

AASHTOWare BrDR 7.5.0

Prestressed Concrete Structure Tutorial
PS5 – Void Prestressed Box Beam Example

PS5 – Void Prestressed Box Beam Example

BrDR Training

PS5 – Void Prestressed Box Beam Example


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

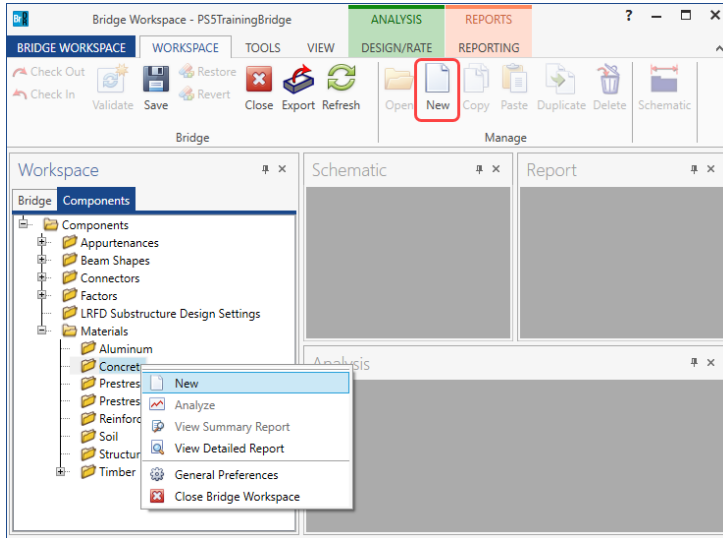
The screenshot shows a software window titled "PS5TrainingBridge" with a standard Windows interface (minimize, maximize, close buttons). The window contains several input fields and checkboxes for bridge data entry. At the top, there are fields for "Bridge ID:" (containing "PS5TrainingBridge") and "NBI structure ID (8):" (containing "PS5TrainingBrid"). To the right of these fields are four checkboxes: "Template" (unchecked), "Bridge completely defined" (unchecked), "Superstructures" (checked), and "Substructures" (checked). Below these are five tabs: "Description" (selected), "Description (cont'd)", "Alternatives", "Global reference point", "Traffic", and "Custom agency fields". The "Description" tab contains a form with the following fields: "Name:" (containing "Void PS Box Example"), "Year built:" (empty), "Description:" (empty text area), "Location:" (empty text box), "Length:" (empty text box followed by "ft"), "Facility carried (7):" (empty text box), "Route number:" (containing "-1"), "Feat. intersected (6):" (empty text box), "Mi. post:" (empty text box), and "Default units:" (a dropdown menu showing "US Customary"). At the bottom of the window, there is a "Bridge association..." button, three checkboxes for "BrR" (checked), "BrD" (checked), and "BrM" (unchecked), a "Sync with BrM" button, and three buttons for "OK", "Apply", and "Cancel".

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

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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**).



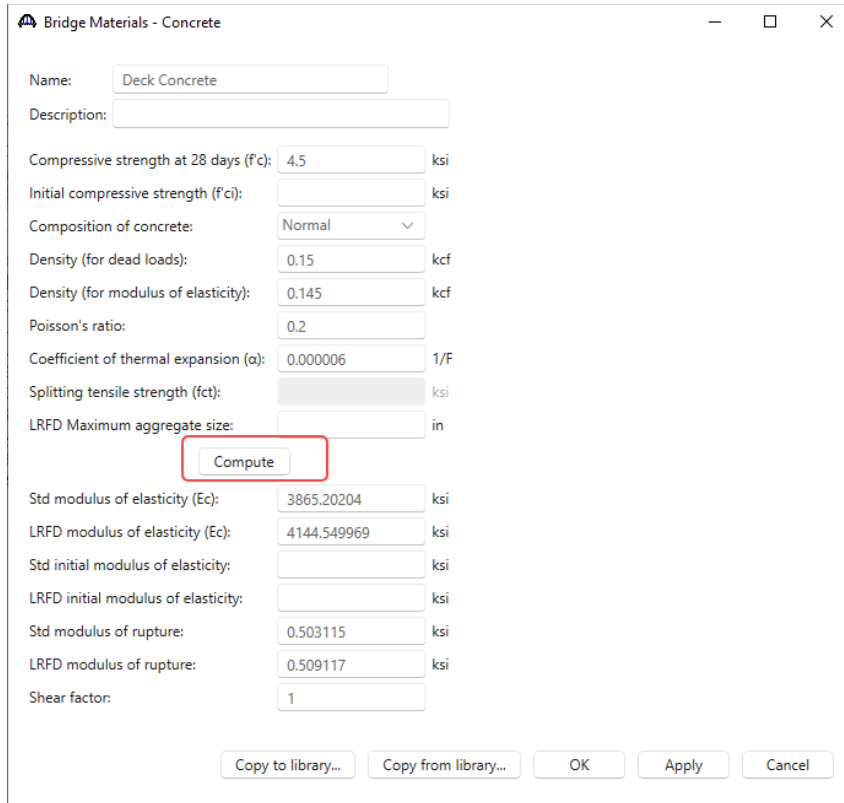
The window shown below will open. Enter the values above the **Compute** button and click on the **Compute** button to compute the remaining values as shown below.

| | |
|--|---------------------------------------|
| Name: | PS 6.5 ksi |
| Description: | PS 6.5 ksi (F _c = 4.5 ksi) |
| Compressive strength at 28 days (f _c): | 6.5 ksi |
| Initial compressive strength (f _{ci}): | 4.5 ksi |
| Composition of concrete: | Normal |
| Density (for dead loads): | 0.15 kcf |
| Density (for modulus of elasticity): | 0.15 kcf |
| Poisson's ratio: | 0.2 |
| Coefficient of thermal expansion (α): | 0.000006 1/F |
| Splitting tensile strength (f _{ct}): | |
| LRFD Maximum aggregate size: | |
| Std modulus of elasticity (E _c): | 4887.73337 ksi |
| LRFD modulus of elasticity (E _c): | 5007.548587 ksi |
| Std initial modulus of elasticity: | 4066.839989 ksi |
| LRFD initial modulus of elasticity: | 4435.309122 ksi |
| Std modulus of rupture: | 0.604669 ksi |
| LRFD modulus of rupture: | 0.611882 ksi |
| Shear factor: | 1 |

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

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Add concrete material for the **deck** in the same manner. The windows will look like the one shown below.



Bridge Materials - Concrete

Name: Deck Concrete

Description:

Compressive strength at 28 days (f_c): 4.5 ksi

Initial compressive strength (f_c): ksi

Composition of concrete: Normal

Density (for dead loads): 0.15 kcf

Density (for modulus of elasticity): 0.145 kcf

Poisson's ratio: 0.2

Coefficient of thermal expansion (α): 0.000006 1/F

Splitting tensile strength (f_{ct}): ksi

LRFD Maximum aggregate size: in

Compute

Std modulus of elasticity (E_c): 3865.20204 ksi

LRFD modulus of elasticity (E_c): 4144.549969 ksi

Std initial modulus of elasticity: ksi

LRFD initial modulus of elasticity: ksi

Std modulus of rupture: 0.503115 ksi

LRFD modulus of rupture: 0.509117 ksi

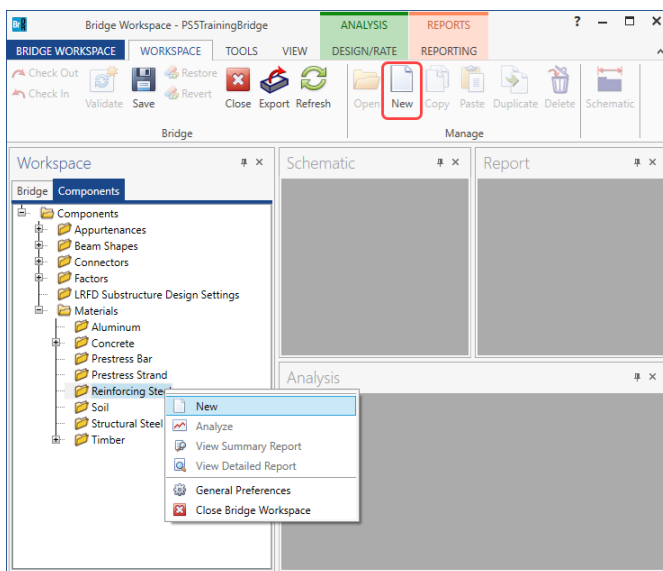
Shear factor: 1

Copy to library... Copy from library... OK Apply Cancel

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

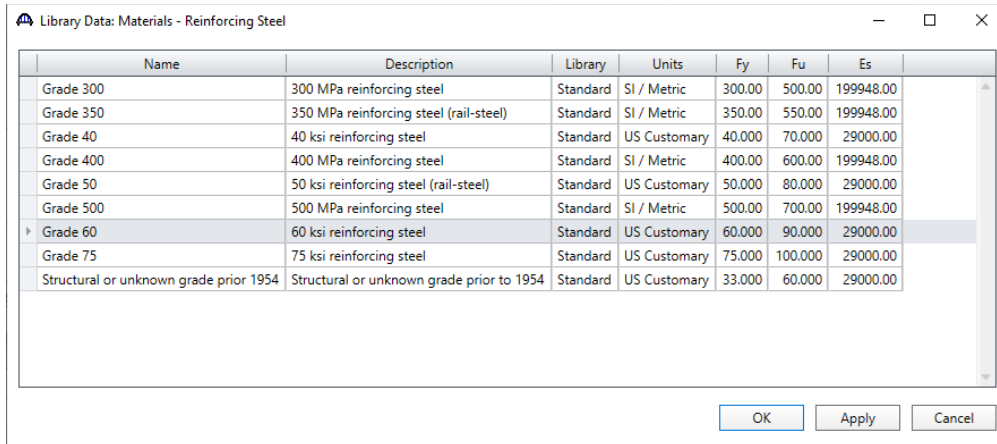
Bridge Materials – Reinforcement steel

To add a new reinforcement steel material, select **Reinforcement Steel** in the **Components** tree, and select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **Reinforcement Steel** and select **New**).



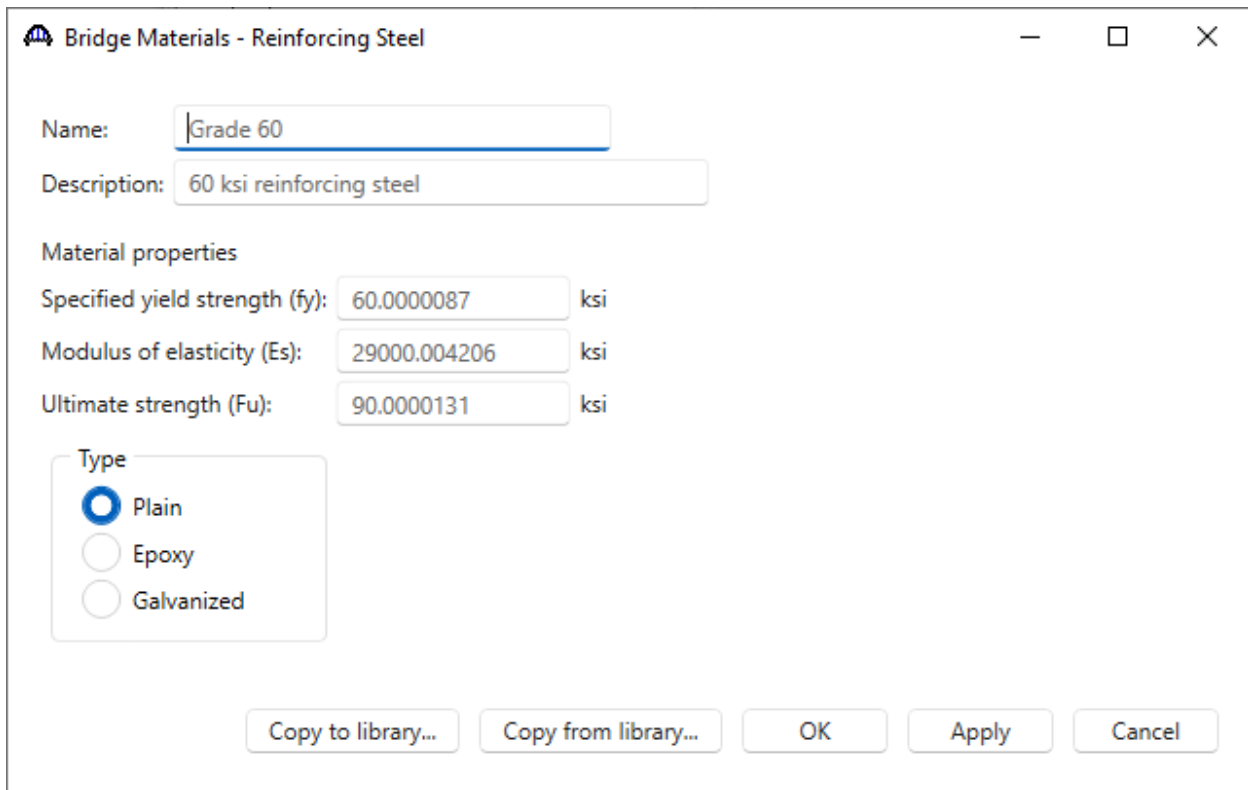
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Click on the **Copy from library...** button in this window and select **Grade 60** from the library and click **OK**.



| Name | Description | Library | Units | Fy | Fu | Es |
|--|---|----------|--------------|--------|---------|-----------|
| Grade 300 | 300 MPa reinforcing steel | Standard | SI / Metric | 300.00 | 500.00 | 199948.00 |
| Grade 350 | 350 MPa reinforcing steel (rail-steel) | Standard | SI / Metric | 350.00 | 550.00 | 199948.00 |
| Grade 40 | 40 ksi reinforcing steel | Standard | US Customary | 40.000 | 70.000 | 29000.00 |
| Grade 400 | 400 MPa reinforcing steel | Standard | SI / Metric | 400.00 | 600.00 | 199948.00 |
| Grade 50 | 50 ksi reinforcing steel (rail-steel) | Standard | US Customary | 50.000 | 80.000 | 29000.00 |
| Grade 500 | 500 MPa reinforcing steel | Standard | SI / Metric | 500.00 | 700.00 | 199948.00 |
| Grade 60 | 60 ksi reinforcing steel | Standard | US Customary | 60.000 | 90.000 | 29000.00 |
| Grade 75 | 75 ksi reinforcing steel | Standard | US Customary | 75.000 | 100.000 | 29000.00 |
| Structural or unknown grade prior 1954 | Structural or unknown grade prior to 1954 | Standard | US Customary | 33.000 | 60.000 | 29000.00 |

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



Name:

Description:

Material properties

Specified yield strength (fy): ksi

Modulus of elasticity (Es): ksi

Ultimate strength (Fu): ksi

Type

Plain

Epoxy

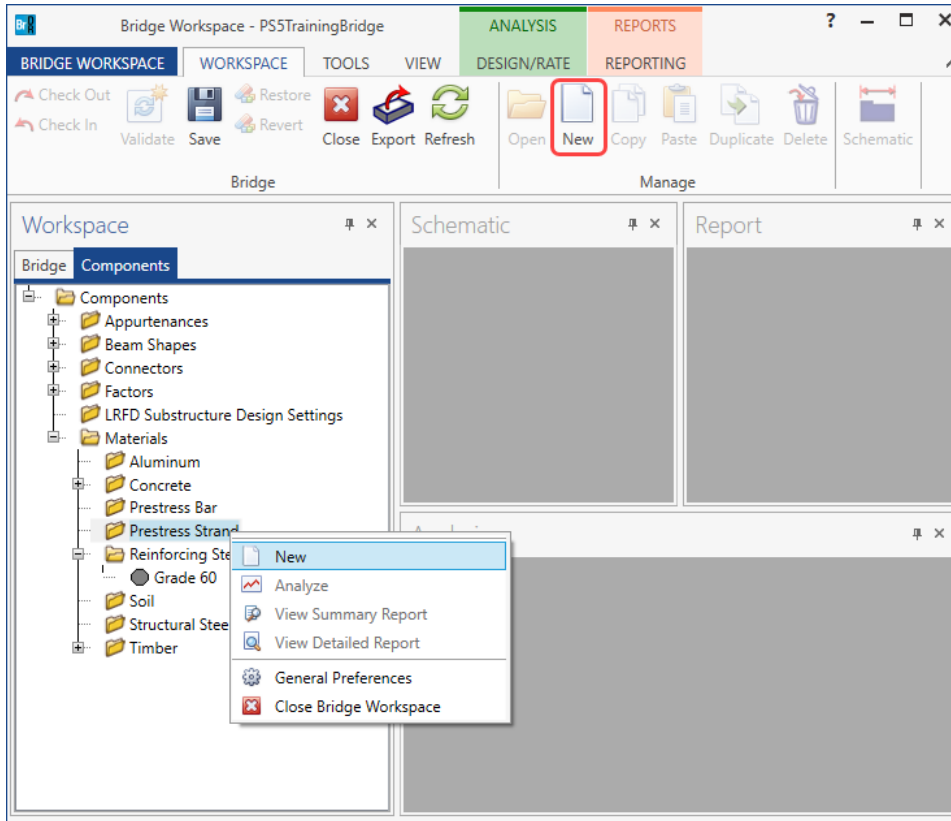
Galvanized

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

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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 **1/2" (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 |

OK Apply Cancel

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

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 (Fu): 270.000 ksi

Yield strength (fy): 243.000 ksi

Modulus of elasticity (E): 28500.00 ksi

Compute

Transfer length (Std): 25.0000 in

Transfer length (LRFD): 30.0000 in

Unit load per length: 0.520 lb/ft

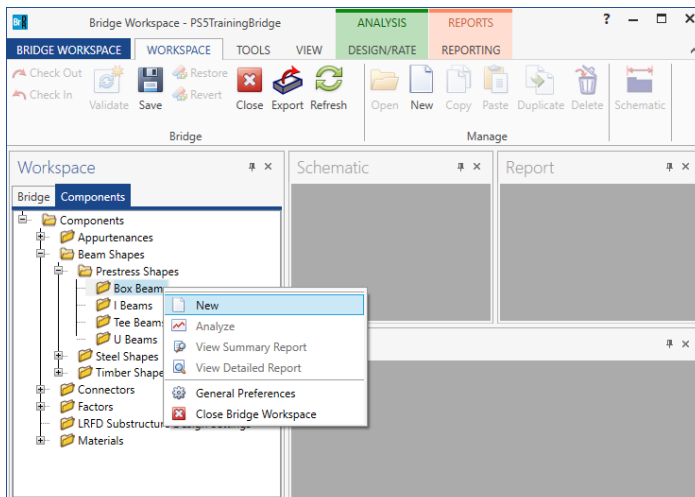
Epoxy coated

Copy to library... Copy from library... OK Apply Cancel

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

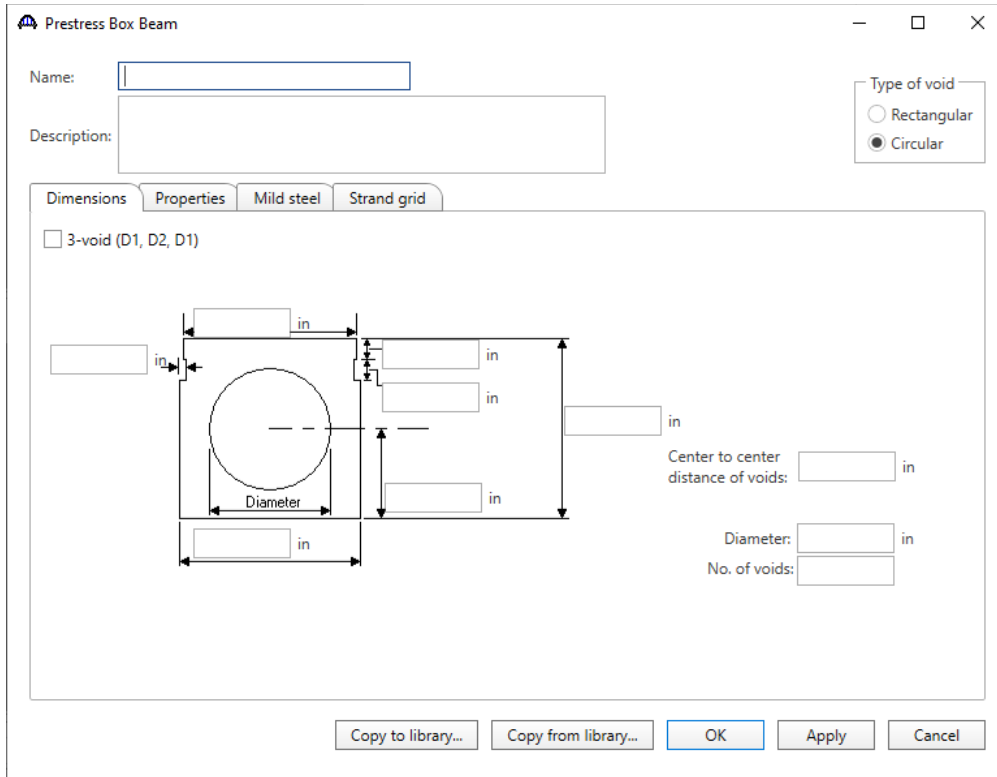
Beam Shapes

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).

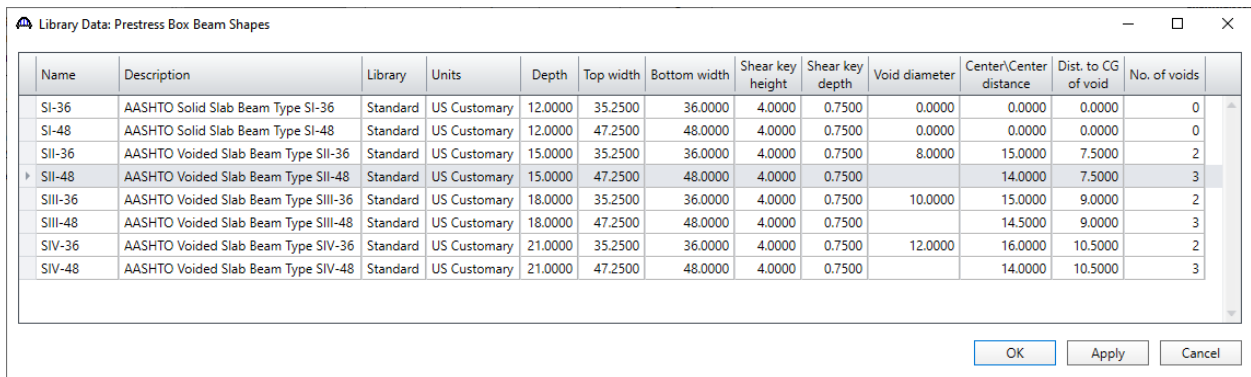


PS5 – Void Prestressed Box Beam Example

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



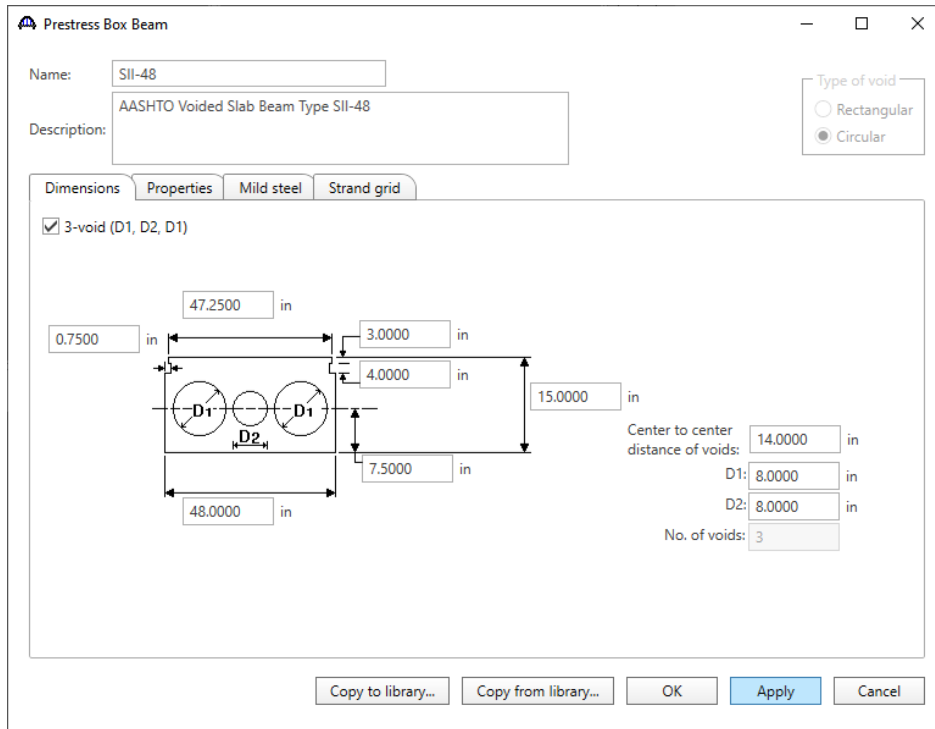
Set the **Type of Void** as **Circular** and click on the **Copy from Library** button. The window shown below appears.



Select **SII48 (AASHTO Voided Slab Beam Type SII-48)** and click **OK**.

PS5 – Void Prestressed Box Beam Example

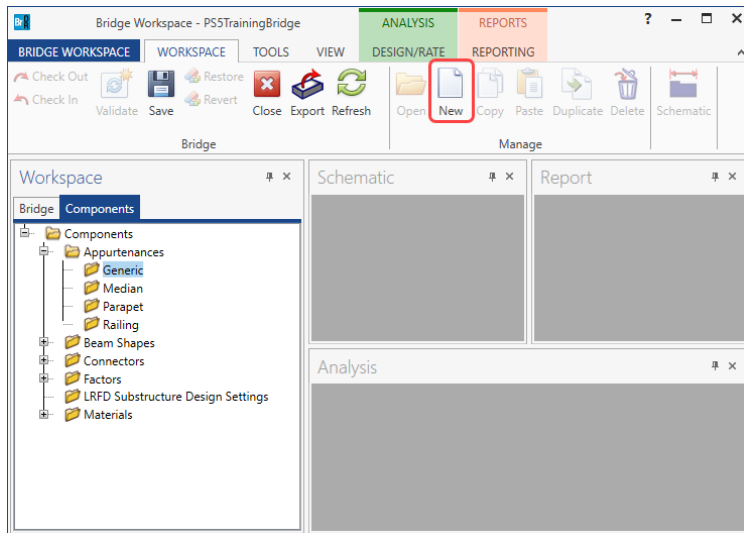
The beam properties are copied to the **PS Box Beam** window as shown below. Make sure that all the dimensions match with the window shown below.



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

Bridge - Appurtenances

This bridge has a concrete pedestrian railing. Define a **Generic** appurtenance to model the concrete railing. To enter the appurtenances to be used within the bridge expand the tree branch labeled **Appurtenances**. Select **Generic** and click on **New** from the **Manage** button on the **WORKSPACE** ribbon (or double click on **Generic** in the **Components** tree).



PS5 – Void Prestressed Box Beam Example

Enter the data as shown below.

Bridge Appurtenances - Generic

Name: Pedestrian Barrier

Description:

All dimensions are in inches

Distance from edge to centroid: 6.0000

Barrier load: 0.525 kip/ft

Width: 12.0000

Effective wind height: 42.0000

Reference Line

Back

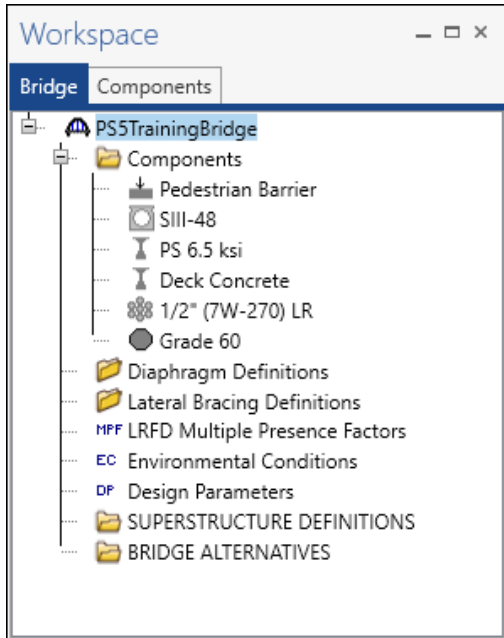
Front

Generic Shape

Copy from library... OK Apply Cancel

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

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

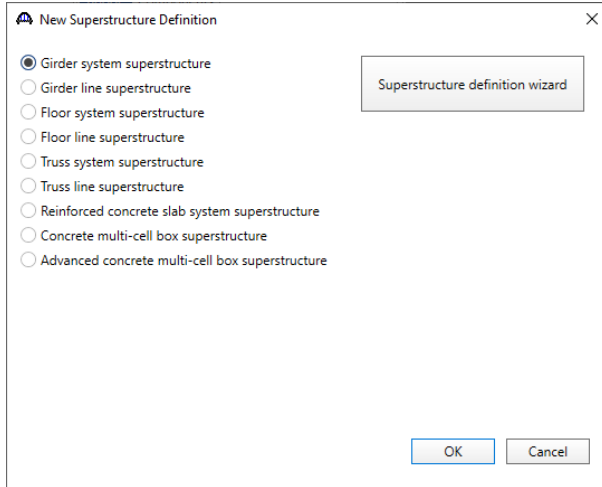


The default impact factors, standard LRFD and LFD factors will be used. **Bridge Alternatives** will be added after entering the Structure Definition.

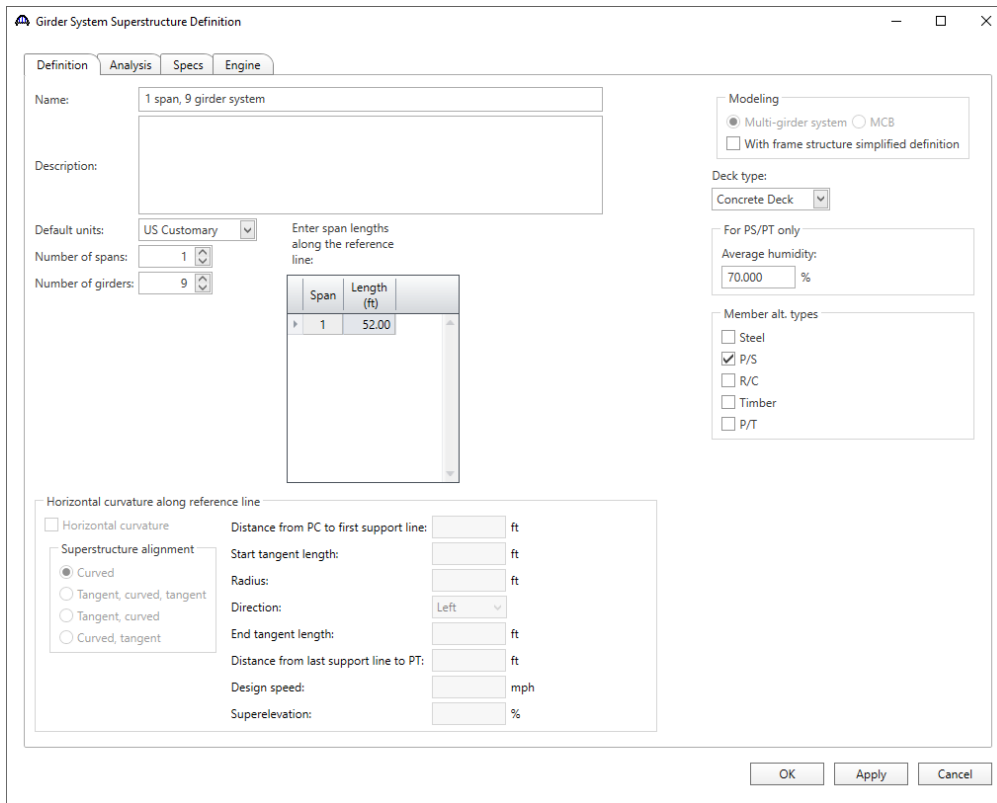
PS5 – Void Prestressed Box Beam Example

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.

PS5 – Void Prestressed Box Beam Example

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.

Bridge Alternative

Alternative name:

Description Substructures

Description:

Horizontal curvature

Reference line length: ft

Start bearing End bearing

Starting station: ft

Bearing:

Global positioning

Distance: ft

Offset: ft

Elevation: ft

Bridge alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Start tangent length: ft

Curve length: ft

Radius: ft

Direction:

End tangent length: ft

Superstructure wizard...

Culvert wizard...

OK Apply Cancel

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

PS5 – Void Prestressed Box Beam Example

Expand the **Single Bridge** 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.

Superstructure

Superstructure name:

Description Alternatives Vehicle path Engine Substructures

Description:

Reference line

Distance: ft

Offset: ft

Angle: Degrees

Starting station: ft

OK Apply Cancel

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

PS5 – Void Prestressed Box Beam Example

Expand the **Single Span Superstructure** 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 **1 span, 9 girder system** as the current superstructure definition for this Superstructure Alternative.

Superstructure Alternative

Alternative name: Existing Superstructure

Description:

Superstructure definition: 1 span, 9 girder system

Superstructure type: Girder

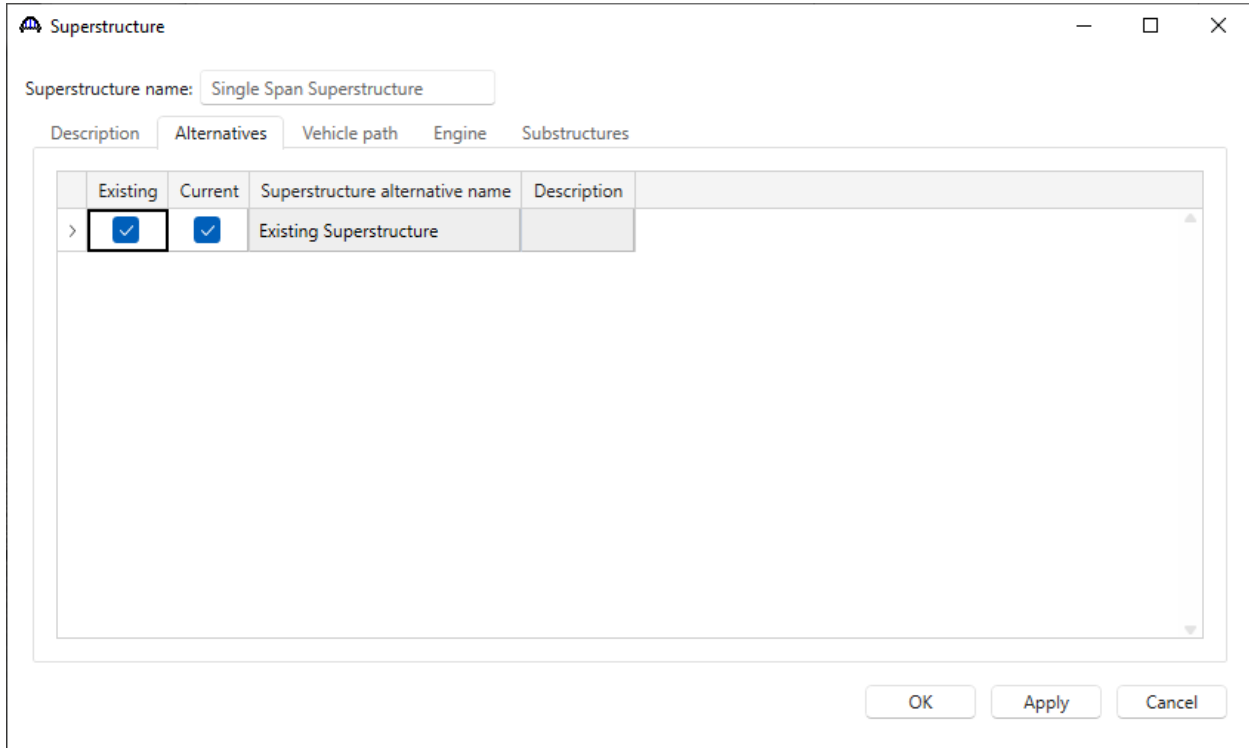
Number of main members: 9

| | Span | Length (ft) |
|---|------|-------------|
| > | 1 | 52 |

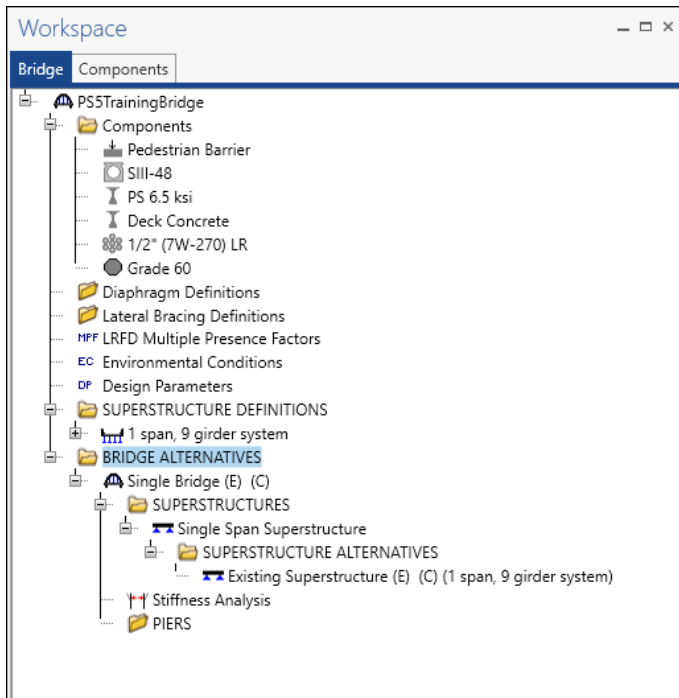
OK Apply Cancel

PS5 – Void Prestressed Box Beam Example

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



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



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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.

| Load case name | Description | Stage | Type | Time* (days) |
|----------------|-------------|---------------------------------|------|--------------|
| DL1 DC | Sidewalks | Non-composite (Stage 1) | D,DC | |
| DL2 DC | Barriers | Composite (long term) (Stage 2) | D,DC | |

*Prestressed members only

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

Structure Framing Plan Detail – Layout

Double-click on the **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.

Number of spans: Number of girders:

Layout Diaphragms

Girder spacing orientation
 Perpendicular to girder
 Along support

| Support | Skew (degrees) |
|---------|----------------|
| 1 | 0.000 |
| 2 | 0.000 |

| Girder bay | Girder spacing (ft) | |
|------------|---------------------|---------------|
| | Start of girder | End of girder |
| 1 | 4.00 | 4.00 |
| 2 | 4.00 | 4.00 |
| 3 | 4.00 | 4.00 |
| 4 | 4.00 | 4.00 |
| 5 | 4.00 | 4.00 |
| 6 | 4.00 | 4.00 |
| 7 | 4.00 | 4.00 |
| 8 | 4.00 | 4.00 |

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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. This structure does not have any external diaphragms since it is an adjacent box beam system. Click **OK** to apply the data and close the window.

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.

Structure Typical Section

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

Deck thickness | Superstructure Definition Reference Line

Left overhang | Right overhang

Deck | Deck (cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane position | Striped lanes | Wearing surface

Superstructure definition reference line is within the bridge deck.

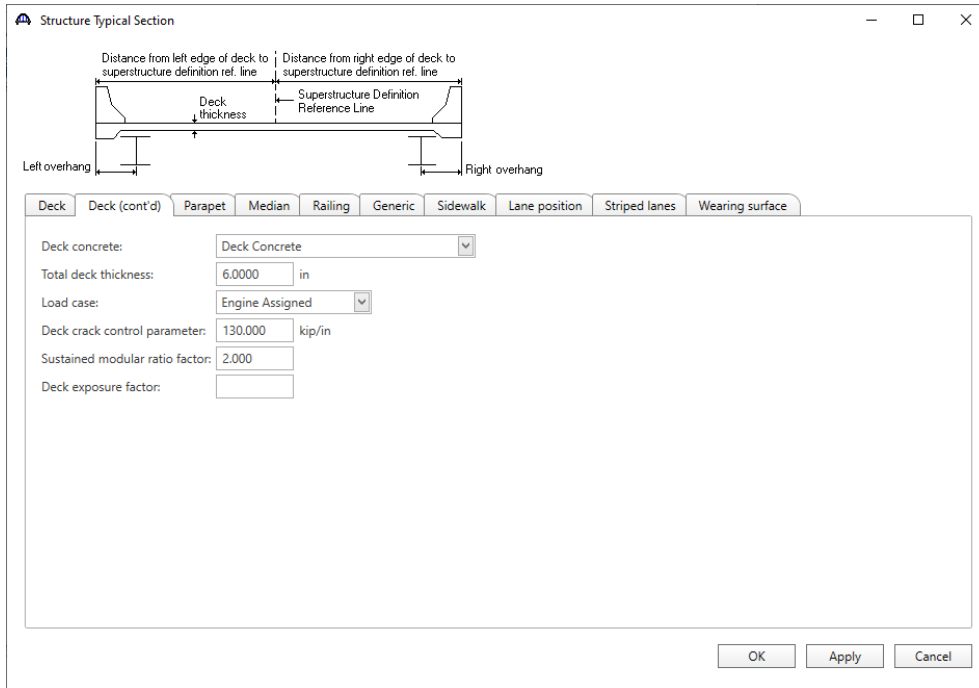
| | Start | End |
|---|----------|----------|
| Distance from left edge of deck to superstructure definition reference line: | 18.00 ft | 18.00 ft |
| Distance from right edge of deck to superstructure definition reference line: | 18.00 ft | 18.00 ft |
| Left overhang: | 2.00 ft | 2.00 ft |
| Computed right overhang: | 2.00 ft | 2.00 ft |

OK Apply Cancel

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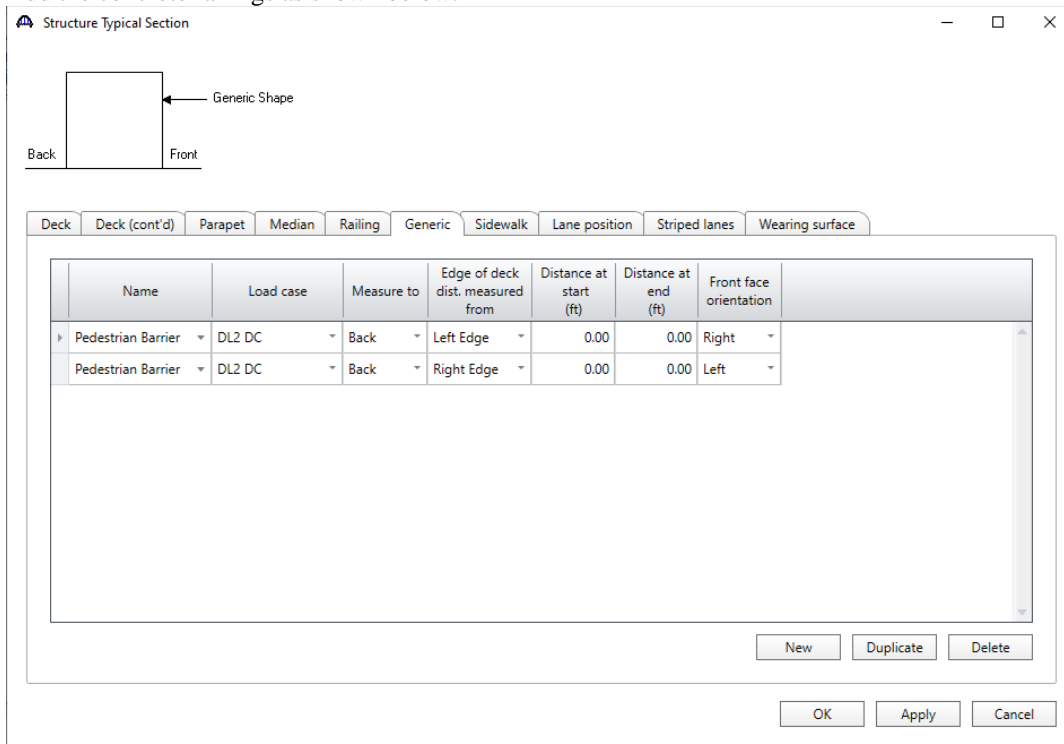
Structure Typical Section – Deck (cont'd)

The **Deck (cont'd)** tab is used to enter information about the **Deck concrete** and the **Total deck thickness**. The material to be used for the deck concrete is selected from the list of bridge materials. Enter data as shown below.



Structure Typical Section – Generic

Add the concrete railings as shown below.



PS5 – Void Prestressed Box Beam Example

Structure Typical Section – Sidewalk

Add the sidewalk details as shown below.

| Width (in) | Thickness (in) | Concrete material | Load case | Measure to | Edge of deck dist. measured from | Distance at start (ft) | Distance at end (ft) | Pedestrian load (ksf) |
|------------|----------------|-------------------|-----------|------------|----------------------------------|------------------------|----------------------|-----------------------|
| 72.0... | 6.0000 | Deck Concrete | DL1 DC | Left | Left Edge | 0.00 | 0.00 | |
| 72.0... | 6.0000 | Deck Concrete | DL1 DC | Right | Right Edge | 0.00 | 0.00 | |

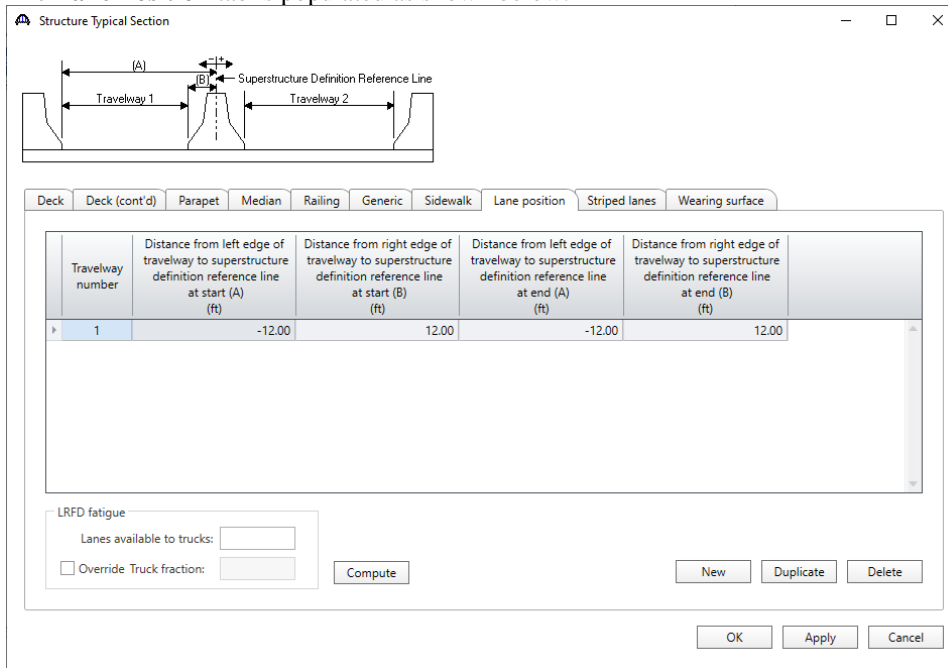
Structure Typical Section – Lane Positions

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.

| 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 | -12.00 | 12.00 | -12.00 | 12.00 |

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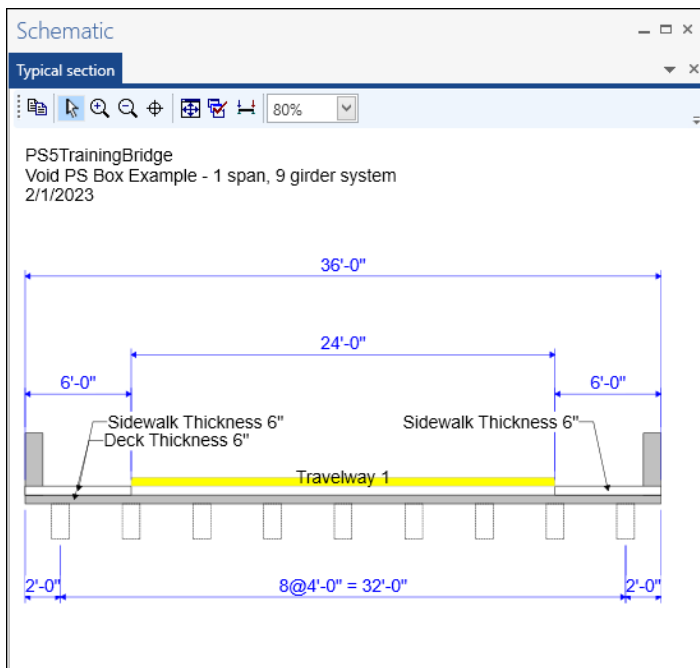
The **Lane Position** tab is populated as shown below.



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

Schematic – Structure Typical Section

While the **Structure Typical Section** is selected in the **Bridge Workspace** tree, open the schematic for the structure typical section by selecting the **Schematic** button on the **WORKSPACE** ribbon (or right click on **Structure Typical Section** in the **Bridge Workspace** and select **Schematic** from the menu).



Since the member alternatives are not defined yet, the beams are displayed as dashed boxes.

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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 **PS 6.5 ksi** concrete material from the drop-down menu of the **Concrete material**. 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. Enter this value manually as shown in the window below.

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, leave the **Final allowable tension stress limit coef. (US) override checkbox** unchecked. If not overridden, BrDR uses the default stress limit coefficient.

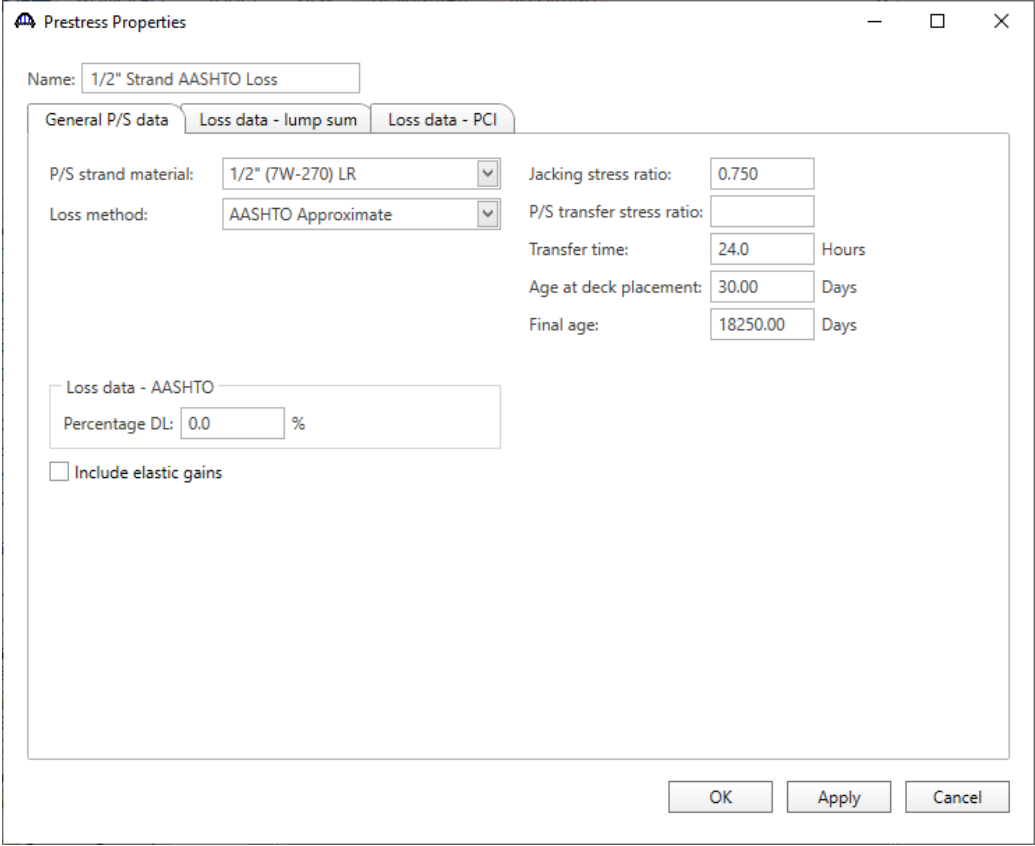
| | LFD | | LRFD | |
|---|-----------|-----|-----------|-----|
| Initial allowable compression: | 2.7 | ksi | 2.925 | ksi |
| Initial allowable tension: | 0.2 | ksi | 0.2 | ksi |
| Final allowable compression: | 3.9 | ksi | 3.9 | ksi |
| Final allowable tension: | 0.4844069 | ksi | 0.4844069 | ksi |
| Final allowable DL compression: | 2.6 | ksi | 2.925 | ksi |
| Final allowable slab compression: | 2.7 | ksi | 2.7 | ksi |
| Final allowable compression: (LL+1/2(Pe+DL)) | 2.6 | ksi | 2.6 | ksi |

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

PS5 – Void Prestressed Box Beam Example

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.



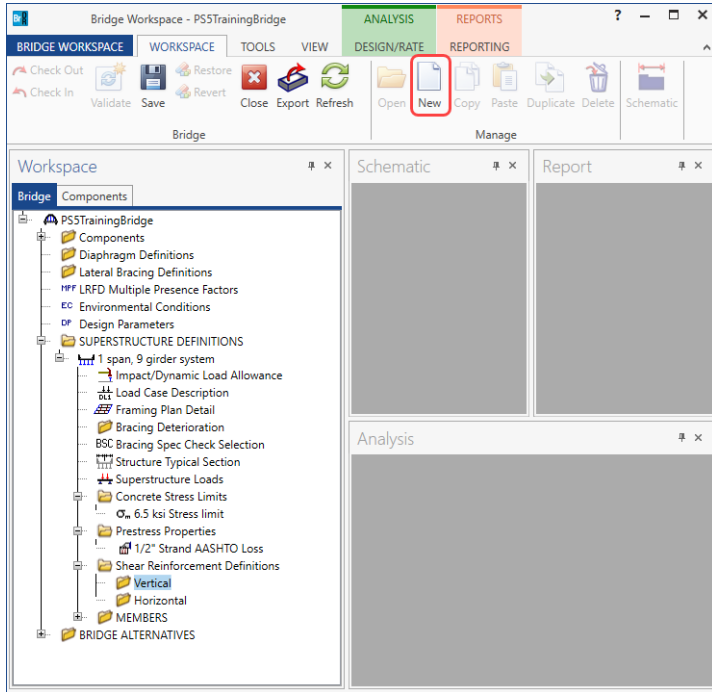
The screenshot shows a software dialog box titled "Prestress Properties". At the top, there is a "Name:" field containing "1/2\" Strand AASHTO Loss". Below this are three tabs: "General P/S data" (selected), "Loss data - lump sum", and "Loss data - PCI". The "General P/S data" tab contains several input fields: "P/S strand material:" with a dropdown menu showing "1/2\" (7W-270) LR"; "Loss method:" with a dropdown menu showing "AASHTO Approximate"; "Jacking stress ratio:" with a text box containing "0.750"; "P/S transfer stress ratio:" with an empty text box; "Transfer time:" with a text box containing "24.0" and the unit "Hours"; "Age at deck placement:" with a text box containing "30.00" and the unit "Days"; and "Final age:" with a text box containing "18250.00" and the unit "Days". Below these fields is a section titled "Loss data - AASHTO" containing a "Percentage DL:" text box with "0.0" and a "%" symbol. At the bottom of this section is a checkbox labeled "Include elastic gains" which is currently unchecked. At the very bottom of the dialog box are three buttons: "OK", "Apply", and "Cancel".

Click OK to apply the data and close the window.

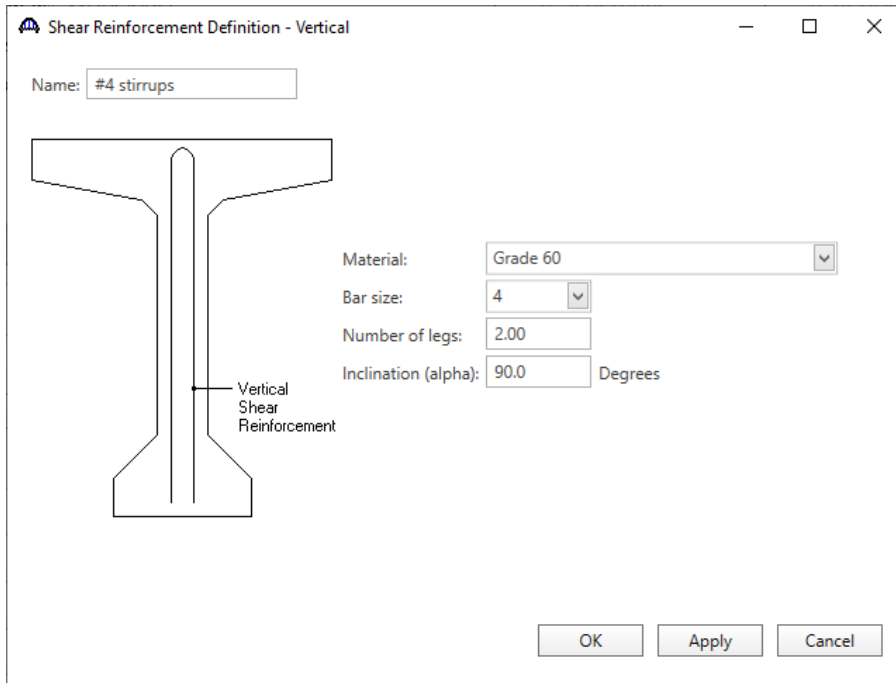
PS5 – Void Prestressed Box Beam Example

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**).



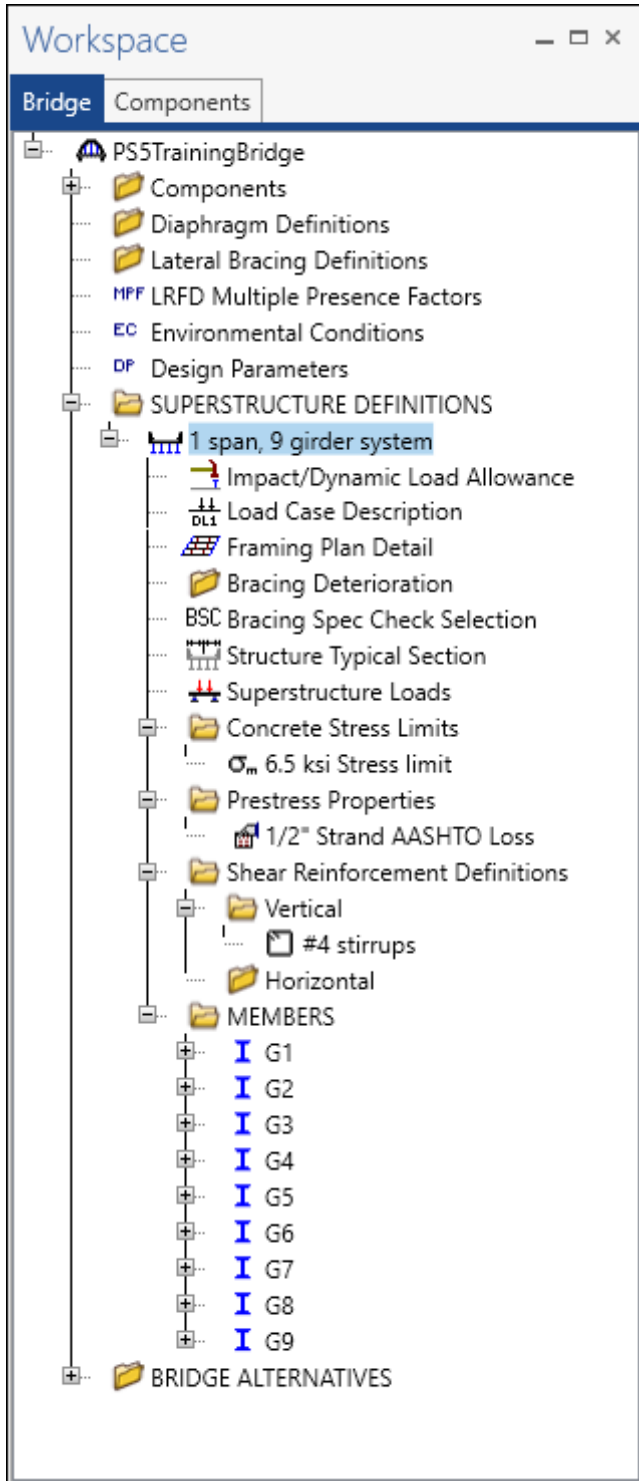
Enter the data as shown below.



Click OK to apply the data and close the window.

PS5 – Void Prestressed Box Beam Example

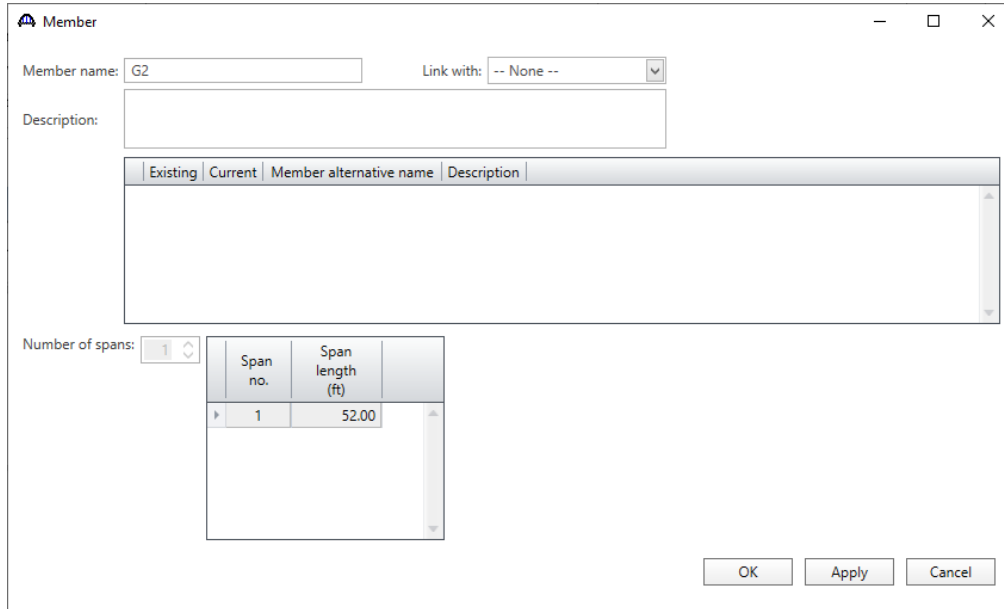
A partially expanded **Bridge Workspace** is shown below.



PS5 – Void Prestressed 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 in this window. The first member alternative created will automatically be assigned as the **Existing** and **Current member alternative** for this member.



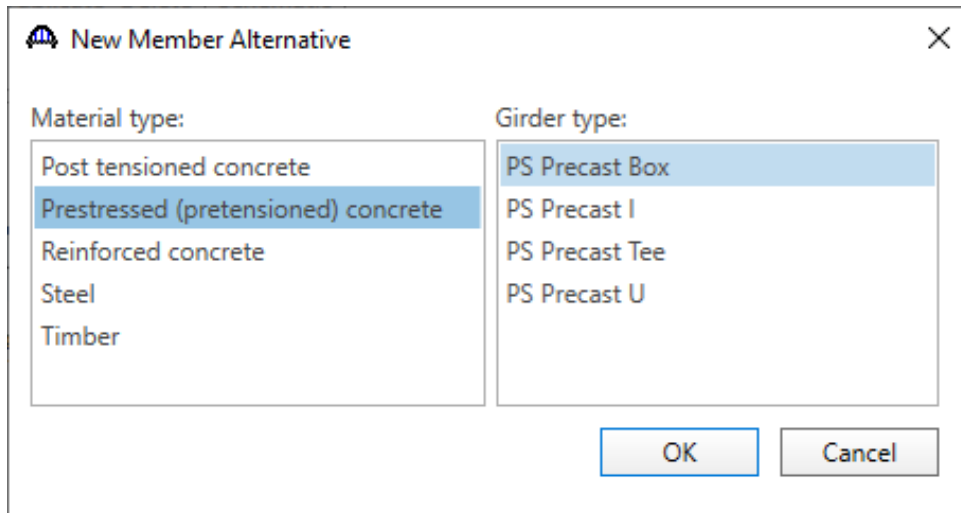
The screenshot shows the 'Member' dialog box. The 'Member name' is 'G2' and 'Link with' is '-- None --'. The 'Description' field is empty. Below is a table with columns 'Existing', 'Current', 'Member alternative name', and 'Description'. The 'Number of spans' is set to 1. A table below shows the span details:

| Span no. | Span length (ft) |
|----------|------------------|
| 1 | 52.00 |

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

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**.



The screenshot shows the 'New Member Alternative' dialog box. It has two list boxes: 'Material type' and 'Girder type'. The 'Material type' list includes 'Post tensioned concrete', 'Prestressed (pretensioned) concrete', 'Reinforced concrete', 'Steel', and 'Timber'. The 'Girder type' list includes 'PS Precast Box', 'PS Precast I', 'PS Precast Tee', and 'PS Precast U'. 'OK' and 'Cancel' buttons are at the bottom.

Click **OK** to close the window and create a new member alternative.

PS5 – Void Prestressed Box Beam Example

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 the data as shown below.

Member alternative: S11-48 Box Beam

Description Specs Factors Engine Import Control options

Description:

Material type: Prestressed (Pretensioned)

Girder type: PS Precast Box

Modeling type: Multi Girder System

Default units: US Customary

Girder property input method

Schedule based

Cross-section based

Self load

Load case: Engine Assigned

Additional self load: kip/ft

Additional self load: %

Default rating method: LFR

Crack control parameter (Z)

Bottom of beam: kip/in

Exposure factor

Bottom of beam:

Use creep

OK Apply Cancel

Click **OK** to save to memory 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.

| Span number | Beam shape | Girder material | Prestress properties | n | Beam projection | |
|-------------|------------|-----------------|----------------------|---|-----------------|----------------|
| | | | | | Left end (in) | Right end (in) |
| 1 | S11-48 | PS 6.5 ksi | 1/2" Strand AASHT... | | 7.0000 | 7.0000 |

OK Apply Cancel

PS5 – Void Prestressed Box Beam Example

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. Enter the data as shown below.

| Span number | Name | Start distance (ft) | Length (ft) | End distance (ft) |
|-------------|----------------------|---------------------|-------------|-------------------|
| 1 | 6.5 ksi Stress limit | 0 | 53.166667 | 53.166667 |

Beam Details – Slab interface

Enter the data as shown below.

Interface type: Intentionally Roughened

Default interface width to beam widths:

Interface width: in

Cohesion factor: 0.100 ksi

Friction factor:

K1:

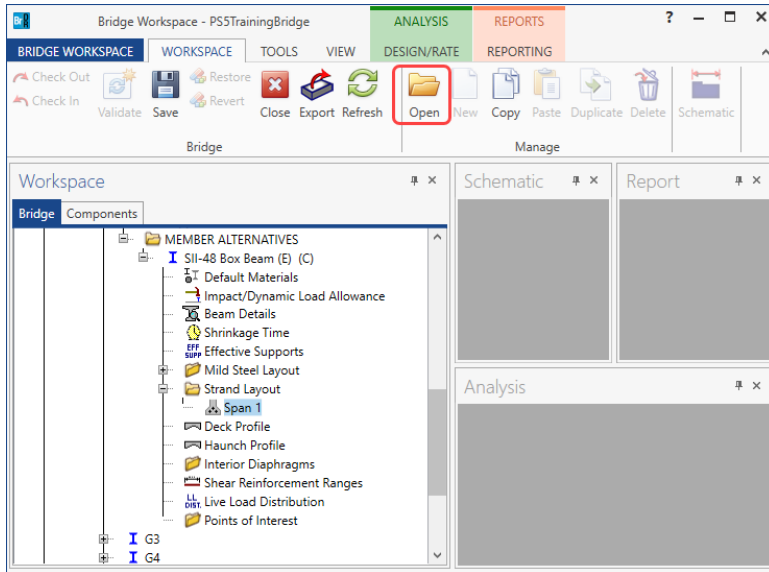
K2: ksi

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

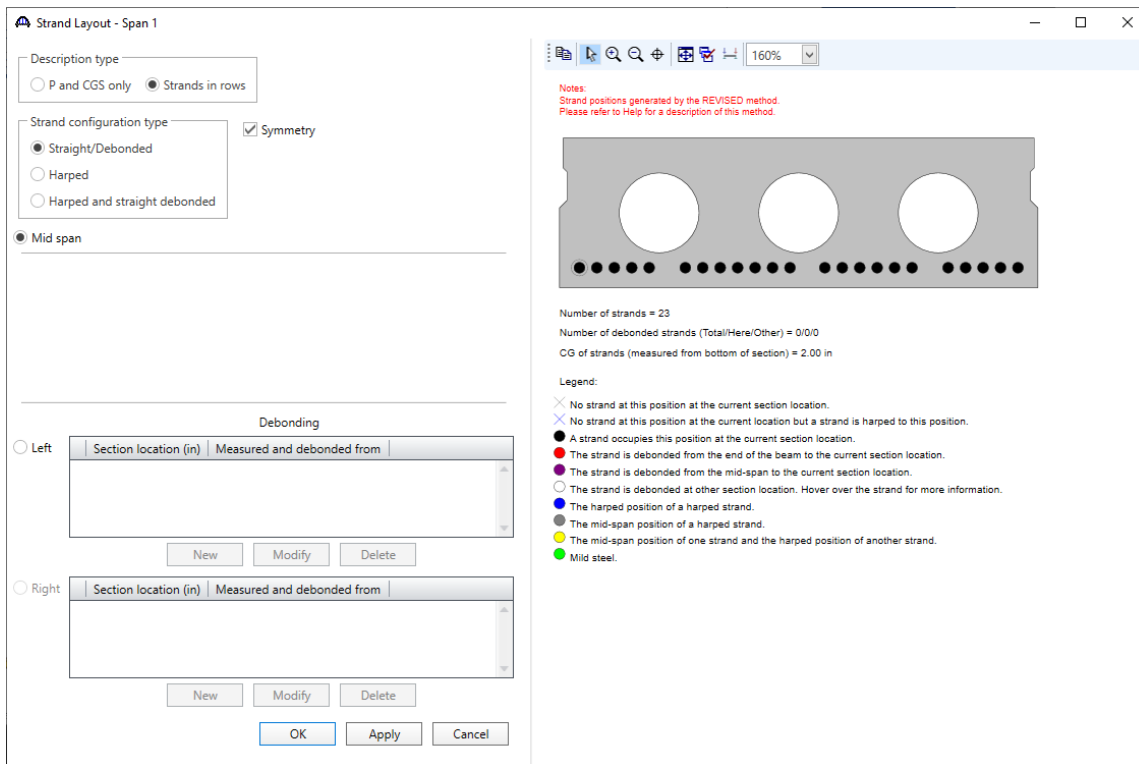
PS5 – Void Prestressed Box Beam Example

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.



Select the **Description type** as **Strands in rows** and the **Strand configuration type** as **Straight/Debonded**. Select the **Mid span** radio button. 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. There is no debonding to describe for this beam.



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

PS5 – Void Prestressed Box Beam Example

Deck Profile

Next open the **Deck Profile** window by double-clicking the **Deck Profile** node in the **Bridge Workspace** tree and enter the data describing the structural properties of the deck. The window is shown below.

The screenshot shows the 'Deck Profile' window with the 'Type' set to 'PS Precast Box'. The 'Reinforcement' tab is selected. A table contains one row of data for 'Deck Concrete'.

| Material | Support number | Start distance (ft) | Length (ft) | End distance (ft) | Structural thickness (in) | Start effective flange width (Std) (in) | End effective flange width (Std) (in) | Start effective flange width (LRFD) (in) | End effective flange width (LRFD) (in) | n |
|---------------|----------------|---------------------|-------------|-------------------|---------------------------|---|---------------------------------------|--|--|---|
| Deck Concrete | 1 | 0.00 | 52.00 | 52.00 | 6.0000 | 48.0000 | 48.0000 | 48.0000 | 48.0000 | |

Buttons at the bottom: Compute from typical section..., New, Duplicate, Delete, OK, Apply, Cancel.

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

No reinforcement or haunch profile is described for this example. .

Interior Diaphragms

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.

The screenshot shows the 'Interior Diaphragms' window with a table containing one row of data for span 1.

| Span number | Start distance (ft) | Diaphragm spacing (ft) | Number of spaces | Length (ft) | End distance (ft) | Diaphragm thickness (in) | Diaphragm load (kip) |
|-------------|---------------------|------------------------|------------------|-------------|-------------------|--------------------------|----------------------|
| 1 | 0 | 17.333333 | 2 | 34.666666 | 34.666666 | 12 | 0.3 |

Buttons at the bottom: New, Duplicate, Delete, OK, Apply, Cancel.

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

PS5 – Void Prestressed Box Beam Example

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 vertical shear reinforcement is defined as extending into the deck in the **Vertical** 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 that has been defined by extending the vertical bars into the deck. Enter the data as shown below.

PS Shear Reinforcement Ranges

Vertical Horizontal

Span: 1

| Name | Extends into deck | Start distance (ft) | Number of spaces | Spacing (in) | Length (ft) | End distance (ft) |
|-------------|-------------------------------------|---------------------|------------------|--------------|-------------|-------------------|
| #4 stirrups | <input checked="" type="checkbox"/> | 0.58 | 1 | 0.0000 | 0.00 | 0.58 |
| #4 stirrups | <input checked="" type="checkbox"/> | 0.58 | 3 | 4.0000 | 1.00 | 1.58 |
| #4 stirrups | <input checked="" type="checkbox"/> | 1.58 | 50 | 12.0000 | 50.00 | 51.58 |
| #4 stirrups | <input checked="" type="checkbox"/> | 51.58 | 3 | 4.0000 | 1.00 | 52.58 |

Stirrup wizard... Stirrup design tool... View calcs New Duplicate Delete

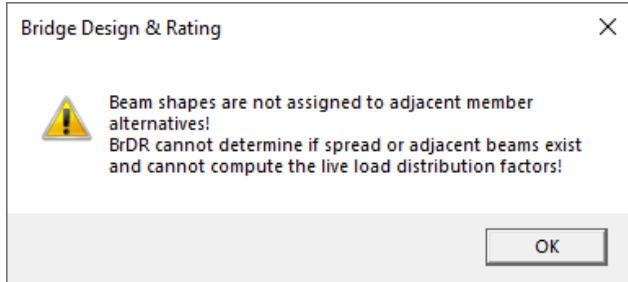
OK Apply Cancel

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

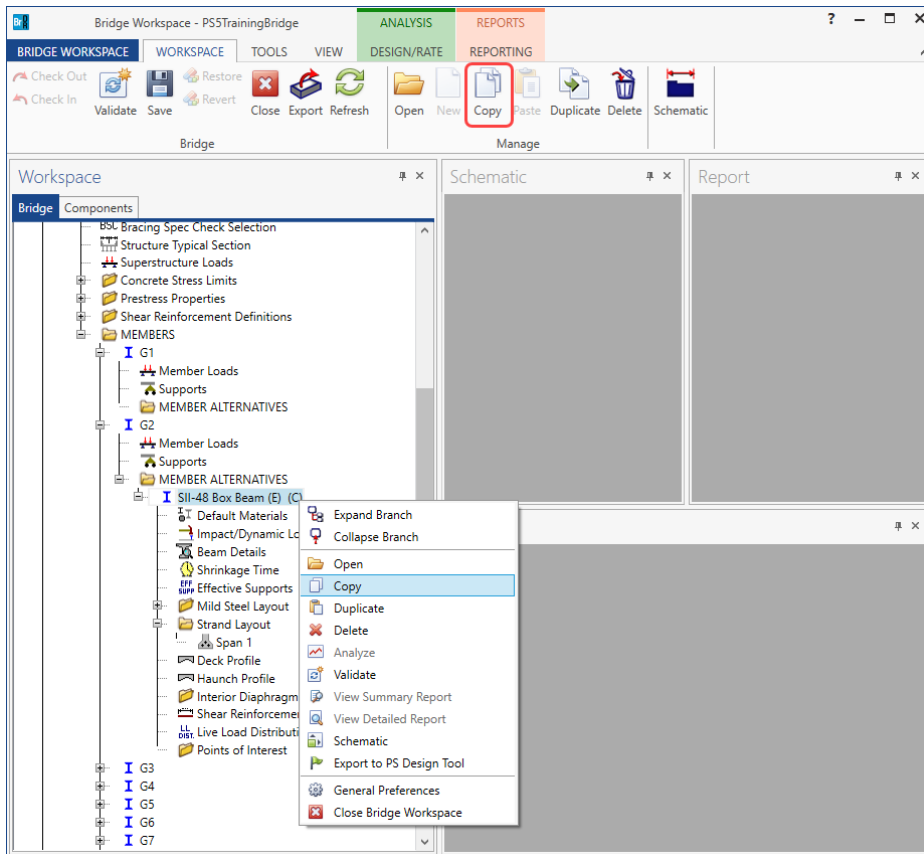
PS5 – Void Prestressed Box Beam Example

Live Load Distribution

Open the **Live Load Distribution** window from the **Bridge Workspace** tree. On the **Standard** tab click on the **Compute from Typical Section...** button to populate the Standard live load distribution factors based on the structure typical section. BrDR 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. On clicking the **Compute from Typical Section...** BrDR prompts the user with the following warning message.

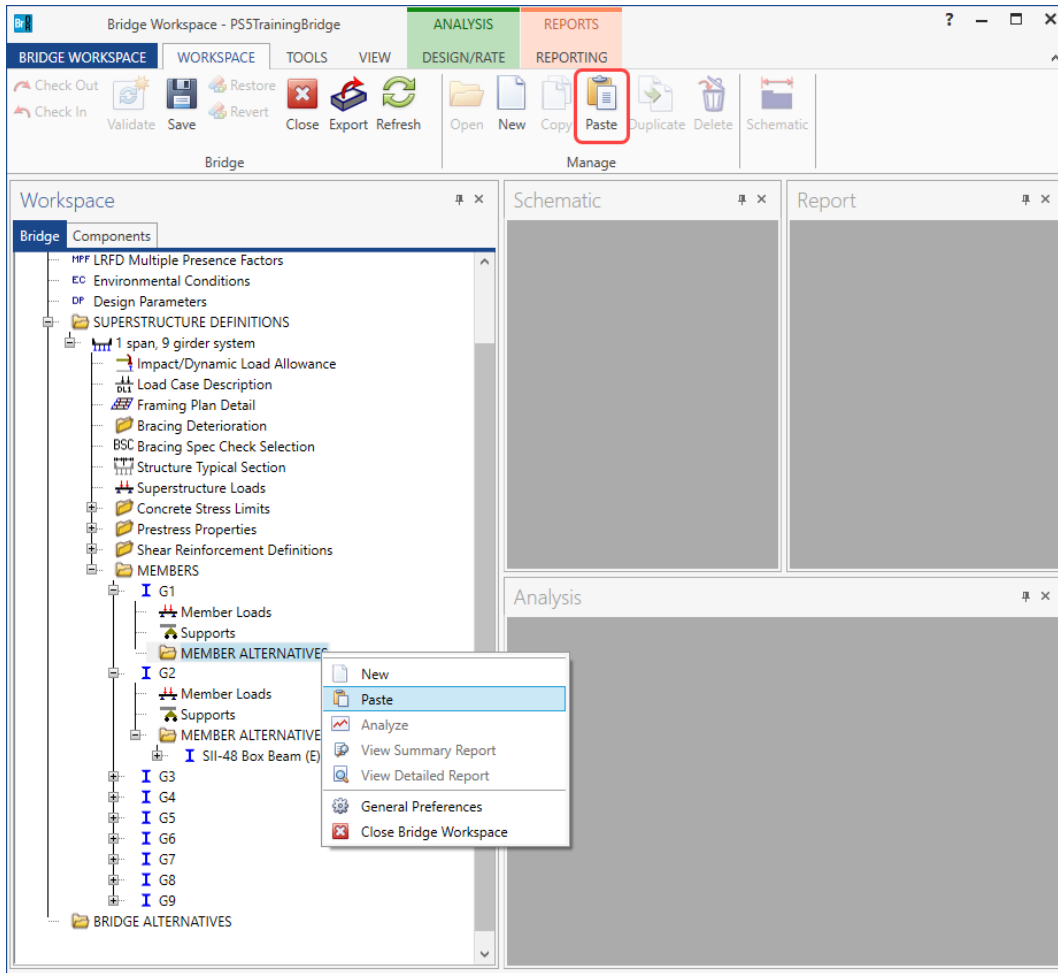


For a **PS Precast Box** beam, live load distribution factors cannot be computed if spread or adjacent beams do not exist. Member **G2** is the only member that has a member alternative defined. This member alternative can be copied to Member **G1** to minimize the amount of data entry for this structure. Select **SII-48 Box Beam** under Member **G2** in the **Bridge Workspace** tree and click the **Copy** button from the **Manage** group of the **WORKSPACE** ribbon (or right click on the member alternative and select **Copy** from the menu options).



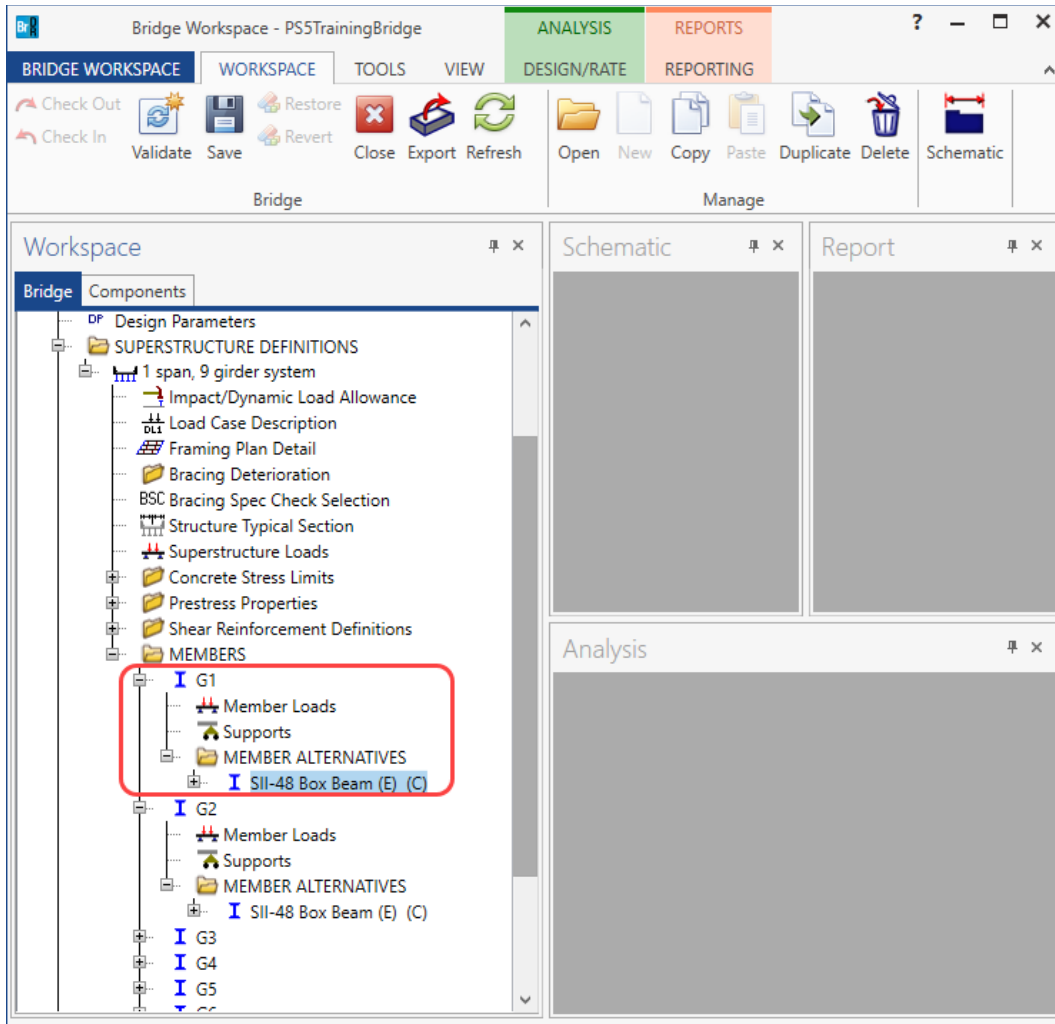
PS5 – Void Prestressed Box Beam Example

Select **MEMBER ALTERNATIVES** under Member **G1** and click the **Paste** button from the **Manage** group of the **WORKSPACE** ribbon (or right click on the member alternative and select **Copy** from the menu options).



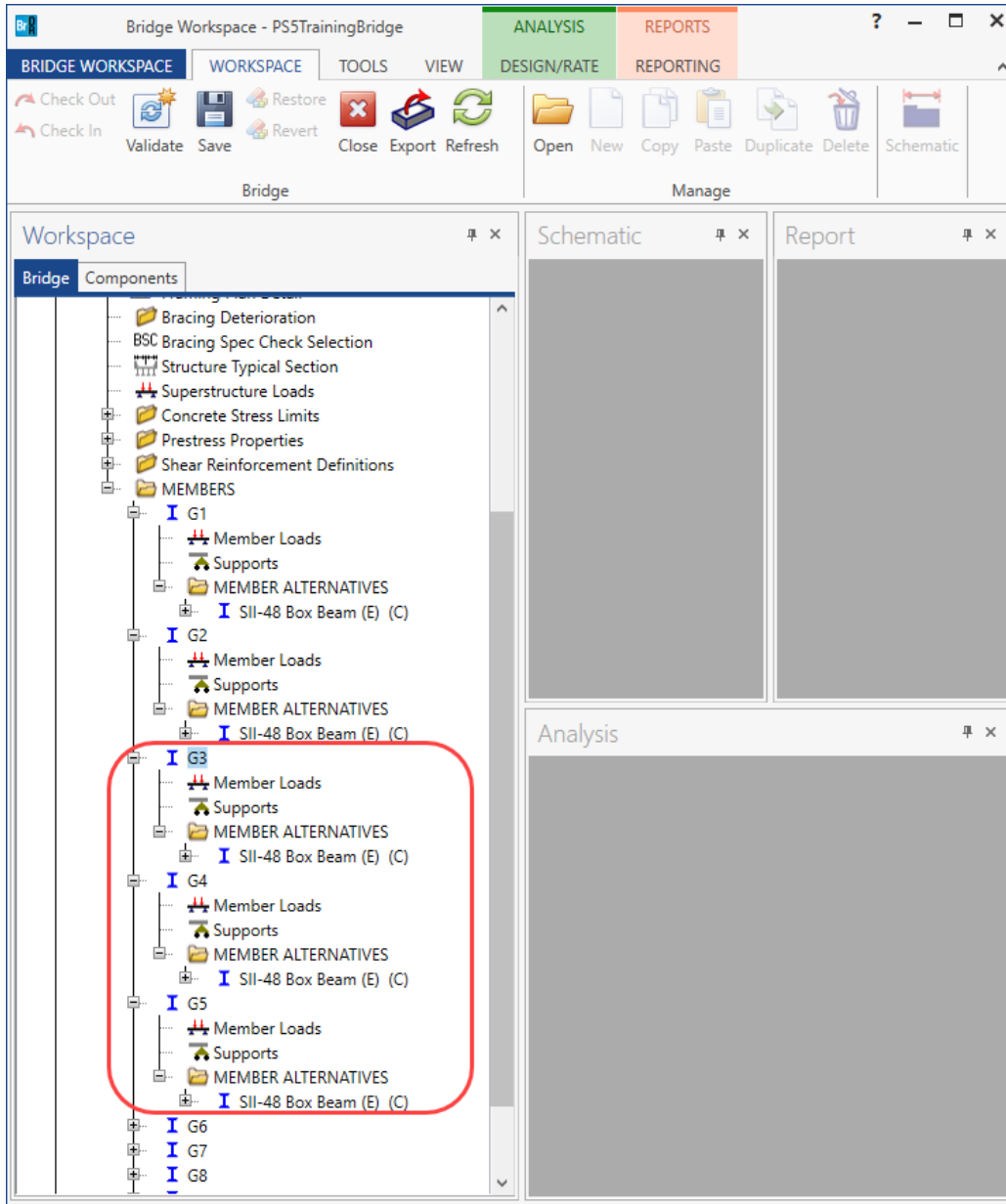
PS5 – Void Prestressed Box Beam Example

Now Member **G1** has a member alternative named **SII-48 Box Beam**. Since **G1** is an exterior girder and **G2** is an interior girder, there are a few windows under **G1** that must be revisited to modify the data to represent an exterior girder. The **Live Load Distribution** window should be opened, and appropriate distribution factors should be entered for this exterior girder. The **Deck Profile** and **Haunch Profile** windows should also be modified to represent the exterior girder.



PS5 – Void Prestressed Box Beam Example

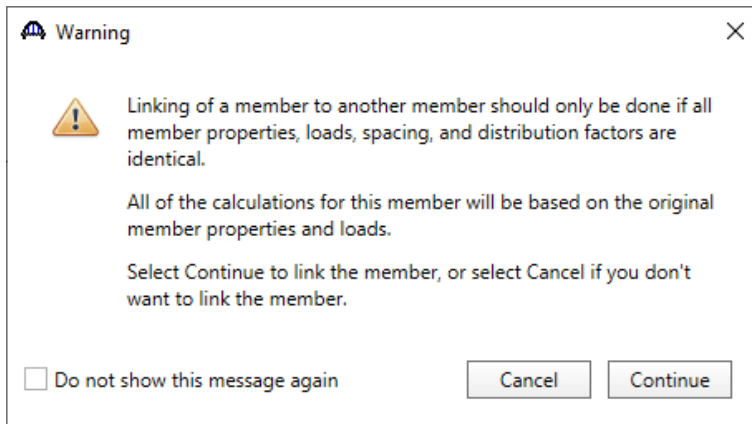
Use the **Copy** function to copy the member alternative for Member **G2** to Members **G3**, **G4**, and **G5**. Adjust the live load distribution factors as necessary for Members **G3**, **G4**, and **G5**. Depending on the arrangement of the lane positions and the girders, the simple beam distribution factors for the interior girders may differ. It is a good idea to recalculate the distribution factors for copied member alternatives. Half of the girders in the structure are now defined.



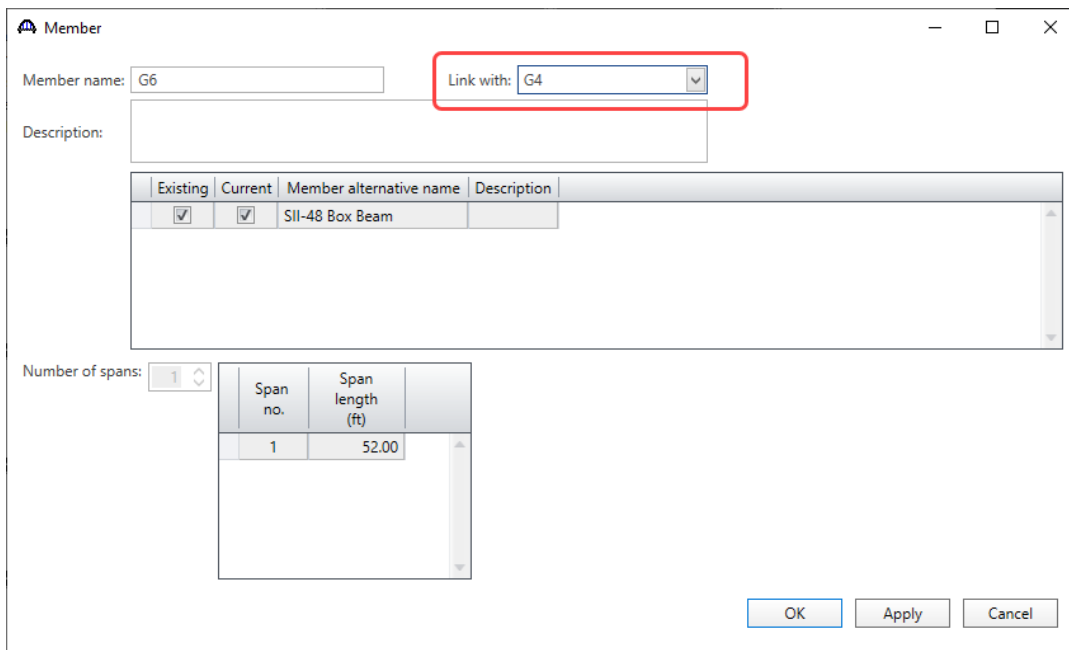
PS5 – Void Prestressed Box Beam Example

The **Link** function in BrDR can be used to link the remaining girders in the structure to the members defined. If two members are linked, they share the same definition and any revisions to one member affects the other member. If there are any differences between two members, then they should not be linked with one another. If the applied loads acting on the two members are different (due to different tributary widths, different arrangements of parapets, medians, sidewalks, and railings, and different lane positions), then they should not be linked with one another. All calculations are based on the properties and loads of the original girder.

Open the Member **G6** window from the **Bridge Workspace** tree and select **G4** in the **Link with** box as shown below. A warning message will appear to remind that both members must share the exact same definition if they are to be linked. Click the **Continue** button to link the two members.



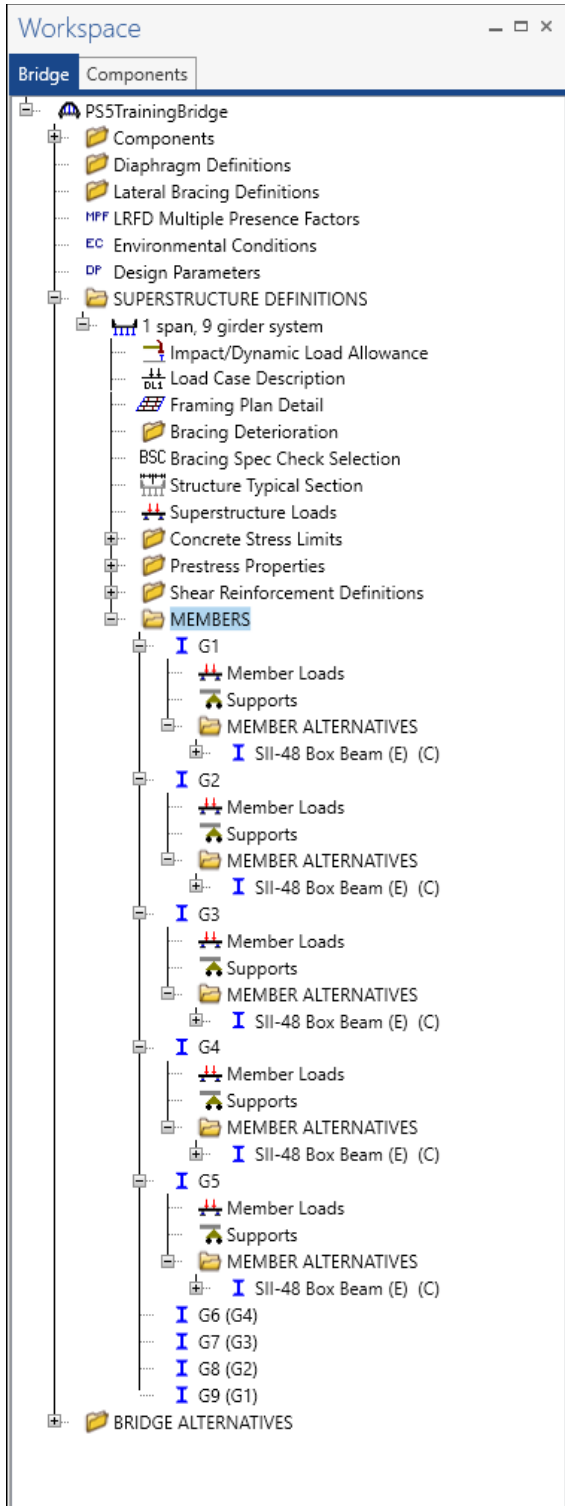
Member **G6** now shares the same definition as Member **G4**. Use this procedure to link Member **G7** with **G3**, Member **G8** with **G2**, and Member **G9** with **G1**.



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

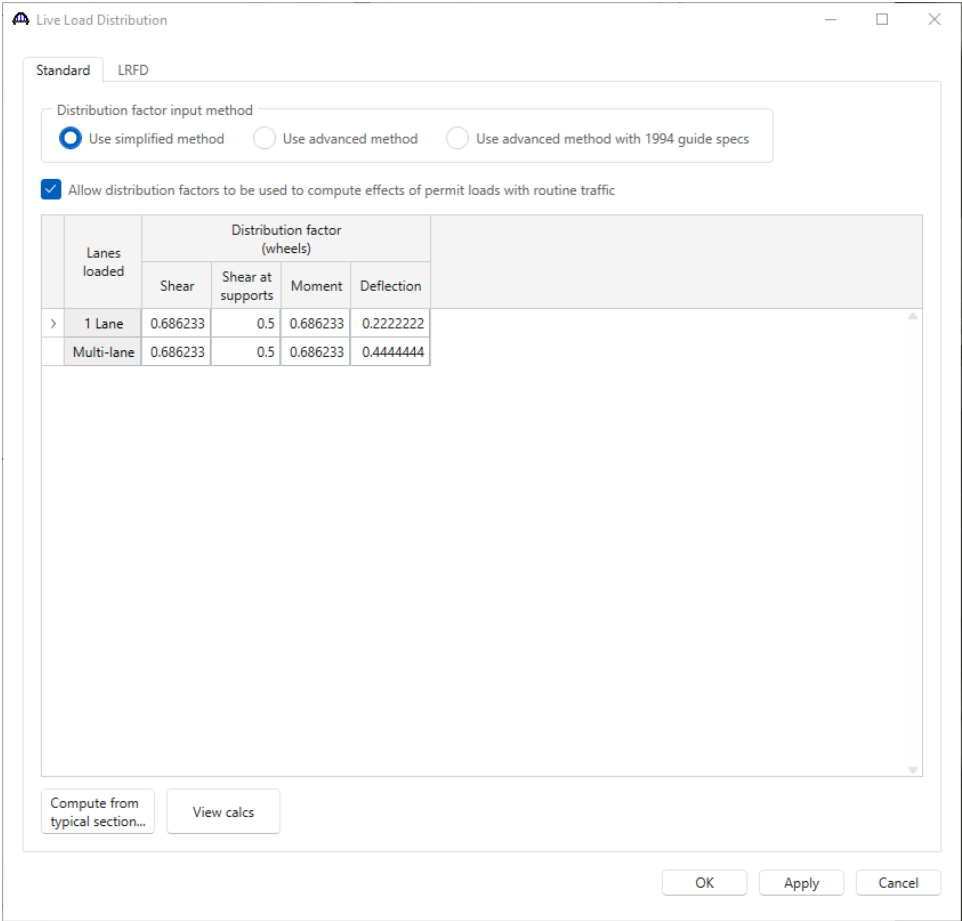
PS5 – Void Prestressed Box Beam Example

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



PS5 – Void Prestressed Box Beam Example

Returning to the **Live Load Distribution** window for member alternative **SII-48 Box Beam (E) (C)** of member **G2**, Click the **Compute from typical section...** to compute the standard live load distribution factors. The window is populated with the factors as shown below.



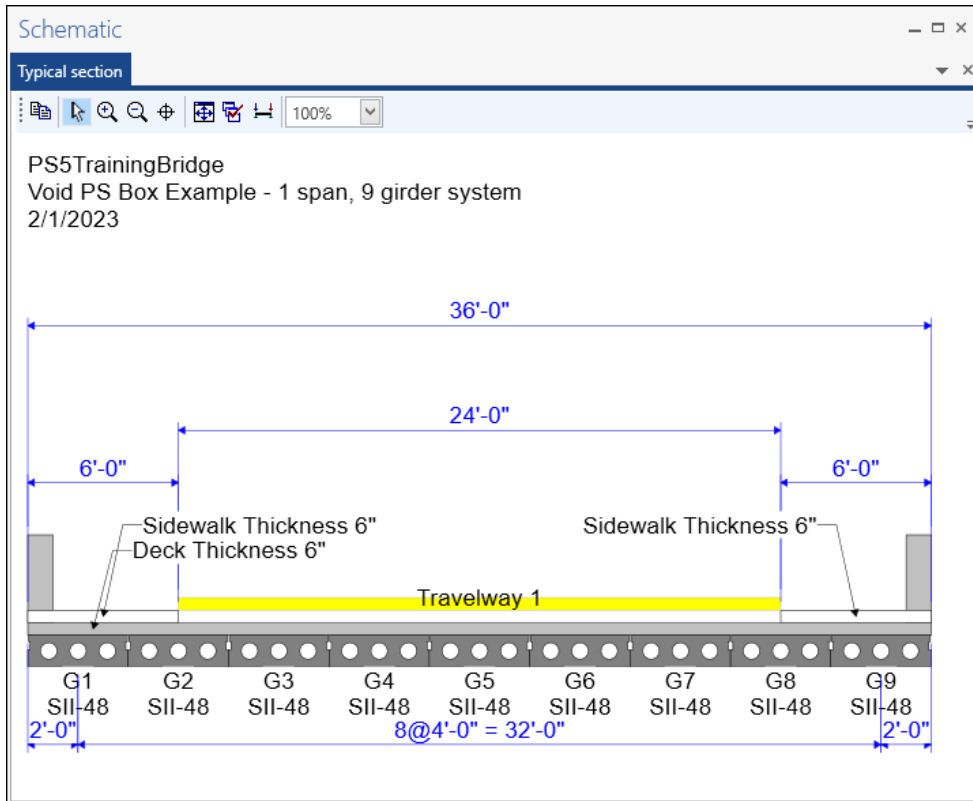
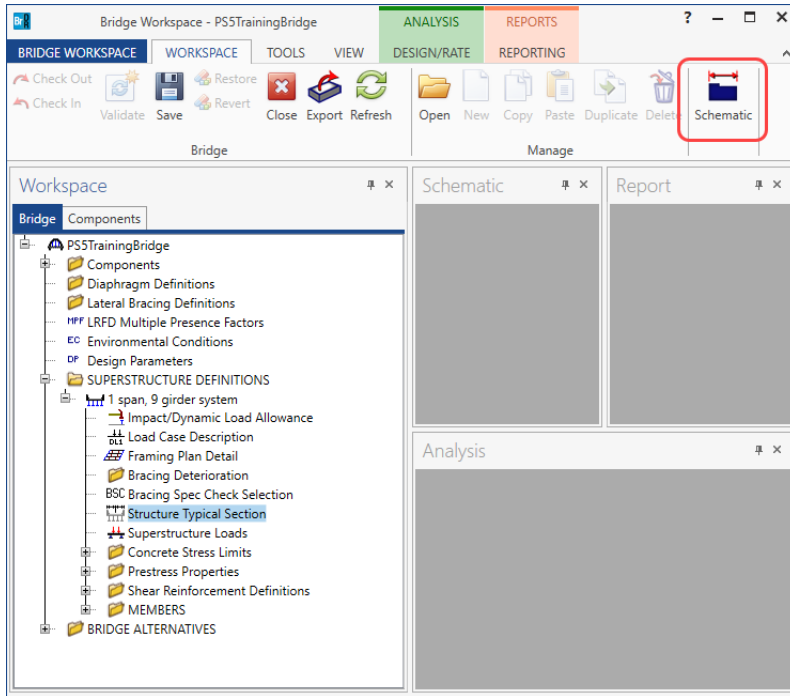
Click **OK** to apply the data and close the window.

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

PS5 – Void Prestressed Box Beam Example

Schematic – Structure Typical Section

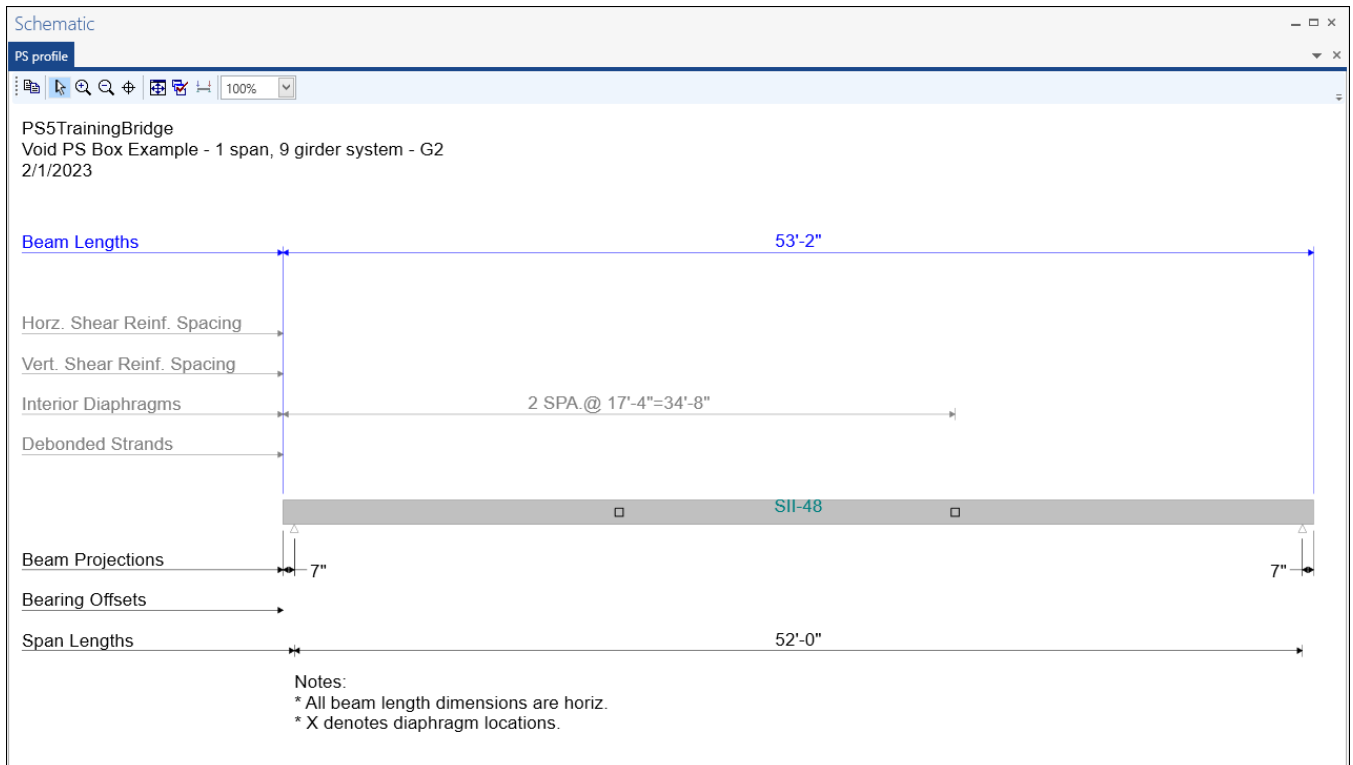
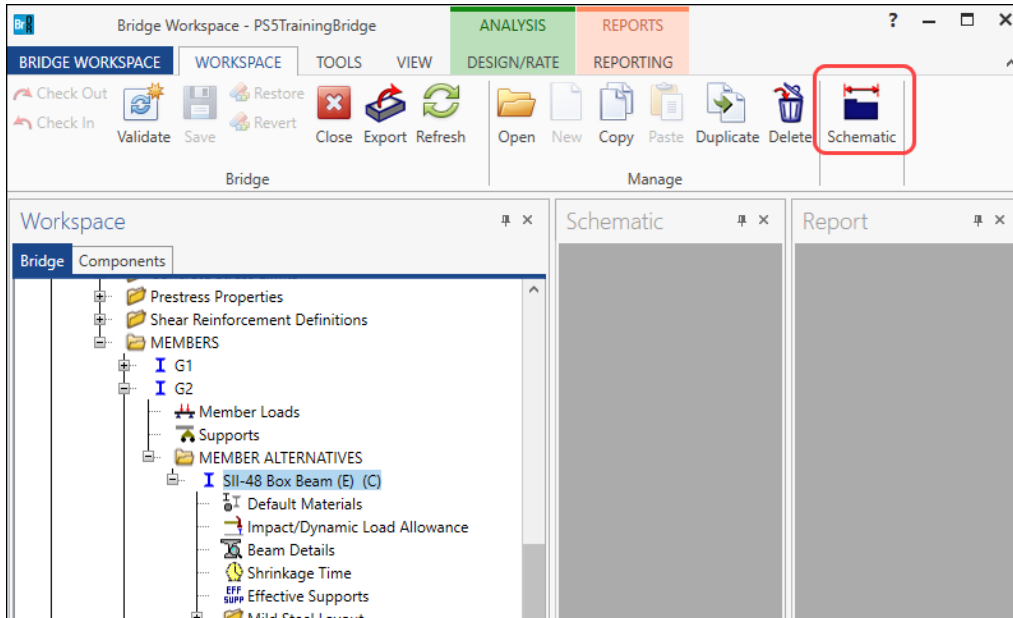
Select the **Structure Typical Section** in the **Bridge Workspace** tree and click the **Schematic** button on the **WORKSPACE** ribbon as shown below.



PS5 – Void Prestressed Box Beam Example

Schematic – PS Profile

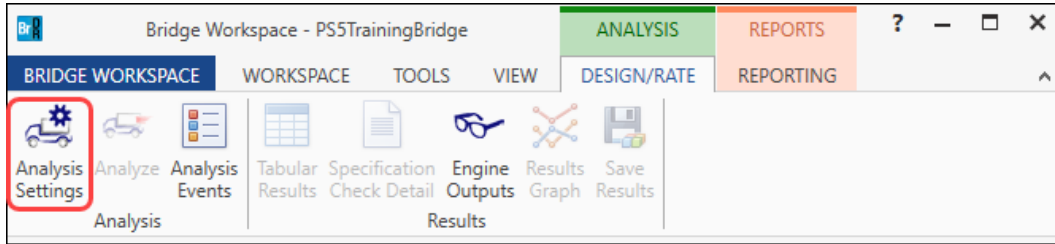
The girder elevation can be displayed by selecting the **Schematic** button on the **WORKSPACE** ribbon while the **SII-48 Box Beam** member alternative of member **G2** is selected in the **Bridge Workspace** tree.



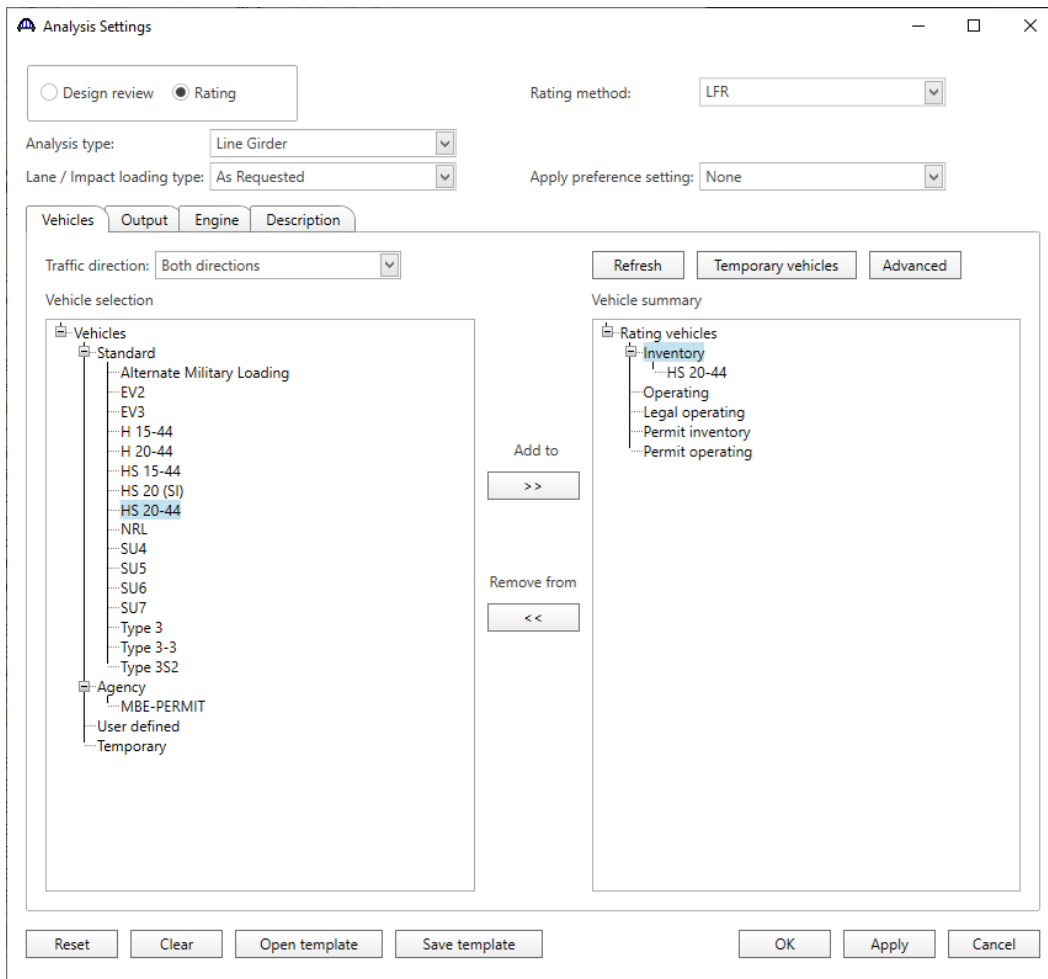
PS5 – Void Prestressed Box Beam Example

LFR Rating

To perform an **LFR** rating on the **G2** member alternative, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon to open the window shown below.



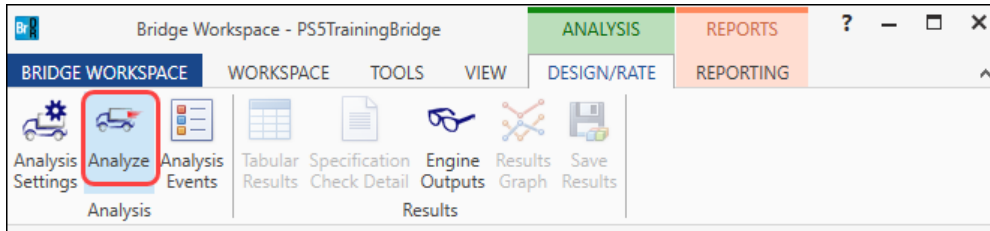
Select the vehicle to be used in the rating as shown below and click **OK**.



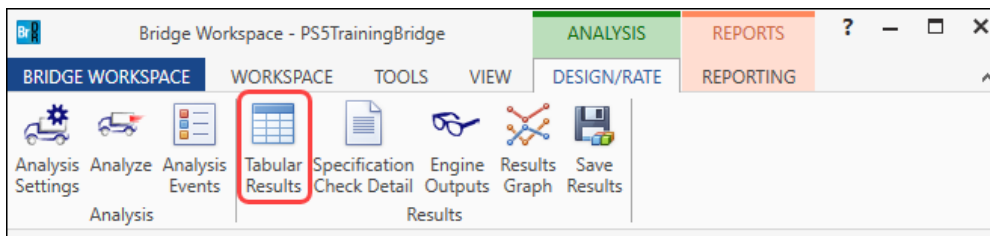
PS5 – Void Prestressed Box Beam Example

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.

Analysis Results - SII-48 Box Beam

Print

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 |
|-----------|----------------|---------------|--------------|-------------------|---------------|---------------|-------------------|------------------------------|--------------|--------------|
| HS 20-44 | Axle Load | LFR | Inventory | 24.13 | 0.670 | 26.00 | 1 - (50.0) | PS Tensile Stress - Concrete | As Requested | As Requested |
| HS 20-44 | Lane | LFR | Inventory | 35.15 | 0.976 | 26.00 | 1 - (50.0) | PS Tensile Stress - Concrete | As Requested | As Requested |

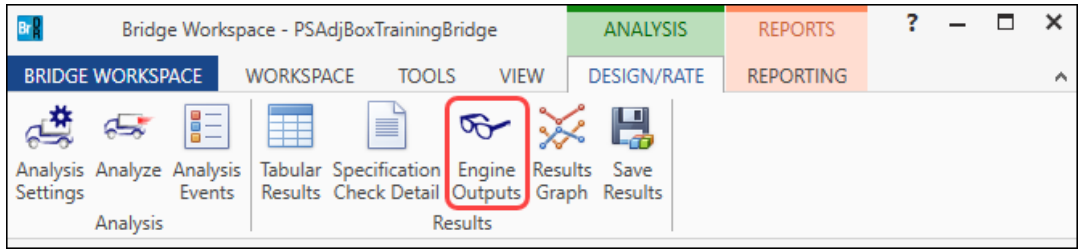
AASHTO LFR Engine Version 7.5.0.3001
Analysis preference setting: None

Close

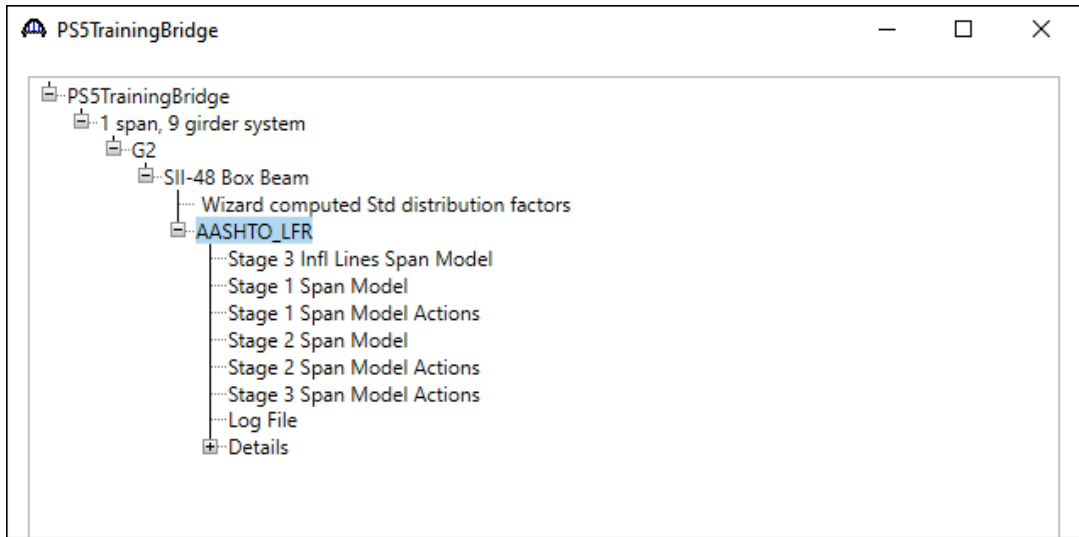
PS5 – Void Prestressed Box Beam Example

Engine Outputs

The analysis output files can be viewed by clicking the **Engine outputs** button on the **Results** group of the ribbon.



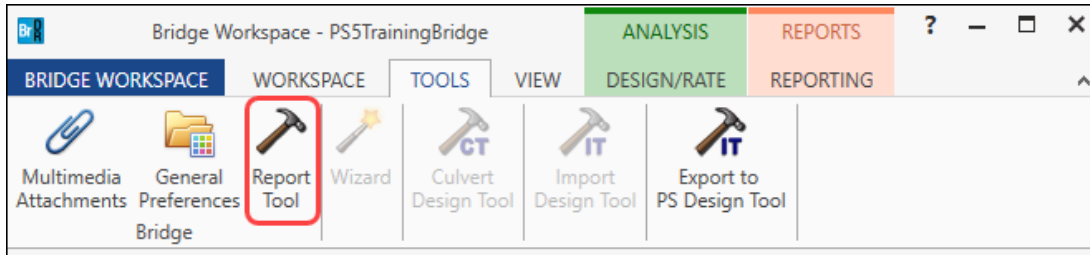
The following window will open.



PS5 – Void Prestressed Box Beam Example

LFR Report

A summarized report of the output can be generated by selecting the **Report Tool** button on the **Bridge** group of the **TOOLS** ribbon.



Select the **LFR analysis output** as the **Report type**. Specific topics in the report can be selected by checking the checkbox against the categories displayed. Selecting the **Generate** button will open the generated report in Internet Explorer (or the default browser set by the user). The report can be printed from the browser.

