The Reference Girder section has 'Left girder' selected and 'Right girder' unselected. There are two input fields for 'Support diaphragm load' and 'Interior diaphragm load', both in kip. A table at the bottom contains the following data:

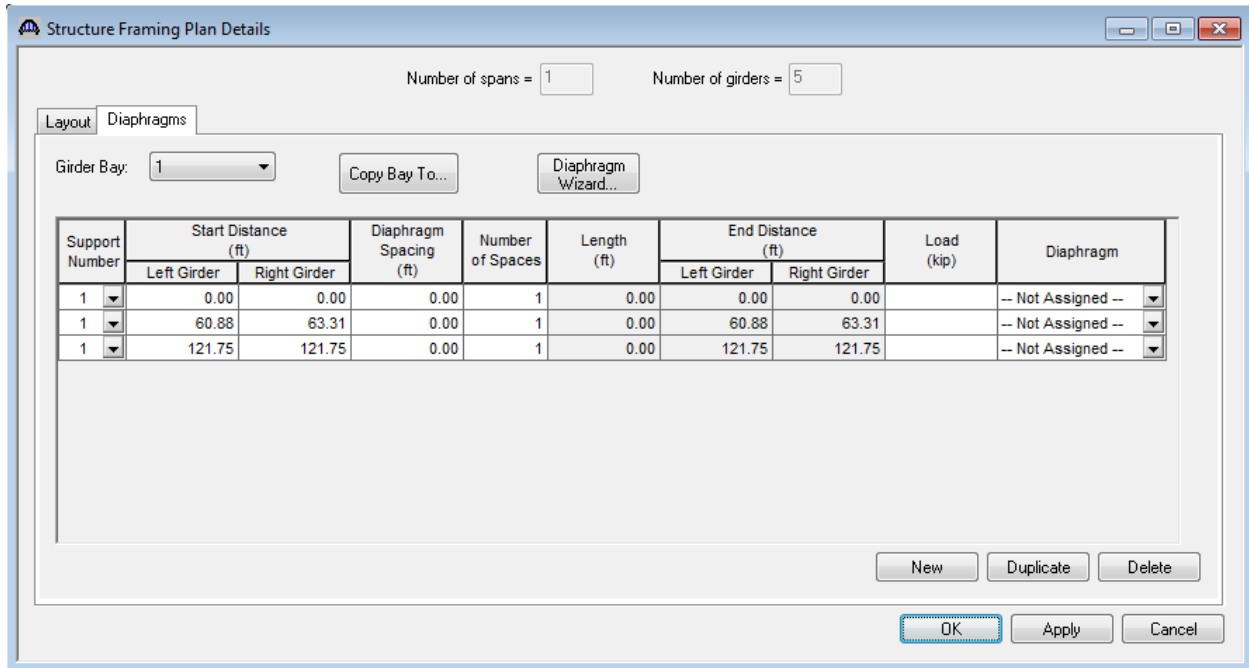
Span	Length (ft)	Distance D (ft)	Equal Spacing S (ft)
1	121.75	60.88	60.875

At the bottom of the dialog are four buttons: '< Back', 'Finish', 'Cancel', and 'Help'.

Click the Finish button to add the diaphragms. The Diaphragm Wizard will create diaphragms for all of the girder bays in the structure.

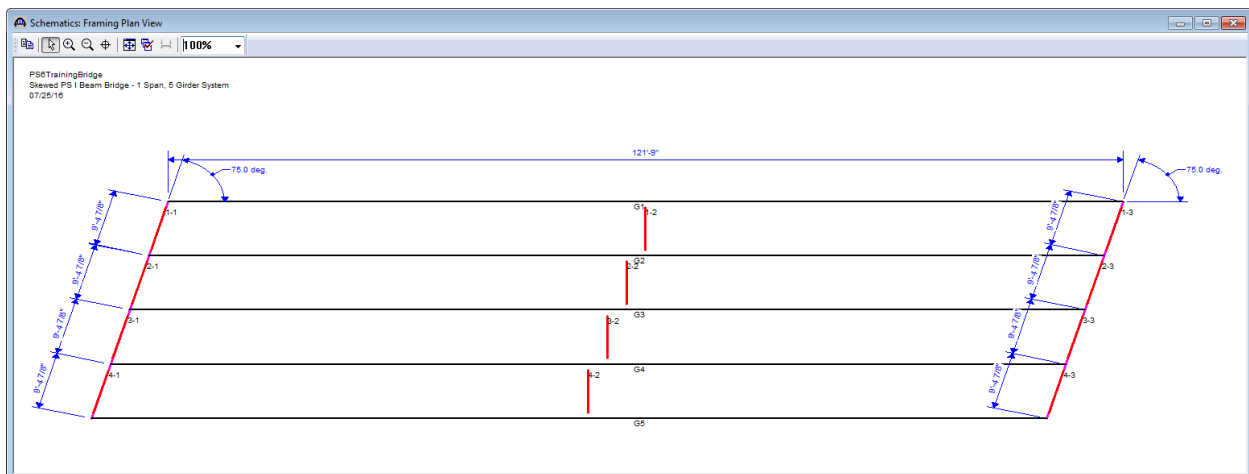
PS6 – Skewed, Simple Span Prestressed I Beam Example

The diaphragms created for Girder Bay 1 are shown below:



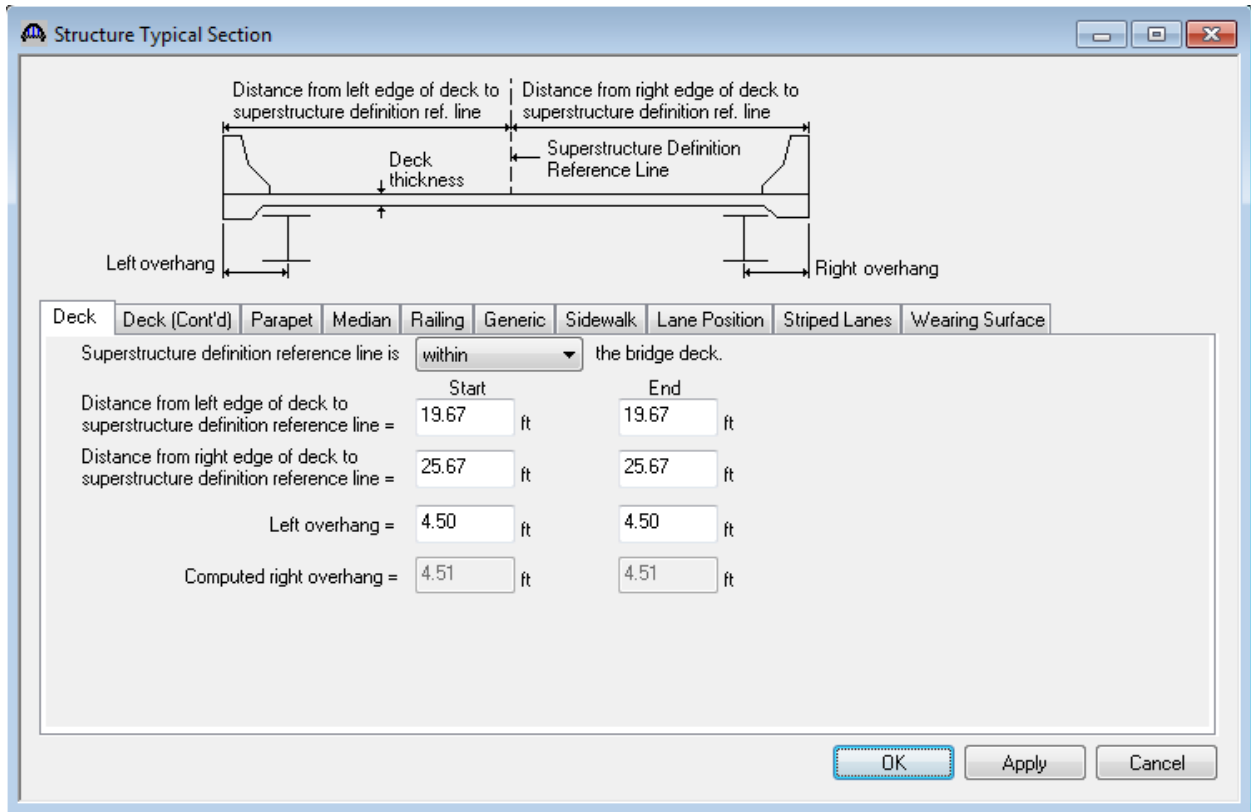
Select Ok to close the window.

The schematic for the framing plan can now be viewed by selecting Framing Plan Detail in the Bridge Workspace tree and clicking the “View Schematic” toolbar button. The following schematic is displayed. Notice that the span length is displayed along the first girder in the plan. Until we visit the Structure Typical Section window, the Superstructure Definition Reference line that we entered the span lengths along in the Girder System Superstructure Definition window is located under the first girder.

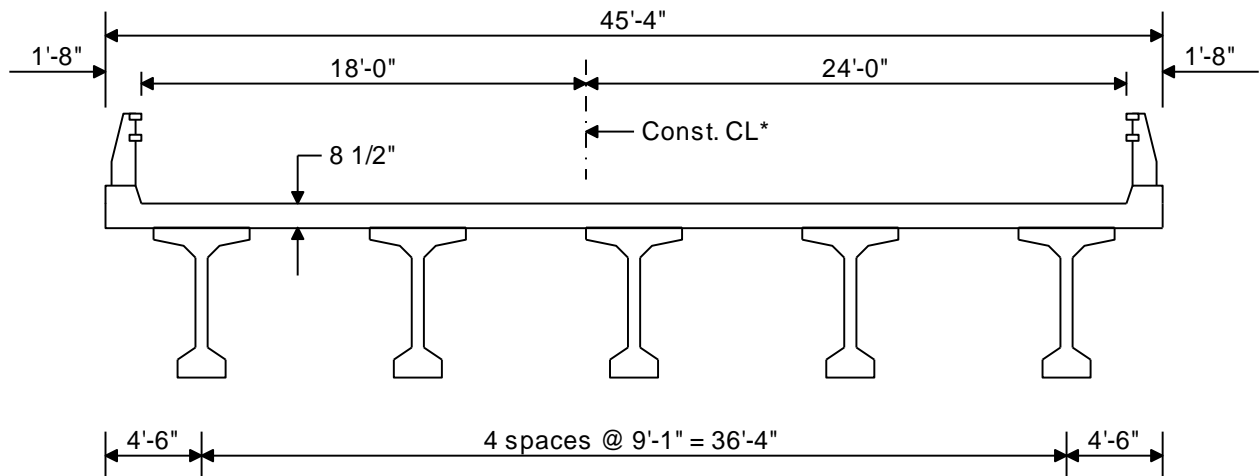


PS6 – Skewed, Simple Span Prestressed I Beam Example

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.



In this example, the Structure Definition Reference line is located at the construction CL in the typical section.



*The construction CL is used as the Structure Definition Reference line in this example

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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.

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: 8.5000 in

Load case: Engine Assigned

Deck crack control parameter: 130.000 kip/in

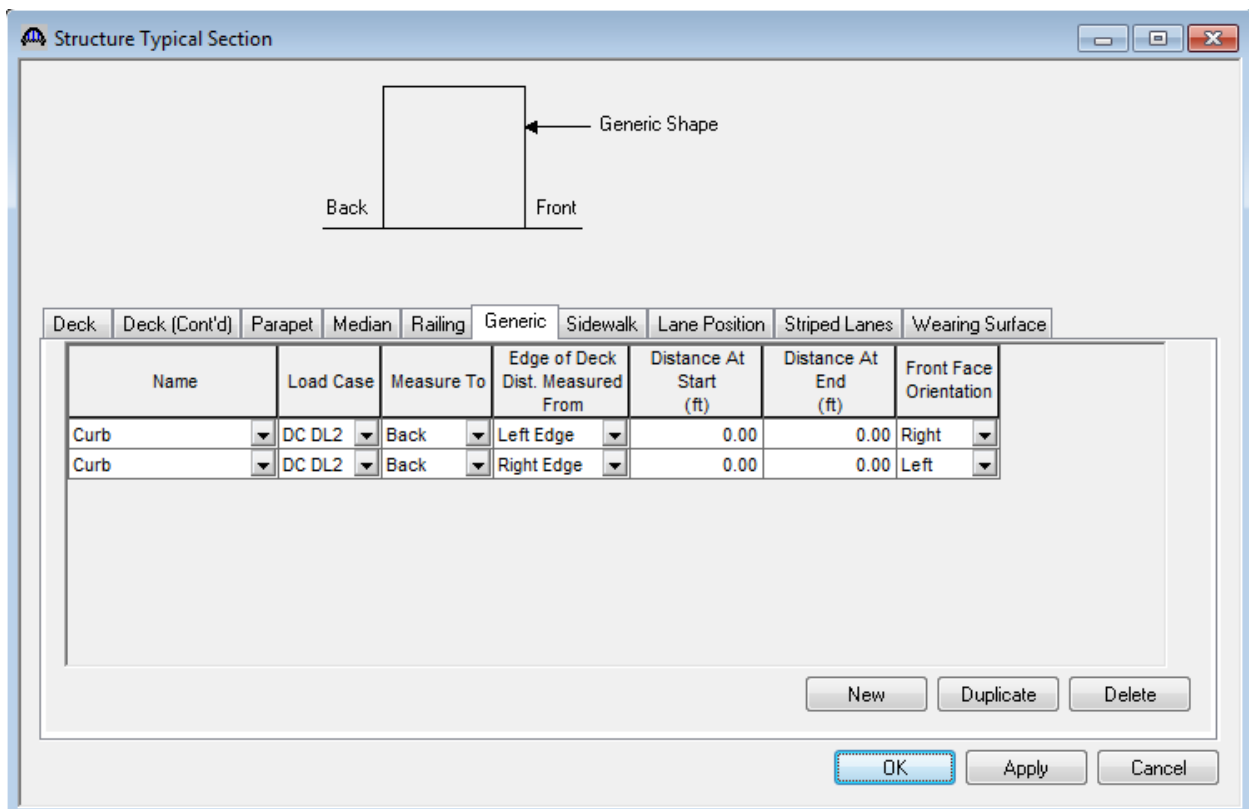
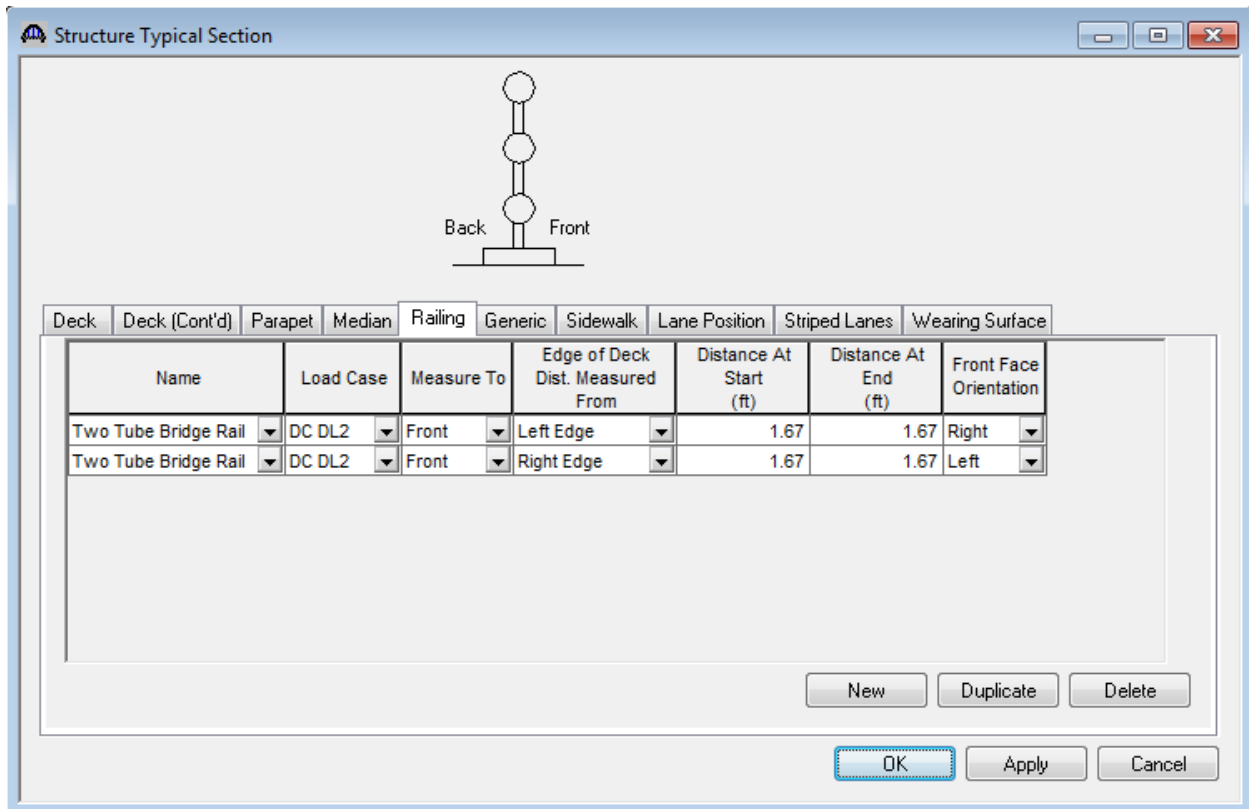
Sustained modular ratio factor: 2.000

Deck exposure factor:

OK Apply Cancel

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Add two steel railings and two generic curbs as follows:



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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 screenshot shows the 'Structure Typical Section' dialog box with the 'Lane Position' tab selected. The diagram at the top illustrates the bridge cross-section with 'Travelway 1' on the left and 'Travelway 2' on the right, separated by a central 'Superstructure Definition Reference Line'. Dimensions (A) and (B) are indicated for the travelway widths. Below the diagram is a table with the following data:

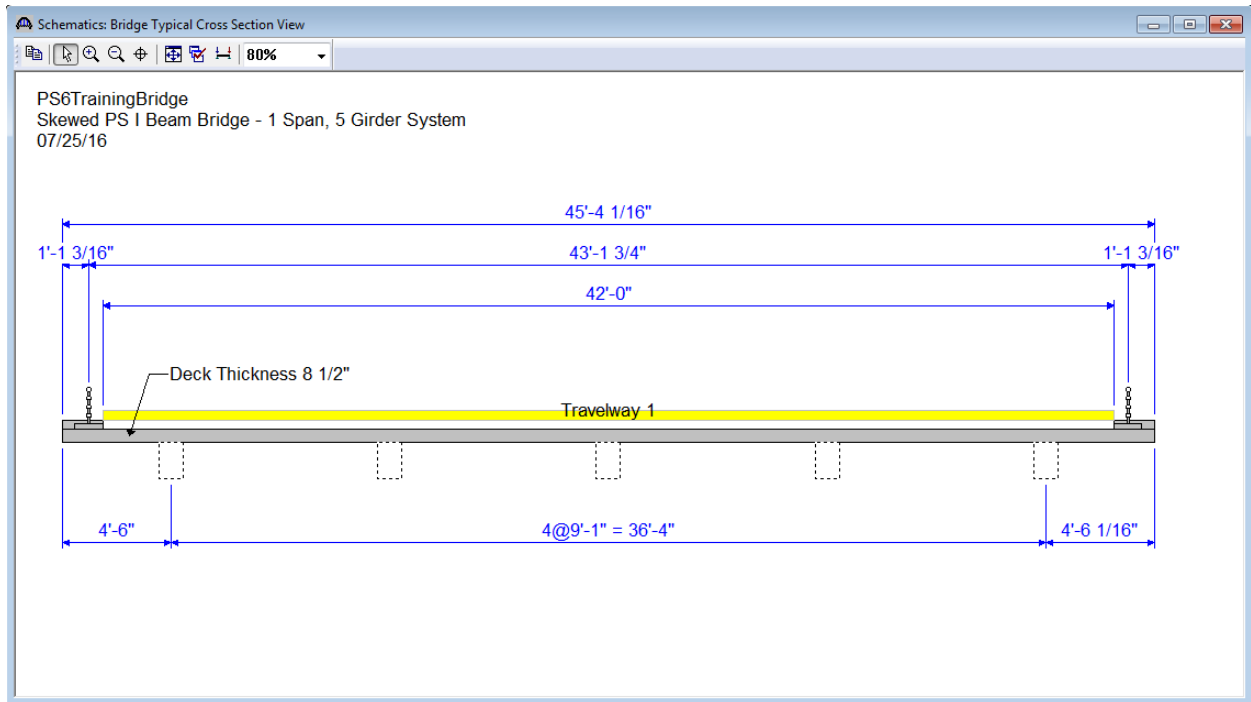
Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-18.00	24.00	-18.00	24.00

Below the table, there are controls for 'LRFD Fatigue' with a 'Lanes available to trucks' input field and an 'Override Truck fraction' checkbox. A 'Compute...' button is located to the right of these controls. At the bottom right, there are buttons for 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel'.

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

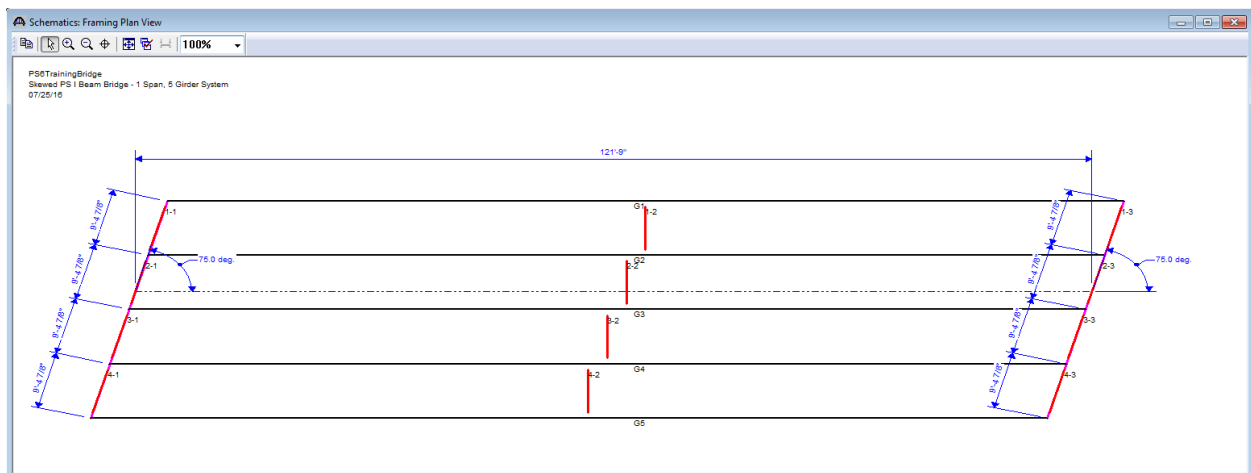
PS6 – Skewed, Simple Span Prestressed I Beam Example

The structure typical section schematic can be viewed by selecting “Structure Typical Section” in the Bridge Workspace tree and clicking the “View Schematic” toolbar button.



The beams are displayed as dashed boxes since we have not defined the beams yet.

The Framing Plan Detail schematic now shows the span length along the superstructure definition reference line.



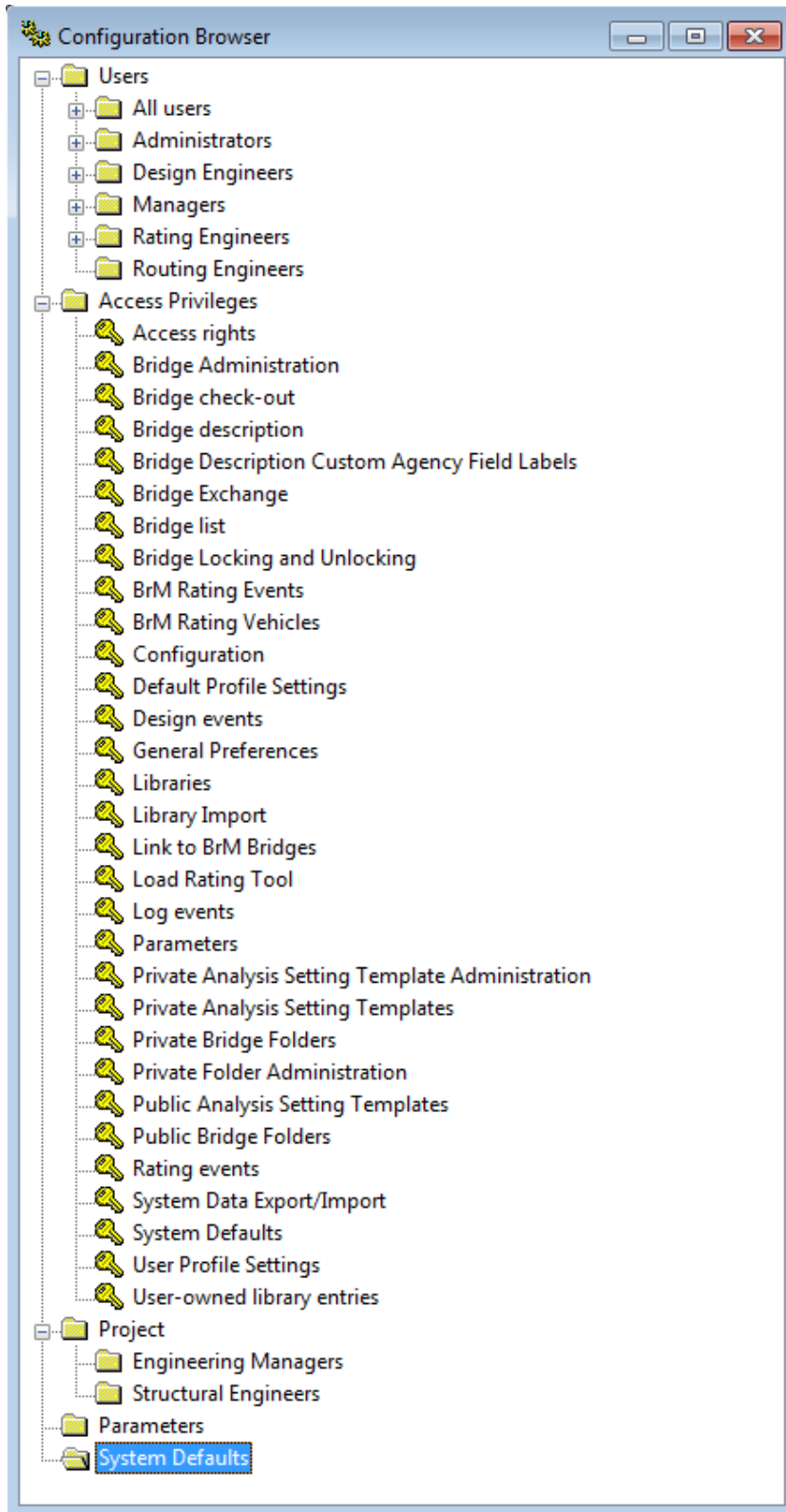
PS6 – Skewed, Simple Span Prestressed I Beam Example

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.

	LFD	LRFD
Initial allowable compression:	3.315 ksi	3.591 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

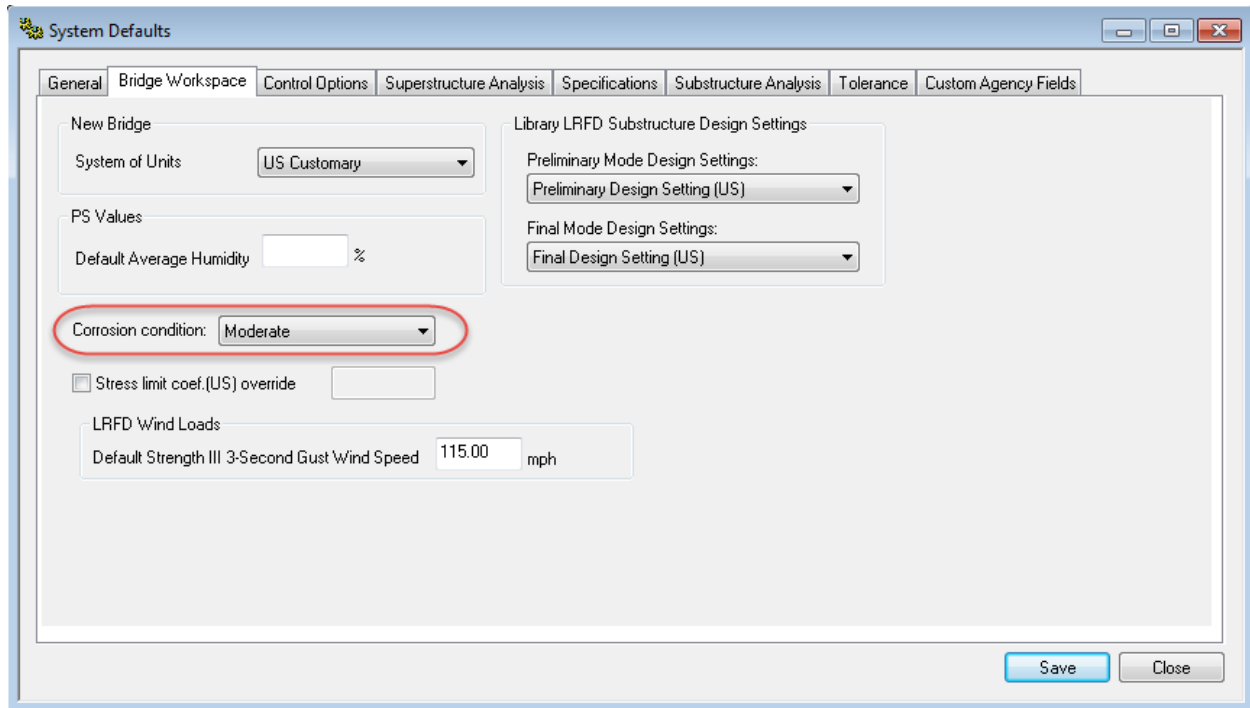
The final allowable tension values are calculated using the Stress Limit Coefficient found on the System Defaults: Bridge Workspace window. This coefficient is dependent on the moderate or severe corrosive condition to which the members are exposed.

The System Defaults window can be accessed by opening the Configuration Browser by selecting the Configuration Browser toolbar button. The Configuration Browser provides access to the configuration features of BrR/BrD.



PS6 – Skewed, Simple Span Prestressed I Beam Example

Double-click System Defaults in the tree and select the Bridge Workspace tab to view the following window:



PS6 – Skewed, Simple Span Prestressed I Beam Example

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 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" Strand 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: 18250.00 Days

Loss Data - AASHTO

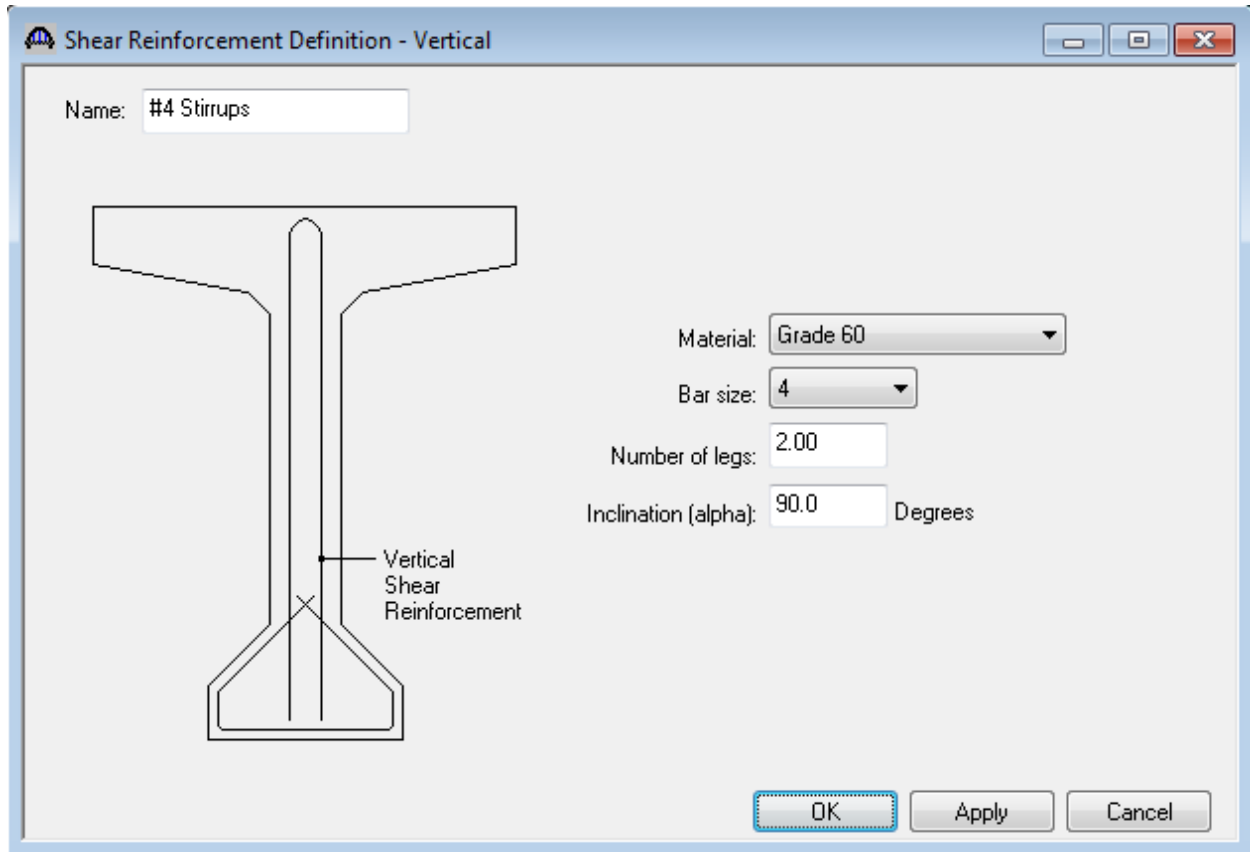
Percentage DL: 0.0 %

Include elastic gains

OK Apply Cancel

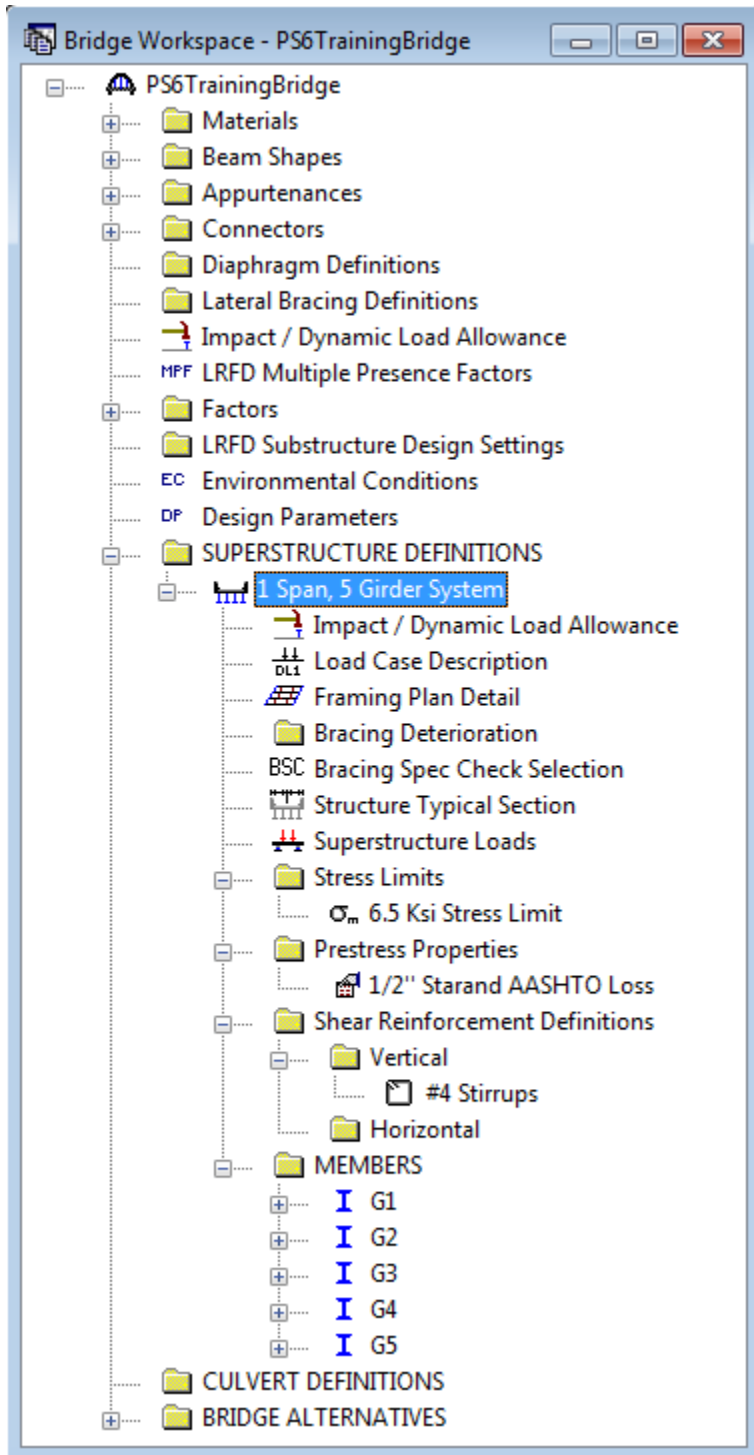
PS6 – Skewed, Simple Span Prestressed I Beam Example

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.



PS6 – Skewed, Simple Span Prestressed I Beam Example

A partially expanded Bridge Workspace is shown below.



PS6 – Skewed, Simple Span Prestressed I Beam Example

Describing a member:

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

Member name: G2 Link with: None

Description:

Existing	Current	Member Alternative Name	Description
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Number of spans: 1

Span No.	Span Length (ft)
1	121.75

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.

PS6 – Skewed, Simple Span Prestressed I Beam Example

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.

The screenshot shows the "Member Alternative Description" dialog box. The "Member Alternative" field is set to "Type VI Beam". The "Description" tab is active, showing a description field and a "Girder property input method" section with "Schedule based" selected. The "Material Type" is "Prestressed (Pretensioned)", "Girder Type" is "PS Precast I", and "Default Units" is "US Customary". The "Default rating method" is "LFD". The "Self Load" section has "Load case" set to "Engine Assigned" and two empty input fields for "Additional self load" in kip/ft and percent. The "Crack control parameter (Z)" section has two empty input fields for "Top of beam" and "Bottom of beam" in kip/in. The "Exposure factor" section has two empty input fields for "Top of beam" and "Bottom of beam". The "OK", "Apply", and "Cancel" buttons are at the bottom right.

Member Alternative: Type VI Beam

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

Description:

Material Type: Prestressed (Pretensioned)

Girder Type: PS Precast I

Default Units: US Customary

Girder property input method

Schedule based

Cross-section based

Default rating method: LFD

Self Load

Load case: Engine Assigned

Additional self load = kip/ft

Additional self load = %

Crack control parameter (Z)

Top of beam: kip/in

Bottom of beam: kip/in

Exposure factor

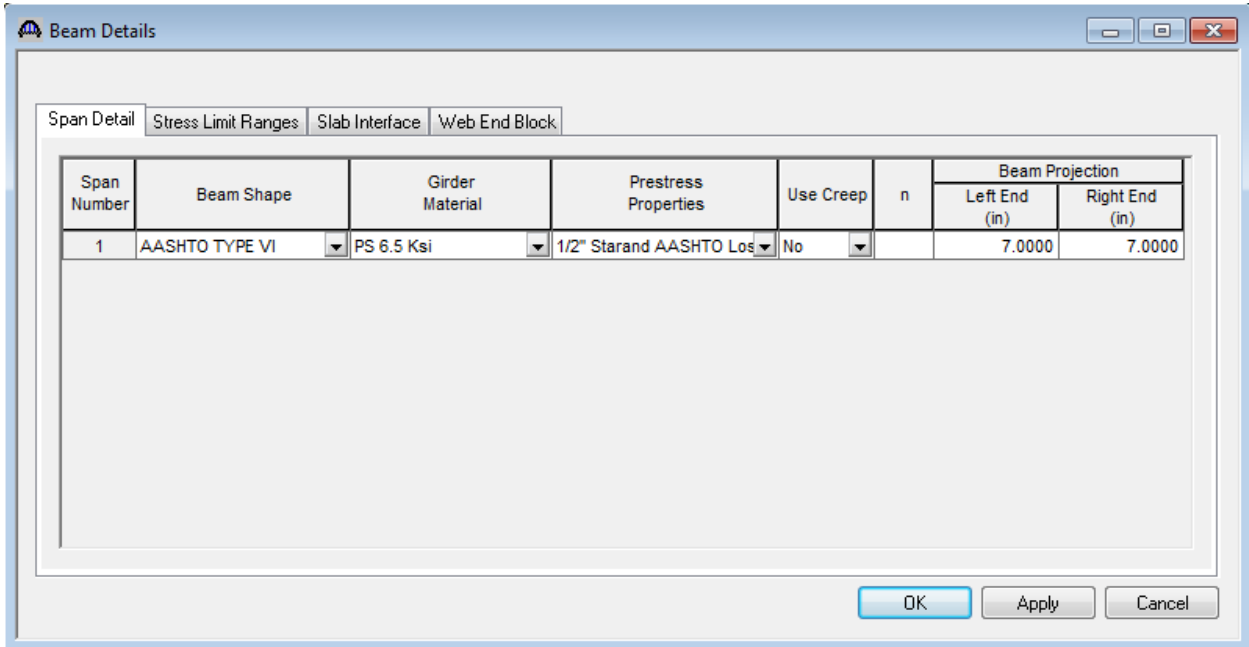
Top of beam:

Bottom of beam:

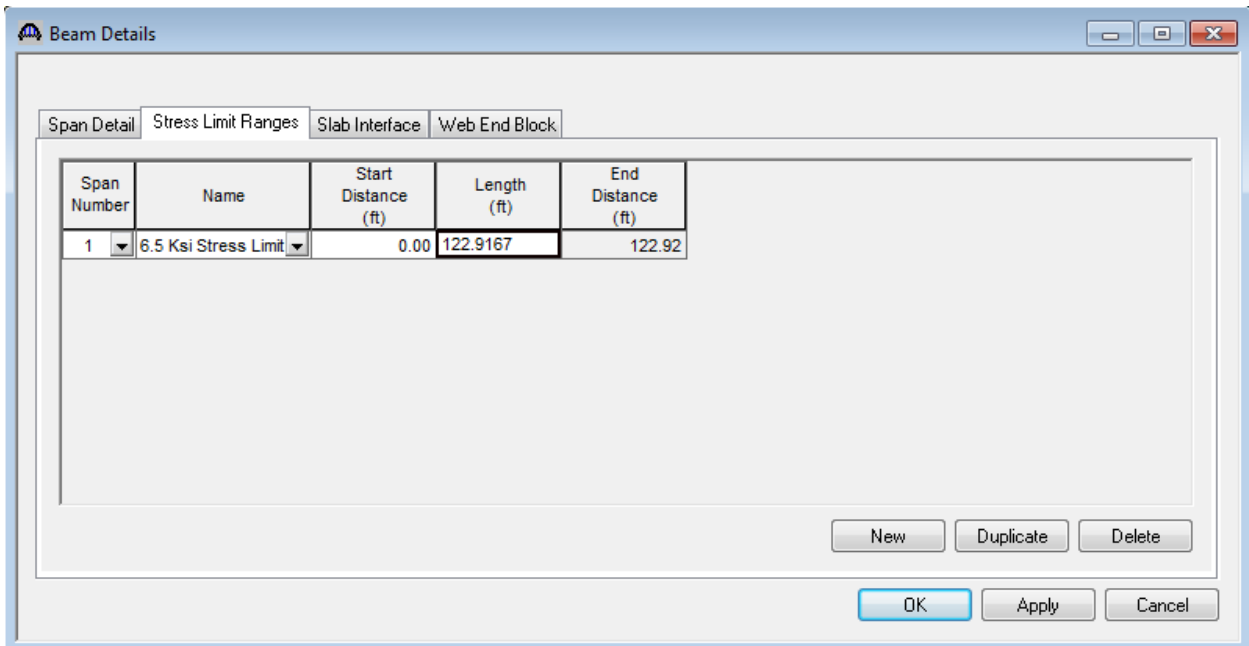
OK Apply Cancel

PS6 – Skewed, Simple Span Prestressed I Beam Example

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



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.



The defaults on the Slab Interface tab are acceptable. Click Ok to save the Beam Details data to memory and close the window.

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Open the Live Load Distribution window. On the Standard tab click on the Compute from Typical Section button to populate the LFD live load distribution factors based on the Structure Typical Section. BrR/BrD will compute the distribution factors based on the girder type, girder spacing, deck geometry and lane positions as per the AASHTO Standard Specifications for Highway Bridges.

Live Load Distribution

Standard **LRFD**

Distribution Factor Input Method

Use Simplified Method Use Advanced Method Use Advanced Method with 1994 Guide Specs

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	1.297614	1.339447	1.297614	0.400000
Multi-Lane	1.651509	1.899079	1.651509	1.080000

Compute from Typical Section... View Calcs

OK Apply Cancel

PS6 – Skewed, Simple Span Prestressed I Beam Example

Expand the Bridge Workspace tree under Strand Layout and open the Span 1 window. Select the Description Type as “P and CGS only”. The schematic of the beam shape is no longer displayed in the right hand side of this window. Since we are going to enter the center of gravity of the strands, we do not need to specify the location of each strand. Enter the following data to describe the prestress strand configuration.

The screenshot shows the 'Strand Layout - Span 1' dialog box. The 'Description Type' section has two radio buttons: 'P and CGS only' (selected) and 'Strands in rows'. Below this are several input fields with their respective units:

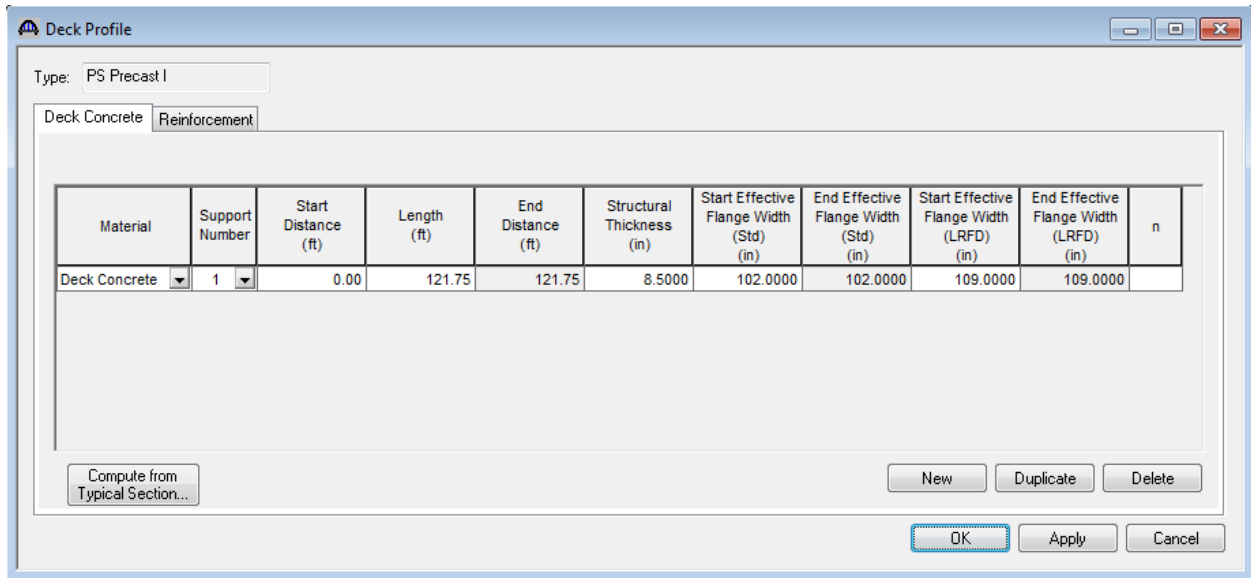
Field	Value	Unit
Left harp pt. dist. (X1):	49.00	ft
Left harp pt. radius:		in
Right harp pt. dist. (X2):	49.00	ft
Right harp pt. radius:		in
Force:	1859.00	kip
Left CGS:	20.8700	in
Mid CGS:	6.4700	in
Right CGS:	20.8700	in

At the bottom of the dialog, there are three buttons: 'OK' (highlighted with a blue border), 'Apply', and 'Cancel'. The right side of the dialog is a large empty white area, and the bottom has a horizontal scrollbar.

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

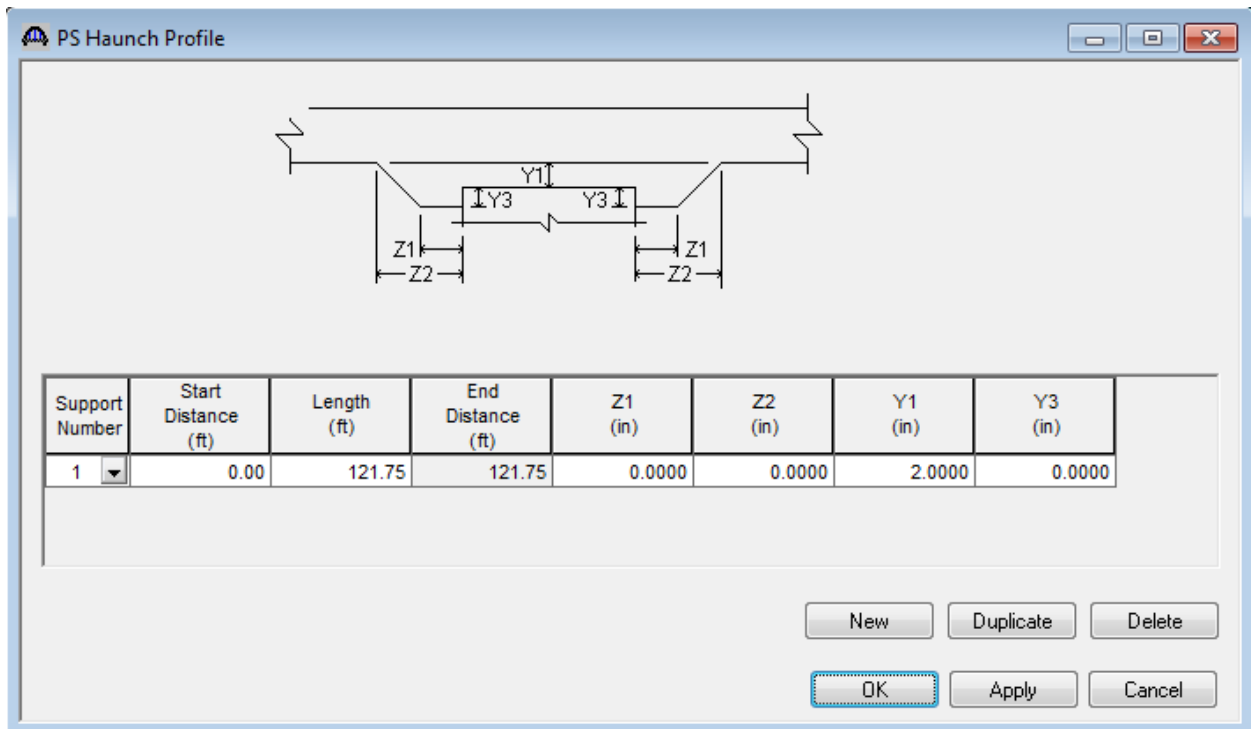
PS6 – Skewed, Simple Span Prestressed I Beam Example

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



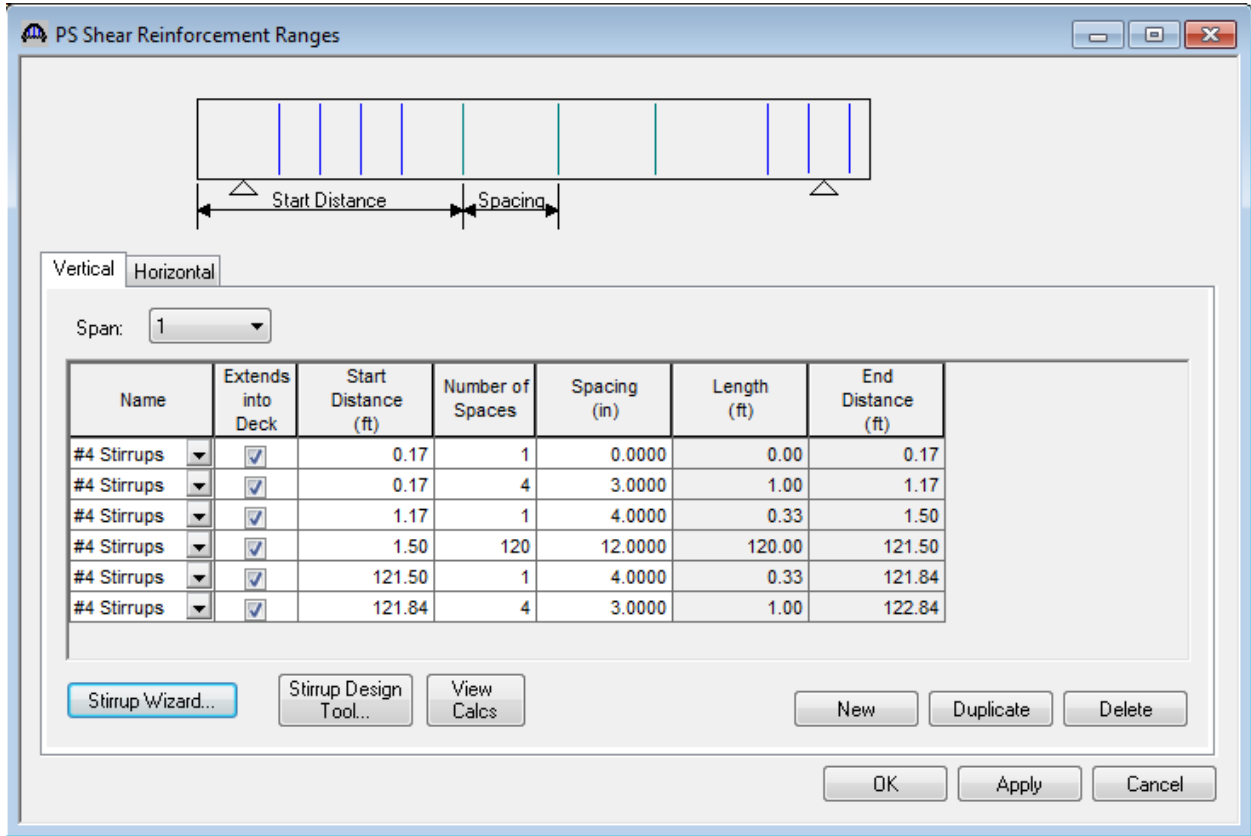
No reinforcement is described.

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



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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 interior beam for this structure definition is complete.

The results for rating an HS20 vehicle using Load Factor Design are shown below:

