AASHTOWare BrDR 7.5.0

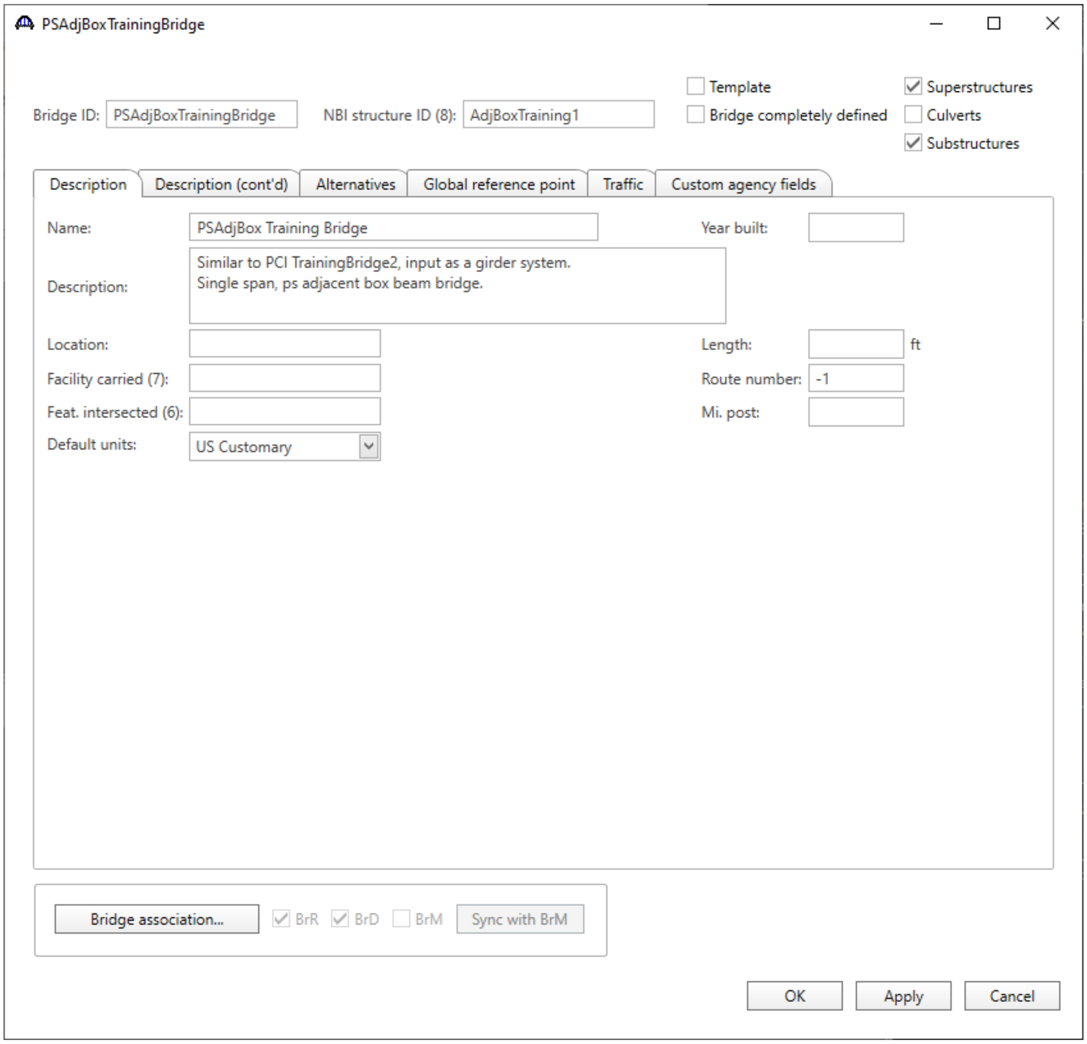
Prestressed Concrete Structure Tutorial

PS3 – Adjacent PS Box Example

BrDR Training

PS3 - Adjacent PS Box Example

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

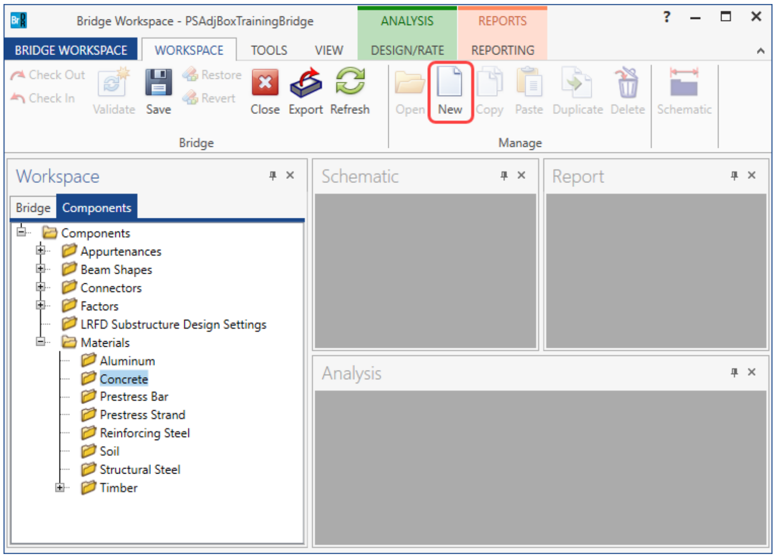


Click **OK** to apply the data and close the window.

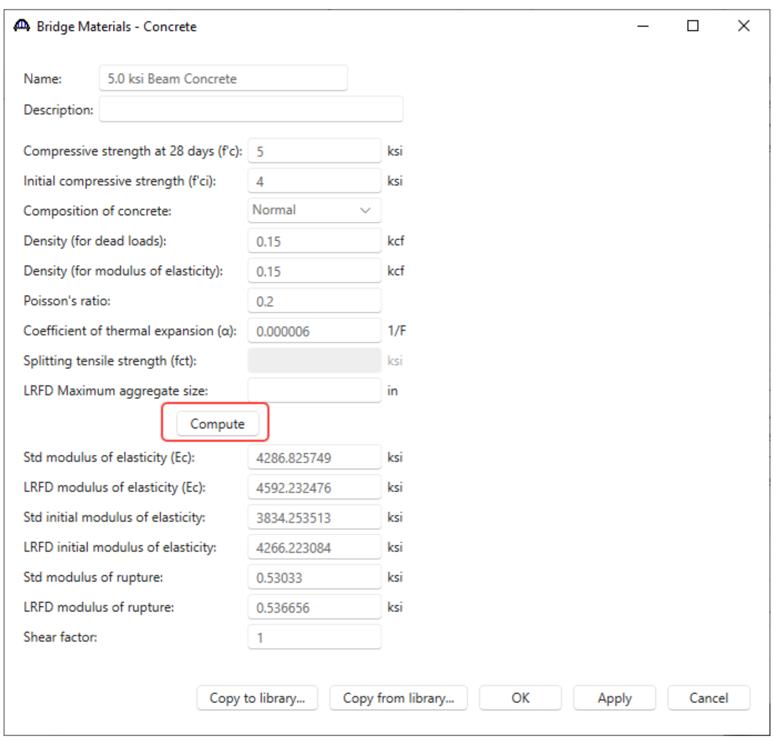
Bridge Components

Bridge Materials - Concrete

To add a new concrete material, in the **Components** tab of the **Bridge Workspace**, expand the **Materials** node by clicking the ⊞ button, select **Concrete,** and select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **Concrete** and select **New**).



The window shown below will open. Enter the values as shown below.



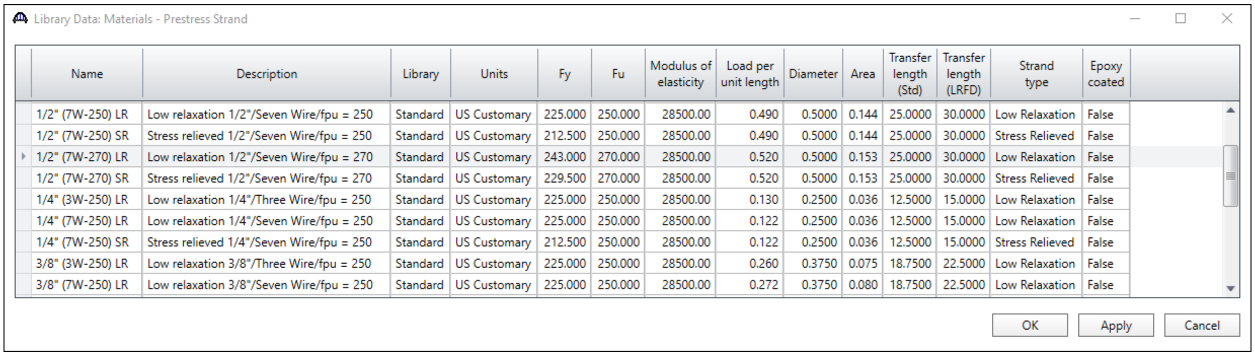
Click **OK** to apply the data and close the window.

Since a bituminous surface will be used on this bridge as a wearing surface, deck concrete material is not required.

Bridge Materials – Prestress strand

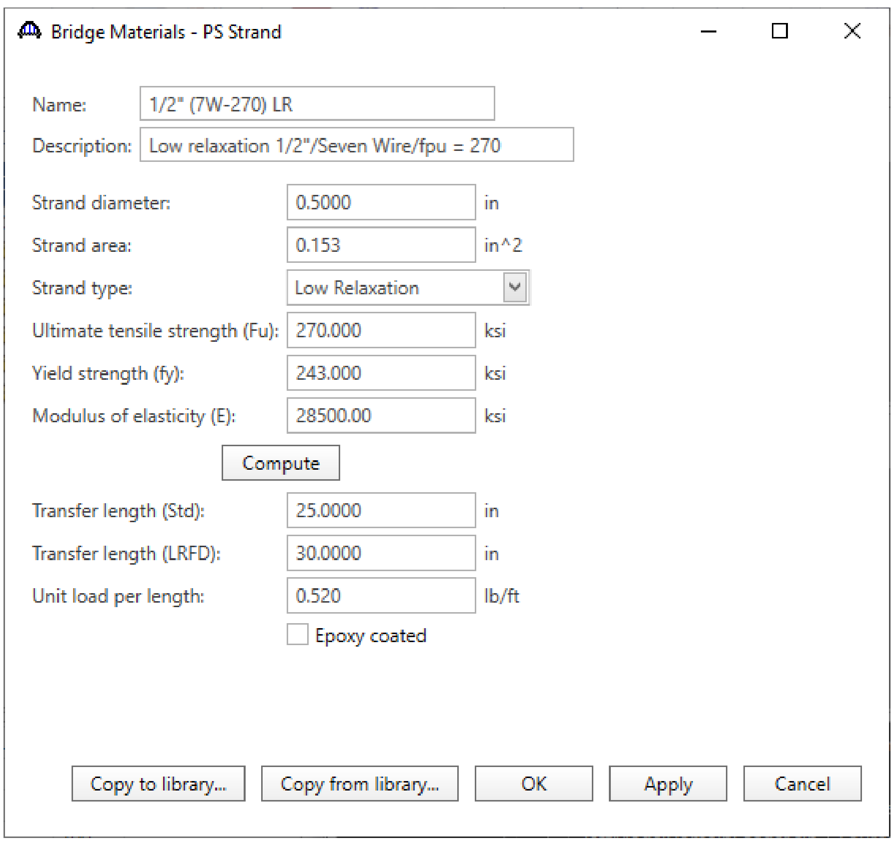
To add a new prestress strand material, select **Prestress Strand** in the **Components** tree**,** and select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **Prestress Strand** and select **New**).

Click on the **Copy from library…** button in this window and select **½" (7W-270) LR** from the library and click **OK.**


Library Data: Materials - Prestress Strand

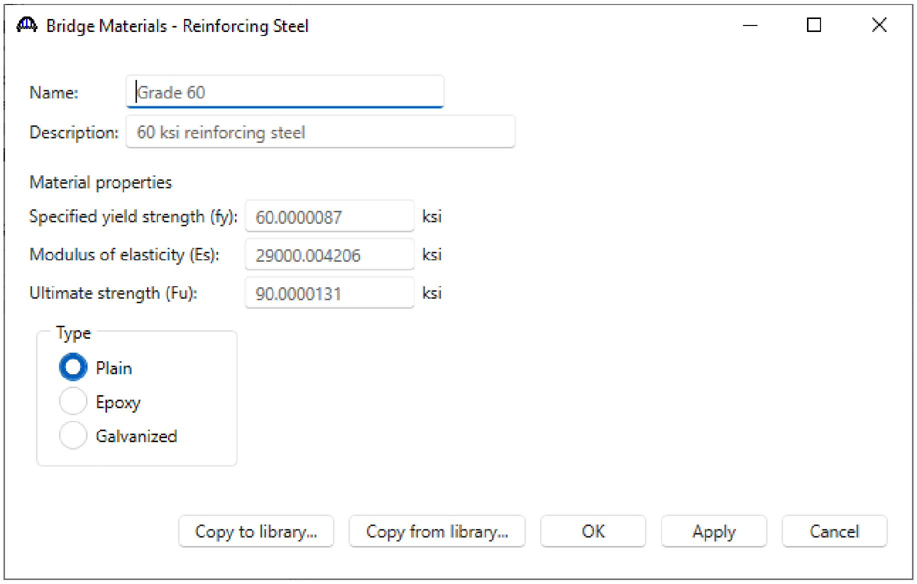
Name	Description	Library	Units	Fy	Fu	Modulus of elasticity	Load per unit length	Diameter	Area	Transfer length (Std)	Transfer length (LRFD)	Strand type	Epoxy coated
1/2" (7W-250) LR	Low relaxation 1/2"/Seven Wire/fpu = 250	Standard	US Customary	225.000	250.000	28500.00	0.490	0.5000	0.144	25.0000	30.0000	Low Relaxation	False
1/2" (7W-250) SR	Stress relieved 1/2"/Seven Wire/fpu = 250	Standard	US Customary	212.500	250.000	28500.00	0.490	0.5000	0.144	25.0000	30.0000	Stress Relieved	False
1/2" (7W-270) LR	Low relaxation 1/2"/Seven Wire/fpu = 270	Standard	US Customary	243.000	270.000	28500.00	0.520	0.5000	0.153	25.0000	30.0000	Low Relaxation	False
1/2" (7W-270) SR	Stress relieved 1/2"/Seven Wire/fpu = 270	Standard	US Customary	229.500	270.000	28500.00	0.520	0.5000	0.153	25.0000	30.0000	Stress Relieved	False
1/4" (3W-250) LR	Low relaxation 1/4"/Three Wire/fpu = 250	Standard	US Customary	225.000	250.000	28500.00	0.130	0.2500	0.036	12.5000	15.0000	Low Relaxation	False
1/4" (7W-250) LR	Low relaxation 1/4"/Seven Wire/fpu = 250	Standard	US Customary	225.000	250.000	28500.00	0.122	0.2500	0.036	12.5000	15.0000	Low Relaxation	False
1/4" (7W-250) SR	Stress relieved 1/4"/Seven Wire/fpu = 250	Standard	US Customary	212.500	250.000	28500.00	0.122	0.2500	0.036	12.5000	15.0000	Stress Relieved	False
3/8" (3W-250) LR	Low relaxation 3/8"/Three Wire/fpu = 250	Standard	US Customary	225.000	250.000	28500.00	0.260	0.3750	0.075	18.7500	22.5000	Low Relaxation	False
3/8" (7W-250) LR	Low relaxation 3/8"/Seven Wire/fpu = 250	Standard	US Customary	225.000	250.000	28500.00	0.272	0.3750	0.080	18.7500	22.5000	Low Relaxation	False

The selected material properties are copied to the **Bridge Materials – PS Strand** window as shown below.



Click **OK** to apply the data and close the window.

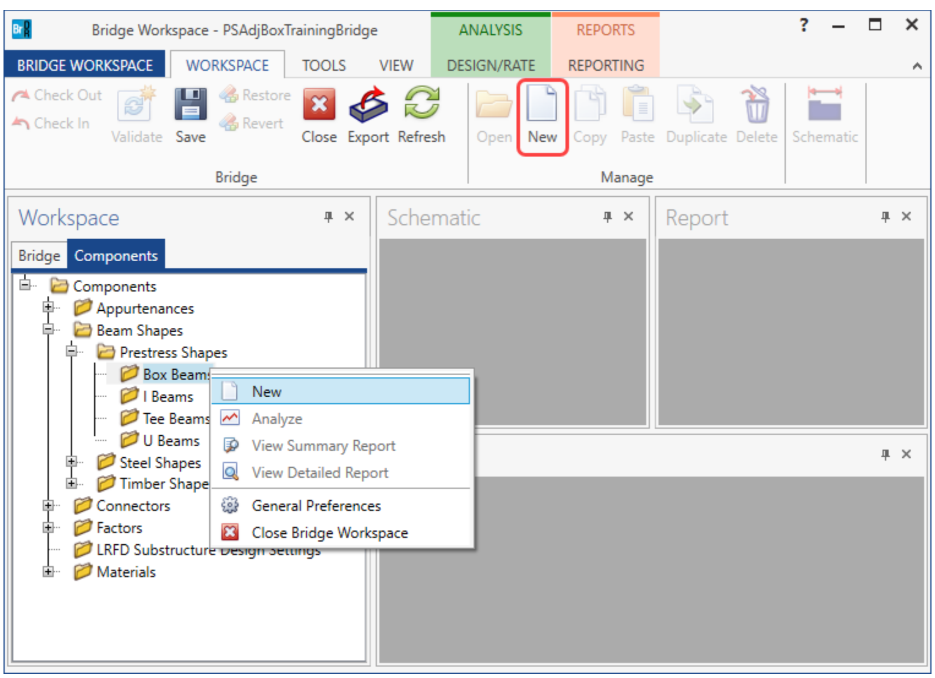
Add the following reinforcement steel in the same manner.



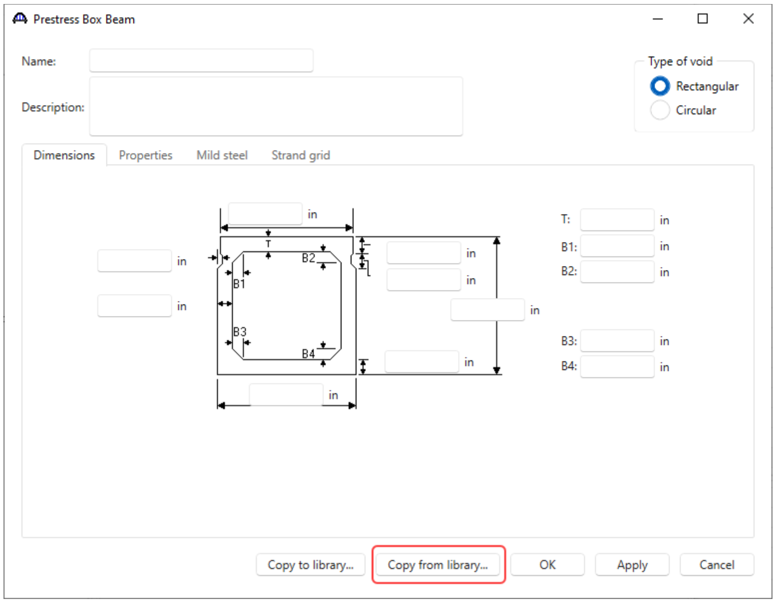
Click **OK** to apply the data and close the window.

Beam Shape

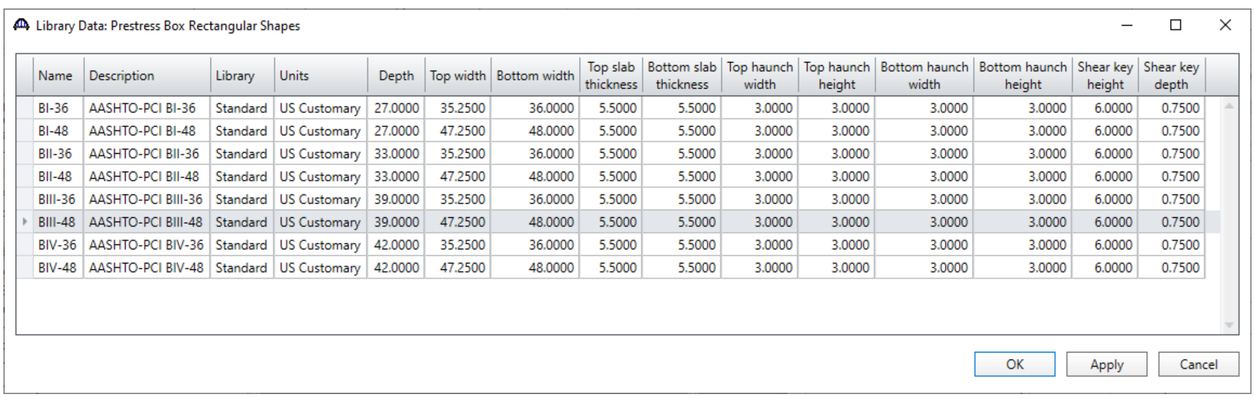
To enter a prestress beam shape to be used in this bridge expand the tree labelled **Beam Shapes** and **Prestress Shapes** as shown below and click on the **Box Beams** node in the **Components** tree, select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **Box Beams** and select **New** or double click on **Box Beams** in the **Components** tree).



The **Prestress Box Beam** window shown below will open.



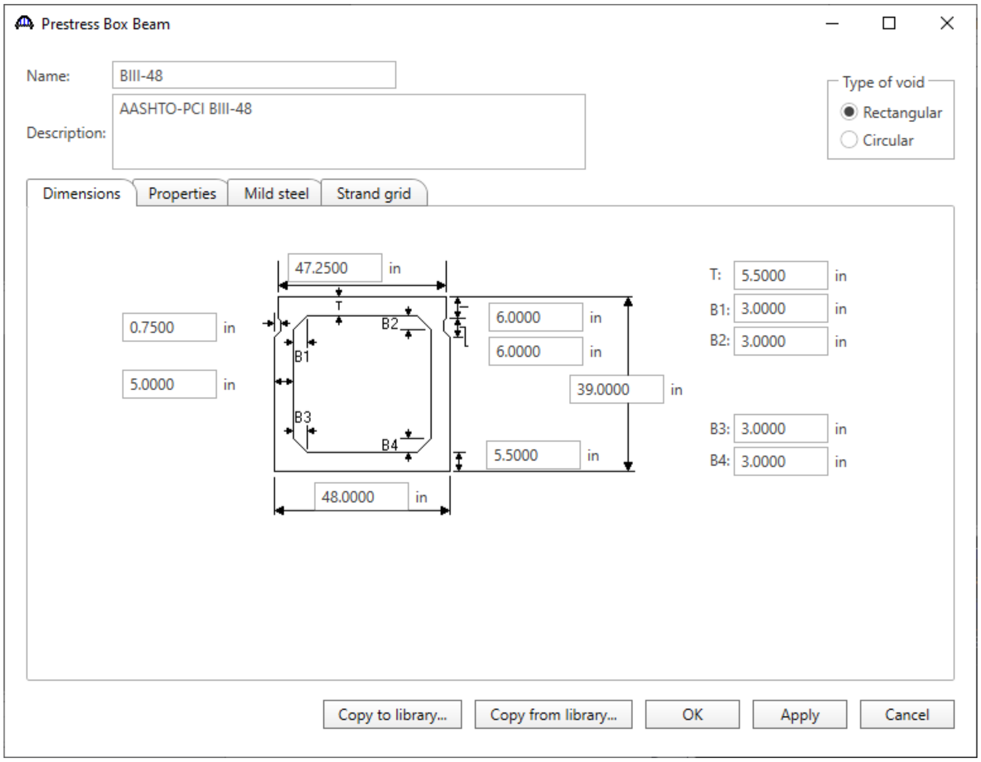
Select the **Type of Void** as **Rectangular** and click on the **Copy from Library** button. The window shown below appears.


Library Data: Prestress Box Rectangular Shapes

Name	Description	Library	Units	Depth	Top width	Bottom width	Top slab thickness	Bottom slab thickness	Top haunch width	Top haunch height	Bottom haunch width	Bottom haunch height	Shear key height	Shear key depth
BI-36	AASHTO-PCI BI-36	Standard	US Customary	27.0000	35.2500	36.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BI-48	AASHTO-PCI BI-48	Standard	US Customary	27.0000	47.2500	48.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BII-36	AASHTO-PCI BII-36	Standard	US Customary	33.0000	35.2500	36.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BII-48	AASHTO-PCI BII-48	Standard	US Customary	33.0000	47.2500	48.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BIII-36	AASHTO-PCI BIII-36	Standard	US Customary	39.0000	35.2500	36.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BIII-48	AASHTO-PCI BIII-48	Standard	US Customary	39.0000	47.2500	48.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BIV-36	AASHTO-PCI BIV-36	Standard	US Customary	42.0000	35.2500	36.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500
BIV-48	AASHTO-PCI BIV-48	Standard	US Customary	42.0000	47.2500	48.0000	5.5000	5.5000	3.0000	3.0000	3.0000	3.0000	6.0000	0.7500

OK Apply Cancel

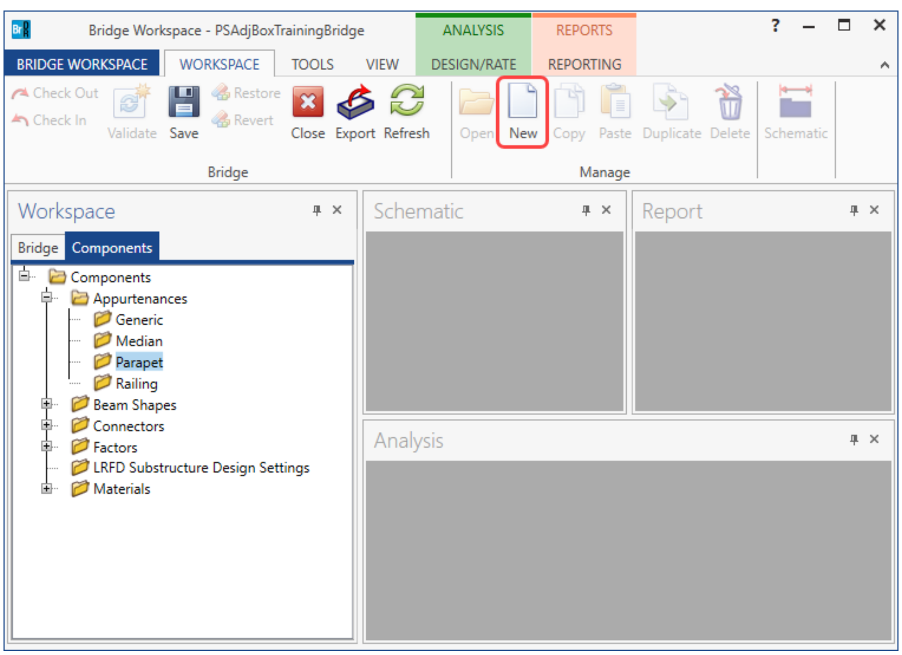
Select **BIII-48 (AASHTO Box Beam, Type BIII-48)** and click **OK**. The beam properties are copied to the **PS Box Beam** window as shown below.



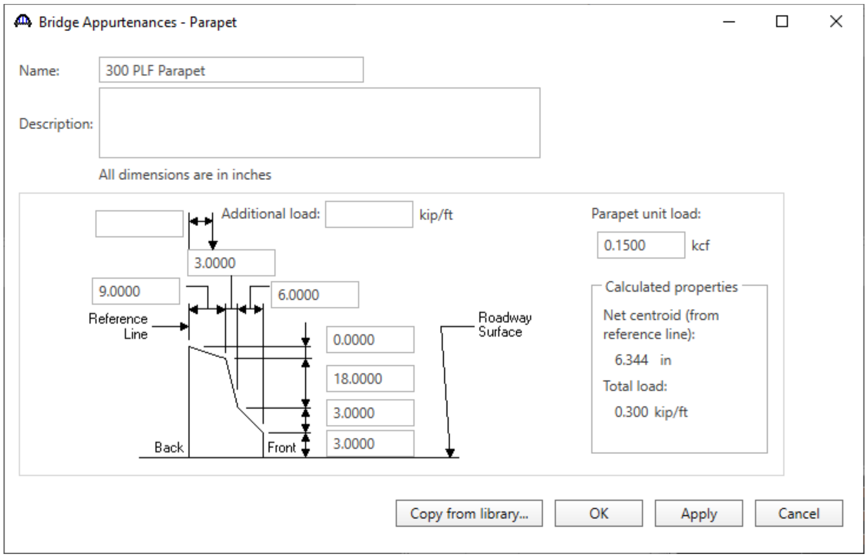
Click **OK** to apply the data and close the window.

Bridge - Appurtenances

To enter the appurtenances to be used within the bridge expand the tree branch labeled **Appurtenances**. To define a parapet, select **Parapet** and click on **New** from the **Manage** button on the **WORKSPACE** ribbon (or double click on **Parapet** in the **Components** tree).



Enter the data as shown below.

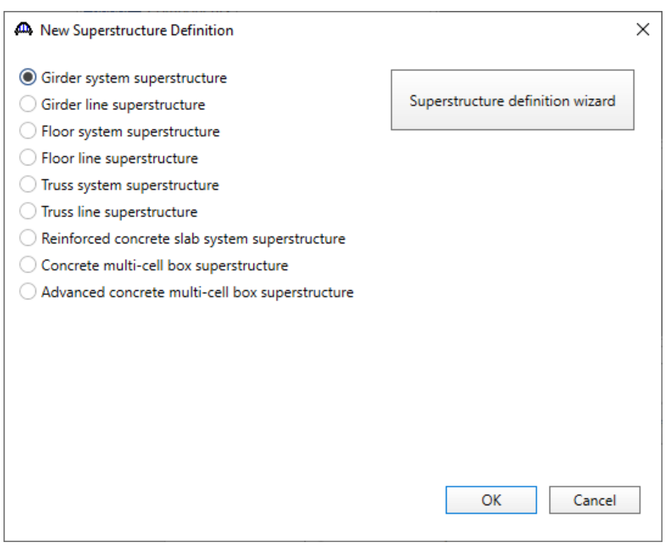


Click **OK** to apply the data and close the window.

The default impact factors, standard LRFD and LFR factors will be used. Bridge Alternatives will be added after entering the Structure Definition.

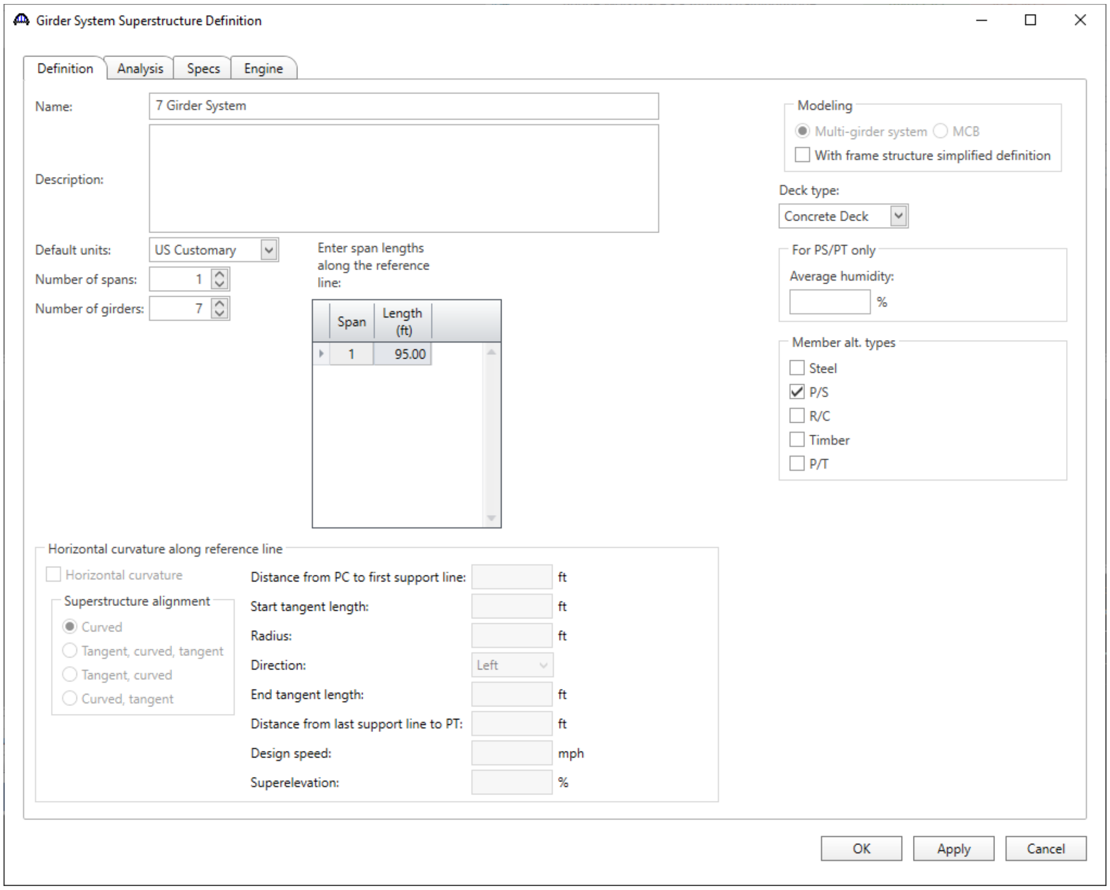
Superstructure Definition

Returning to the **Bridge** tab of the **Bridge Workspace**, double click on **SUPERSTRUCTURE DEFINITIONS** (or click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the **Manage** group of the **WORKSPACE** ribbon or right mouse click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the popup menu) to create a new structure definition. The window shown below will appear.



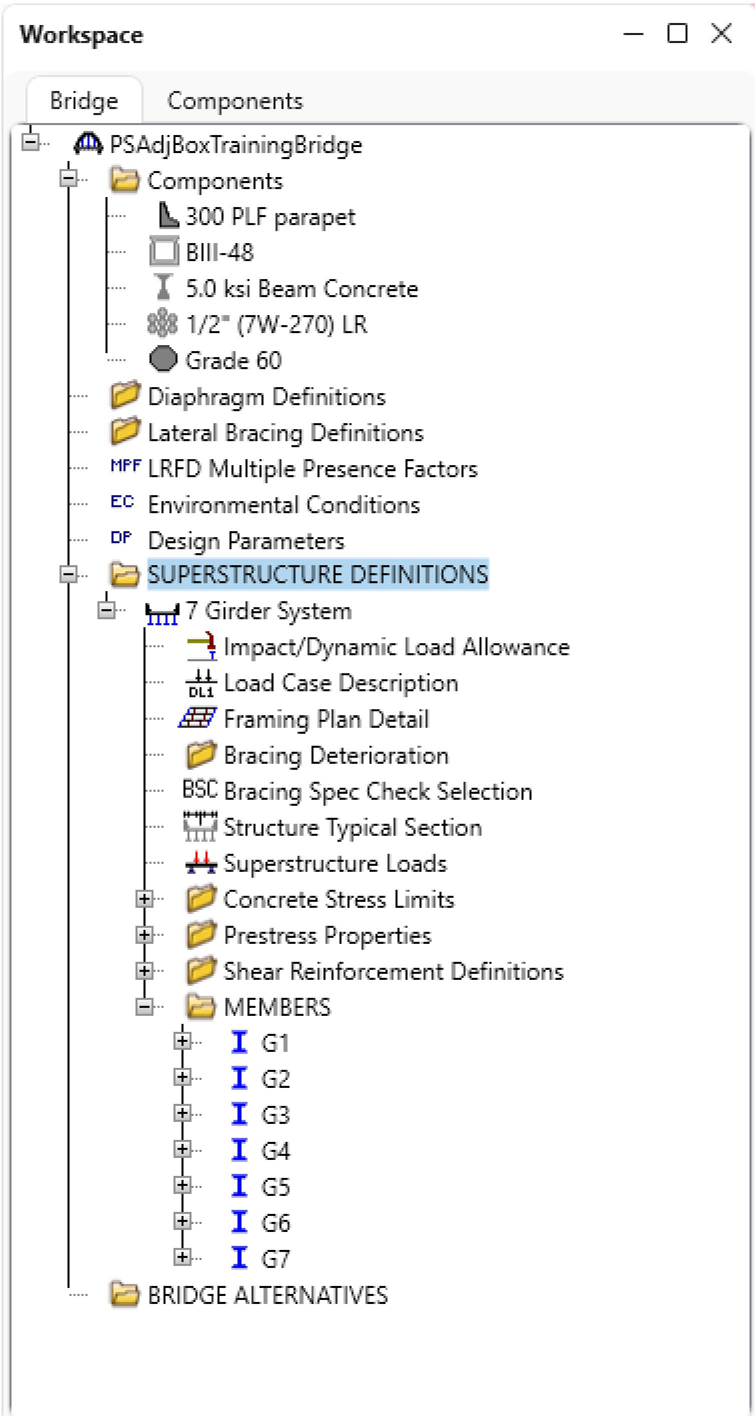
Select **Girder system superstructure**, click **OK** and the **Girder System Superstructure Definition** window will open.

Enter the data as shown below.



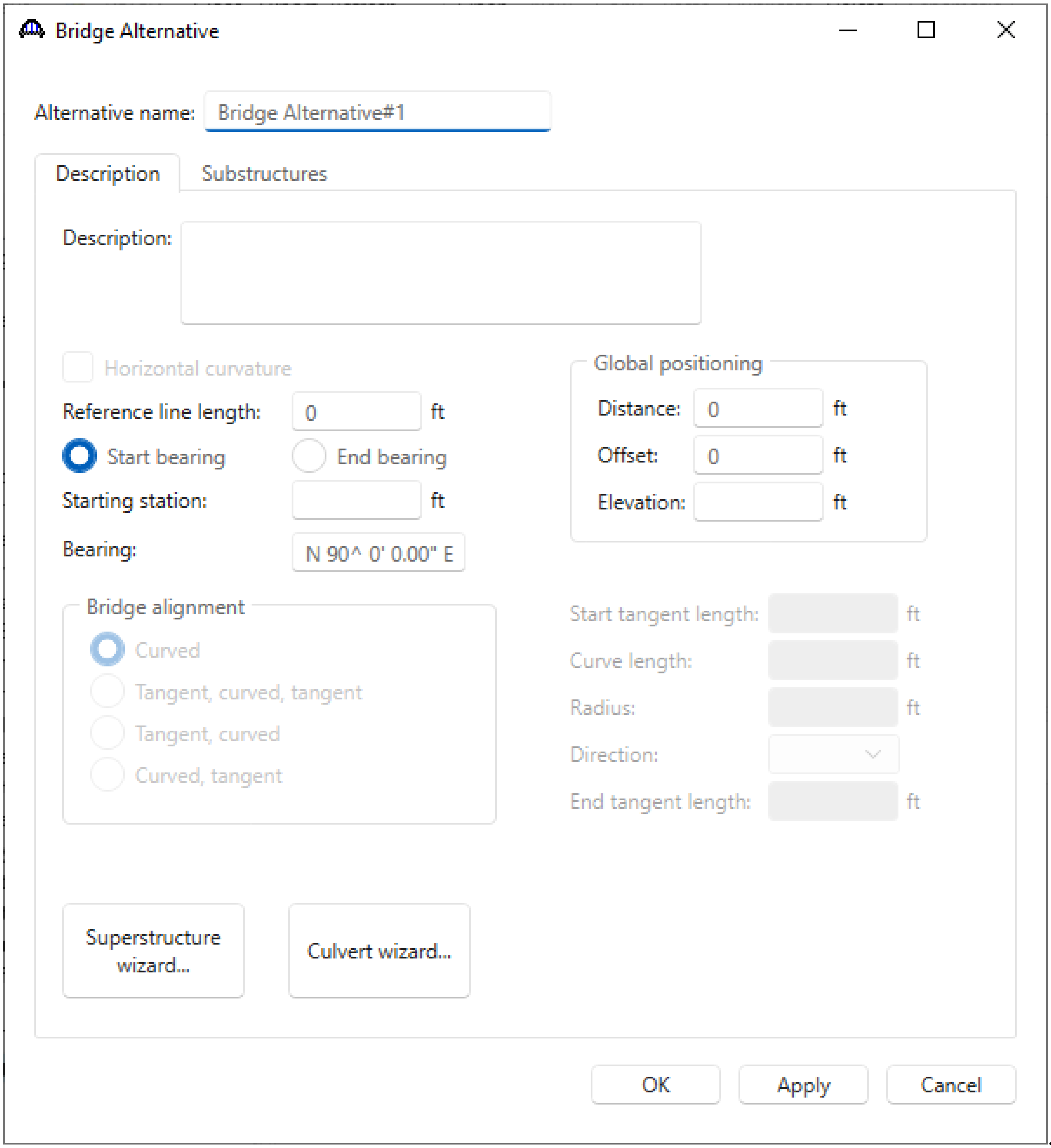
Click **OK** to apply the data and close the window.

The partially expanded **Bridge Workspace** tree is shown below:



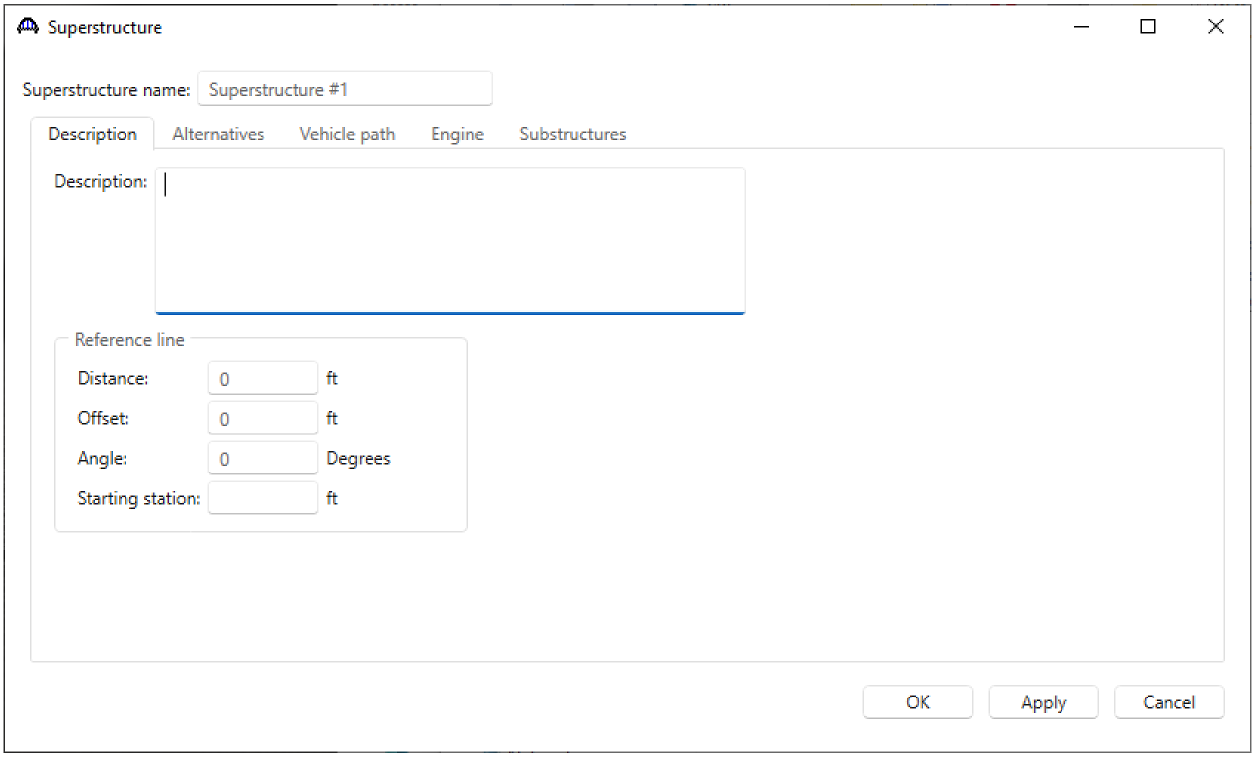
BRIDGE ALTERNATIVES

Navigate to the **BRIDGE ALTERNATIVES** node in the **Bridge Workspace** tree and create a new bridge alternative by double-clicking on **BRIDGE ALTERNATIVES** (or click on **BRIDGE ALTERNATIVES** and select **New** from the **Manage** group of the **WORKSPACE** ribbon). Enter the following data.



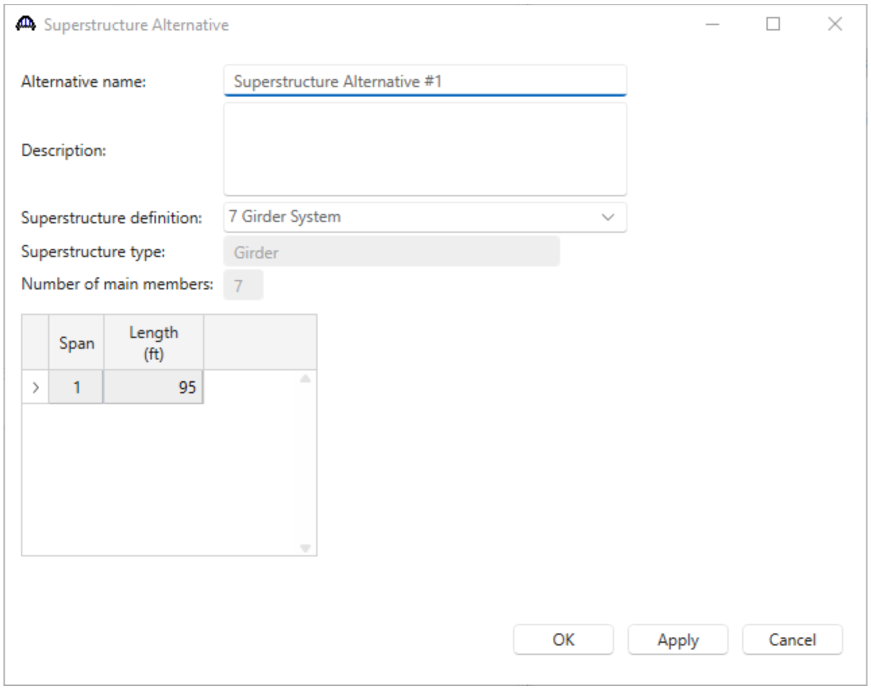
Click **OK** to apply the data and close the window.

Expand the **Bridge Alternative 1** node in the **Bridge Workspace** tree. Double-click on the **SUPERSTRUCTURES** node (or select **SUPERSTRUCTURES** and click **New** from the **Manage** group of the **WORKSPACE** ribbon) and enter the following new superstructure.

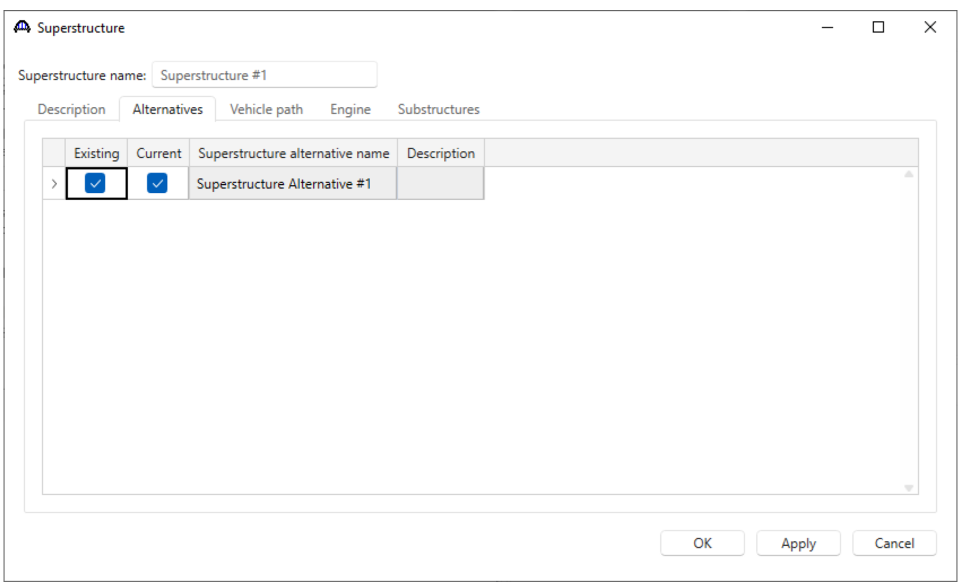


Click **OK** to apply the data and close the window.

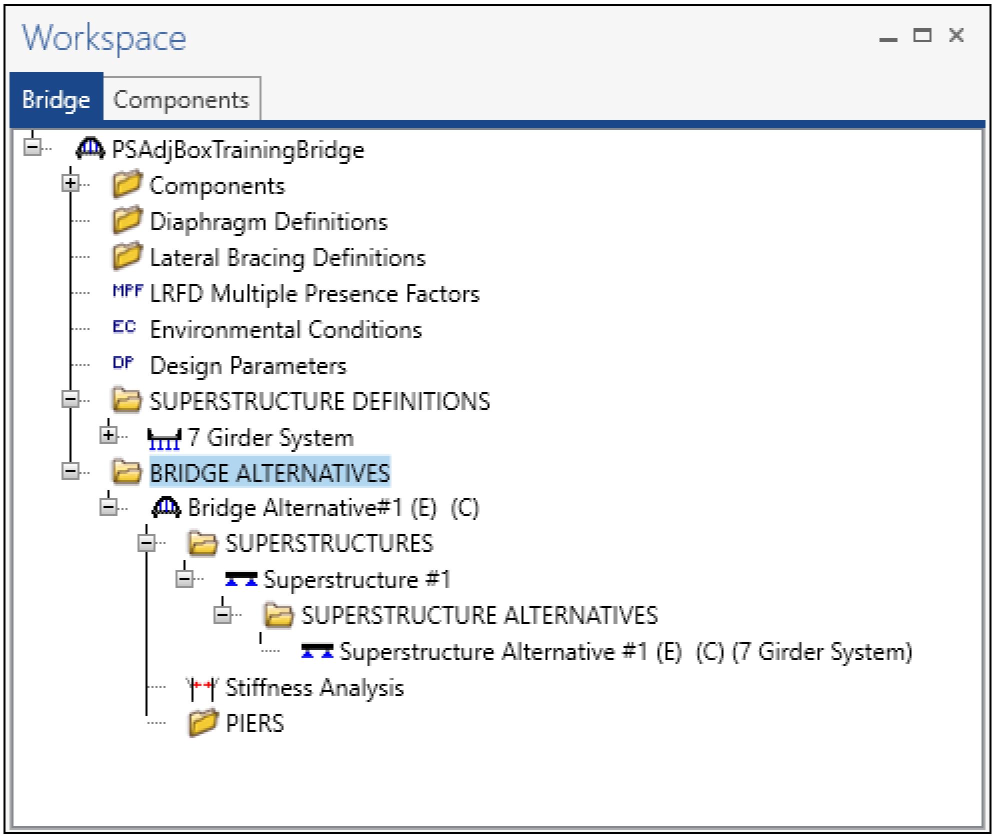
Expand the **Superstructure #1** node in the **Bridge Workspace** tree. Double-click on the **SUPERSTRUCTURE ALTERNATIVES** node (or select **SUPERSTRUCTURE ALTERNATIVES** and click **New** from the **Manage** group of the **WORKSPACE** ribbon) and enter the following new superstructure alternative. Select the superstructure definition **7 Girder System** as the current superstructure definition for this Superstructure Alternative.



Re-open the **Superstructure #1** window and navigate to the **Alternatives** tab. The **Superstructure Alternative #1** will be shown as the **Existing** and **Current** alternative for **Superstructure #1**.

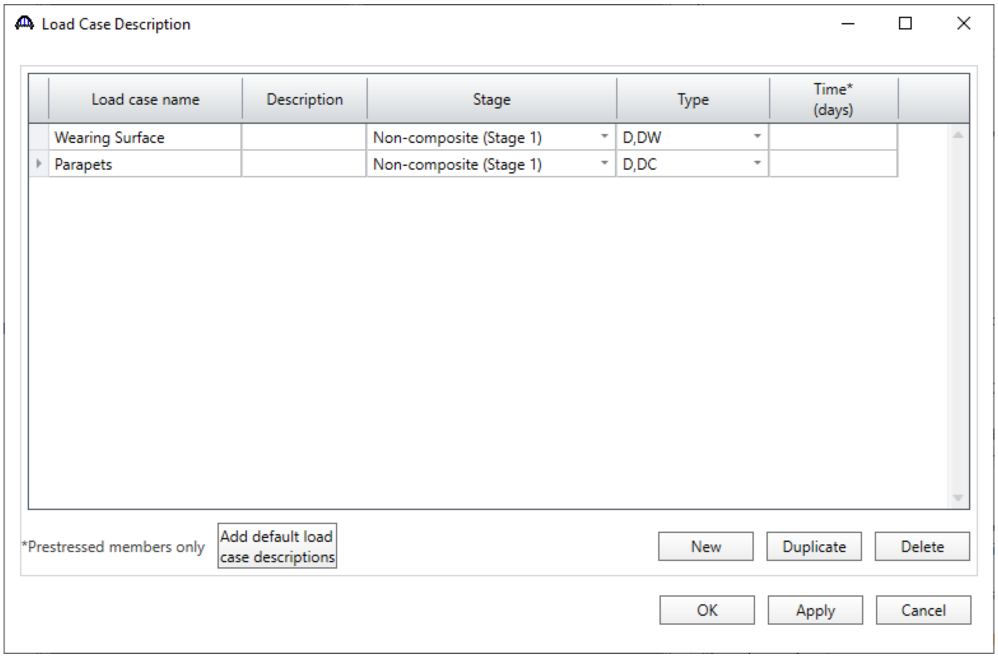


The partially expanded **Bridge Workspace** tree is shown below.



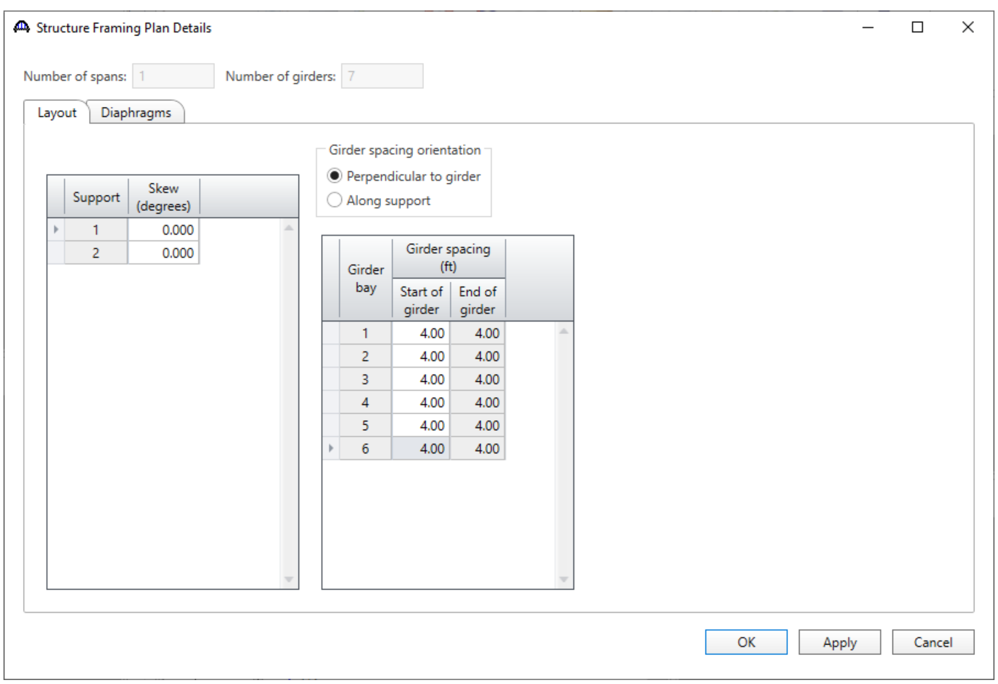
Load Case Description

Double-click on the **Load Case Description** node in the **Bridge Workspace** tree to open the **Load Case Description window** and define the dead load cases as shown below. The completed **Load Case Description** window is shown below.



Structure Framing Plan Detail – Layout

Double-click on **Framing Plan Detail** node in the **Bridge Workspace** tree to describe the framing plan in the **Structure Framing Plan Details** window. Enter the data as shown below.



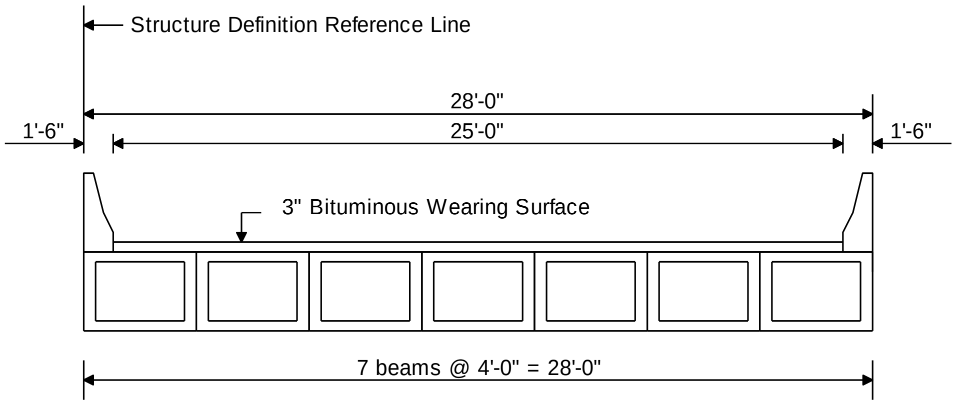
Structure Framing Plan Detail – Diaphragms

The **Diaphragms** tab of this window is used to enter data for exterior diaphragms, in other words diaphragms located between girders. Since an adjacent box beam structure does not have exterior diaphragms, no data will be entered in the **Diaphragms** tab. Interior diaphragms for the box beams will be entered after defining the Member Alternative as a PS box beam.

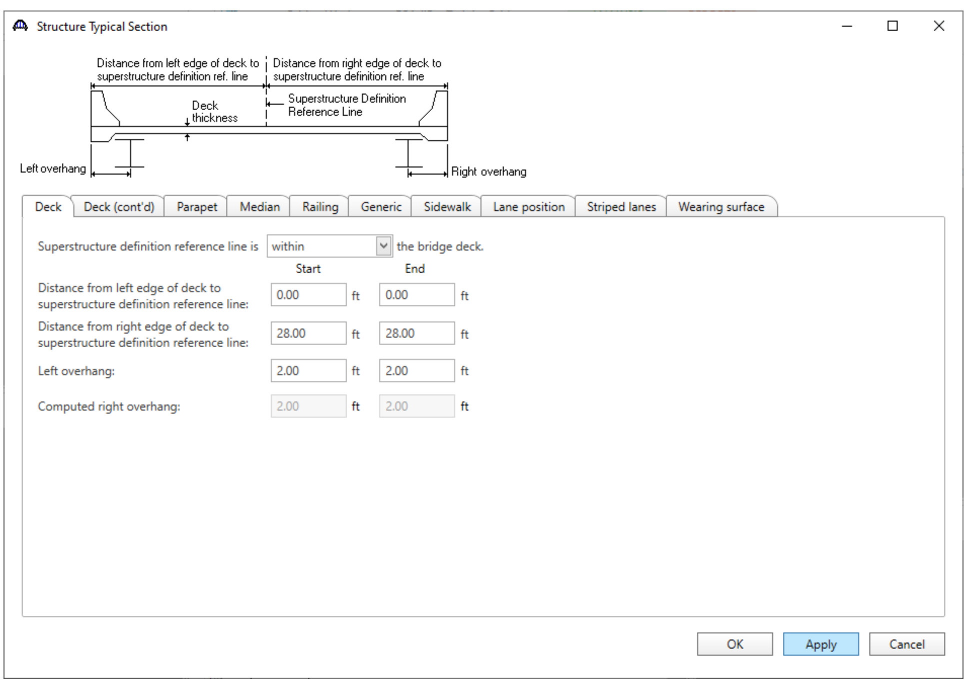
Structure Typical Section - Deck

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

The basic deck geometry is shown below.



Input the data describing the typical section as shown below.

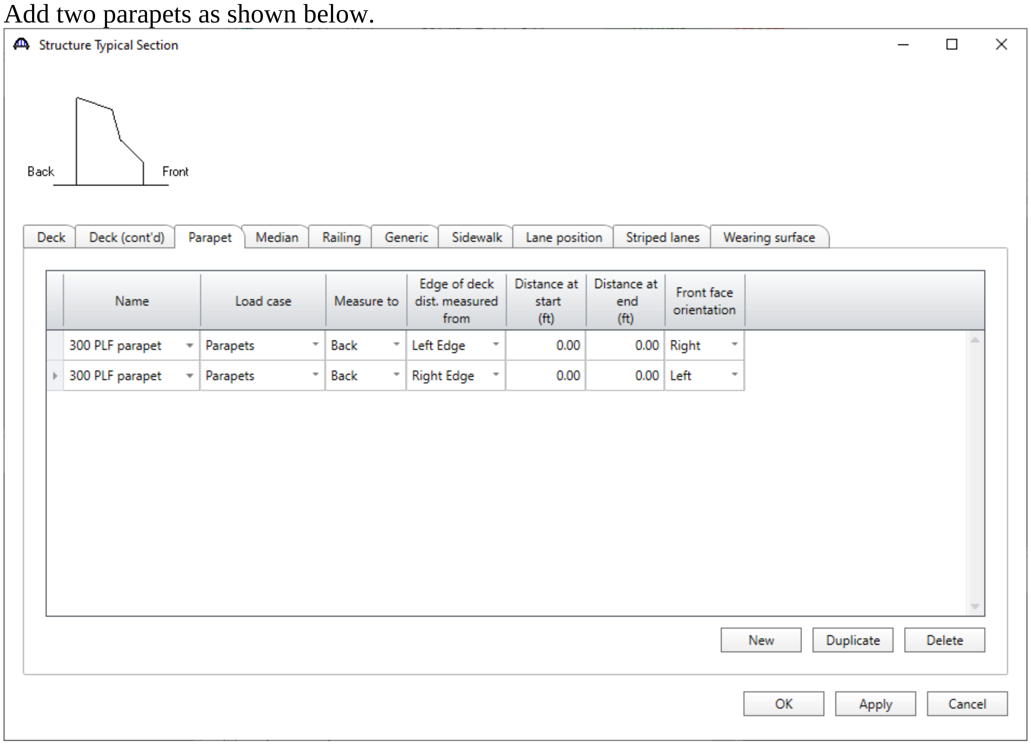


Structure Typical Section – Deck (cont'd)

The **Deck (cont'd)** tab is used to enter information about the **Deck concrete** and the **Total deck thickness**. Since this structure does not have a concrete deck, this tab will be left blank.

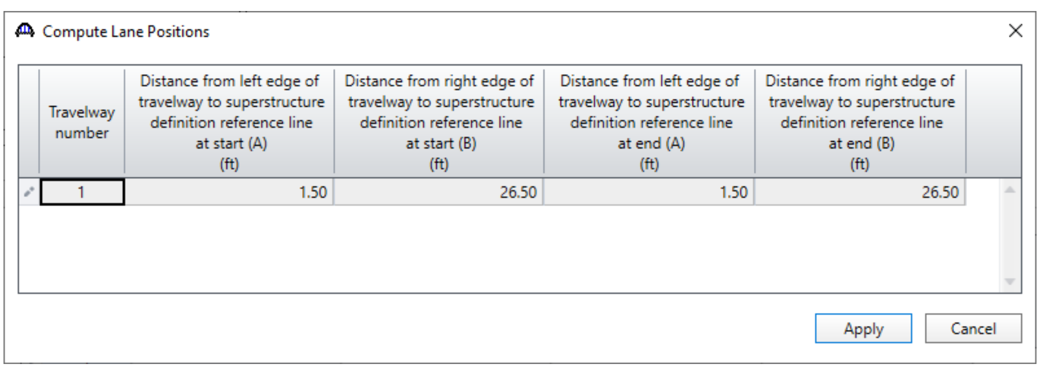
Structure Typical Section – Parapets

Add two parapets as shown below.

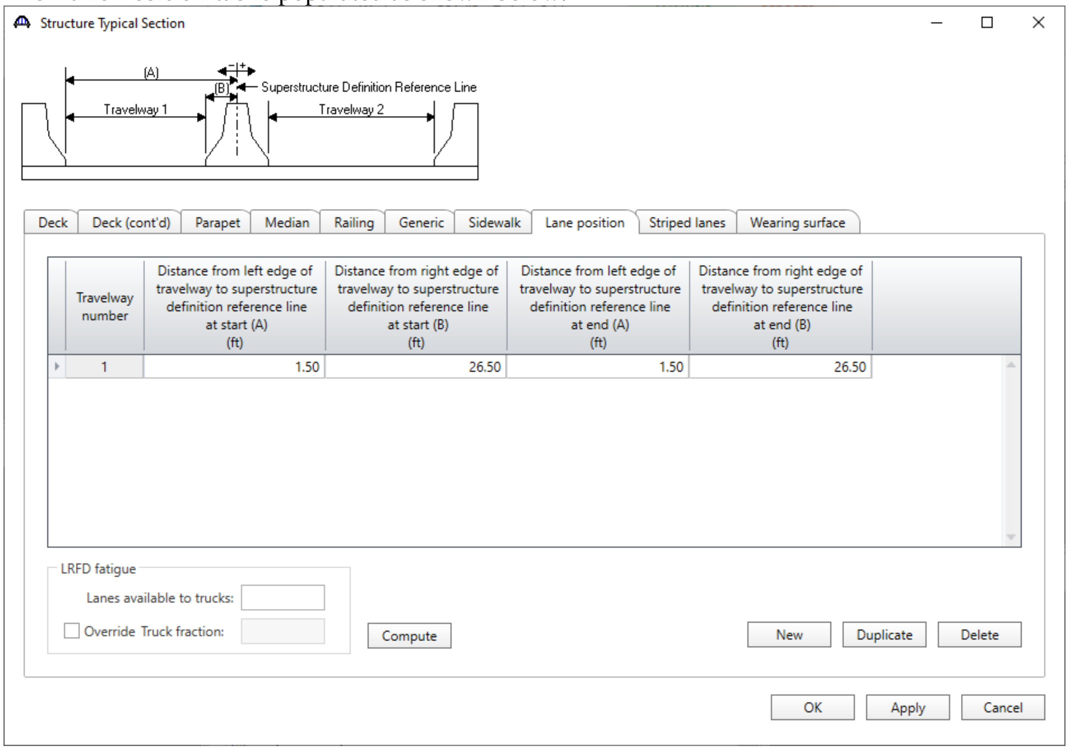


Structure Typical Section – Lane Positions

Select the **Lane position** tab and use the **Compute…** button to compute the lane positions. A window showing the results of the computation opens. Click **Apply** to apply the computed values.

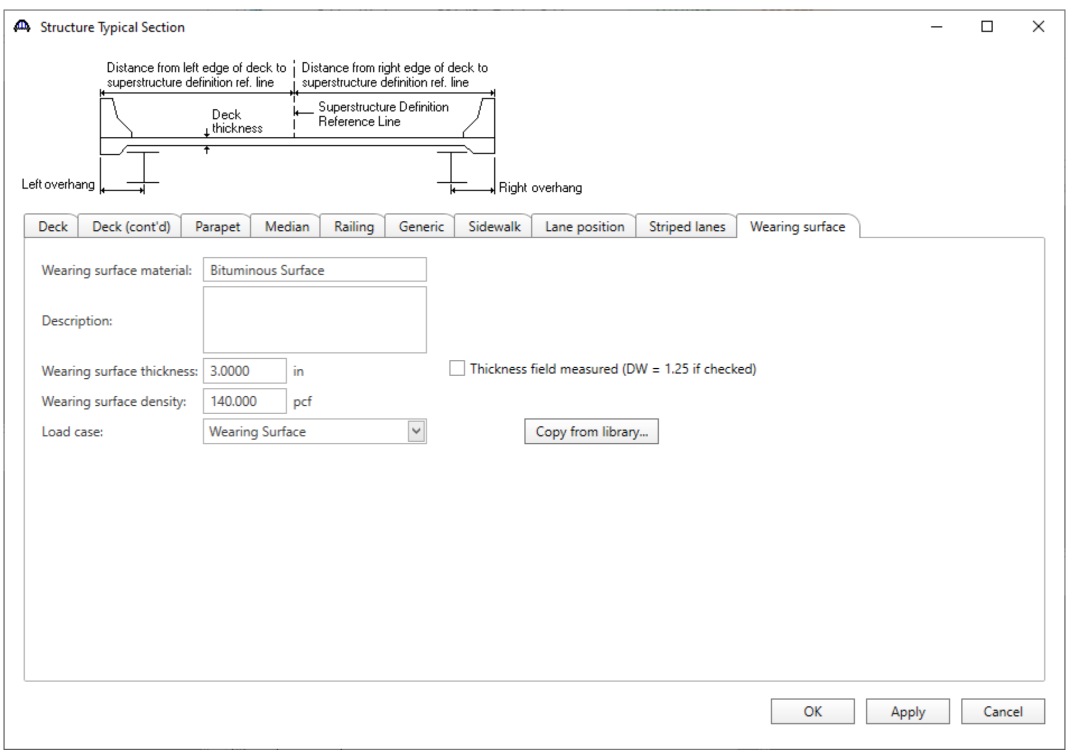


The **Lane Position** tab is populated as shown below.



Structure Typical Section – Wearing surface

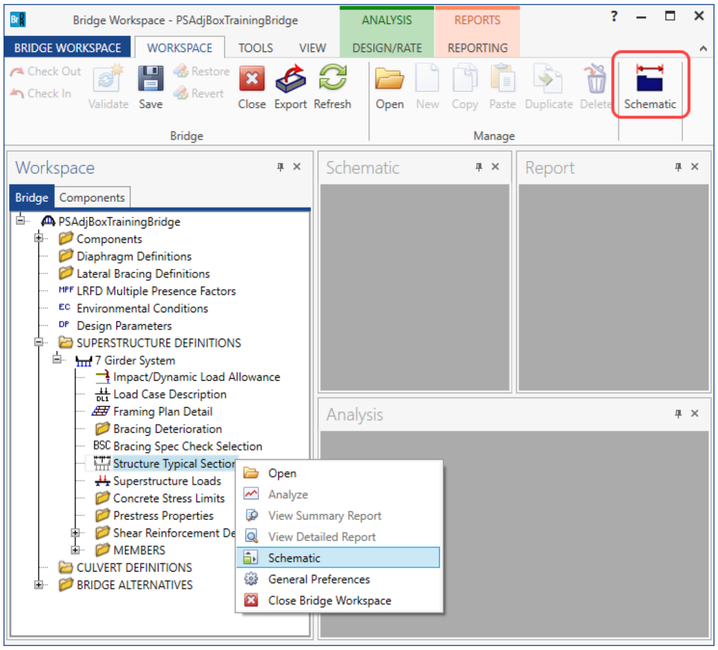
Enter the data shown below.



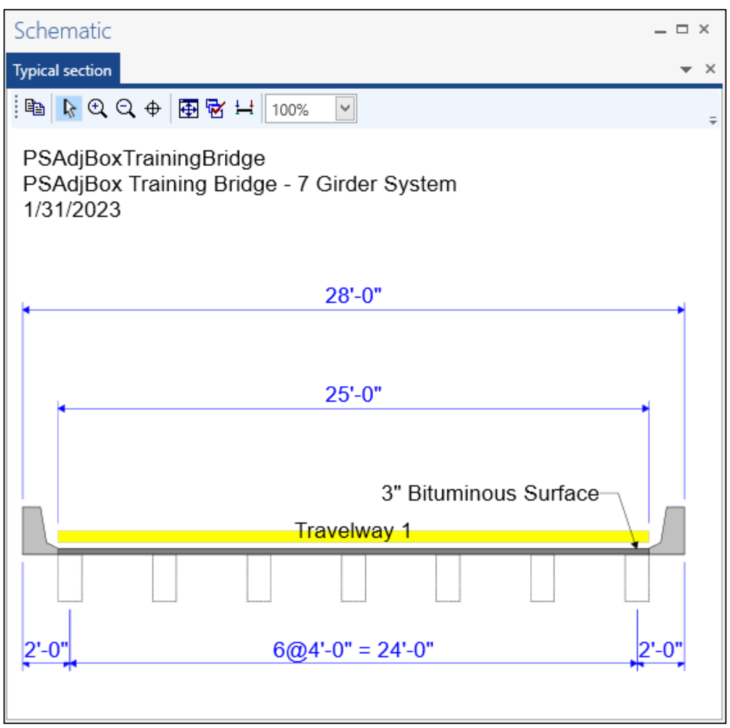
Click **OK** to apply the data and close the window.

Schematic – Structure Typical Section

While **Framing Plan Detail** is selected in the **Bridge Workspace** tree, open the schematic for the framing plan by selecting the **Schematic** button on the **WORKSPACE** ribbon (or right click on **Framing Plan Detail** in the **Bridge Workspace** and select **Schematic** from the menu).



Since the member alternatives are not defined yet, the girders are displayed as dashed boxes. At this point **BrDR** does not know if the girders will be PS boxes, I-beams, steel rolled beams, etc.

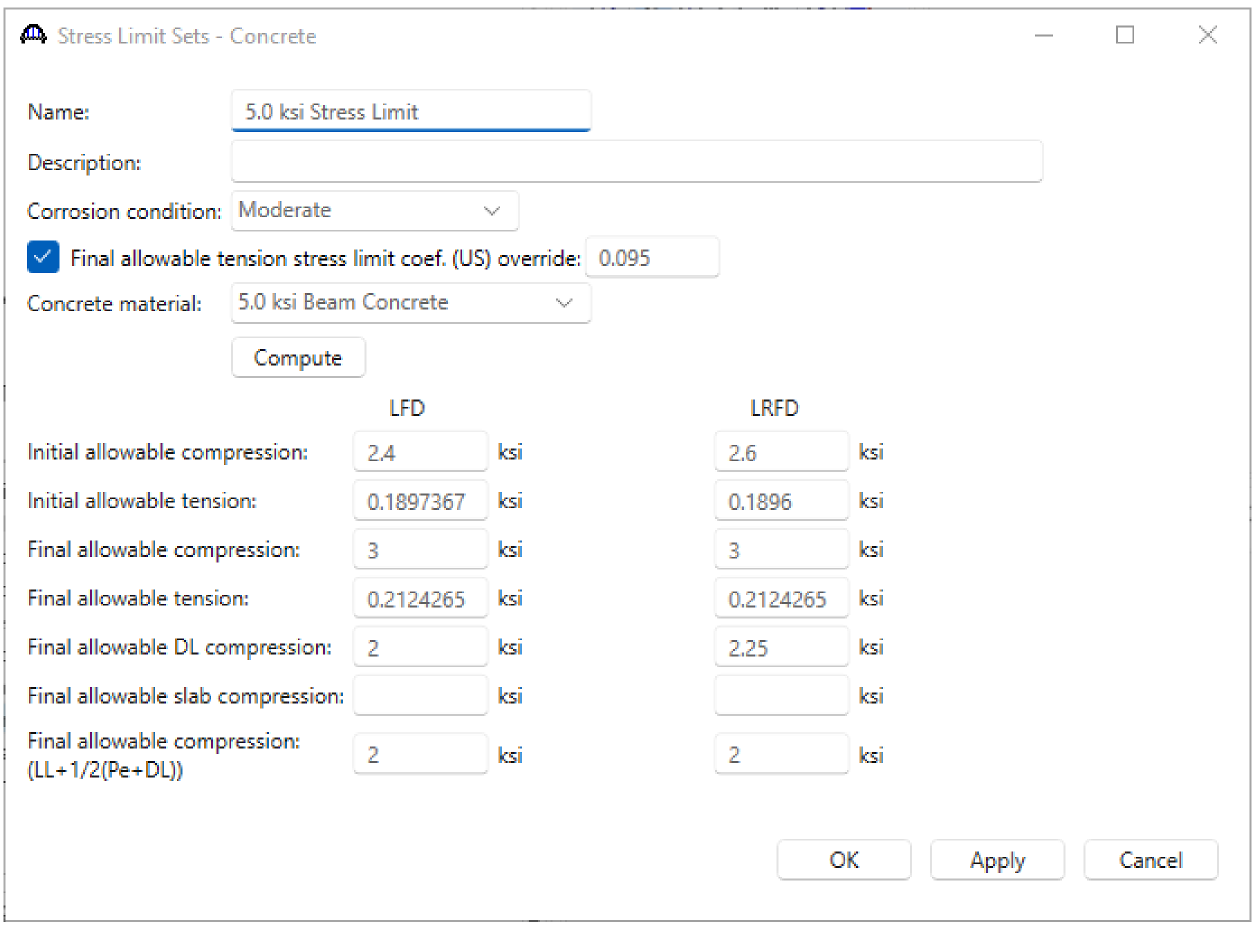


Concrete Stress Limits

A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the **Concrete Stress Limits** node in the **Bridge Workspace** tree to open the **Stress Limit Sets – Concrete** window. Enter data shown above the **Compute** button, select **Moderate** for the **Corrosion condition** and select the **5.0 ksi Beam Concrete** material from the drop-down menu of the **Concrete material**. The **Final allowable tension** in the concrete is dependent upon the moderate or severe corrosive condition to which the member is exposed. BrDR uses the **stress limit coefficient** to calculate this value. For this example, check the **Final allowable tension stress limit coef. (US) override checkbox** and enter the overridden value as shown below. If not overridden, BrDR uses the default stress limit coefficient.

Click the **Compute** button. Default values for the allowable stresses will be computed based on the **Concrete material** selected and the AASHTO Specifications.

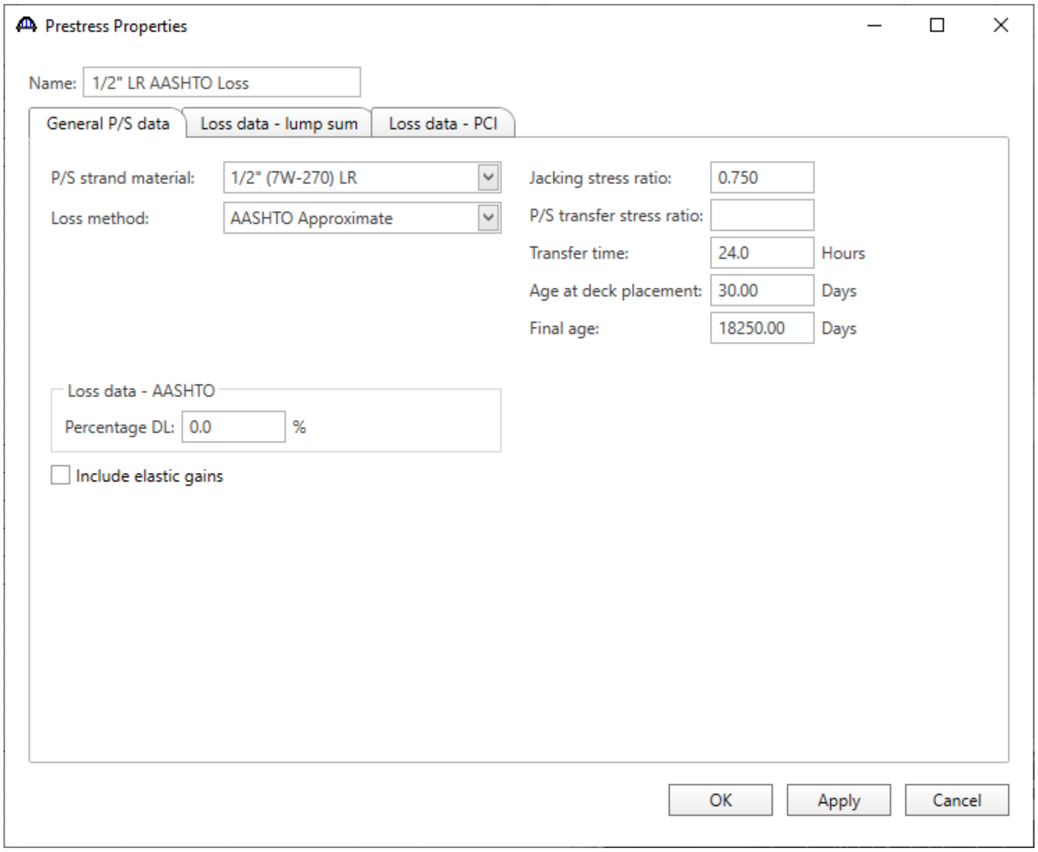
The default value for the **Final allowable slab compression** is not computed since the deck concrete is typically different from the concrete used in the beam. This value will be left blank since this example does not have a concrete deck.



Click **OK** to apply the data and close the window.

Prestress Properties

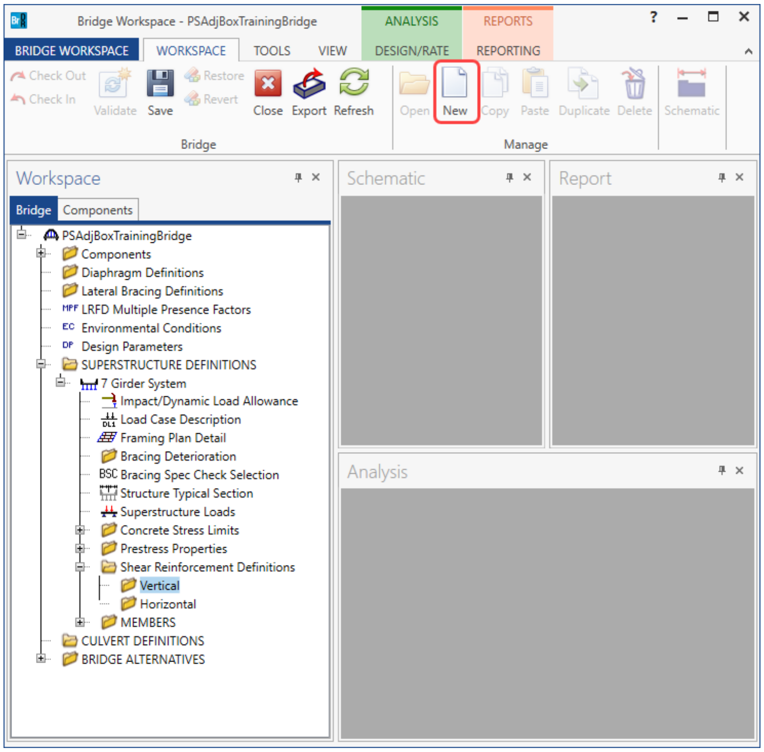
Double click on the **Prestress Properties** node in the **Bridge Workspace** tree to open the **Prestress Properties** window. Define the prestress properties as shown below. Since the **AASHTO Approximate** method is used to compute the losses, only the information on the **General P/S data** tab is required.



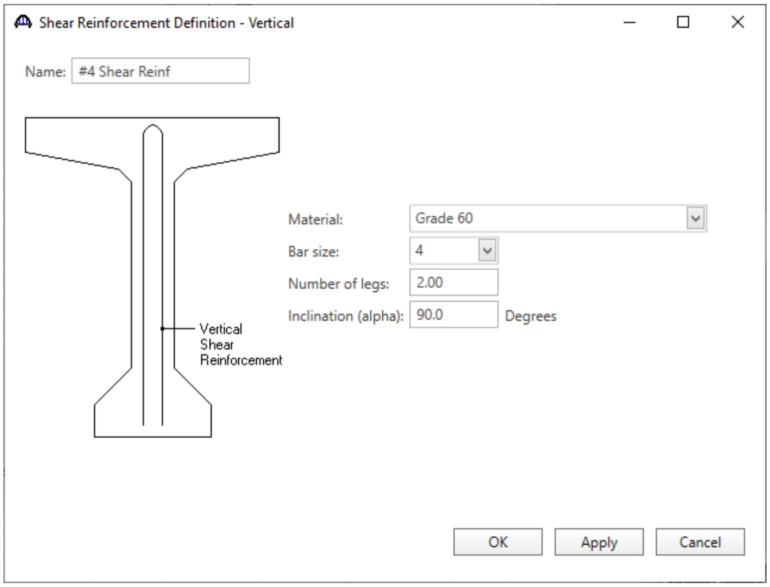
Click **OK** to apply this data and close the window.

Shear Reinforcement

Define the vertical shear reinforcement to be used by the girders. Expand the **Shear Reinforcement Definitions** node in the **Bridge Workspace** tree, select the **Vertical** node and click on **New** from the **Manage** group of the **WORKSPACE** ribbon (or double click on **Vertical)**.

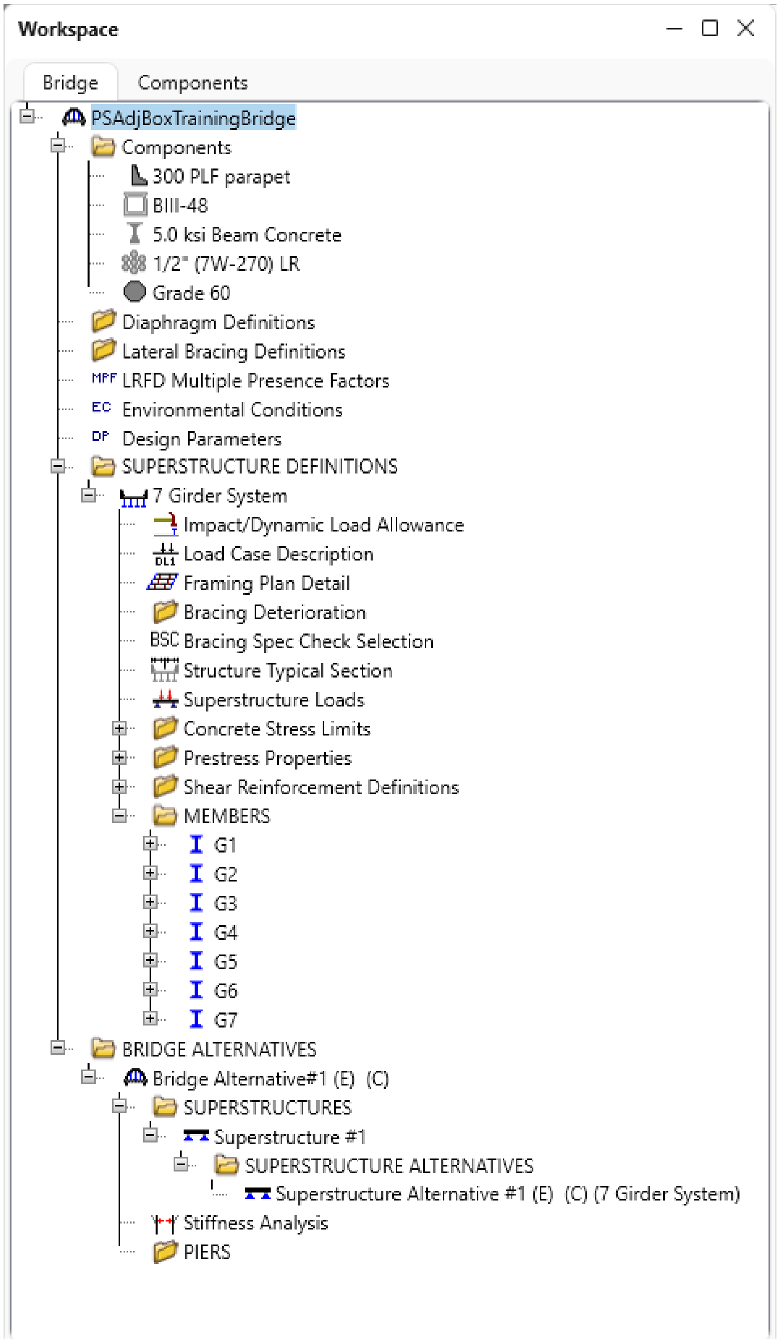


The I shape shown is for illustrative purposes only, it is not meant to display the actual beam shape. Enter data as shown below.



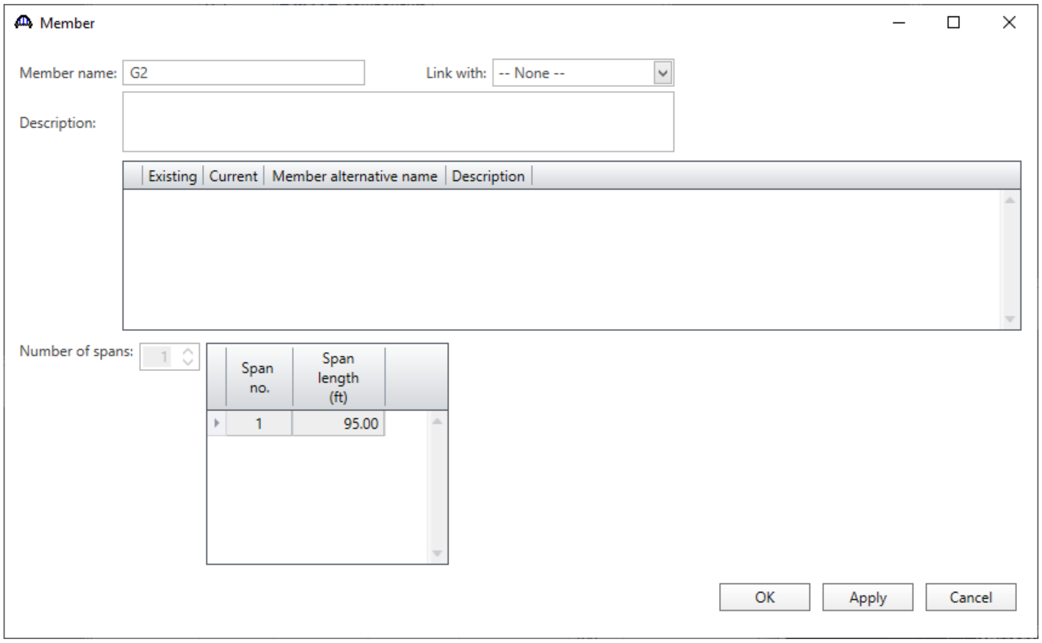
Click **OK** to apply this data and close the window.

A partially expanded **Bridge Workspace** is shown below.



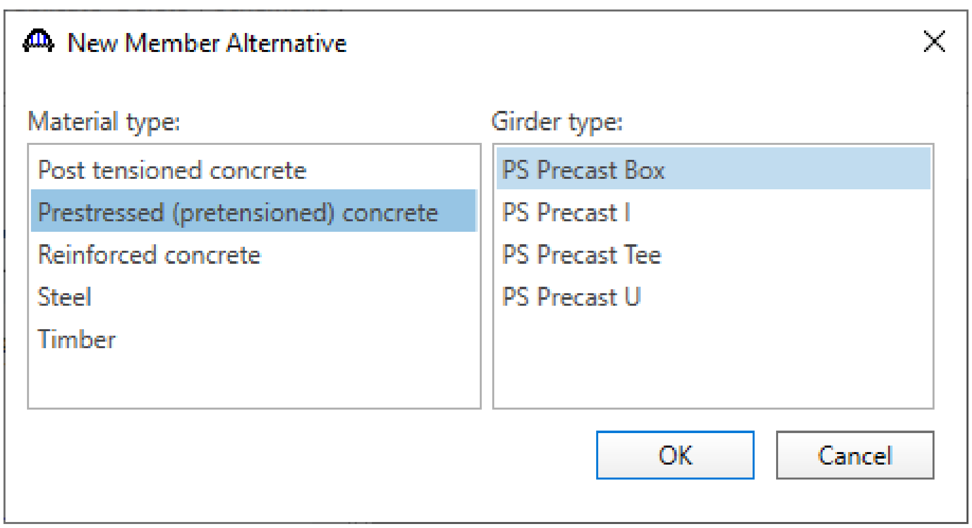
Describing a member

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



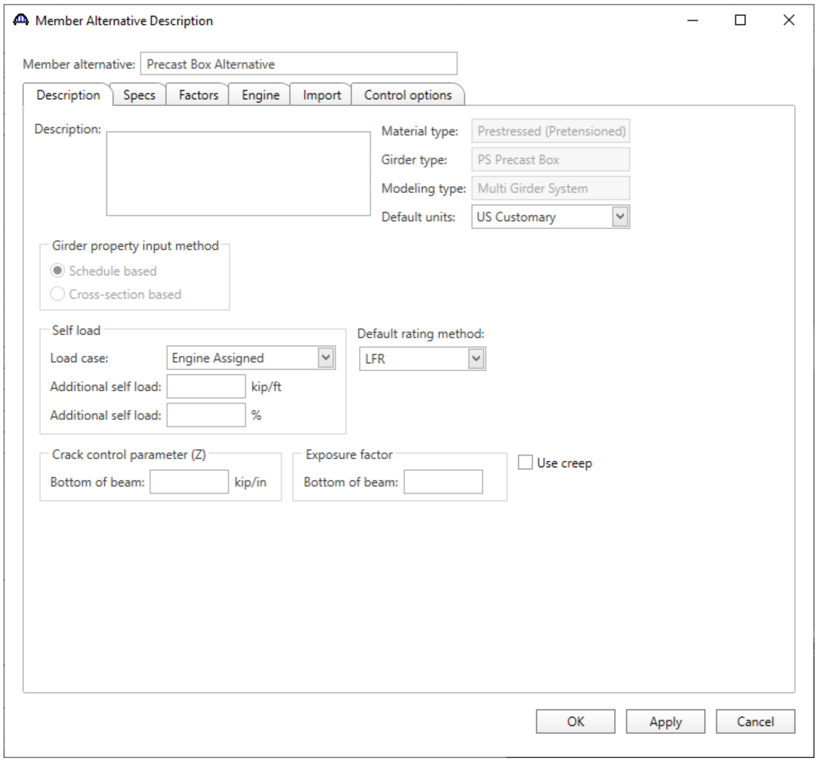
Defining a Member Alternative

Double-click on **MEMBER ALTERNATIVES** in the **Bridge Workspace** tree for member **G2** to create a new member alternative. The **New Member Alternative** window 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 window and create a new member alternative.

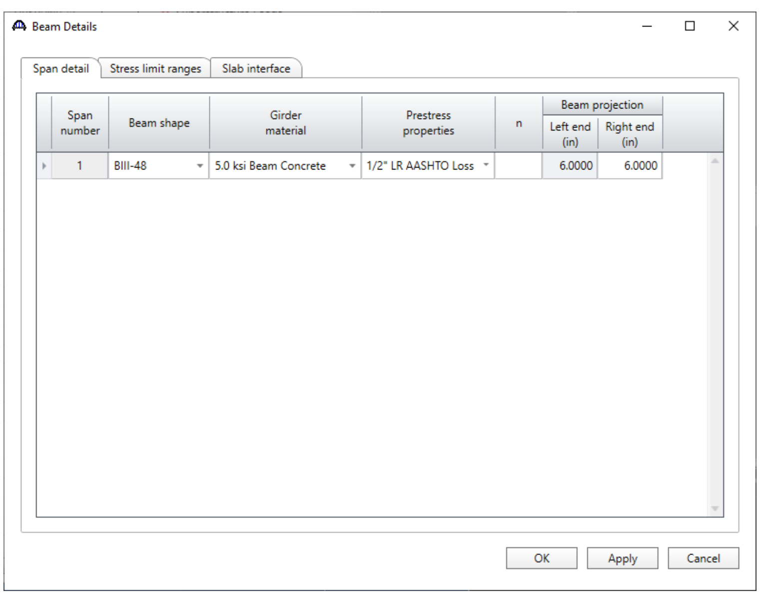
The **Member Alternative Description** window will open. Enter the data as shown below. The **Schedule based Girder property input method** is the only input method available for a prestressed concrete beam. Enter data as shown below.



Click **OK** to apply the data and close the window.

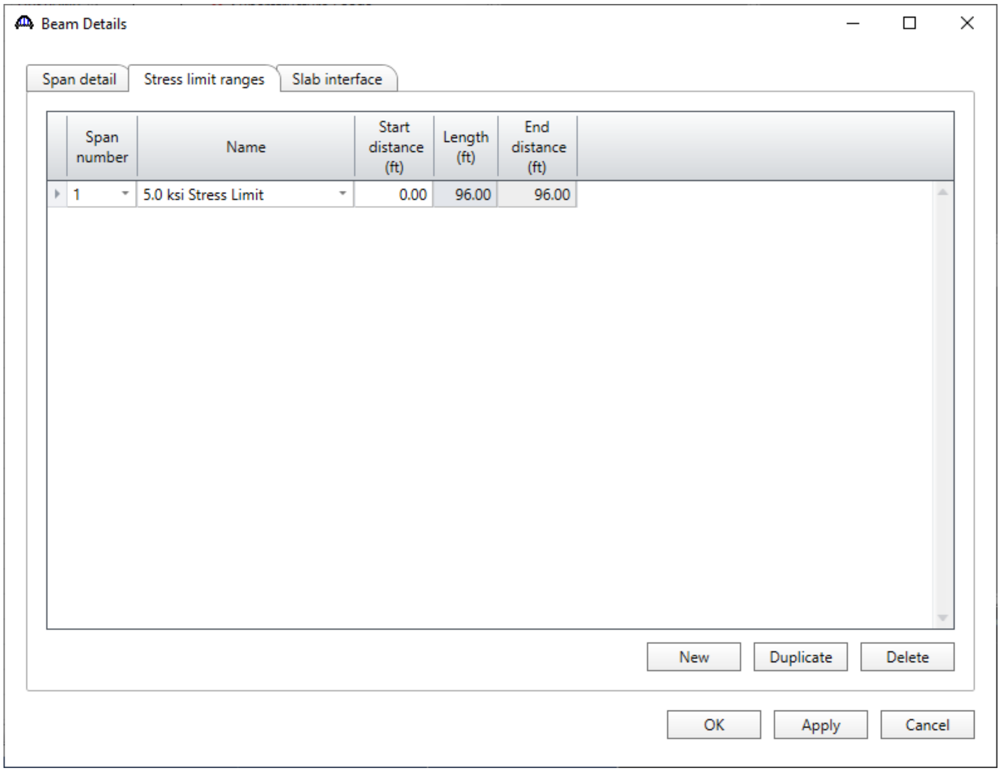
Beam Details – Span detail

Next describe the beam by double clicking on the **Beam Details** node in the **Bridge Workspace** tree. Enter the data in each tab of the **Beam Details** window as shown below.



Beam Details – Stress limit ranges

Note that the **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 drop down menu of the **Name** column correspond to the stress limits associated with the concrete material specified for that span on the **Span Detail** tab.

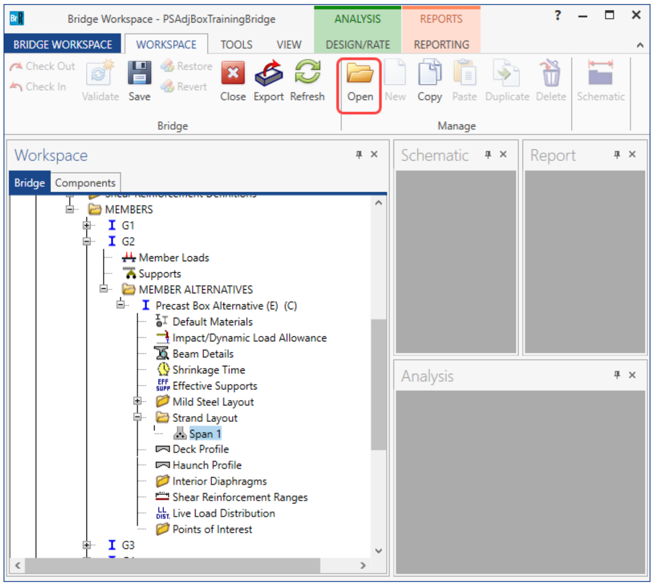


Since this example does not have a concrete deck, the **Slab interface** tab can be left blank.

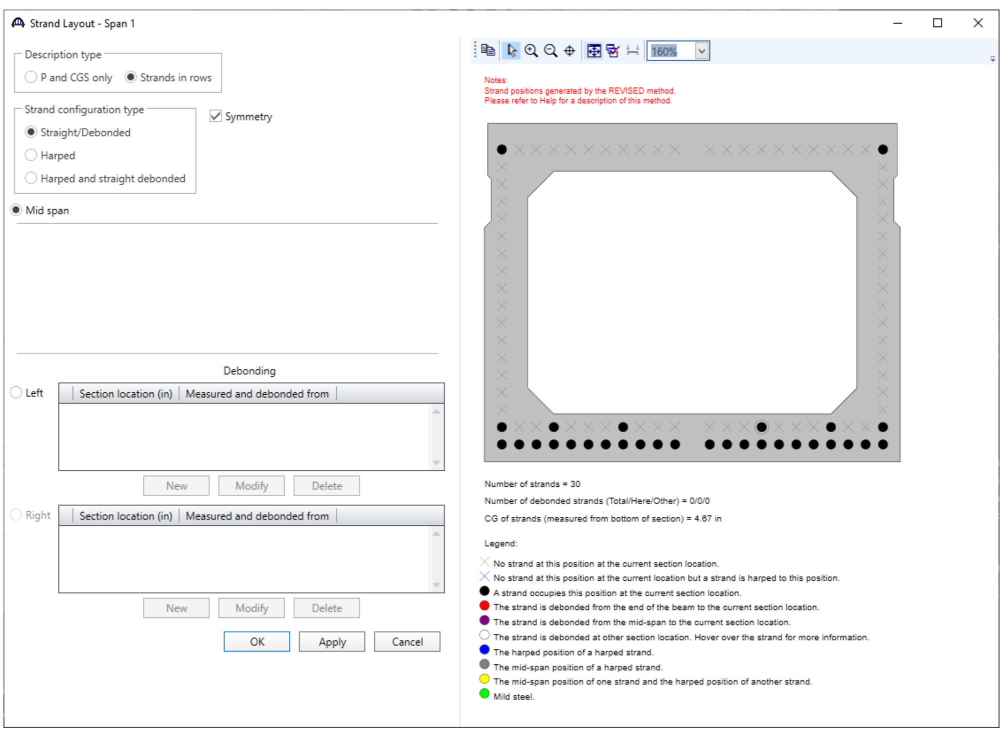
Click **OK** to apply the beam details data and close the window.

Strand Layout – Span 1

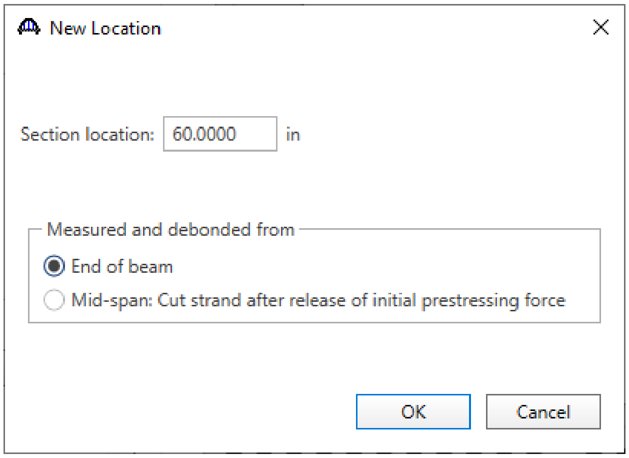
Expand the **Strand Layout** in the **Bridge Workspace** tree and double-click on **Span 1** (or select **Span 1** and click the **Open** button from the **Manage** group of the **WORKSPACE** ribbon) to open the **Stand Layout – Span 1** window.



Use the **Zoom** buttons to shrink/expand the schematic of the beam shape on the right side of the screen so that the entire beam is visible. Select the **Description type** as **Strands in rows** and the **Strand configuration type** as **Straight/Debonded**. The **Mid span** radio button will now become active. Strands can now be defined at the middle of the span by selecting strands in the right-hand schematic. Select the following strands in the schematic so that the CG of the strands is 4.67 inches. Click the **Apply** button to save this information.

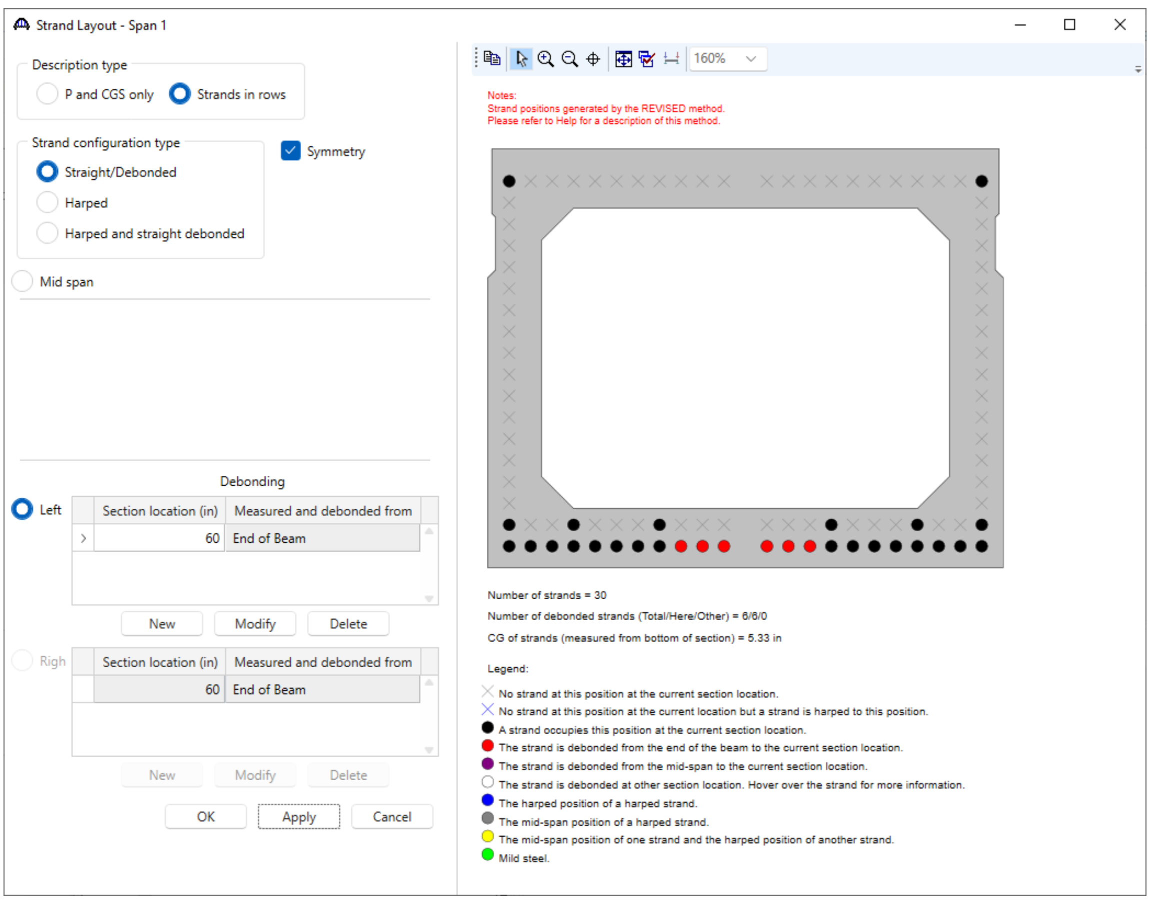


Now select the **Left** radio button to enter data for debonding of the strands. Click the **New** button to enter the location of the debonding point as a distance from the left end of the precast beam. Enter the new location as **60** inches from the left end of the precast beam to the debonding point in the window as shown below.



Click **OK** to close the window and apply the changes.

Select 6 strands in the bottom row in the schematic as being debonded at the section 60 inches from the left end of the beam as shown below.



Click **OK** to apply the data and close the window.

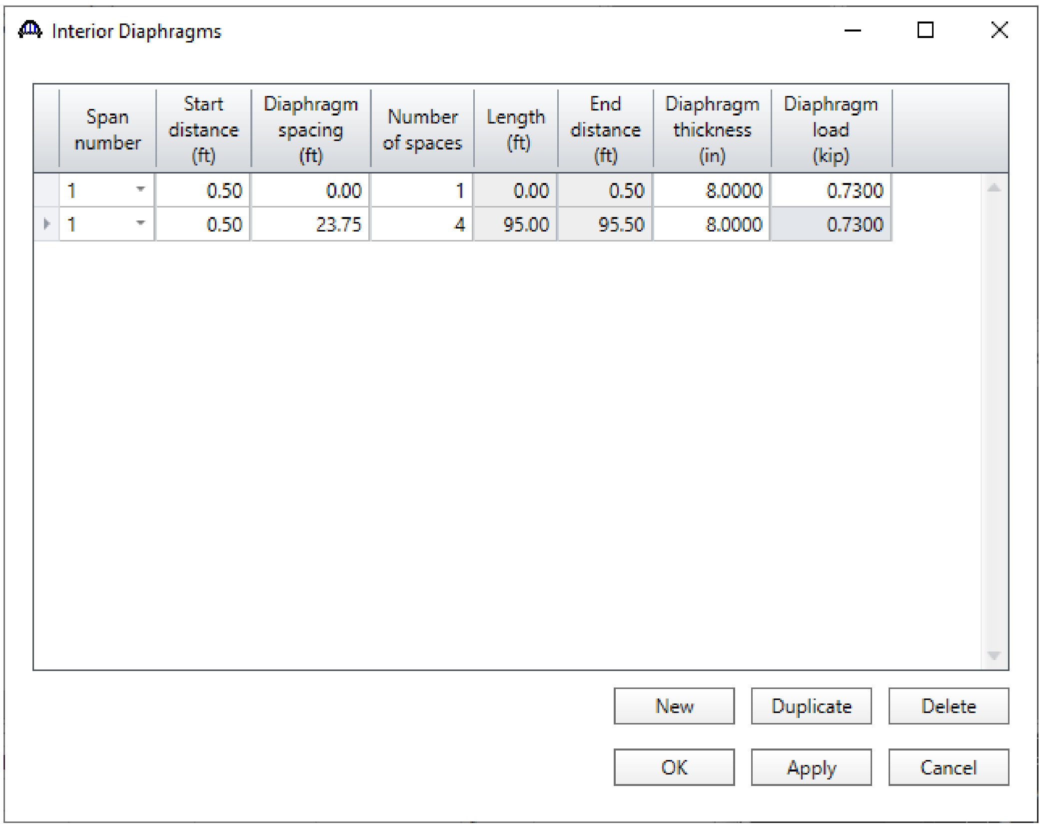
This structure definition does not have a concrete deck, so **Deck profile** and **Haunch profile** data will not be entered.

Interior Diaphragms

Eight inch thick, full depth diaphragms are located at quarter points. The weight of an individual diaphragm is calculated as follows.

$$\frac{8}{12}\left[\frac{(48-10)}{12} * \frac{(39-11)}{12} - 4\left(\frac{1}{2}\right)\left(\frac{3}{12}\right)\left(\frac{3}{12}\right)\right](0.15) = 0.73k \text{ / diaphragm}$$

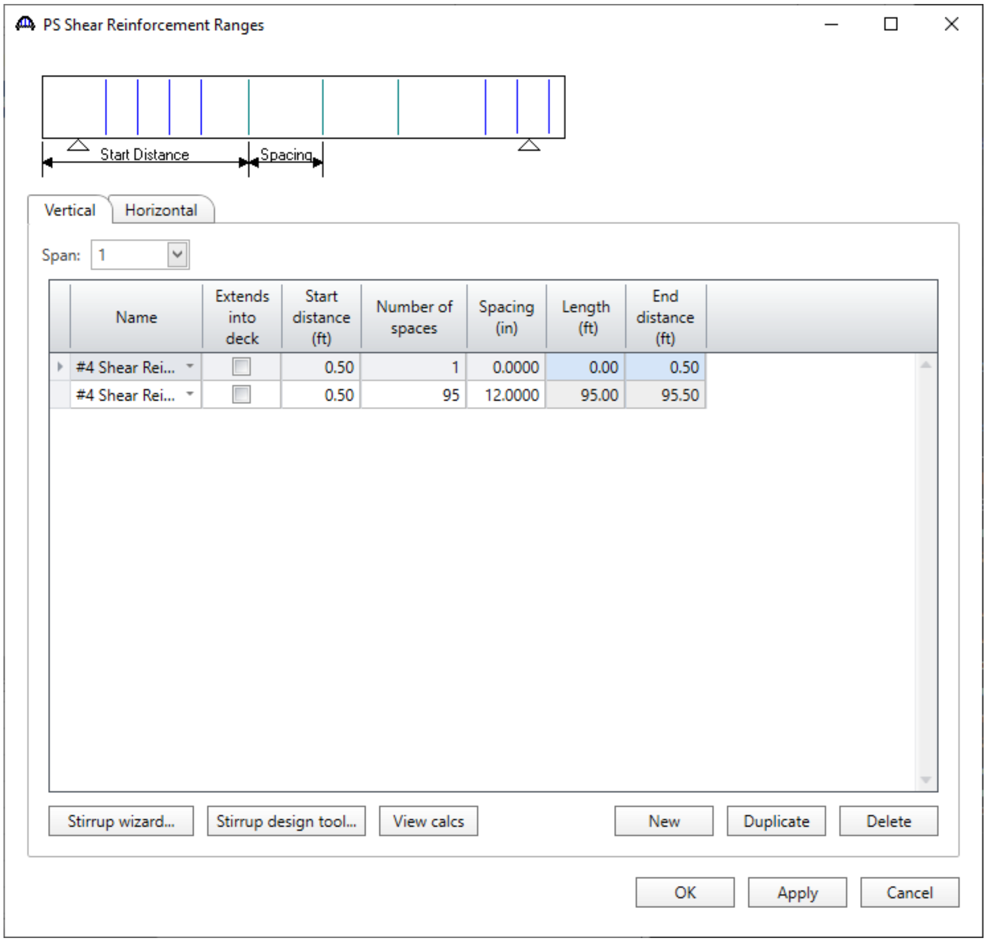
Double-click on the **Interior Diaphragms** node in the **Bridge Workspace** tree to open the **Interior Diaphragms** window and enter data in this window as shown below.



Click **OK** to apply the data and close the window.

Shear Reinforcement Ranges

Double-click on the **Shear Reinforcement Ranges** node in the **Bridge Workspace** tree to open the **PS Shear Reinforcement Ranges** window. The shear reinforcement ranges for each span are entered as described below.

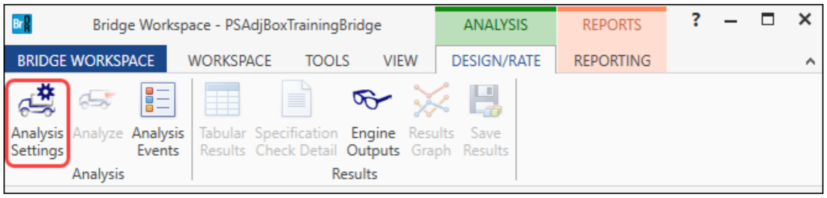


Click **OK** to apply the data and close the window.

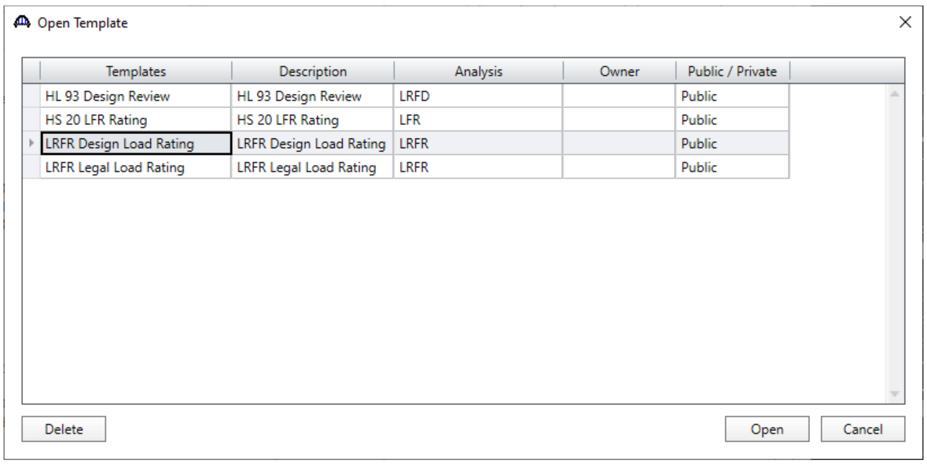
The description of an interior beam for this structure definition is complete. The member alternative can now be analyzed.

LRFR Rating

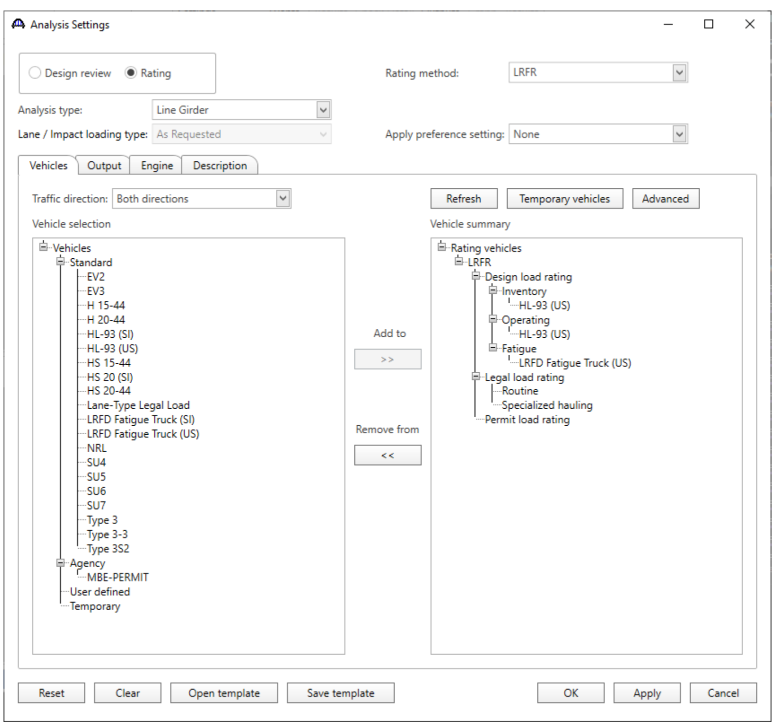
To perform an **LRFR** rating, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon to open the window shown below.



Click the **Open Template** button and select the **LRFR Design Load Rating** to be used in the rating and click **Open**.

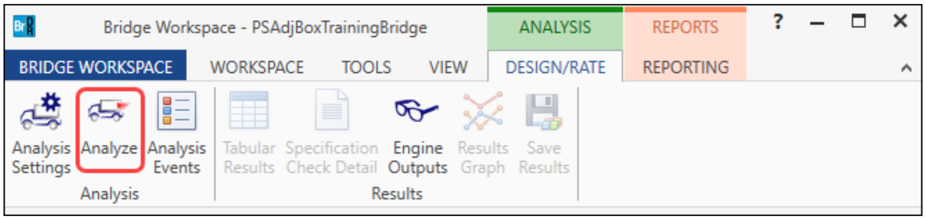


The **Analysis Settings** window will be updated as shown below.

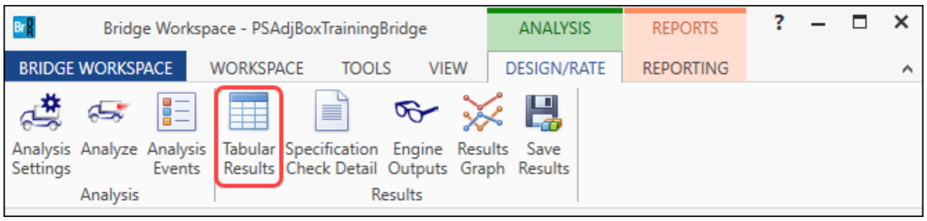


Tabular Results

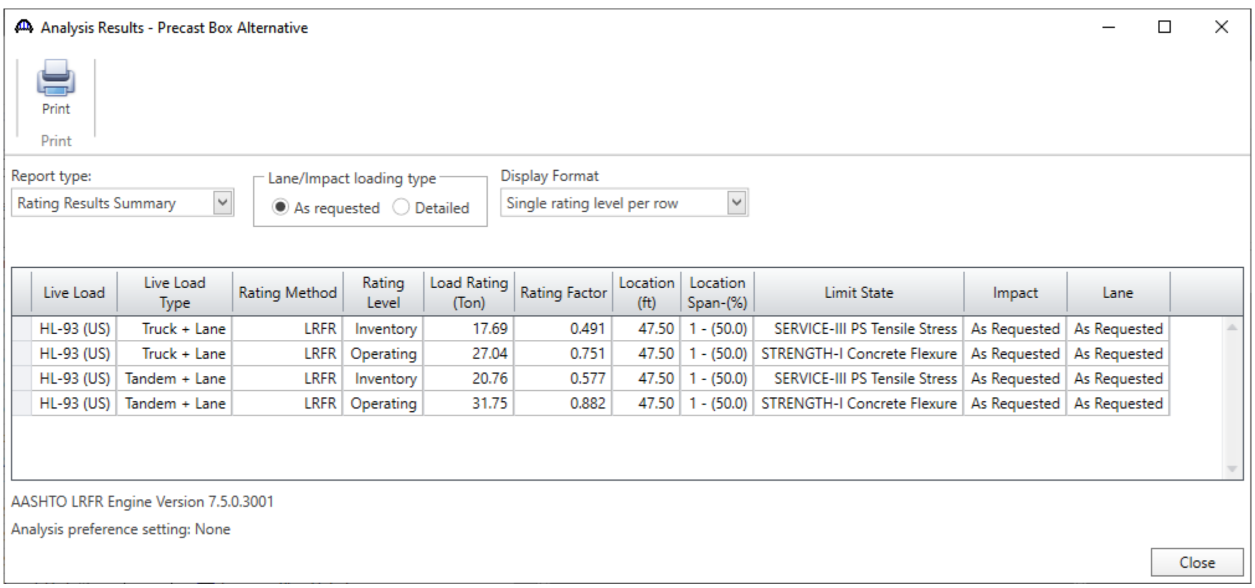
Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



When the rating is finished, results can be reviewed by clicking the **Tabular Results** button on the **Results** group of the **DESIGN/RATE** ribbon.



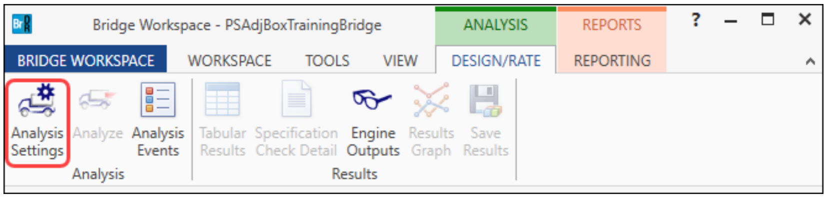
The window shown below will open.



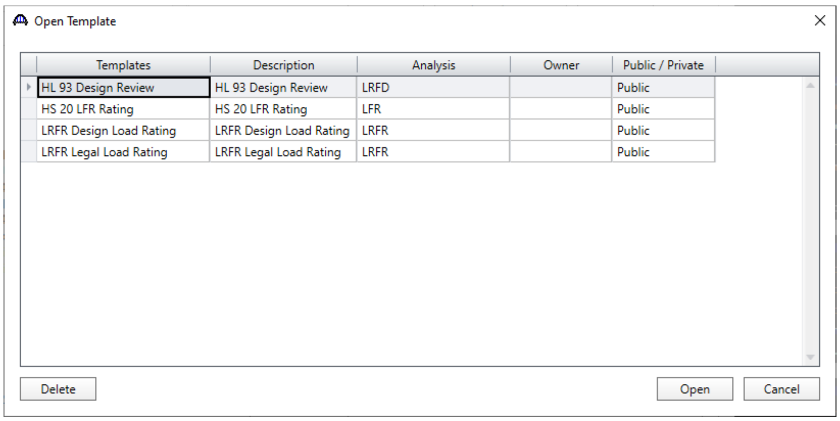
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	17.69	0.491	47.50	1 - (50.0)	SERVICE-III PS Tensile Stress	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	27.04	0.751	47.50	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	20.76	0.577	47.50	1 - (50.0)	SERVICE-III PS Tensile Stress	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	31.75	0.882	47.50	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested

LRFD Design review

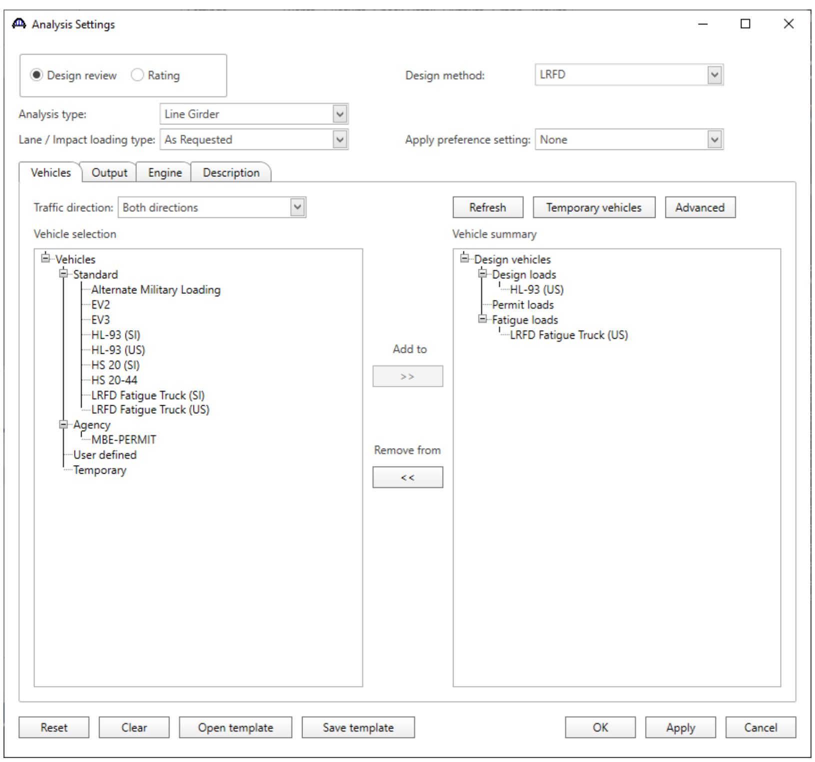
To perform an **LRFD design review** of this girder for HL93 loading, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon to open the window shown below.



Click the **Open Template** button and select the **HL 93 Design Review** to be used in the rating and click **OK**.

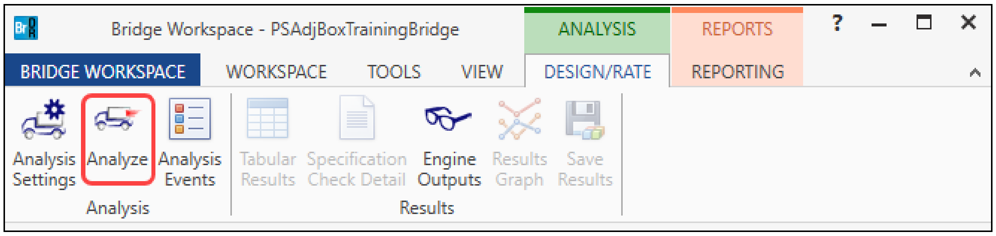


The **Analysis Settings** window will be updated as shown below.

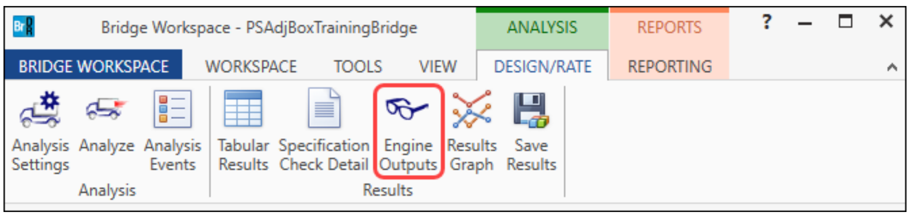


Engine Outputs

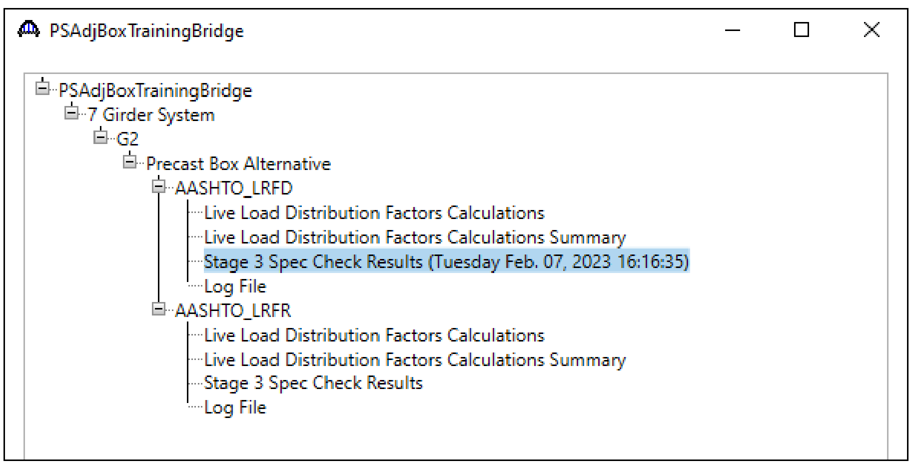
Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the design review.



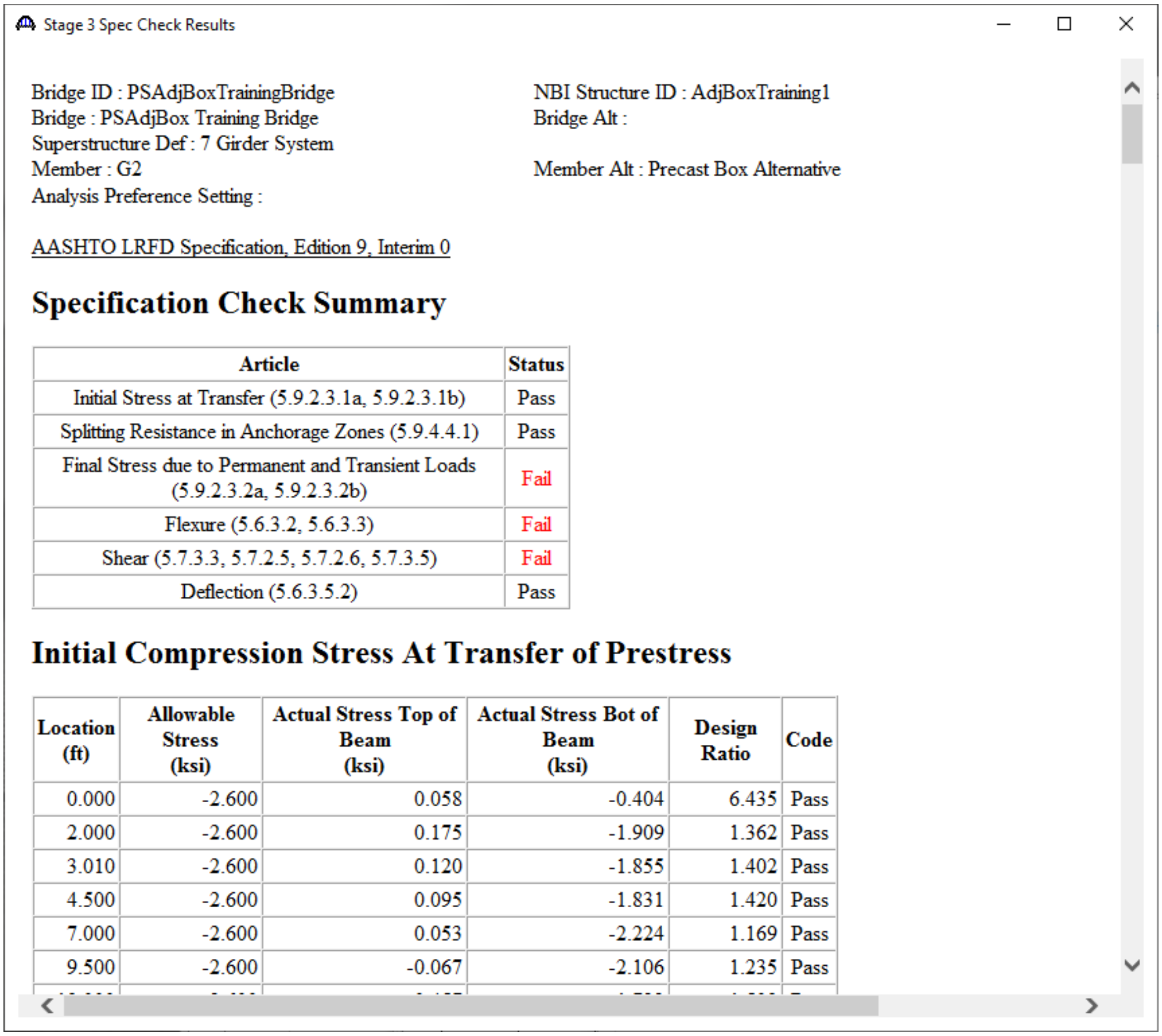
AASHTO LRFD analysis will generate a **Spec Check Results** file. When the design review is finished, results can be reviewed by clicking the **Engine outputs** button on the **Results** group of the ribbon.



The following window opens.



To view the spec check results, double click the **Stage 3 Spec Check Results** file in this window.



Stage 3 Spec Check Results

Bridge ID : PSAdjBoxTrainingBridge
Bridge : PSAdjBox Training Bridge
Superstructure Def : 7 Girder System
Member : G2
Analysis Preference Setting :

NBI Structure ID : AdjBoxTraining1
Bridge Alt :

Member Alt : Precast Box Alternative

AASHTO LRFD Specification, Edition 9, Interim 0

Specification Check Summary

Article	Status
Initial Stress at Transfer (5.9.2.3.1a, 5.9.2.3.1b)	Pass
Splitting Resistance in Anchorage Zones (5.9.4.4.1)	Pass
Final Stress due to Permanent and Transient Loads (5.9.2.3.2a, 5.9.2.3.2b)	Fail
Flexure (5.6.3.2, 5.6.3.3)	Fail
Shear (5.7.3.3, 5.7.2.5, 5.7.2.6, 5.7.3.5)	Fail
Deflection (5.6.3.5.2)	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)	Design Ratio	Code
0.000	-2.600	0.058	-0.404	6.435	Pass
2.000	-2.600	0.175	-1.909	1.362	Pass
3.010	-2.600	0.120	-1.855	1.402	Pass
4.500	-2.600	0.095	-1.831	1.420	Pass
7.000	-2.600	0.053	-2.224	1.169	Pass
9.500	-2.600	-0.067	-2.106	1.235	Pass