

AASHTOWare BrD/BrR 6.8

Prestressed Concrete Structure Tutorial

PS2 - Three Span Spread PS Box Beam Example

BrD and BrR Training

PS2 - Three Span Spread PS Box Beam Example

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

3SpanSprdBoxTrainingBridge

Bridge ID: 3SpanSprdBoxTrain NBI Structure ID (8): 3SpanSprdBoxTra Template Superstructures
 Bridge Completely Defined Culverts

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

Name: 3Span Sprd Box Trn Bridge Year Built:

Description: 3 span spread PS box beam bridge made continuous for live load through continuity

Location: Length: ft

Facility Carried (7): Route Number: -1

Feat. Intersected (6): Mi. Post:


Default Units: US Customary

AASHTOWare Association... BrR BrD BrM

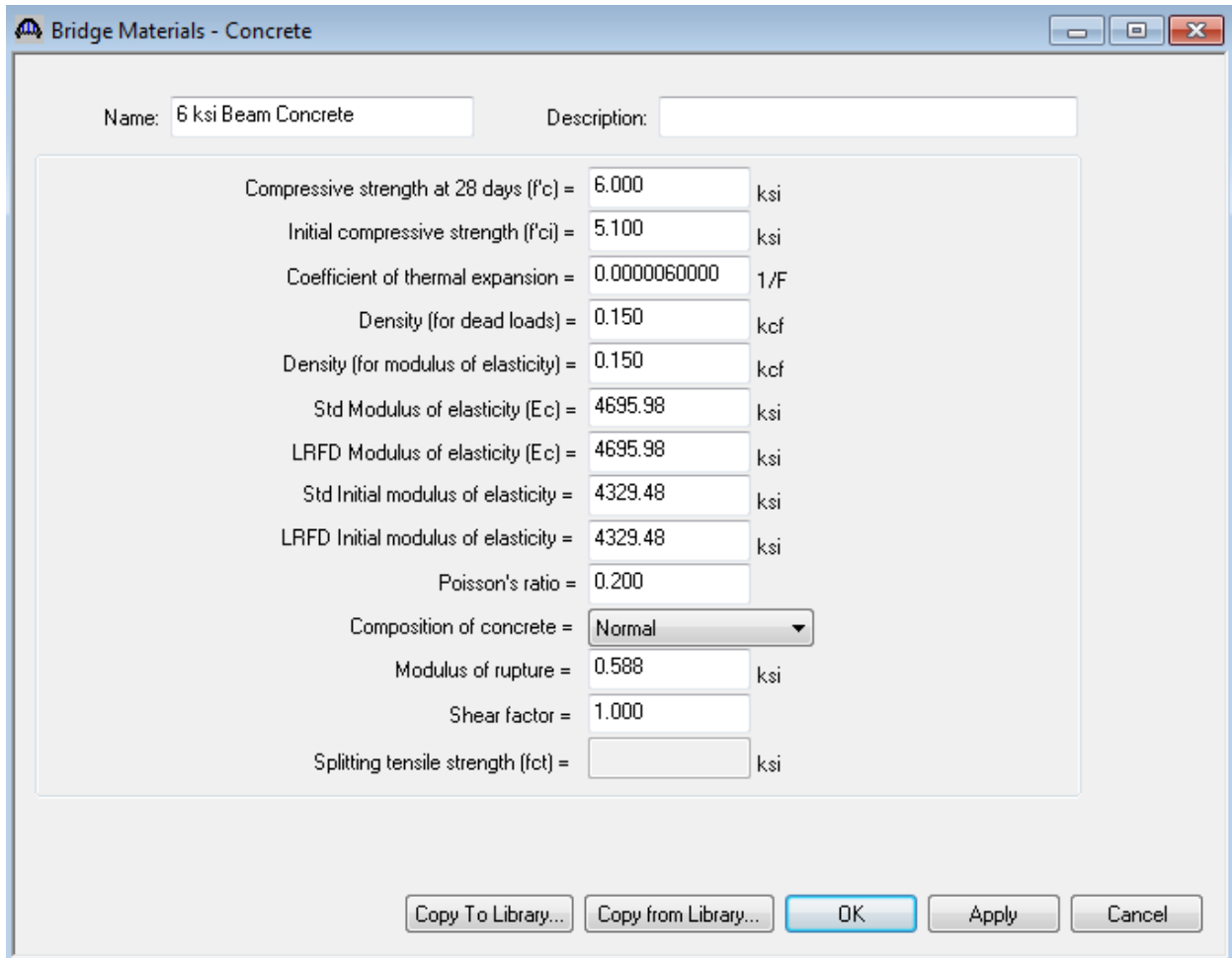
OK Apply Cancel

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

PS2 - Three Span Spread PS Box 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). Enter the following data for the concrete to be used for the beam:

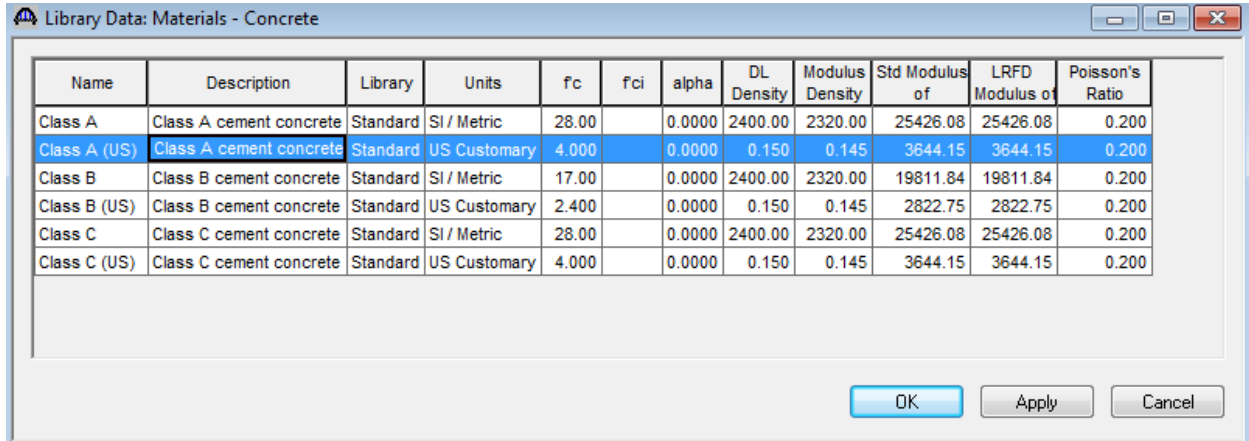


Property	Value	Unit
Compressive strength at 28 days (f'c) =	6.000	ksi
Initial compressive strength (f'ci) =	5.100	ksi
Coefficient of thermal expansion =	0.0000060000	1/F
Density (for dead loads) =	0.150	kcf
Density (for modulus of elasticity) =	0.150	kcf
Std Modulus of elasticity (Ec) =	4695.98	ksi
LRFD Modulus of elasticity (Ec) =	4695.98	ksi
Std Initial modulus of elasticity =	4329.48	ksi
LRFD Initial modulus of elasticity =	4329.48	ksi
Poisson's ratio =	0.200	
Composition of concrete =	Normal	
Modulus of rupture =	0.588	ksi
Shear factor =	1.000	
Splitting tensile strength (fct) =		ksi

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

PS2 - Three Span Spread PS Box Beam Example

Create another new concrete material to be used for the deck concrete. Add the concrete material “Class A (US)” from the Library by clicking the Copy from Library button.



Name	Description	Library	Units	f _c	f _{ci}	alpha	DL Density	Modulus Density	Std Modulus of	LRFD Modulus of	Poisson's Ratio
Class A	Class A cement concrete	Standard	SI / Metric	28.00		0.0000	2400.00	2320.00	25426.08	25426.08	0.200
Class A (US)	Class A cement concrete	Standard	US Customary	4.000		0.0000	0.150	0.145	3644.15	3644.15	0.200
Class B	Class B cement concrete	Standard	SI / Metric	17.00		0.0000	2400.00	2320.00	19811.84	19811.84	0.200
Class B (US)	Class B cement concrete	Standard	US Customary	2.400		0.0000	0.150	0.145	2822.75	2822.75	0.200
Class C	Class C cement concrete	Standard	SI / Metric	28.00		0.0000	2400.00	2320.00	25426.08	25426.08	0.200
Class C (US)	Class C cement concrete	Standard	US Customary	4.000		0.0000	0.150	0.145	3644.15	3644.15	0.200

Select the Class A (US) material and click Ok. The selected material properties are copied to the Bridge Materials – Concrete window.

PS2 - Three Span Spread PS Box Beam Example

Bridge Materials - Concrete

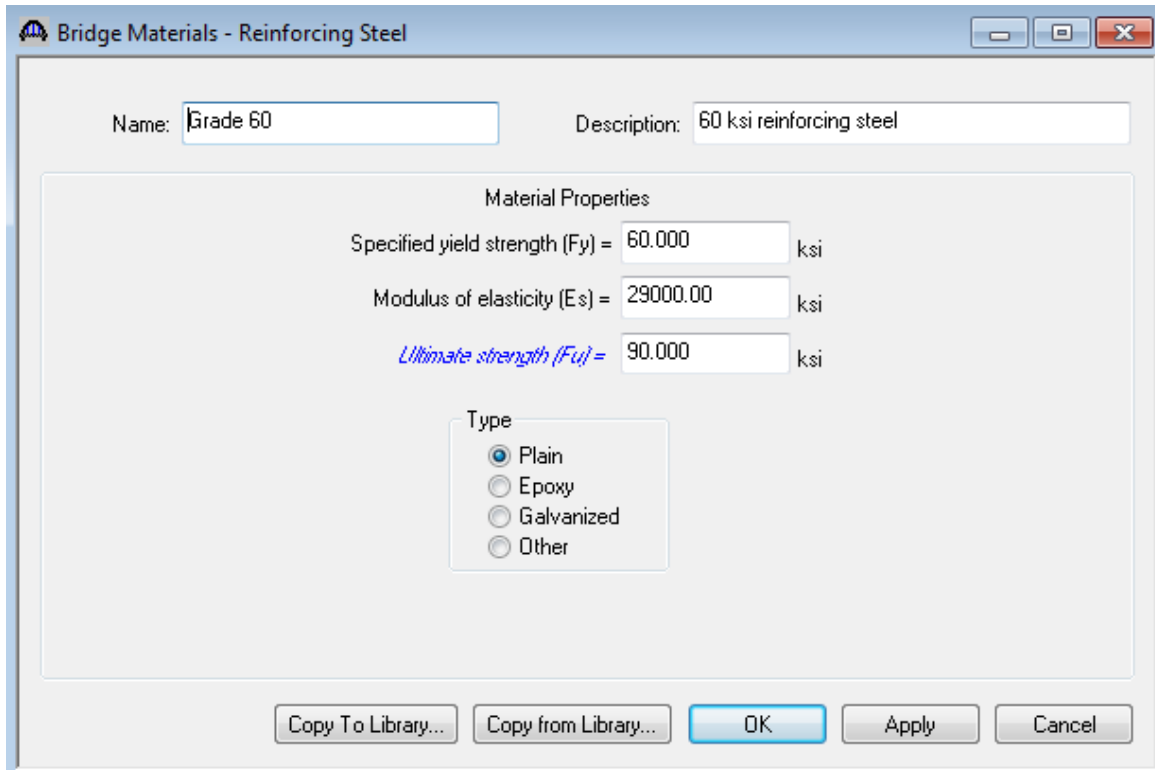
Name: Description:

Compressive strength at 28 days (f'c) =	<input type="text" value="4.000"/>	ksi
Initial compressive strength (f'ci) =	<input type="text"/>	ksi
Coefficient of thermal expansion =	<input type="text" value="0.0000060000"/>	1/F
Density (for dead loads) =	<input type="text" value="0.150"/>	kcf
Density (for modulus of elasticity) =	<input type="text" value="0.145"/>	kcf
Std Modulus of elasticity (Ec) =	<input type="text" value="3644.15"/>	ksi
LRFD Modulus of elasticity (Ec) =	<input type="text" value="3644.15"/>	ksi
Std Initial modulus of elasticity =	<input type="text"/>	ksi
LRFD Initial modulus of elasticity =	<input type="text"/>	ksi
Poisson's ratio =	<input type="text" value="0.200"/>	
Composition of concrete =	<input type="text" value="Normal"/>	
Modulus of rupture =	<input type="text" value="0.480"/>	ksi
Shear factor =	<input type="text" value="1.000"/>	
Splitting tensile strength (fct) =	<input type="text"/>	ksi

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

PS2 - Three Span Spread PS Box Beam Example

Add a concrete material for the 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

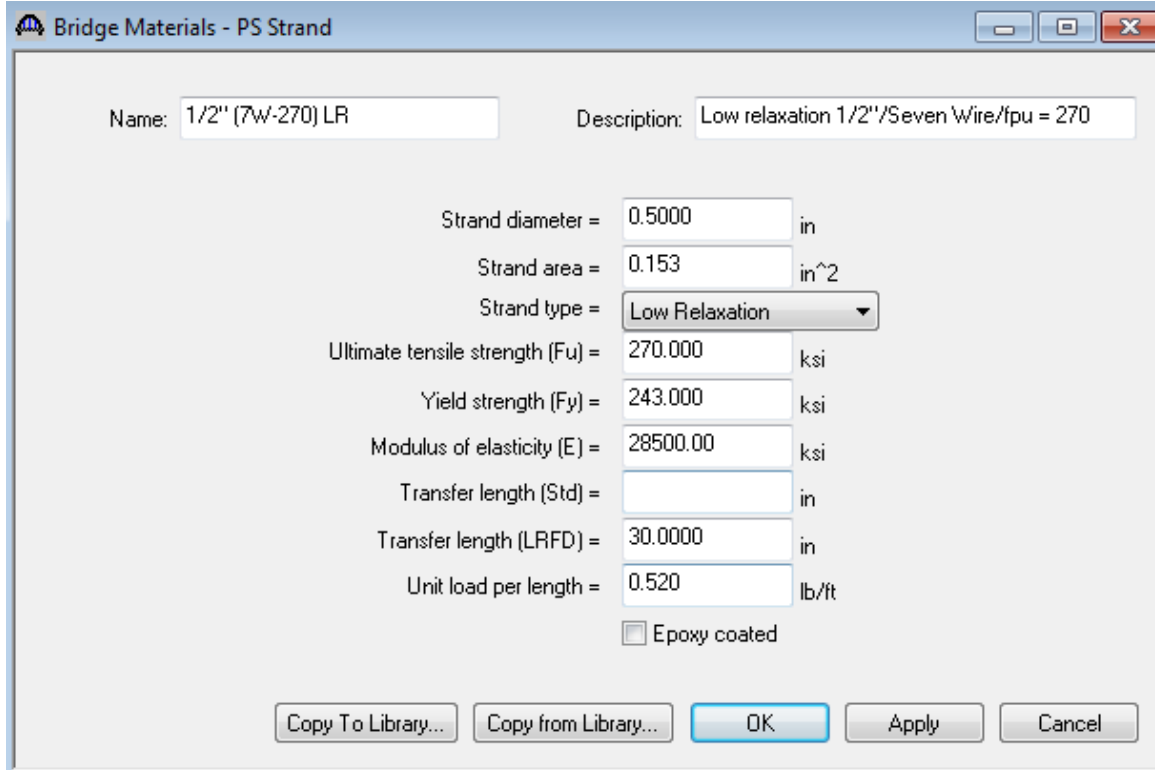
Specified yield strength (Fy) = ksi

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

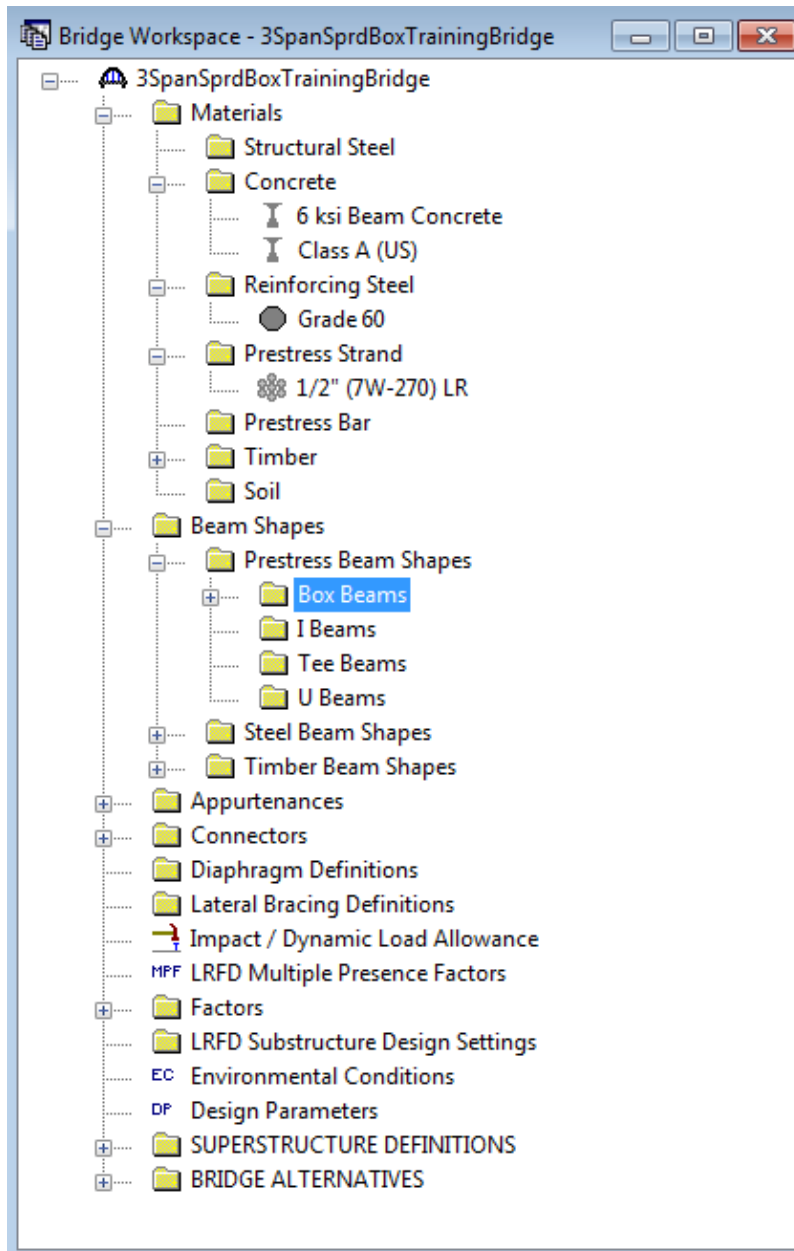
Transfer length (LRFD) = in

Unit load per length = lb/ft

Epoxy coated

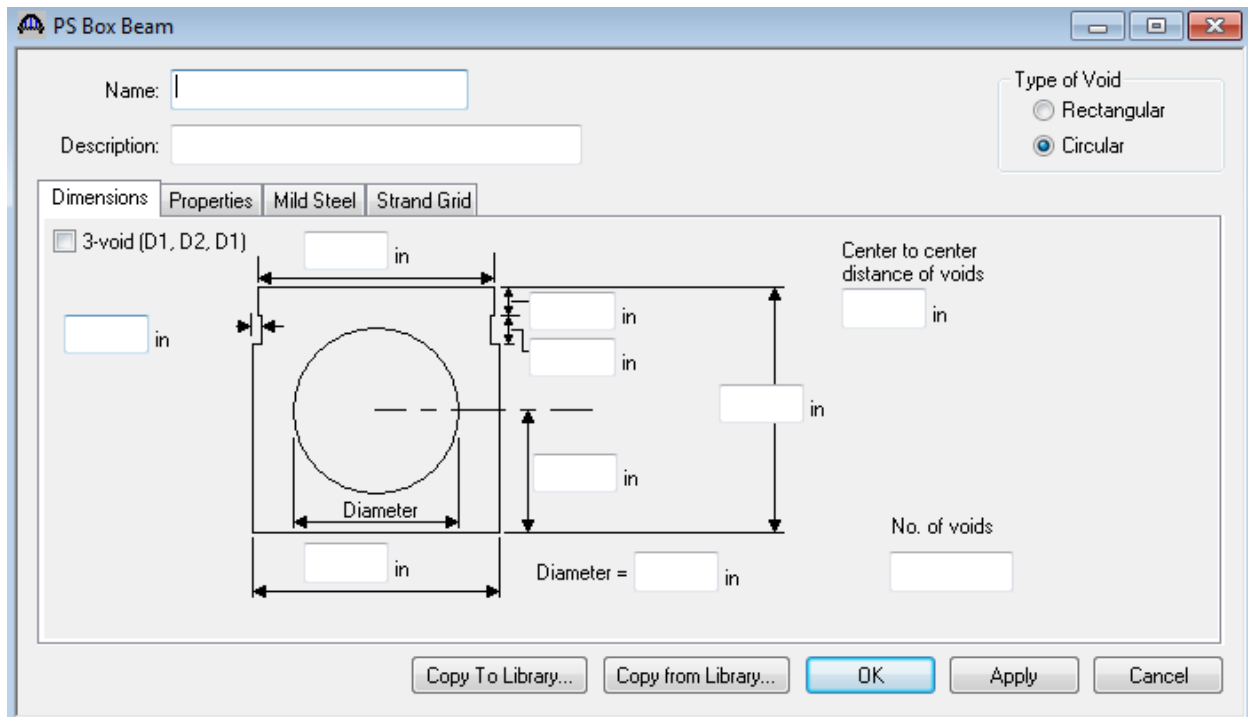
PS2 - Three Span Spread PS Box Beam Example

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



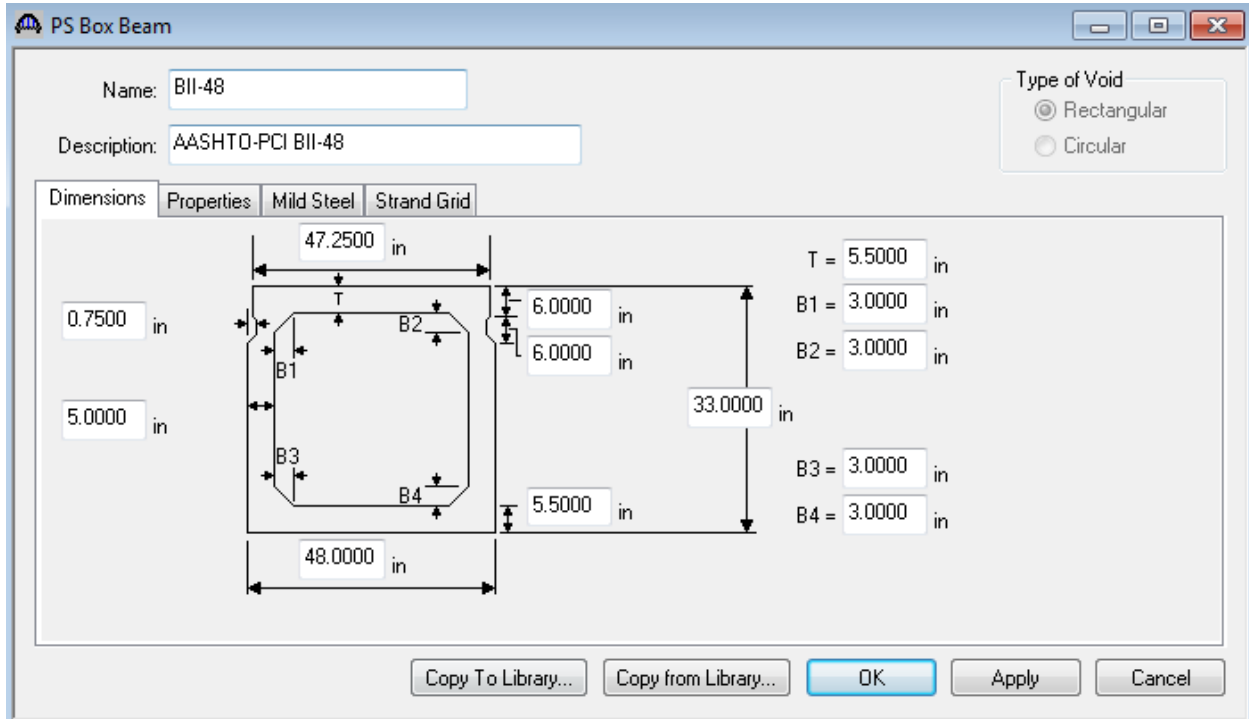
PS2 - Three Span Spread PS Box Beam Example

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



PS2 - Three Span Spread PS Box Beam Example

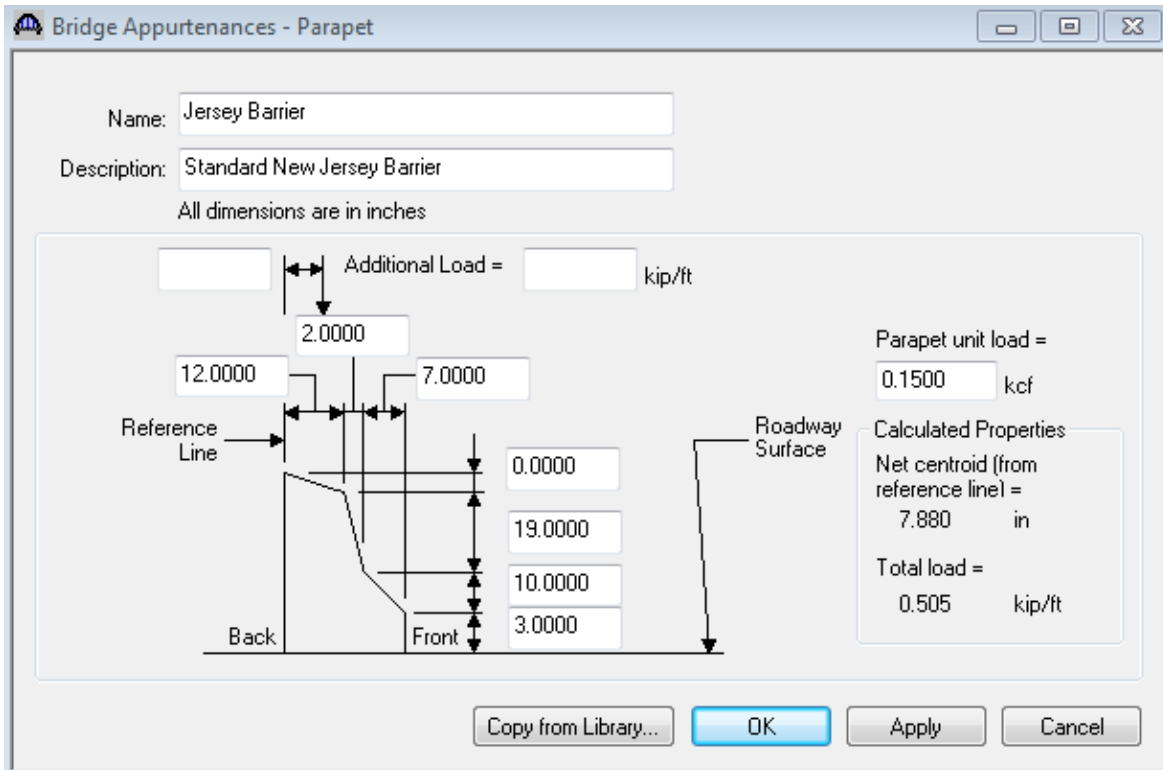
Select the Type of Void as Rectangular and click on the copy from Library button. Select BII-48 (AASHTO-PCI BII-48) and click Ok. The beam properties are copied to the Box Beam window as shown below.



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

PS2 - Three Span Spread PS Box Beam Example

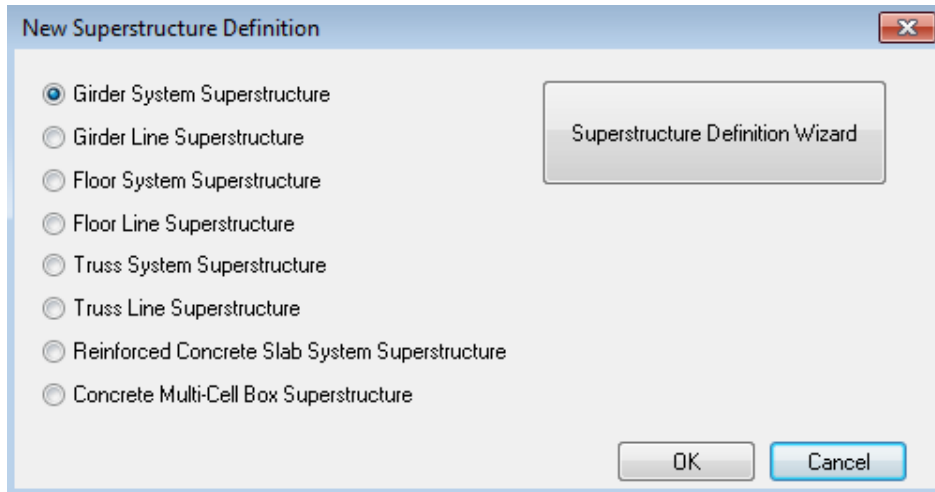
To enter the appurtenances to be used within the bridge expand the tree branch labeled Appurtenances. To define a parapet double click on Parapet in the tree and click the Copy from Library button. Select Jersey Barrier and click Ok. The parapet properties are copied to Parapet window as shown below. Click Ok to save the data to memory and close the window.



The default impact factors, 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.

PS2 - Three Span Spread PS Box Beam Example

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 pop up menu) to create a new structure definition. The window shown below will open.



PS2 - Three Span Spread PS Box Beam Example

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: 5 Girder System

Description:

Default Units: US Customary

Number of spans: 3

Number of girders: 5

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	75.00
2	60.00
3	60.00

Horizontal Curvature Along Reference Line

Horizontal curvature

Superstructure Alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

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: _____ %

Frame Structure Simplified Definition

Deck type: Concrete

For PS only

Average humidity: _____ %

Member Alt. Types

Steel

P/S

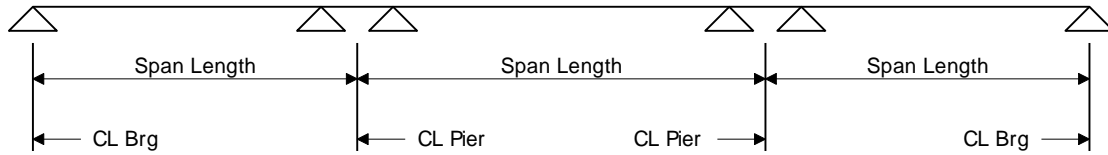
R/C

Timber

OK Apply Cancel

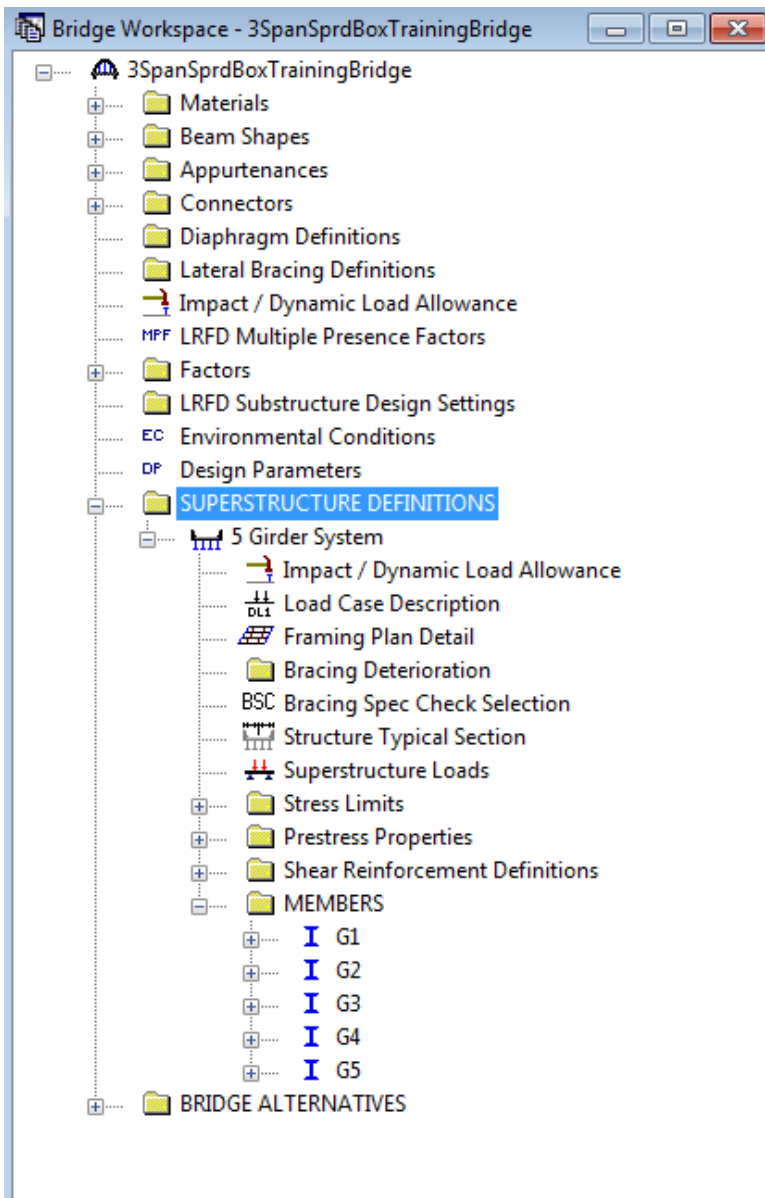
PS2 - Three Span Spread PS Box Beam Example

Span lengths for a prestressed beam structure made continuous for live load should be entered as follows:



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

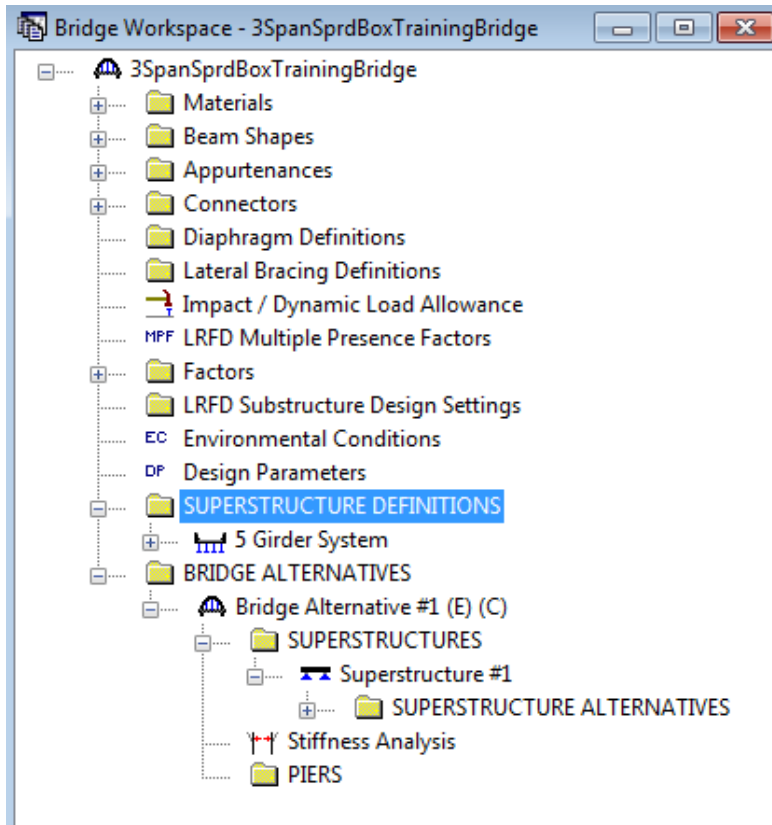
The partially expanded Bridge Workspace tree is shown below:



PS2 - Three Span Spread PS Box Beam Example

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Superstructure, and a new Superstructure Alternative as we did in previously.

The partially expanded Bridge Workspace tree is shown below:



PS2 - Three Span Spread PS Box Beam Example

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

Load Case Name	Description	Stage	Type	Time* (Days)
Dead Load 2		Composite (long term) (Stage 2)	D,DC	

*Prestressed members only

Add Default Load Case Descriptions

New Duplicate Delete

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

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

Structure Framing Plan Details

Number of spans = 3 Number of girders = 5

Layout Diaphragms

Girder Spacing Orientation

- Perpendicular to girder
- Along support

Support	Skew (Degrees)
1	0.0000
2	0.0000
3	0.0000
4	0.0000

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	7.50	7.50
2	7.50	7.50
3	7.50	7.50
4	7.50	7.50

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

Switch to the Diaphragms tab to enter the exterior 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: 1.0000 kip

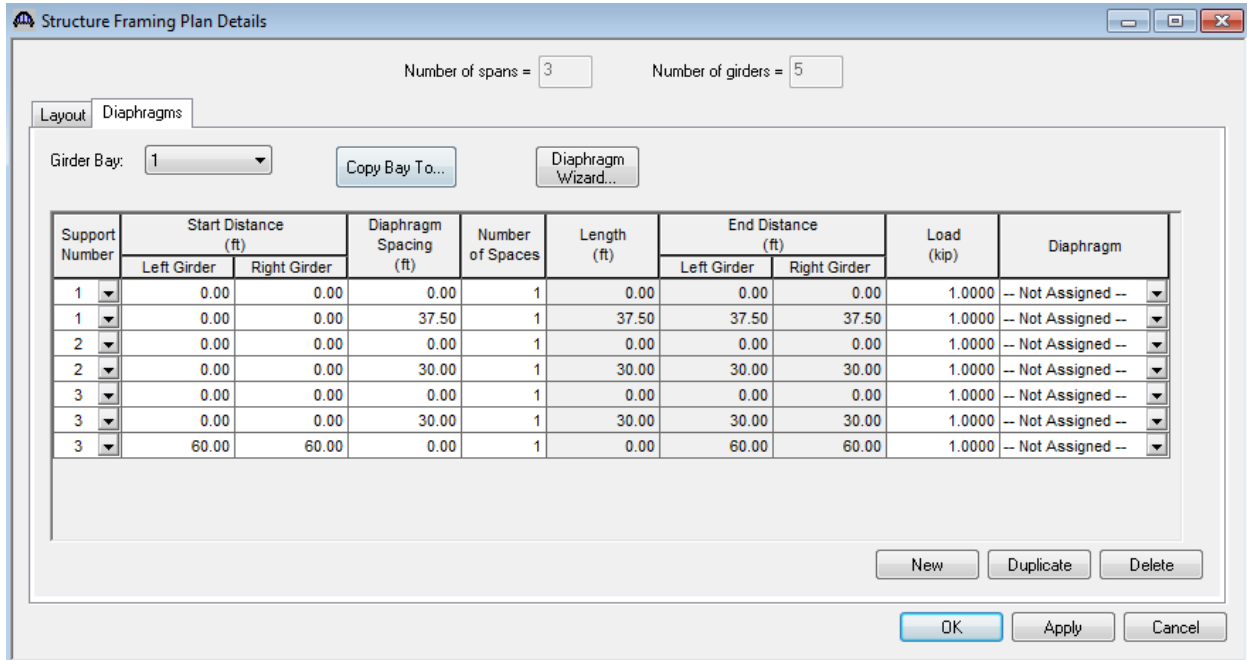
Interior diaphragm load: 1.0000 kip

Span	Length (ft)	Number of Equal Spaces
1	75.00	2
2	60.00	2
3	60.00	2

< Back Finish Cancel Help


PS2 - Three Span Spread PS Box Beam Example

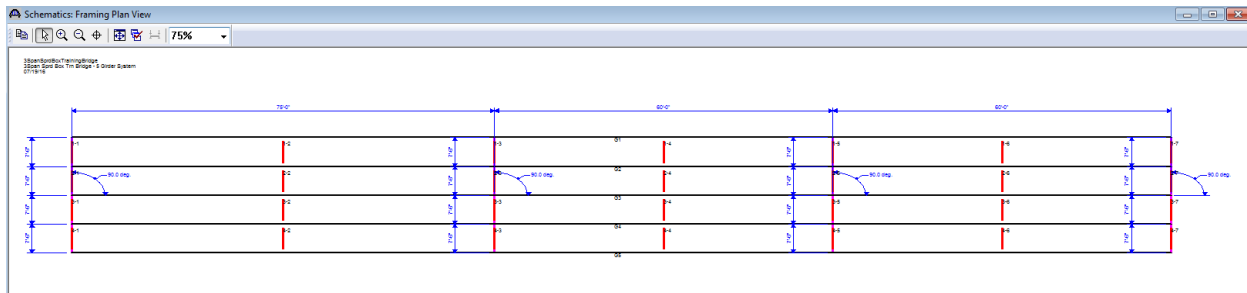
Click the Finish button to add the diaphragms and loads. The Diaphragm Wizard will create diaphragms and loads for all of the girder bays in the structure. The diaphragms created for Girder Bay 1 are shown below.



Select Ok to close the window.

While Framing Plan Detail is selected in the BWS tree, open the schematic for the framing plan by selecting the

View Schematic toolbar button  or Bridge/Schematic from the menu. The following schematic will be displayed.



PS2 - Three Span Spread PS Box 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.

Basic deck geometry:

The screenshot shows the 'Structure Typical Section' dialog box with the 'Deck' tab selected. At the top, a diagram illustrates the deck geometry with labels: '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', and 'Right overhang'. Below the diagram, the 'Deck' tab is active, and the 'Superstructure definition reference line is' dropdown is set to 'within'. The following parameters are defined:

Parameter	Start (ft)	End (ft)
Distance from left edge of deck to superstructure definition reference line =	18.75	18.75
Distance from right edge of deck to superstructure definition reference line =	18.75	18.75
Left overhang =	3.75	3.75
Computed right overhang =	3.75	3.75

Buttons at the bottom right include 'OK', 'Apply', and 'Cancel'.

PS2 - Three Span Spread PS Box Beam Example

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: Class A (US)

Total deck thickness: 8.0000 in

Load case: Engine Assigned

Deck crack control parameter: kip/in

Sustained modular ratio factor: 2.000

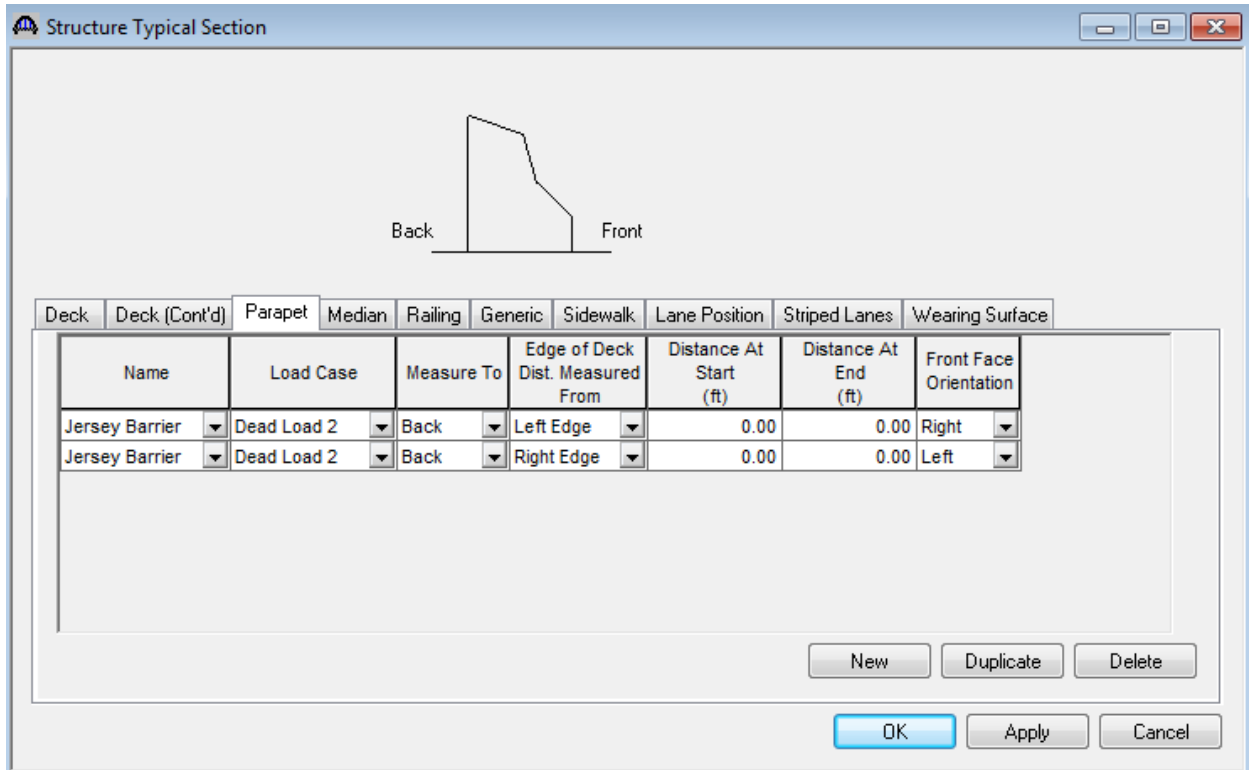
Deck exposure factor:

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

Parapets:

Add two parapets as shown below.



The screenshot shows the 'Structure Typical Section' window. At the top, there is a diagram of a parapet profile with 'Back' and 'Front' labels. Below the diagram is a tabbed interface with the following tabs: Deck, Deck (Cont'd), Parapet, Median, Railing, Generic, Sidewalk, Lane Position, Striped Lanes, and Wearing Surface. The 'Parapet' tab is active, displaying a table with the following data:

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Jersey Barrier	Dead Load 2	Back	Left Edge	0.00	0.00	Right
Jersey Barrier	Dead Load 2	Back	Right Edge	0.00	0.00	Left

At the bottom of the window, there are buttons for 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel'.

PS2 - Three Span Spread PS Box Beam Example

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 a cross-section of a bridge with two travelways, labeled 'Travelway 1' and 'Travelway 2'. A 'Superstructure Definition Reference Line' is shown as a dashed vertical line. Dimensions (A) and (B) are indicated with arrows, representing the distances from the left and right edges of the travelways to the reference line at the start and end of the bridge.

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	-17.00	17.00	-17.00	17.00

Below the table, there are input fields for 'LRFD Fatigue' (Lanes available to trucks, Override, Truck fraction) and buttons for 'Compute...', 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel'.

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

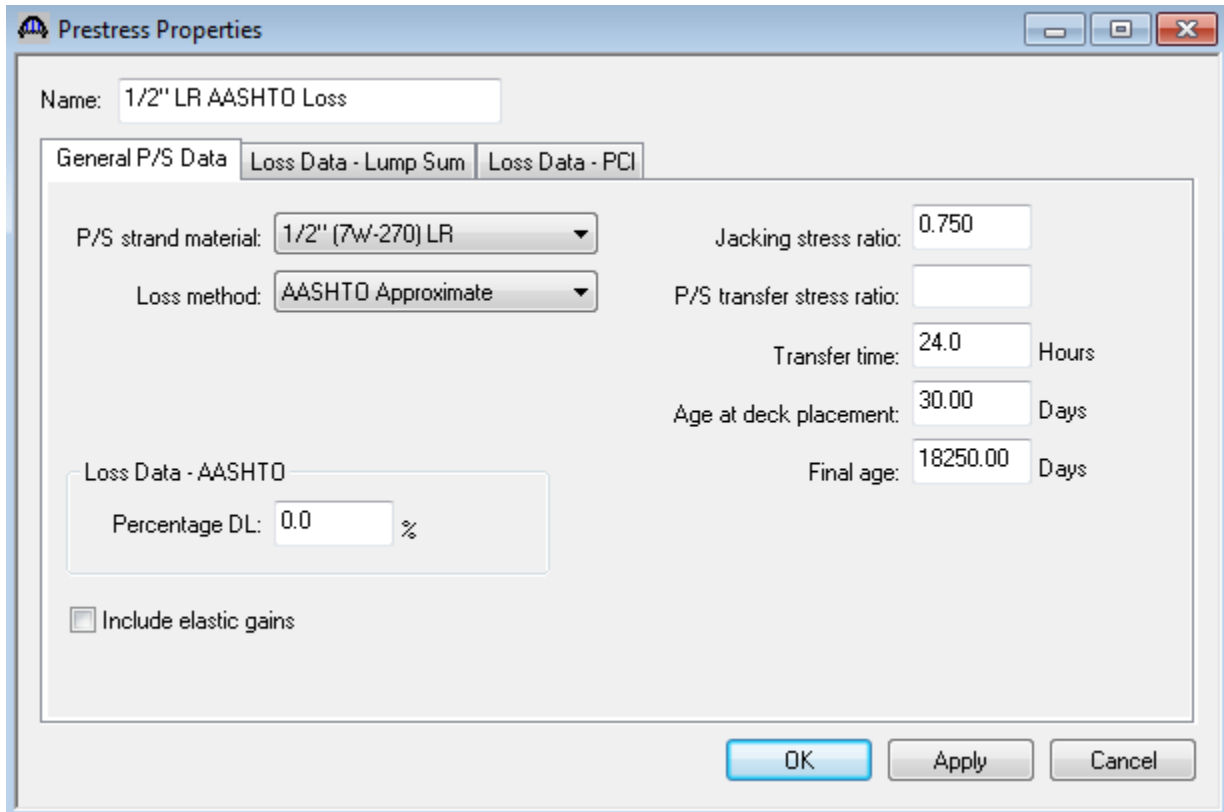
PS2 - Three Span Spread PS Box Beam Example

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 “6 ksi Beam Concrete” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click Ok to save this information to memory and close the window.

	LFD	LRFD
Initial allowable compression:	3.060 ksi	3.060 ksi
Initial allowable tension:	0.200 ksi	0.200 ksi
Final allowable compression:	3.600 ksi	3.600 ksi
Final allowable tension:	0.465 ksi	0.465 ksi
Final allowable DL compression:	2.400 ksi	2.700 ksi
Final allowable slab compression:	2.400 ksi	2.400 ksi
Final allowable compression: (LL + 1/2(Pe + DL))	2.400 ksi	2.400 ksi

PS2 - Three Span Spread PS Box 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 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: 18250.00 Days

Loss Data - AASHTO

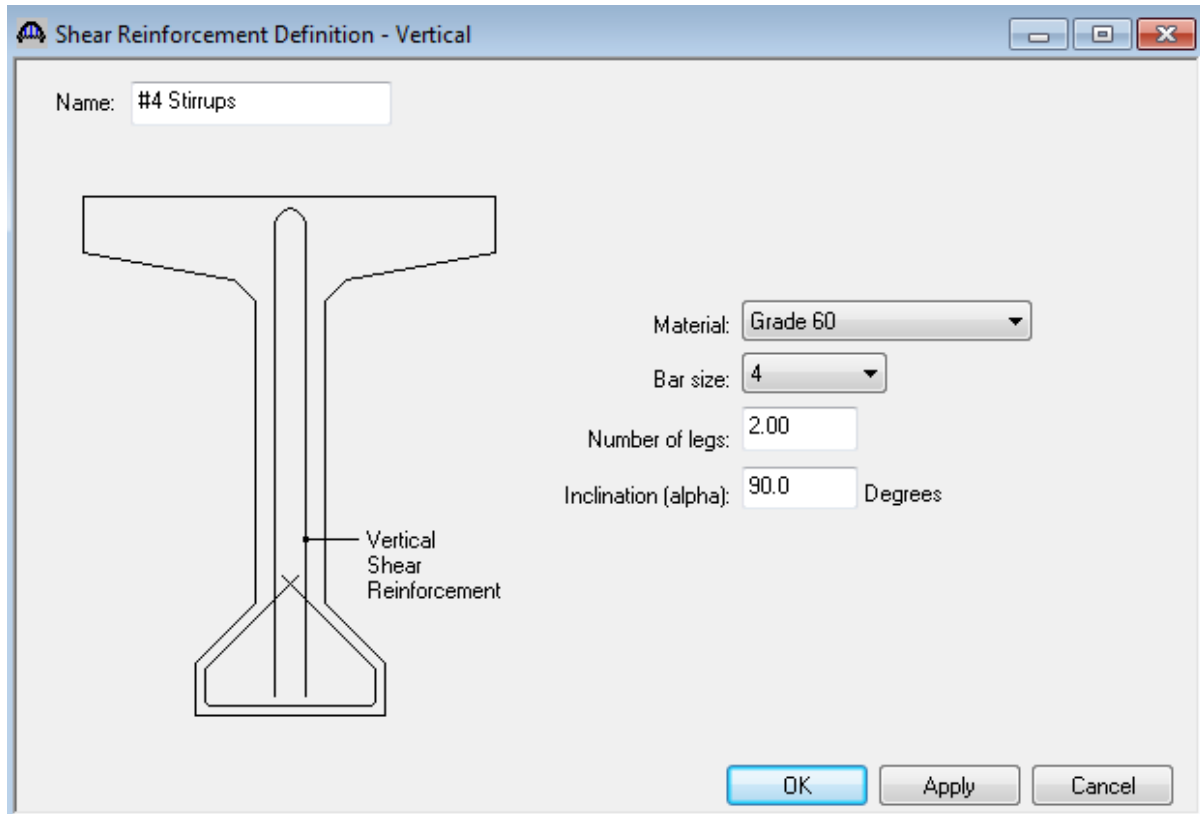
Percentage DL: 0.0 %

Include elastic gains

OK Apply Cancel

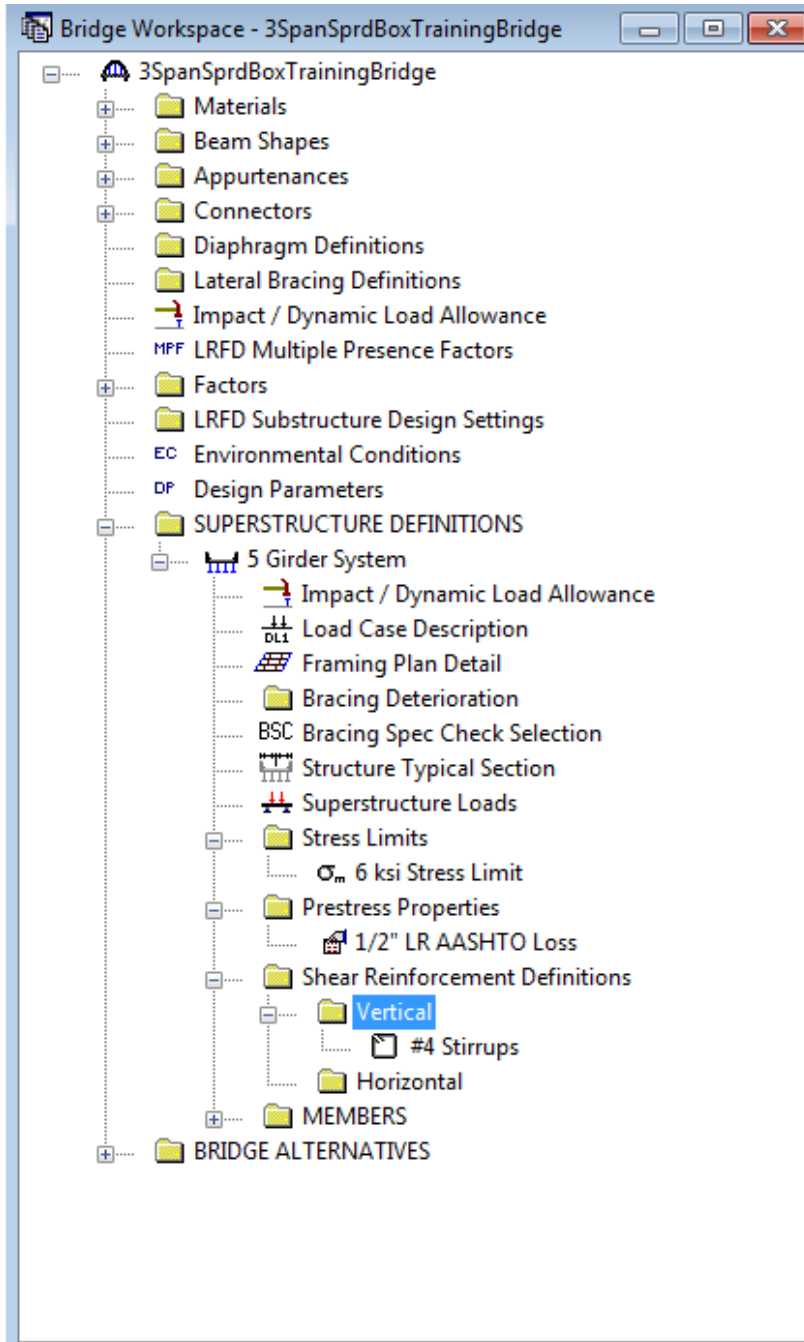
PS2 - Three Span Spread PS Box Beam Example

Define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definitions in the tree). Define the reinforcement as shown. The I shape shown is for illustrative purposes only, it is not meant to display the actual beam shape. Click Ok to save to memory and close the window.



PS2 - Three Span Spread PS Box Beam Example

A partially expanded Bridge Workspace is shown below.



PS2 - Three Span Spread PS Box 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: Link with:

Description:

Existing	Current	Member Alternative Name	Description

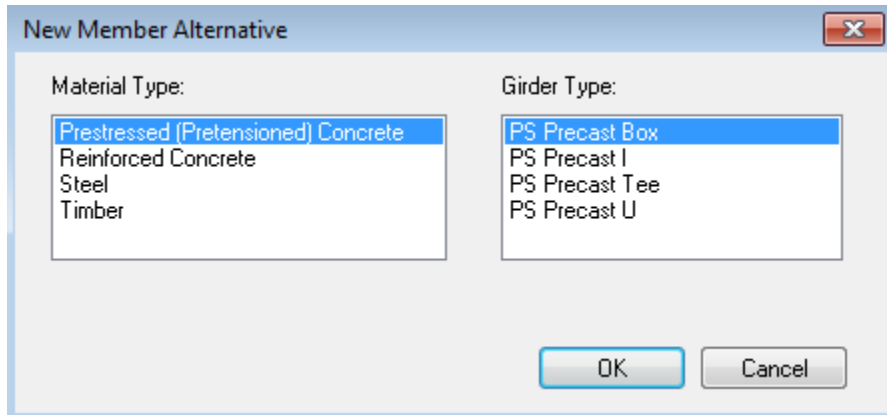
Number of spans:

Span No.	Span Length (ft)
1	75.00
2	60.00
3	60.00

PS2 - Three Span Spread PS Box Beam Example

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 Box for the Girder Type.



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

PS2 - Three Span Spread PS Box 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. At the top, the 'Member Alternative' is set to '48" PS Box'. Below this are tabs for 'Description', 'Specs', 'Factors', 'Engine', 'Import', and 'Control Options'. The 'Description' tab is active, showing a 'Description' text area. To the right, 'Material Type' is 'Prestressed (Pretensioned)', 'Girder Type' is 'PS Precast Box', and 'Default Units' is 'US Customary'. Under 'Girder property input method', 'Schedule based' is selected with a radio button, while 'Cross-section based' is unselected. The 'Self Load' section has 'Load case' set to 'Engine Assigned', with two empty input fields for 'Additional self load' in 'kip/ft' and '%'. The 'Default rating method' is set to 'LFD'. The 'Crack control parameter (Z)' section has an empty input field for 'Bottom of beam' in 'kip/in'. The 'Exposure factor' section also has an empty input field for 'Bottom of beam'. At the bottom right are 'OK', 'Apply', and 'Cancel' buttons.

PS2 - Three Span Spread PS Box Beam Example

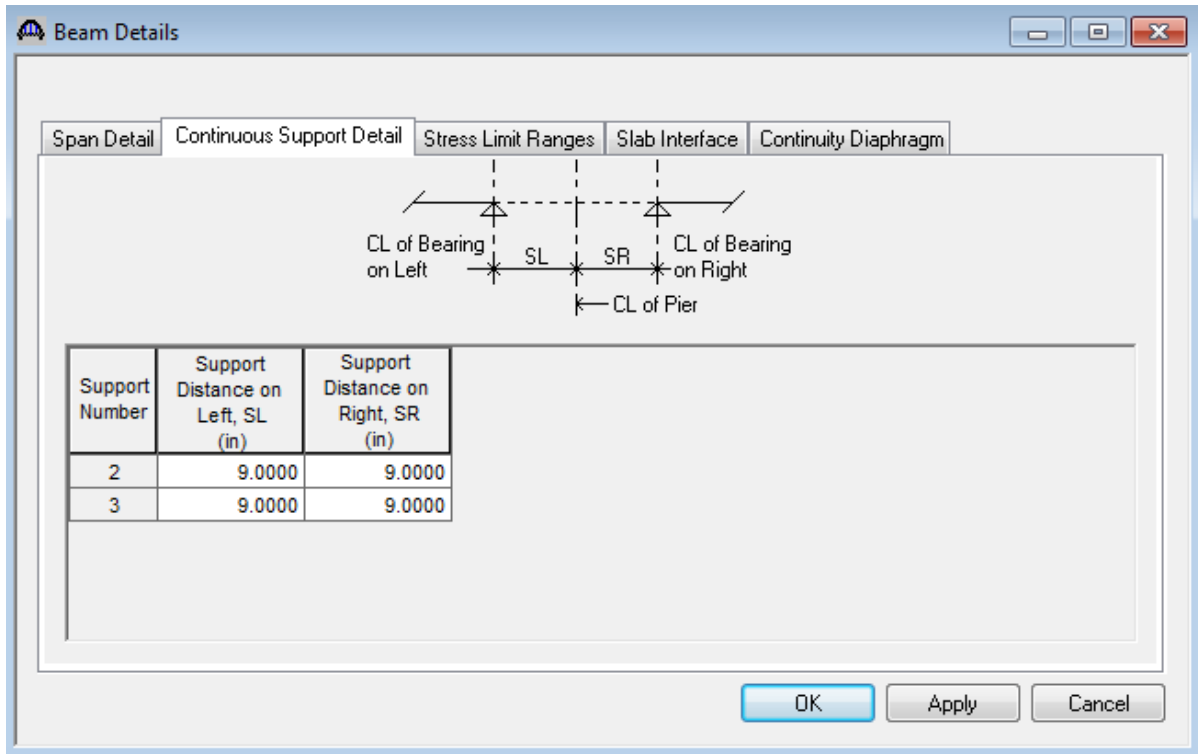
The Live Load Distribution window is not necessarily to be entered. At this point, BrR/BrD does not know if we have spread or adjacent box beams. We will select the beam shape now in the Beam Details window and then BrR will compute the LRFD live load distribution factors automatically while rating.

The screenshot shows the 'Beam Details' window with the following data:

Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	BII-48	6 ksi Beam Concrete	1/2" LR AASHTO Loss	No		9.0000	6.0000
2	BII-48	6 ksi Beam Concrete	1/2" LR AASHTO Loss	No		6.0000	6.0000
3	BII-48	6 ksi Beam Concrete	1/2" LR AASHTO Loss	No		6.0000	9.0000

PS2 - Three Span Spread PS Box Beam Example

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



The screenshot shows the 'Beam Details' window with the 'Continuous Support Detail' tab selected. The diagram illustrates a beam with two supports, showing the centerlines of bearing (CL of Bearing on Left and CL of Bearing on Right) and the centerline of the pier (CL of Pier). The distances from the CL of Pier to the CL of Bearing on the left and right are labeled SL and SR, respectively.

Support Number	Support Distance on Left, SL (in)	Support Distance on Right, SR (in)
2	9.0000	9.0000
3	9.0000	9.0000

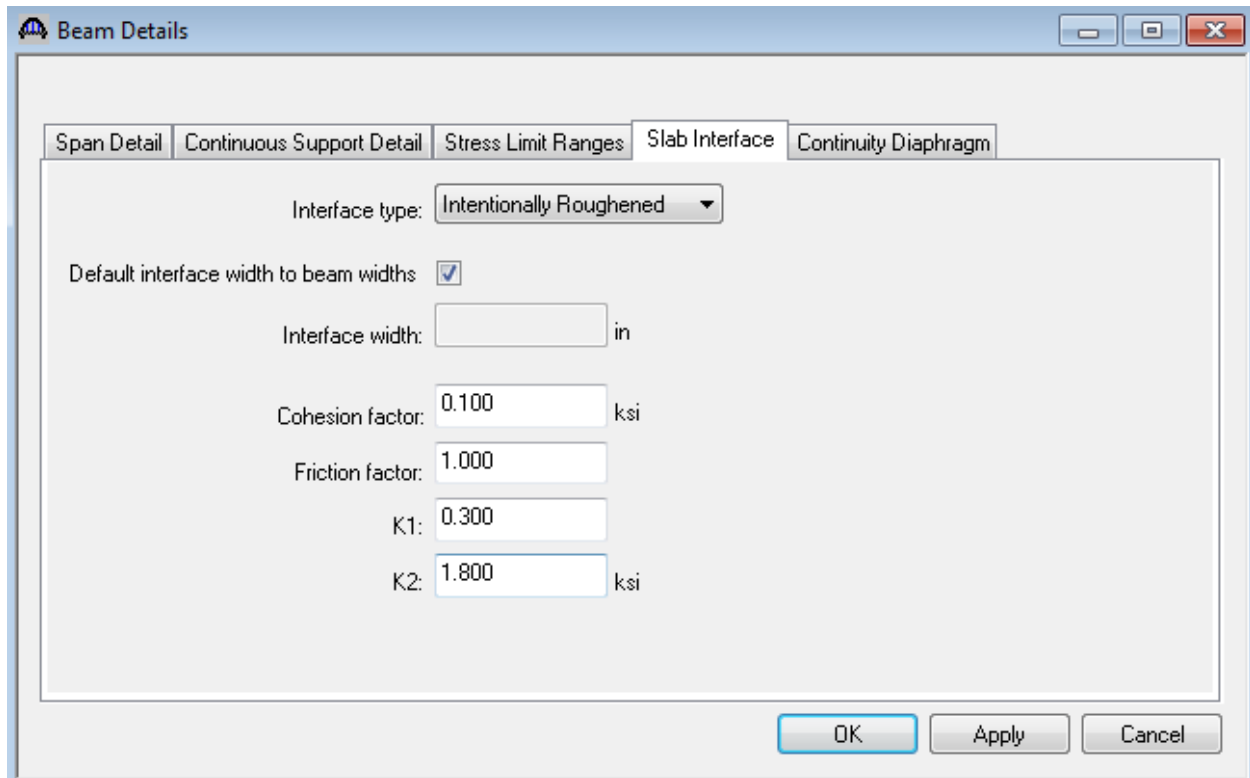
PS2 - Three Span Spread PS Box Beam Example

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 Stress Limit names appearing in the listbox in the Name column correspond to the Stress Limits associated with the concrete material specified for that span on the Span Detail tab.

Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	6 ksi Stress Limit	0.00	75.50	75.50
2	6 ksi Stress Limit	0.00	59.50	59.50
3	6 ksi Stress Limit	0.00	60.50	60.50

PS2 - Three Span Spread PS Box Beam Example

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



The image shows a software dialog box titled "Beam Details" with a standard Windows-style title bar (minimize, maximize, close buttons). The dialog has five tabs: "Span Detail", "Continuous Support Detail", "Stress Limit Ranges", "Slab Interface", and "Continuity Diaphragm". The "Slab Interface" tab is selected and active. Inside the dialog, the following settings are visible:

- Interface type: Intentionally Roughened (dropdown menu)
- Default interface width to beam widths:
- Interface width: in
- Cohesion factor: ksi
- Friction factor:
- K1:
- K2: ksi

At the bottom right of the dialog, there are three buttons: "OK", "Apply", and "Cancel".

PS2 - Three Span Spread PS Box Beam Example

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

Span Number	Left Support				Right Support			
	Material	Distance (in)	Bar Count	Bar Size	Material	Distance (in)	Bar Count	Bar Size
1					Grade 60	3.0000	6.000	5
2	Grade 60	3.0000	6.000	5	Grade 60	3.0000	6.000	5
3	Grade 60	3.0000	6.000	5				

Ignore positive moment at supports in ratings

New Duplicate Delete

OK Apply Cancel

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

PS2 - Three Span Spread PS Box Beam Example

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 26 strands in the schematic so that the CG of the strands is 2.31 inches.

Strand Layout - Span 1

100%

Description Type

P and CGS only Strands in rows

Strand Configuration Type

Straight/Debonded Harped Harped and straight debonded

Symmetry

Mid span

Left end Right end

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

Notes:

Strand positions generated by the REVISCO method.
Please refer to file for a description of this method.

Number of strands = 26

Number of harped strands = 0

CG of strands (measured from bottom of section) = 2.31 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 from the end of the beam to the current section location.
- The strand is debonded from the mid-span to the current section location.
- The strand is debonded at other section location. Hover over the strand for more information.
- 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.

PS2 - Three Span Spread PS Box Beam Example

Now select the Left harp pt. radio button to enter data concerning the harping of the strands. The Modify button can now be used to enter the location of the harp point as a distance from the left end of the precast beam. Click Modify and enter 22.5' as the distance from the left end of the precast beam to the harp point in the dialog that appears. Click Ok to close the dialog. The strand pattern at the harp point is the same as the strand pattern at the middle of the span and cannot be modified.

Select the Left end radio button to enter the following harped strand locations at the left end of the precast beam.

Strand Layout - Span 1

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	22.50	0.0000
Right	22.50	0.0000

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

Number of strands = 26
 Number of harped strands = 4
 CG of strands (measured from bottom of section) = 6.31 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 from the end of the beam to the current section location.
- The strand is debonded from the mid-span to the current section location.
- The strand is debonded at other section location. Hover over the strand for more information.
- 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.

PS2 - Three Span Spread PS Box Beam Example

Enter the following data for Spans 2 and 3 in the same manner as described above. Span 2 is shown below, Span 3 has the same information.

Strand Layout - Span 2

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

Harped Point Locations		
Harped Point	Distance (ft)	Radius (in)
Left	19.00	0.0000
Right	19.00	0.0000

Notes:
 Strand positions generated by the RQ/ISSO method.
 Please refer to help for a description of this method.

Number of strands = 24
 Number of harped strands = 4
 CG of strands (measured from bottom of section) = 8.50 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 from the end of the beam to the current section location.
- The strand is debonded from the mid-span to the current section location.
- The strand is debonded at other section location. Hover over the strand for more information.
- 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.

PS2 - Three Span Spread PS Box Beam Example

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

The screenshot shows a software window titled "Deck Profile" with a standard Windows interface. The window contains a "Type" field set to "PS Precast Box" and two tabs: "Deck Concrete" and "Reinforcement". The "Reinforcement" 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
Class A (US)	1	0.00	195.00	195.00	7.5000	90.0000	90.0000	90.0000	90.0000	

Below the table, there is a "Compute from Typical Section..." button. At the bottom right of the window, there are three buttons: "New", "Duplicate", and "Delete". At the very bottom of the window, there are three buttons: "OK", "Apply", and "Cancel".

PS2 - Three Span Spread PS Box Beam Example

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

Deck Profile

Type: PS Precast Box

Deck Concrete Reinforcement

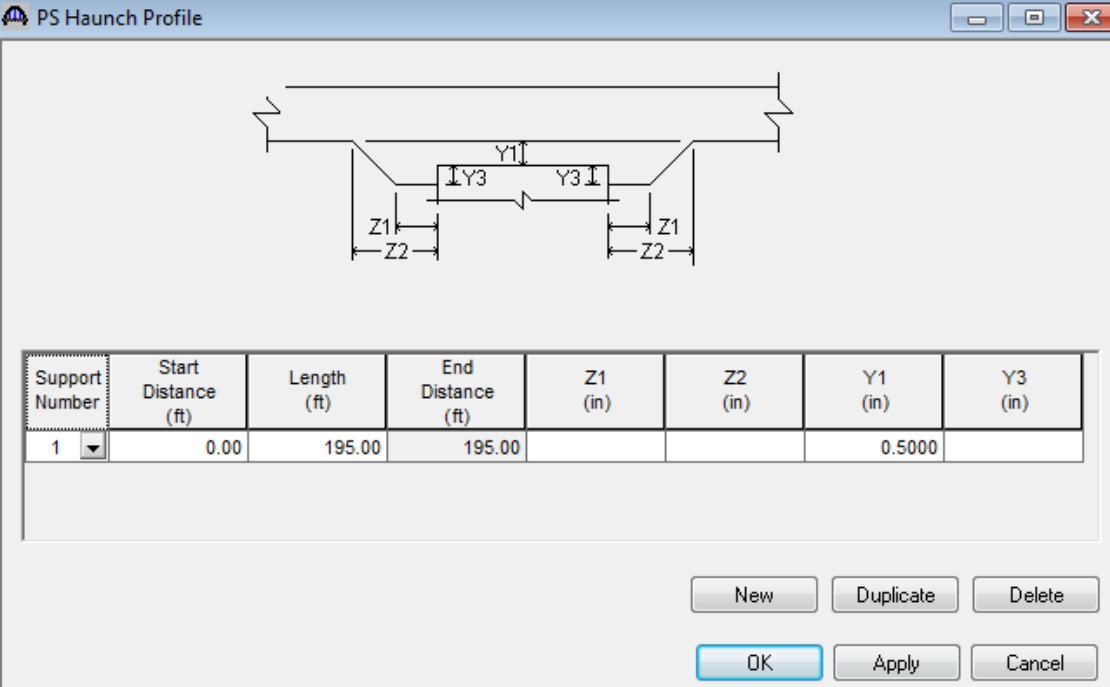
Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Std Bar Count	LRFD Bar Count	Bar Size	Distance (in)	Row	Bar Spacing (in)
Grade 60	1	60.00	30.00	90.00	11.00	11.00	5	2.0000	Bottom of Slab	
Grade 60	1	60.00	30.00	90.00	11.00	11.00	6	3.5000	Top of Slab	
Grade 60	2	45.00	30.00	75.00	11.00	11.00	6	3.5000	Top of Slab	
Grade 60	2	45.00	30.00	75.00	11.00	11.00	5	2.0000	Bottom of Slab	

New Duplicate Delete

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

The haunch profile is defined by double clicking on Haunch Profile in the tree. The window is shown below. The I shape shown is for illustrative purposes only.



The dialog box, titled "PS Haunch Profile", contains a technical drawing of a haunched beam cross-section. The drawing shows a central I-beam section with a central span of length $Y1$ and two side spans of length $Y3$. The side spans are defined by distances $Z1$ from the centerline to the start of the haunch and $Z2$ from the start of the haunch to the support. The haunch profile is a trapezoidal shape that tapers from the top flange to the bottom flange.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)	Y3 (in)
1	0.00	195.00	195.00			0.5000	

At the bottom of the dialog box, there are six buttons: "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

PS2 - Three Span Spread PS Box Beam Example

The interior diaphragms for the box beam are entered as follows.

The screenshot shows a software window titled "Interior Diaphragms" with a table of data. The table has 8 columns: Span Number, Start Distance (ft), Diaphragm Spacing (ft), Number of Spaces, Length (ft), End Distance (ft), Diaphragm Thickness (in), and Diaphragm Load (kip). There are 9 rows of data, representing diaphragms for three spans (1, 2, and 3). Each span has three diaphragms. The Diaphragm Thickness is 0.00 inches for all, and the Diaphragm Load is 0.8000 kips for all. The Diaphragm Spacing is 38.25 ft for span 1, 29.75 ft for span 2, and 29.75 ft for span 3. The Start and End Distances are 0.00, 0.75, and 75.00 for span 1; 0.00, 0.50, and 59.00 for span 2; and 0.00, 0.50, and 59.75 for span 3. The Length is 38.25 ft for span 1, 29.75 ft for span 2, and 29.75 ft for span 3. The Number of Spaces is 1 for all diaphragms. Below the table are buttons for "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

Span Number	Start Distance (ft)	Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)	Diaphragm Thickness (in)	Diaphragm Load (kip)
1	0.00	38.25	1	38.25	38.25	0.00	0.8000
1	0.75	0.00	1	0.00	0.75	0.00	0.8000
1	75.00	0.00	1	0.00	75.00	0.00	0.8000
2	0.00	29.75	1	29.75	29.75	0.00	0.8000
2	0.50	0.00	1	0.00	0.50	0.00	0.8000
2	59.00	0.00	1	0.00	59.00	0.00	0.8000
3	0.00	29.75	1	29.75	29.75	0.00	0.8000
3	0.50	0.00	1	0.00	0.50	0.00	0.8000
3	59.75	0.00	1	0.00	59.75	0.00	0.8000

PS2 - Three Span Spread PS Box Beam Example

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.

PS Shear Reinforcement Ranges

Span: 1 Copy to Span...

Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Stirrups	<input checked="" type="checkbox"/>	0.75	1	0.0000	0.00	0.75
#4 Stirrups	<input checked="" type="checkbox"/>	0.75	99	9.0000	74.25	75.00

Stirrup Wizard... Stirrup Design Tool... View Calcs New Duplicate Delete OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

PS Shear Reinforcement Ranges

Vertical Horizontal

Span: 2 Copy to Span...

Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Stirrups	<input checked="" type="checkbox"/>	0.50	1	0.0000	0.00	0.50
#4 Stirrups	<input checked="" type="checkbox"/>	0.50	78	9.0000	58.50	59.00

Stirrup Wizard... Stirrup Design Tool... View Calcs New Duplicate Delete

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

PS Shear Reinforcement Ranges

Vertical Horizontal

Span: 3 Copy to Span...

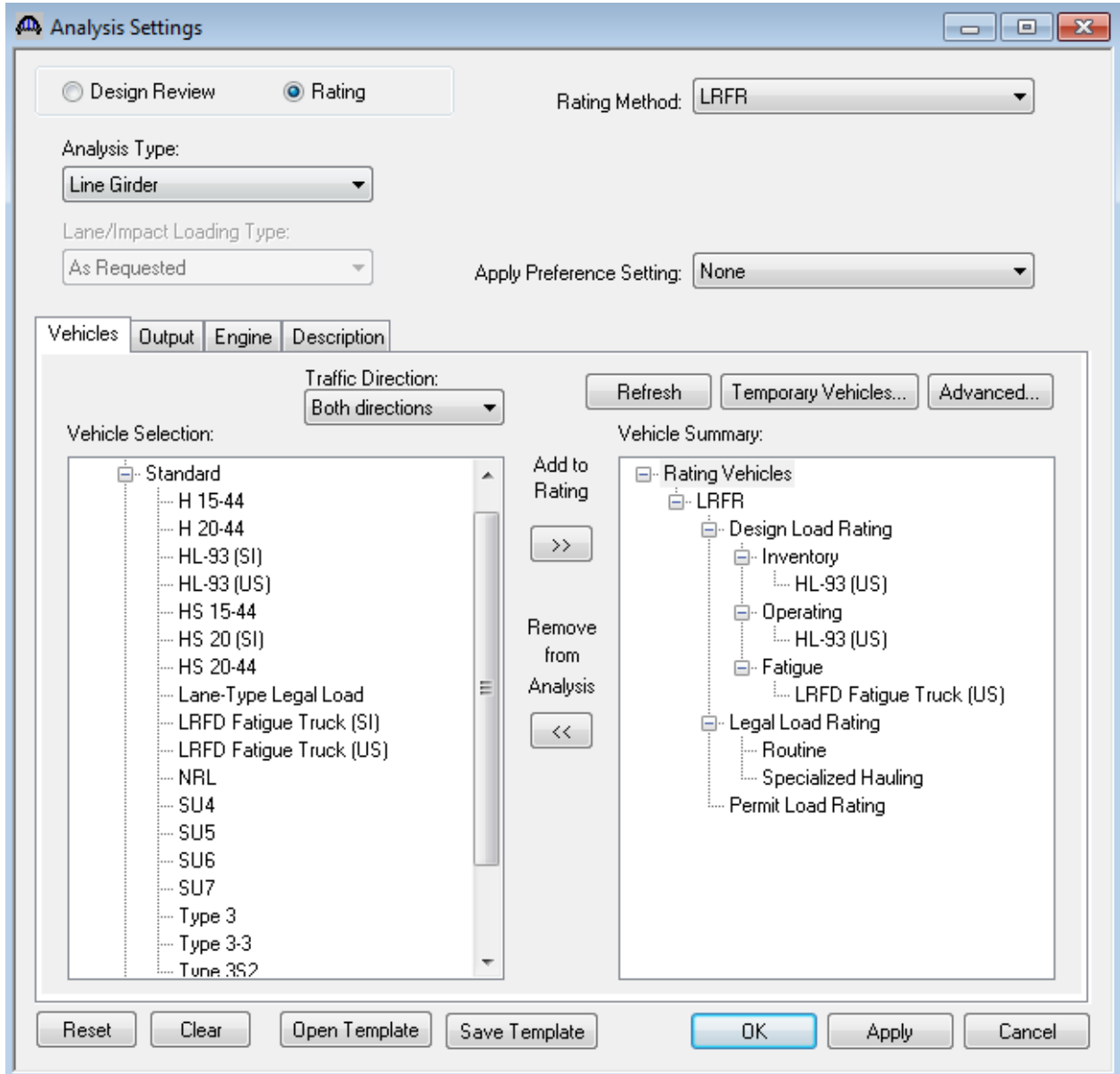
Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#4 Stirrups	<input checked="" type="checkbox"/>	0.50	1	0.0000	0.00	0.50
#4 Stirrups	<input checked="" type="checkbox"/>	0.50	79	9.0000	59.25	59.75

Stirrup Wizard... Stirrup Design Tool... View Calcs New Duplicate Delete

OK Apply Cancel

PS2 - Three Span Spread PS Box Beam Example

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.



PS2 - Three Span Spread PS Box Beam Example

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 - 48" PS Box

Report Type: Rating Results Summary

Lane/Impact Loading Type: As Requested Detailed

Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	32.87	0.913	37.13	1 - (49.5)	SERVICE-III PS Tensil	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	50.52	1.403	75.00	1 - (100.0)	STRENGTH-I Concre	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	37.06	1.029	37.13	1 - (49.5)	SERVICE-III PS Tensil	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	60.97	1.694	75.00	1 - (100.0)	STRENGTH-I Concre	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	35.38	0.983	75.00	1 - (100.0)	STRENGTH-I Concre	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	45.87	1.274	75.00	1 - (100.0)	STRENGTH-I Concre	As Requested	As Requested

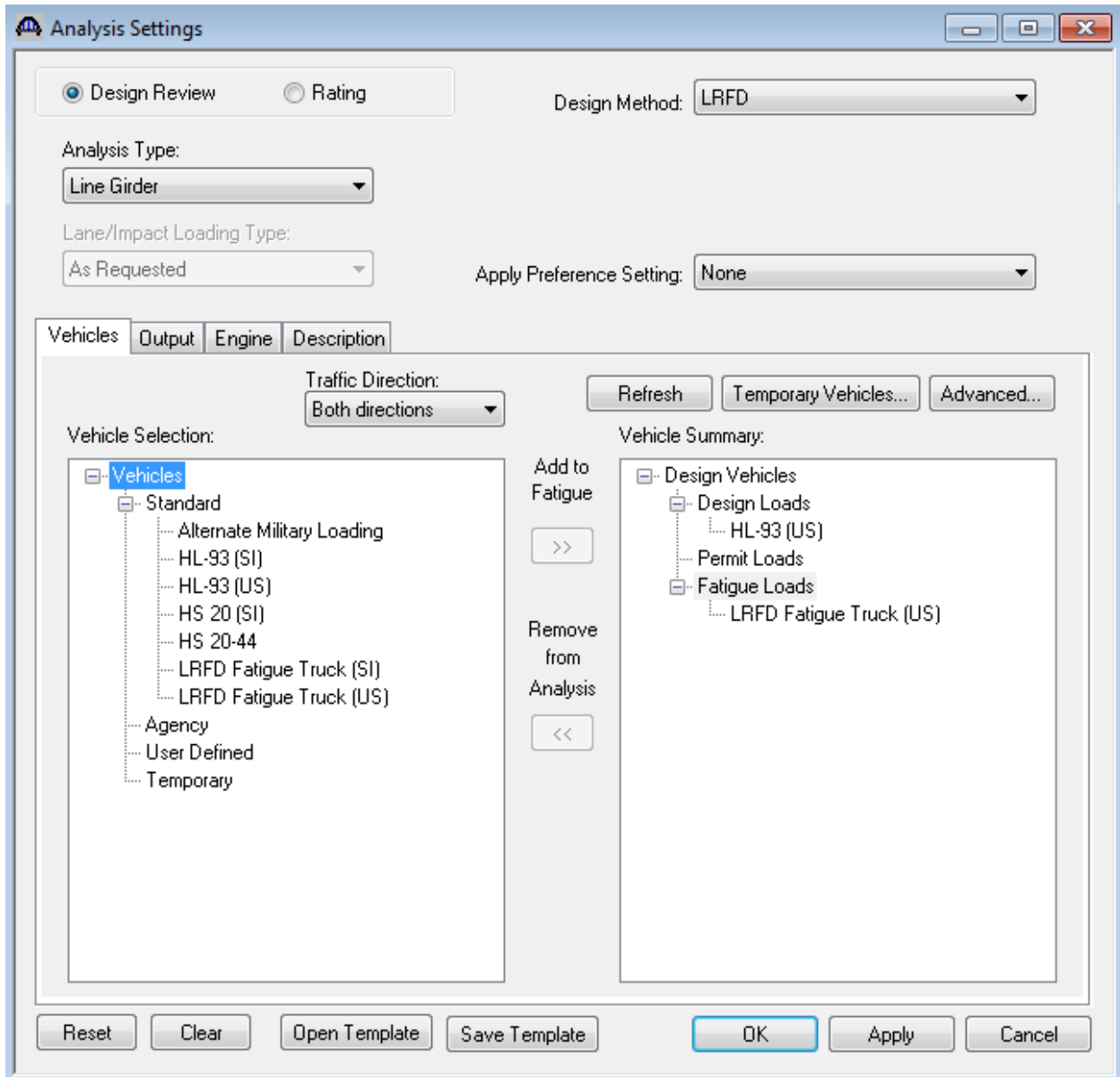
AASHTO LRFR Engine Version 6.8.0.3001

Analysis Preference Setting: None


Close

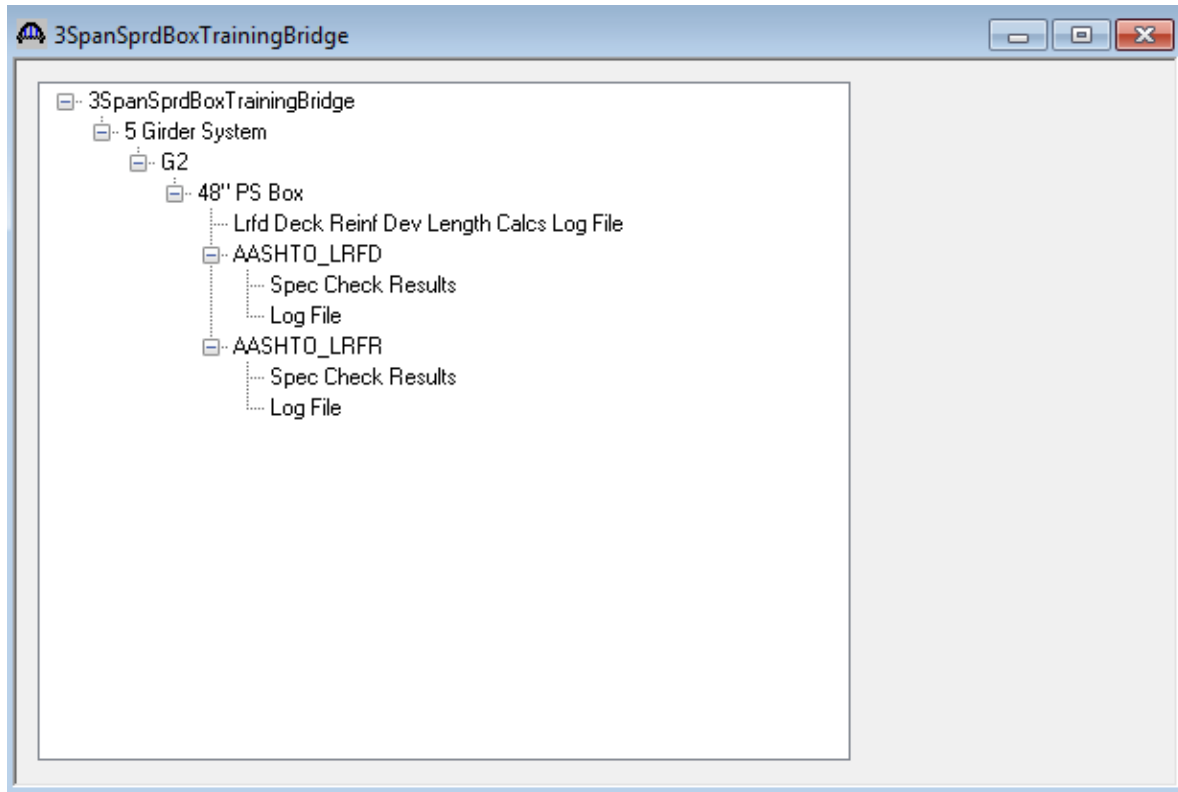
PS2 - Three Span Spread PS Box Beam Example

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:



PS2 - Three Span Spread PS Box Beam Example

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, double click the Spec Check Results in this window.

Bridge ID : -1002
 Bridge : 3Span Sprd Box Trn Bridge
 Superstructure Def : 5 Girder System
 Member : G2
 Analysis Preference Setting : None

NBI Structure ID : 3SpanSprdBoxTra
 Bridge Alt :
 Member Alt : 48" PS Box

AASHTO LRFD Specification, Edition 7, Interim 2016

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)	Fail
Flexure (5.7.3.2, 5.7.3.3.2)	Fail
Shear (5.8.3.3, 5.8.2.5, 5.8.2.7, 5.8.3.5)	Fail
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	-3.06	0.05	-0.65	4.71	Pass
1.750	-3.06	0.10	-2.11	1.45	Pass