AASHTOWare BrDR 7.5.1

Advanced Concrete Beam Tutorial 2

AC2 – Three Span Advanced Concrete PT & RC MCB Web Example

AASHTOWare Bridge Design and Rating Training

AC2 – Advanced Concrete PT MCB Web Example

Topics Covered:

- Advanced Concrete Beam Member Alternative with PT and RC regions
- Model a web in an MCB structure
- LRFR Rating

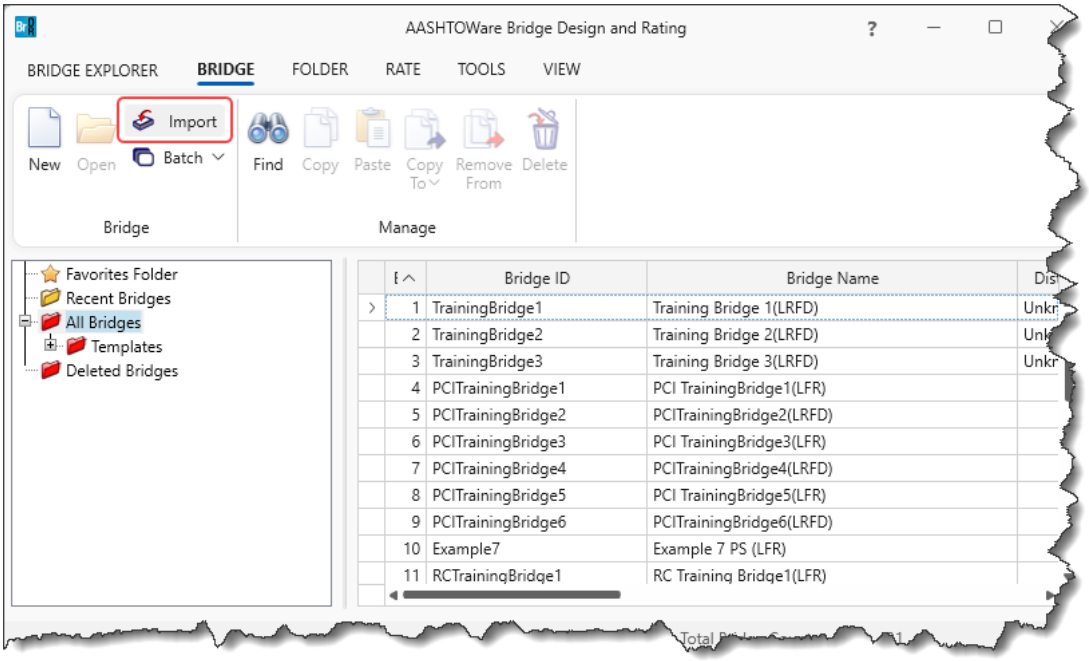
Overview of Advanced Concrete Beam features:

- Advanced concrete beams implemented in BrDR version 7.1.0 in September 2021
- Advanced concrete PT: LRFR/LFR
- Model girders in a multi-girder system or individual webs in a multi-cell box.
- Model schedule based non-symmetric RC Beams
- Post-tensioned/reinforced concrete regions
- Different stages of post-tensioning

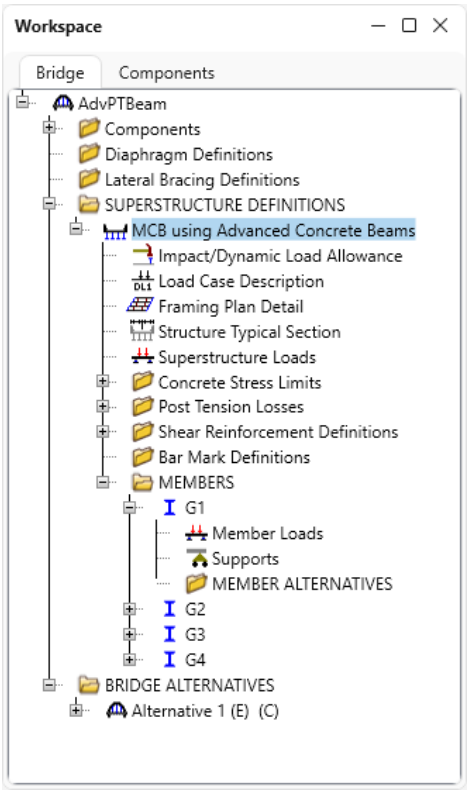
This tutorial describes the data entry for a post-tensioned multi-cell box(MCB) web using the Advanced Concrete beam alternative in BrDR version 7.5.1 Taking this approach to model the webs in an MCB is useful when the multi-cell box superstructure definition in BrDR does not provide a way to model the structure.

Advanced Concrete Beam Member Alternative with PT and RC regions

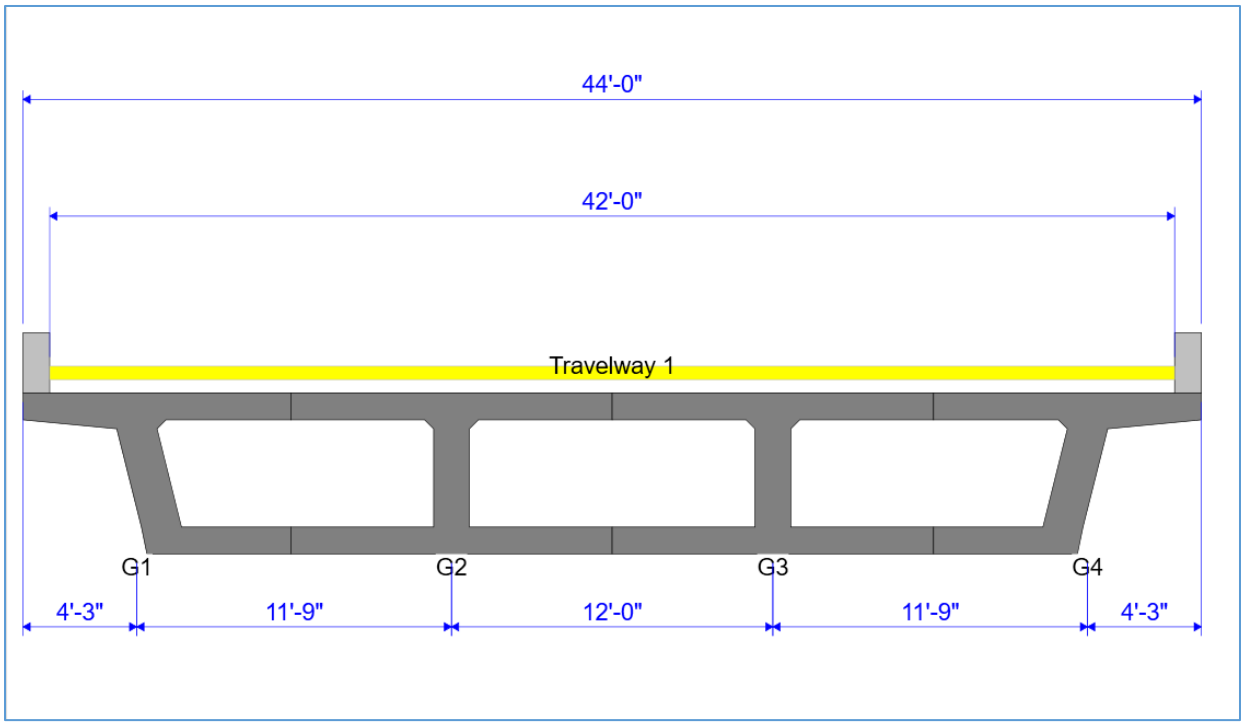
Import the **AC2 – Advanced Concrete PTRC.xml** file provided with this tutorial into BrDR by clicking on the Import button from **BRIDGE** ribbon in the **Bridge Explorer** as shown below.



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

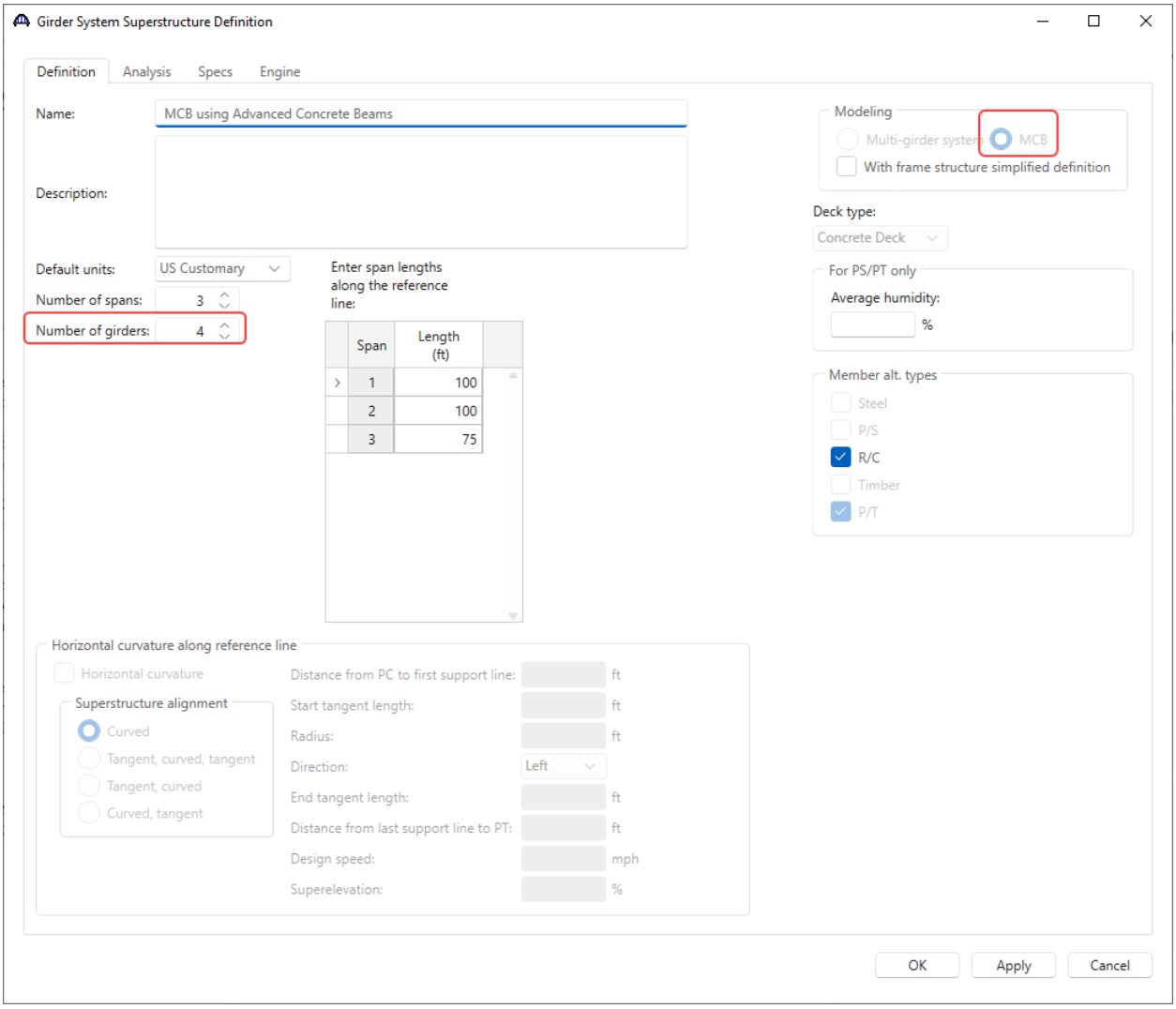


The following sketch shows the superstructure definition that will be described in this example. This training example will first review the superstructure windows in this superstructure definition and then an advanced concrete member alternative will be entered for **G1**.



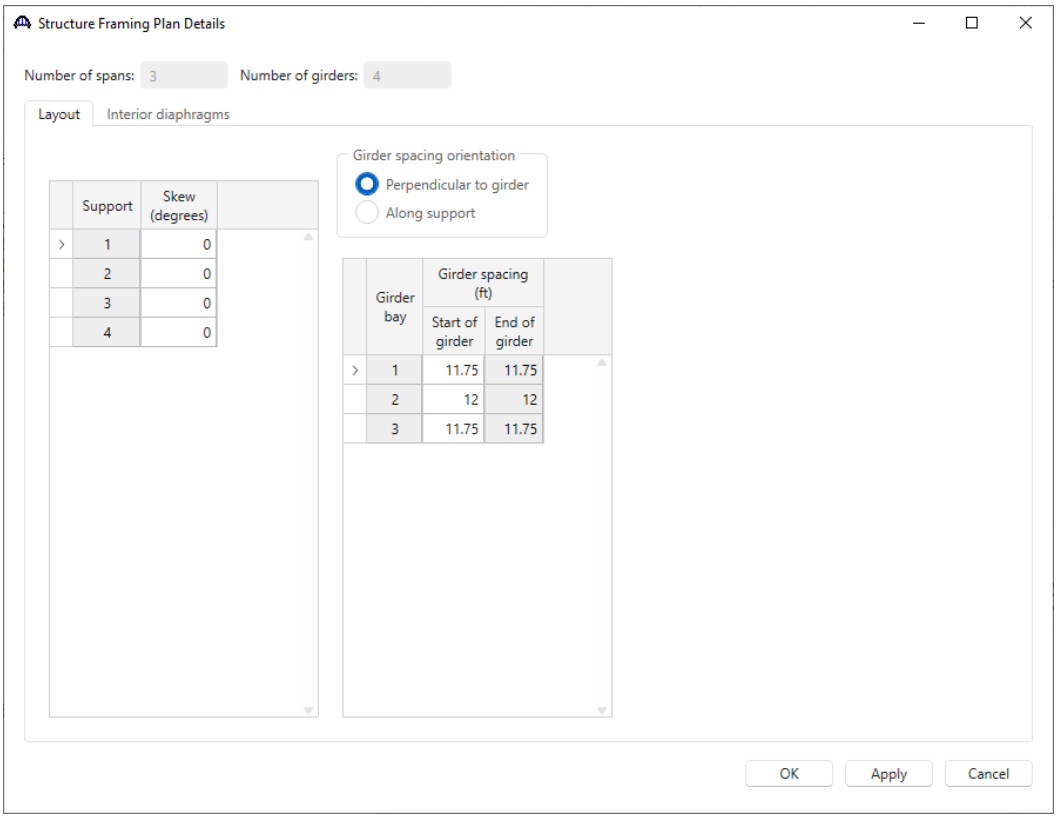
Girder System Superstructure Definition

Double click on the **MCB using Advanced Concrete Beams** node in the **Bridge Workspace** tree to open the **Girder System Superstructure Definition** window as shown below. Note that the **Modeling** type for this superstructure is **MCB**. This selection tailors the data entry of the girders to model the webs in a multi-cell box structure. The number of girders is set to 4. When the modeling type is **MCB**, the number of girders corresponds to the number of webs in the multi-cell box being described. Click **Cancel** to close the window without saving any errant changes that may have been made.

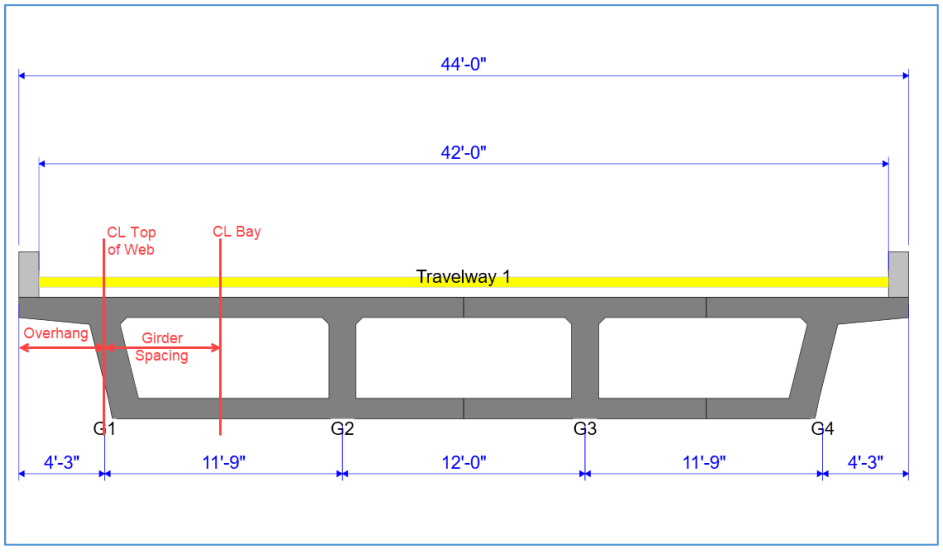


Framing Plan Detail

Open the **Structure Framing Plan Details** window shown below by double clicking on the **Framing Plan Details** node in the **BWS** tree.

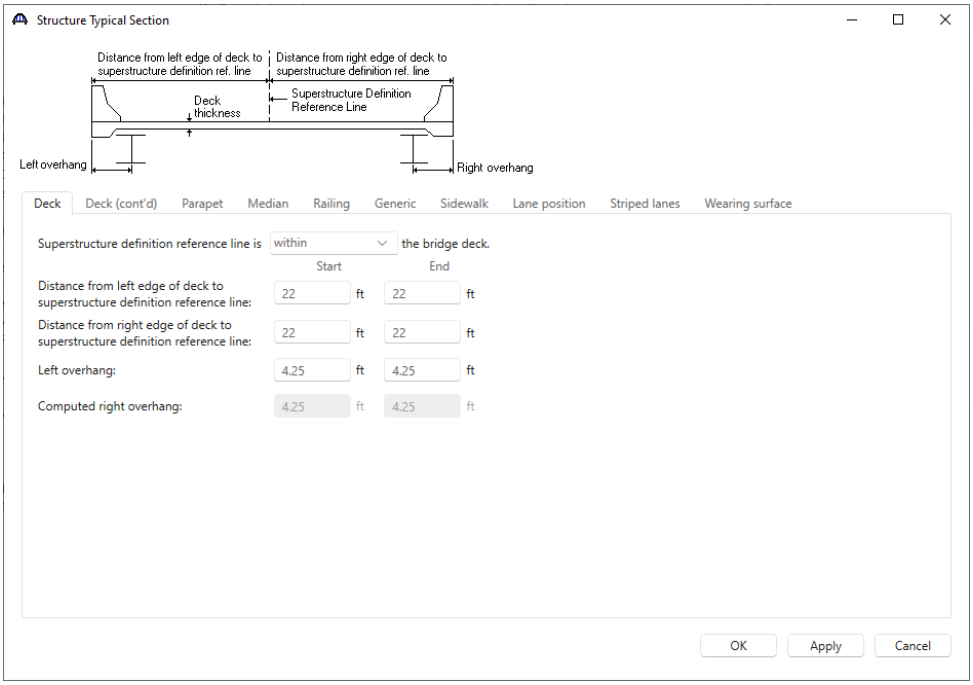


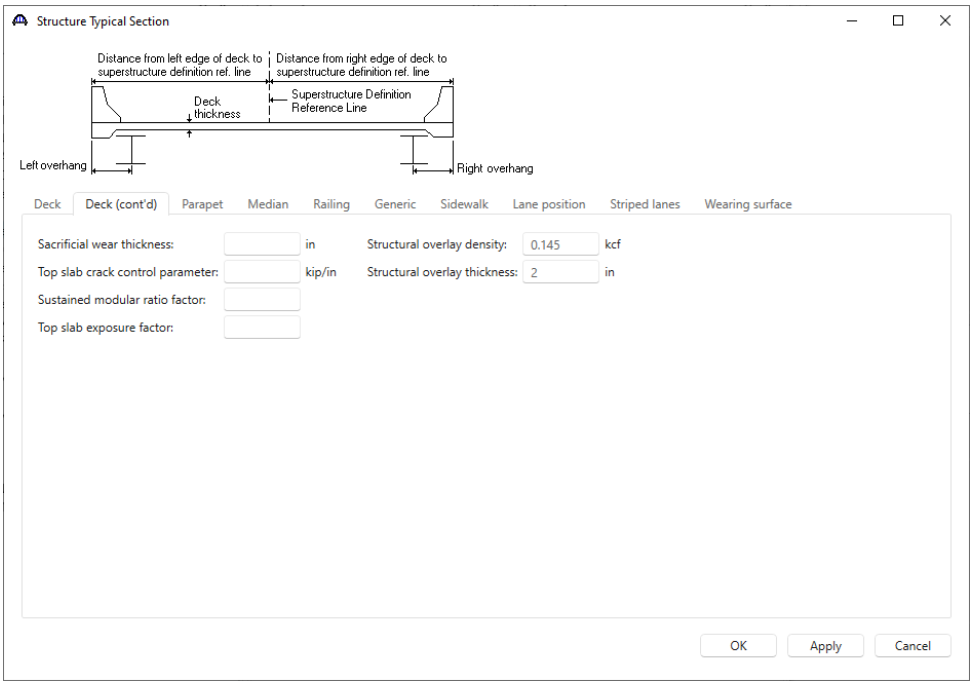
The following sketch documents the rules for entering the overhang and girder spacing for the exterior girder. The overhang is measured from the edge of deck to the centerline of the web top. The girder spacing is measured from the centerline of the web top to the centerline of the bay.



Structure Typical Section

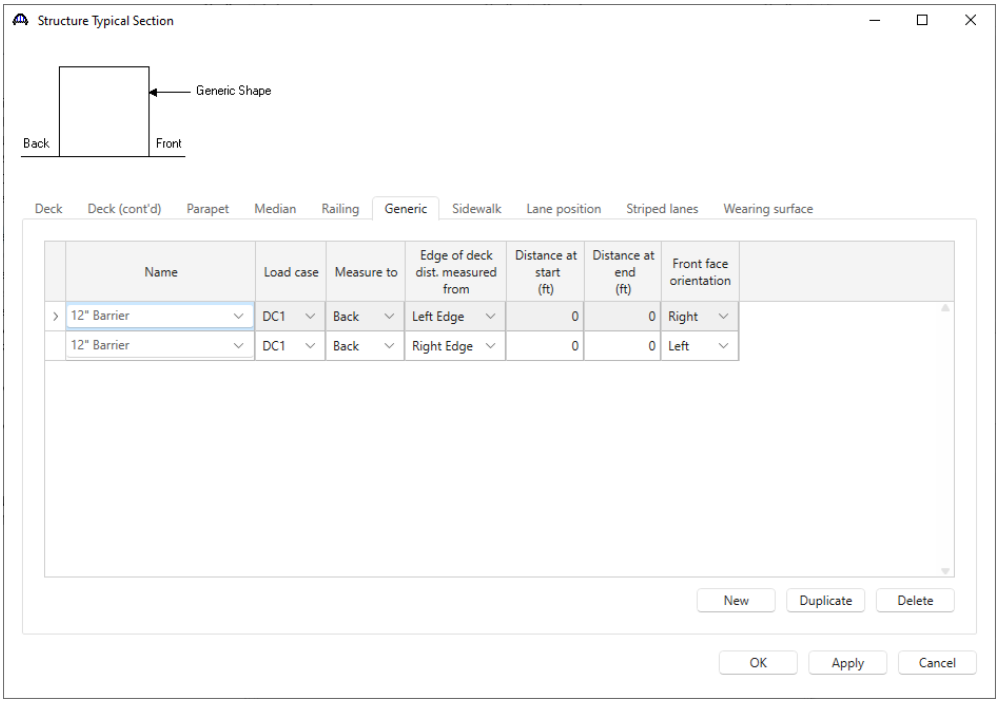
Open the **Structure Typical Section** window shown below and review the following tabs.

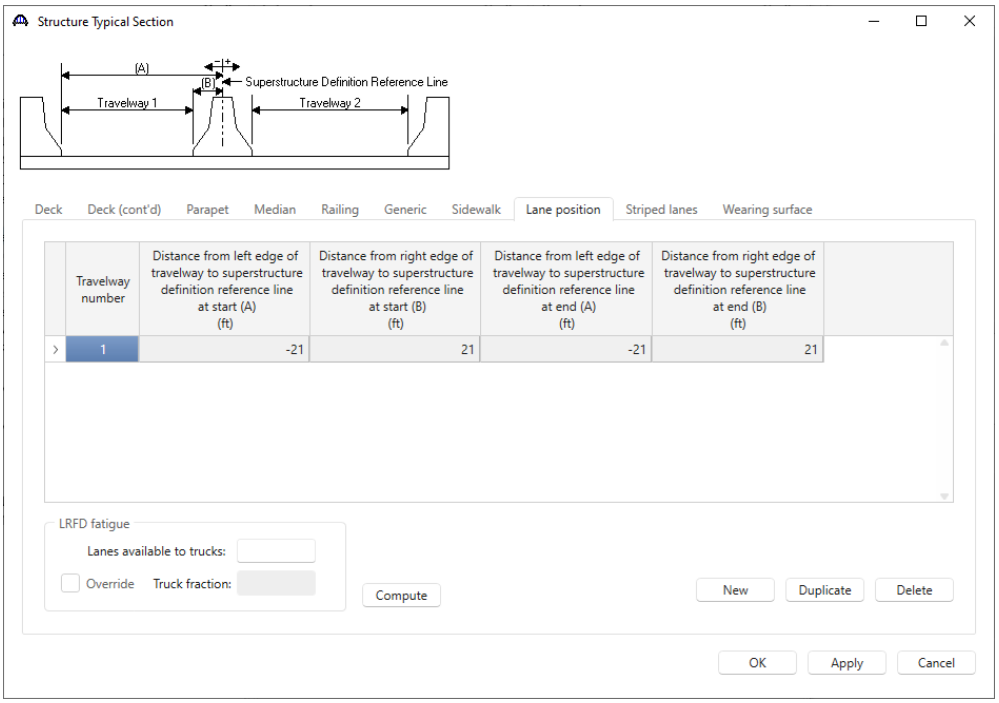




If entered, the depth of the girder is decreased by the **sacrificial wear thickness** in the section property and capacity calculations. The self-weight of the girder is not adjusted by this value.

The depth of the girder is increased by the structural overlay thickness in the section property and capacity calculations. The self-weight of the girder is increased by entering a structural overlay density and thickness.

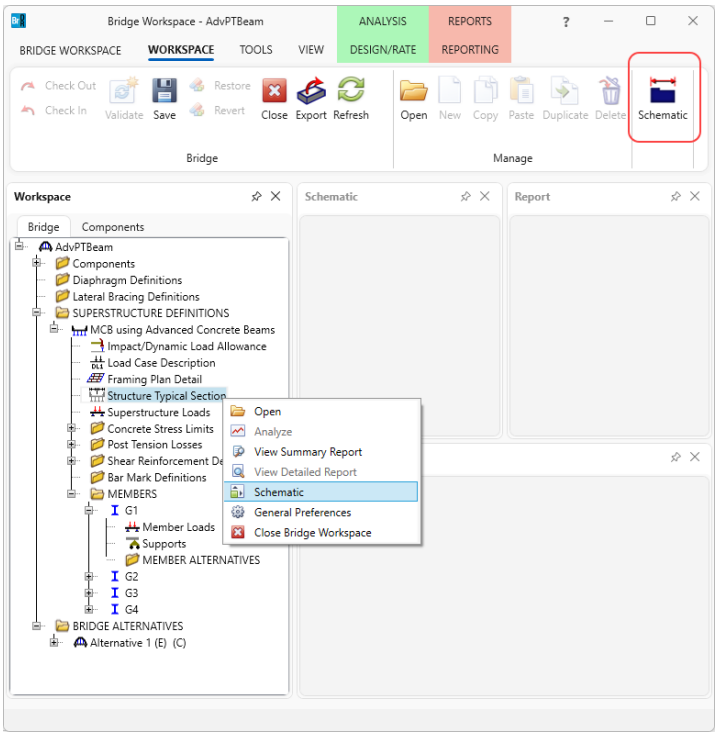


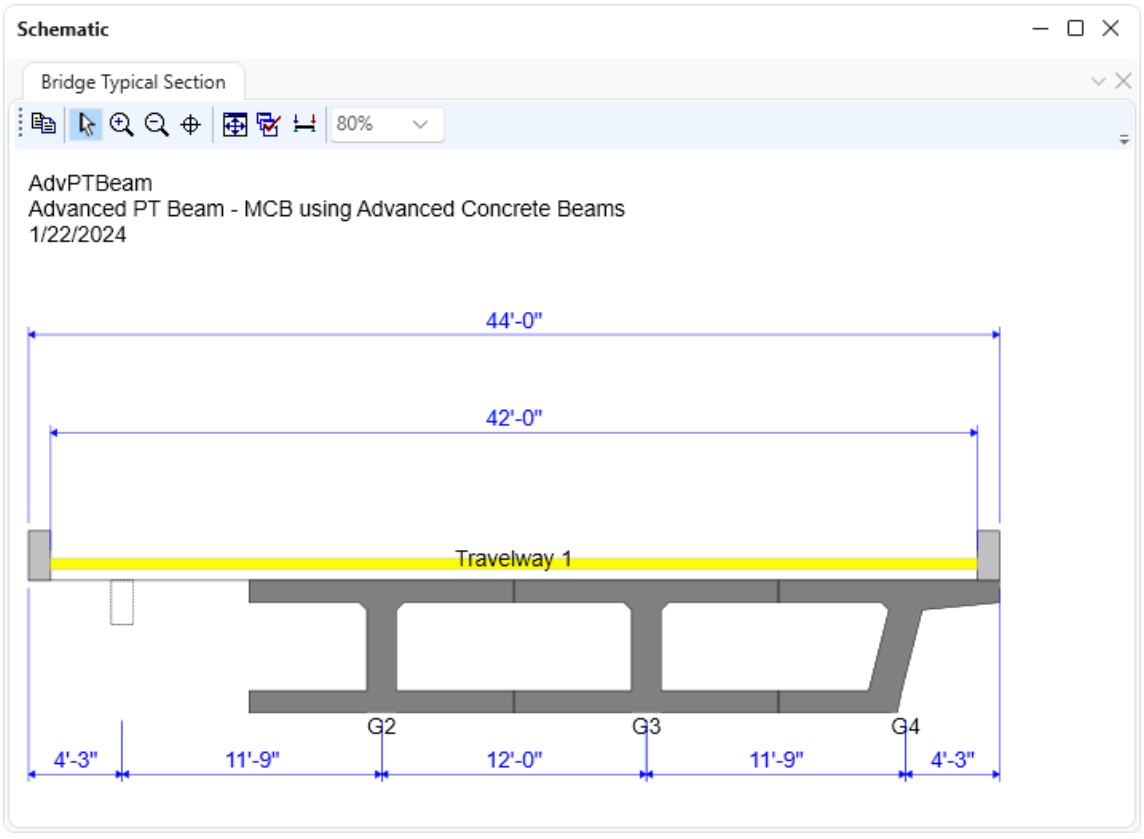


Click **Cancel** to close the window.

Schematic – Structure Typical Section

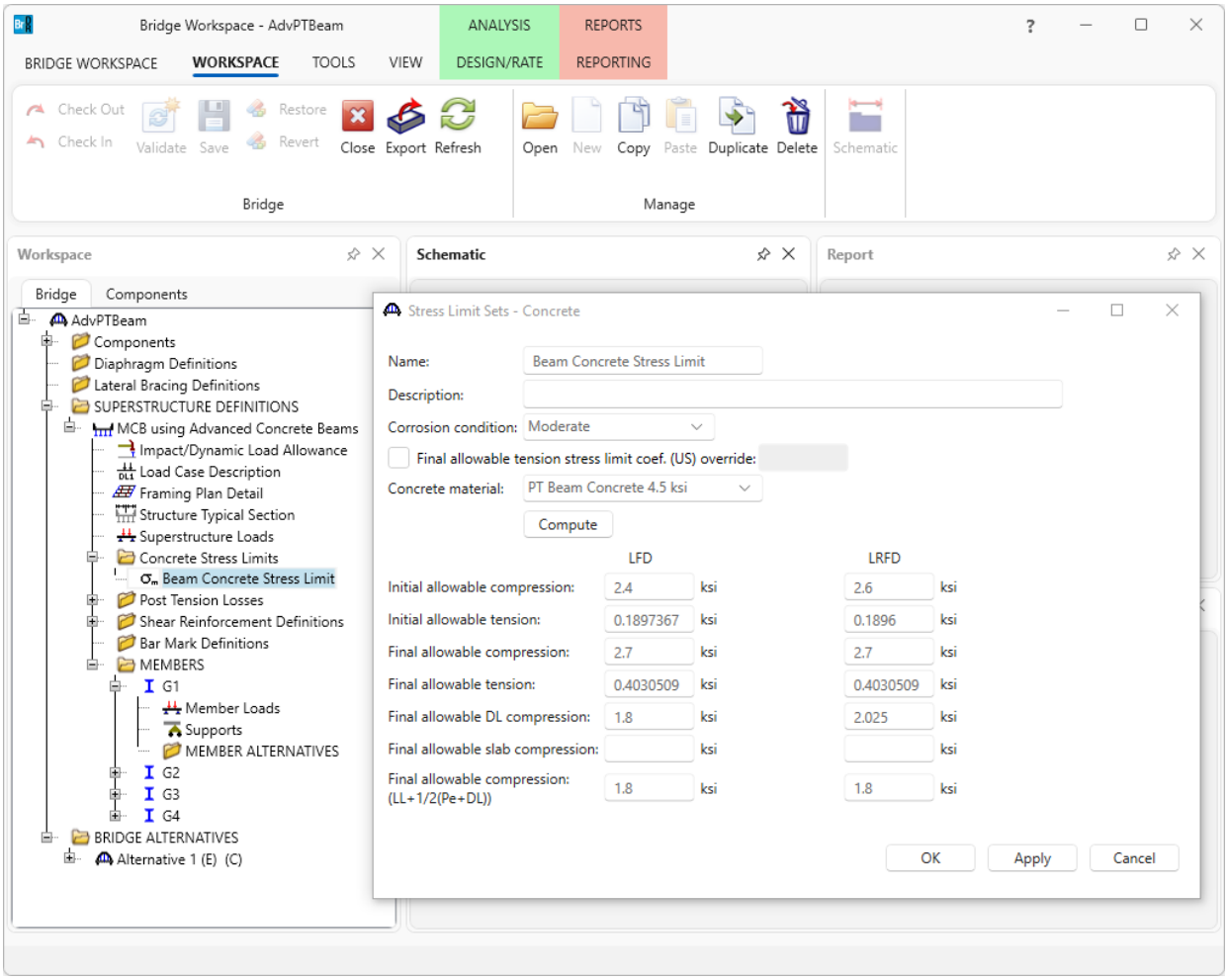
With **Structure Typical Section** selected in the **BWS** tree, click on the **Schematic** button from the **WORKSPACE** ribbon, or right click and select **Schematic** to view the section schematic as shown below.



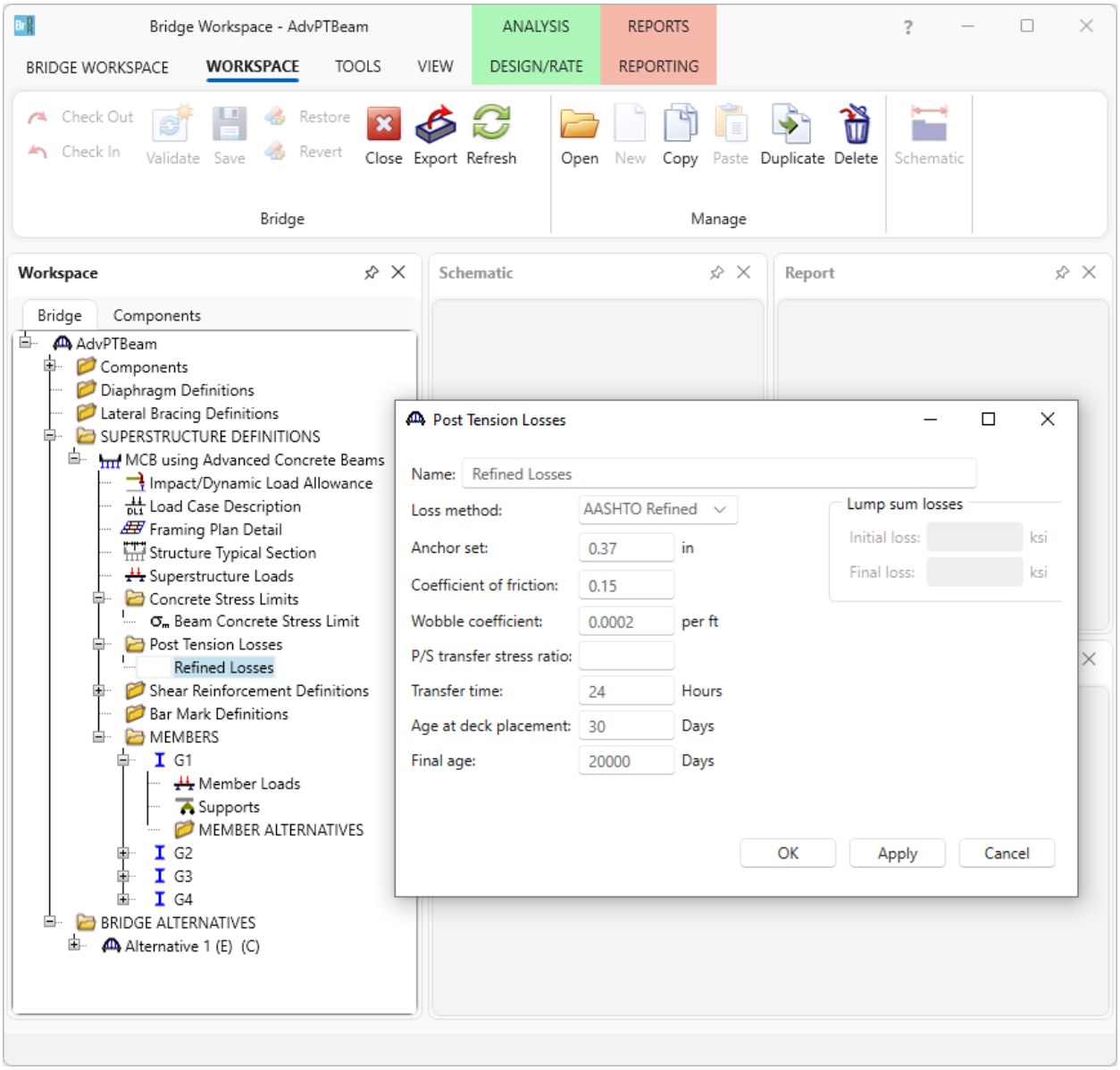


This superstructure definition contains post-tensioned regions, so the following post-tension data is present in this superstructure.

Concrete Stress Limits

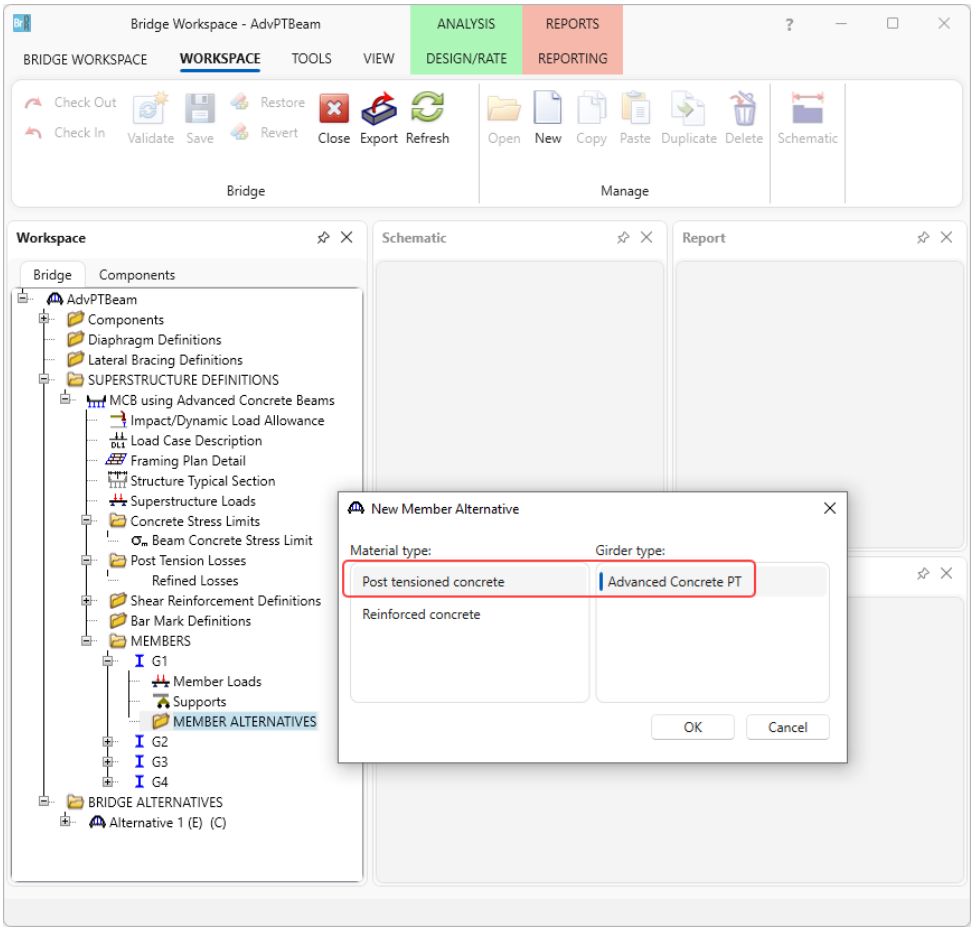


Post Tension Losses



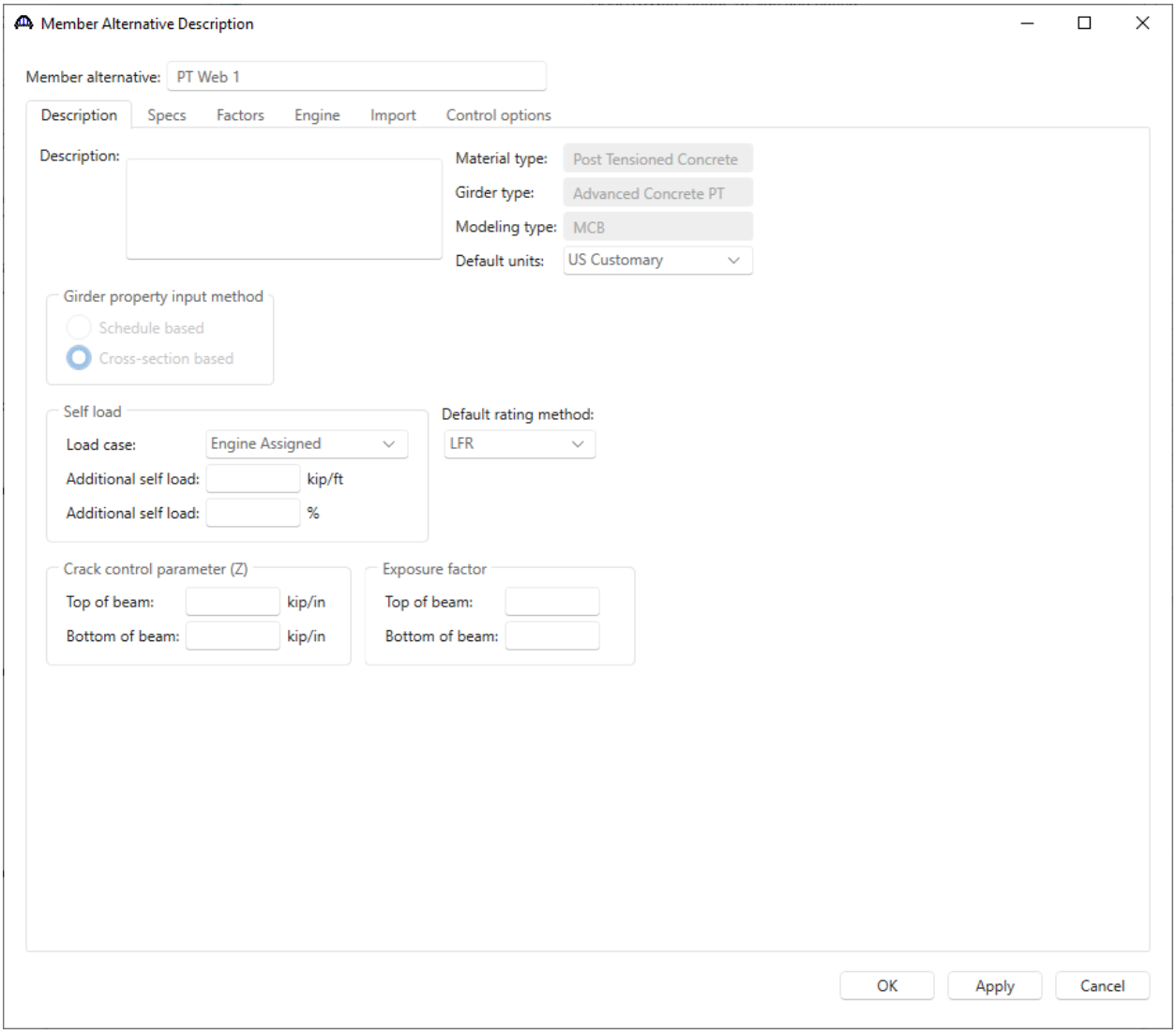
Member Alternative

Double click **MEMBER ALTERNATIVES** under member **G1** to open the **New Member Alternative** window.

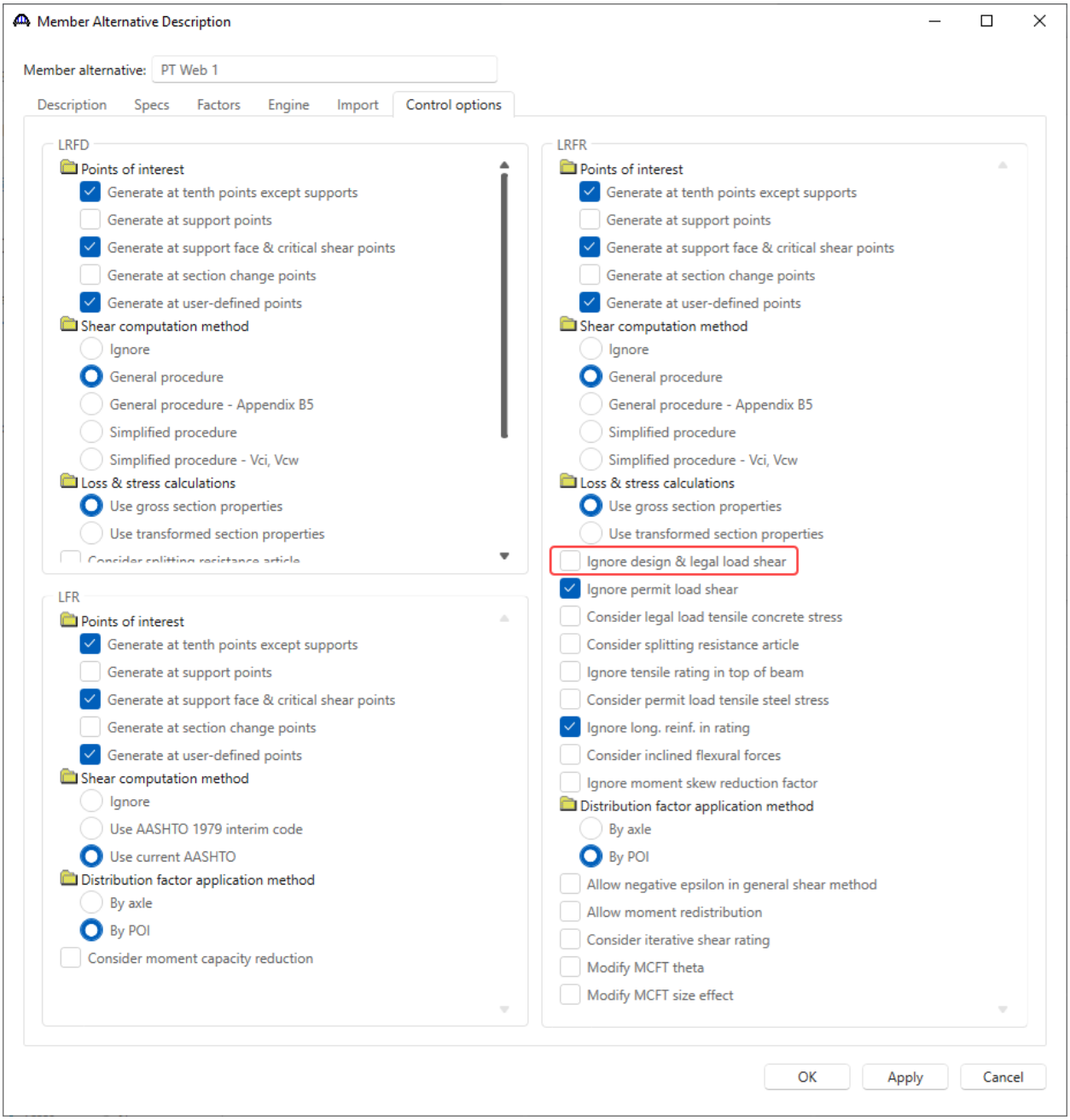


Since this superstructure definition's modeling type is MCB, only Advanced Concrete beams are available. Since this beam contains both post-tensioned and reinforced concrete regions, select **Post tensioned concrete** so the post-tensioning information will be available. Click **OK** and the **Member Alternative Description** window will open.

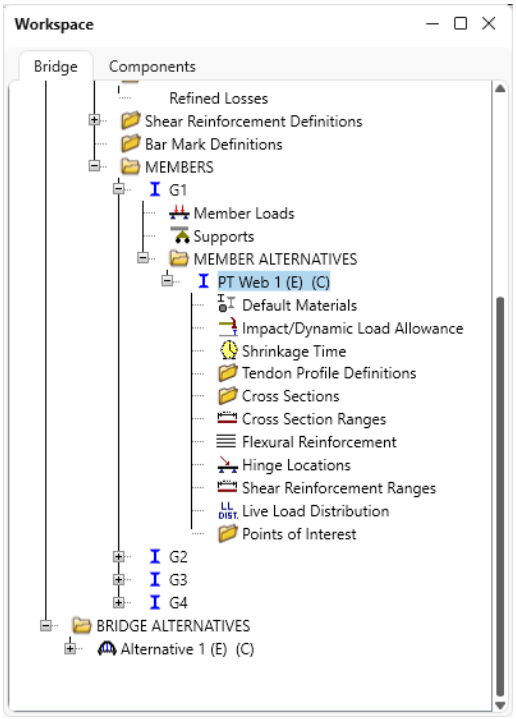
Enter a name for the member alternative.



Switch to the **Control Options** tab and uncheck the **Ignore design & legal load shear** checkbox. Click **OK** to close the window and create the member alternative.

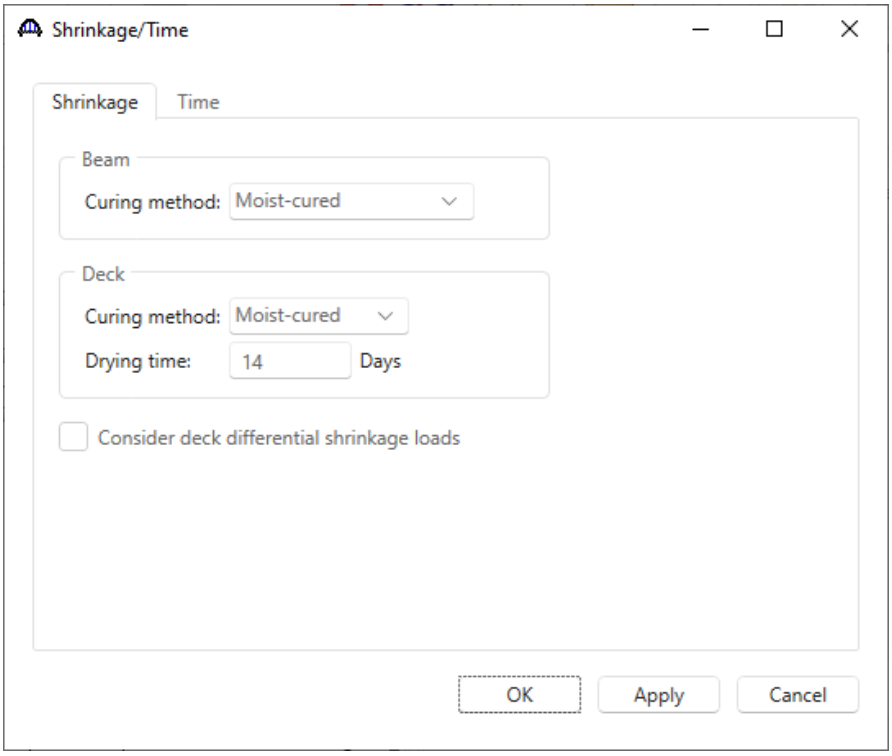


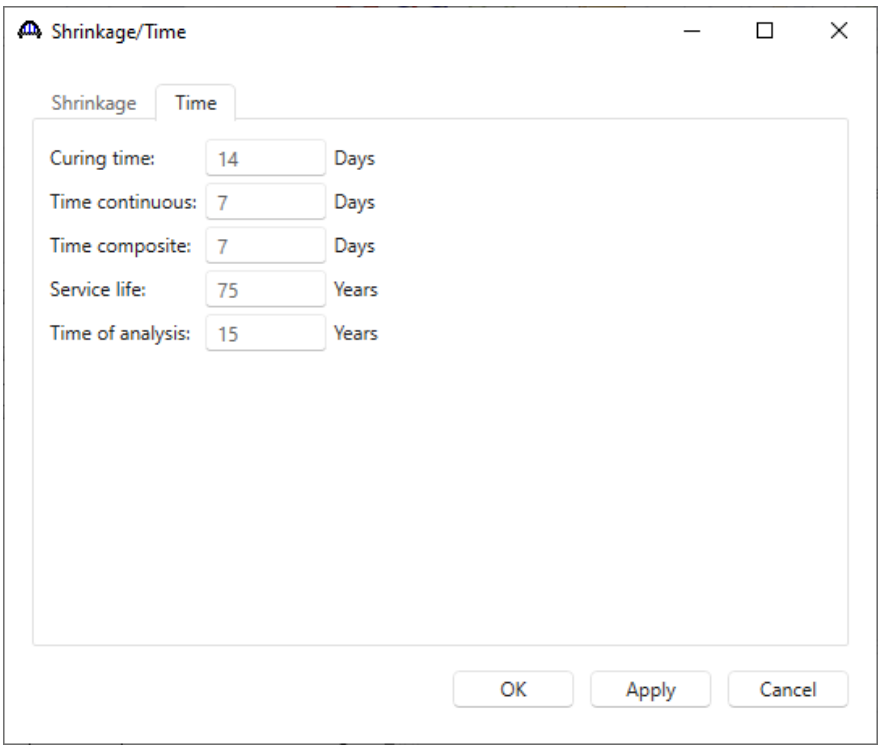
The partially expanded **BWS** is shown below. For a girder system modeled as an MCB, each girder has its own post-tensioning data.



Shrinkage/Time

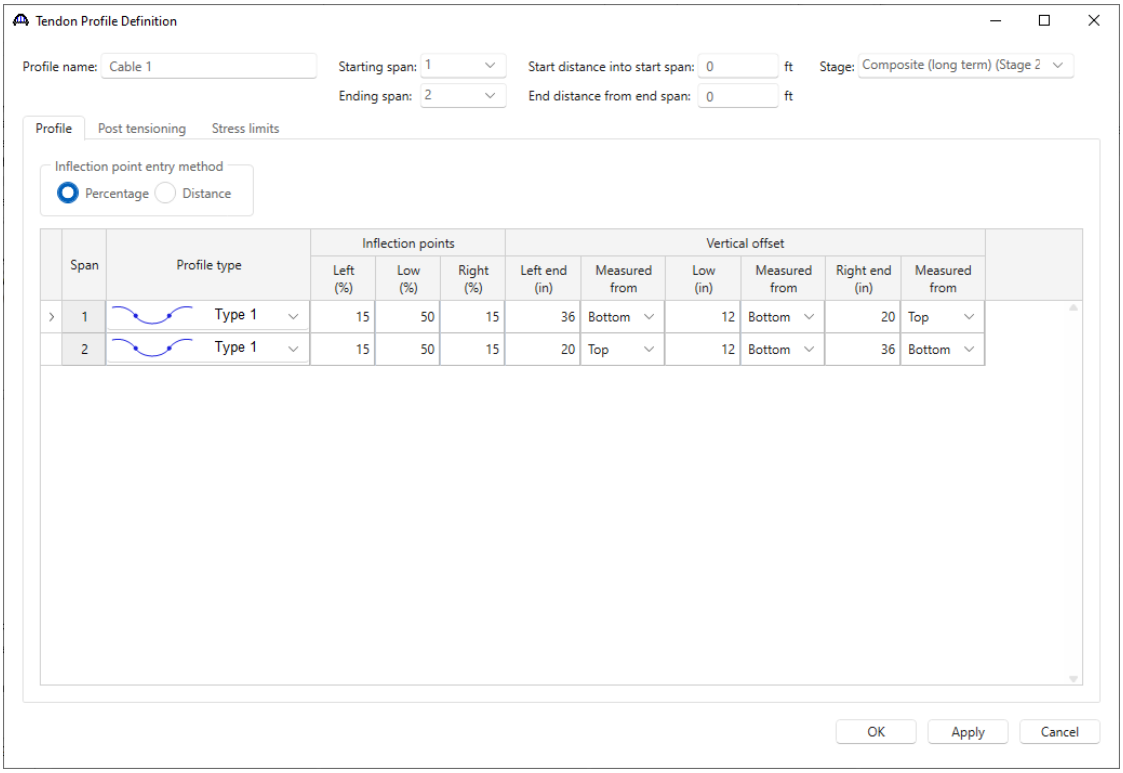
Open the **Shrinkage/Time** window and enter the following data in each tab then click **OK**.

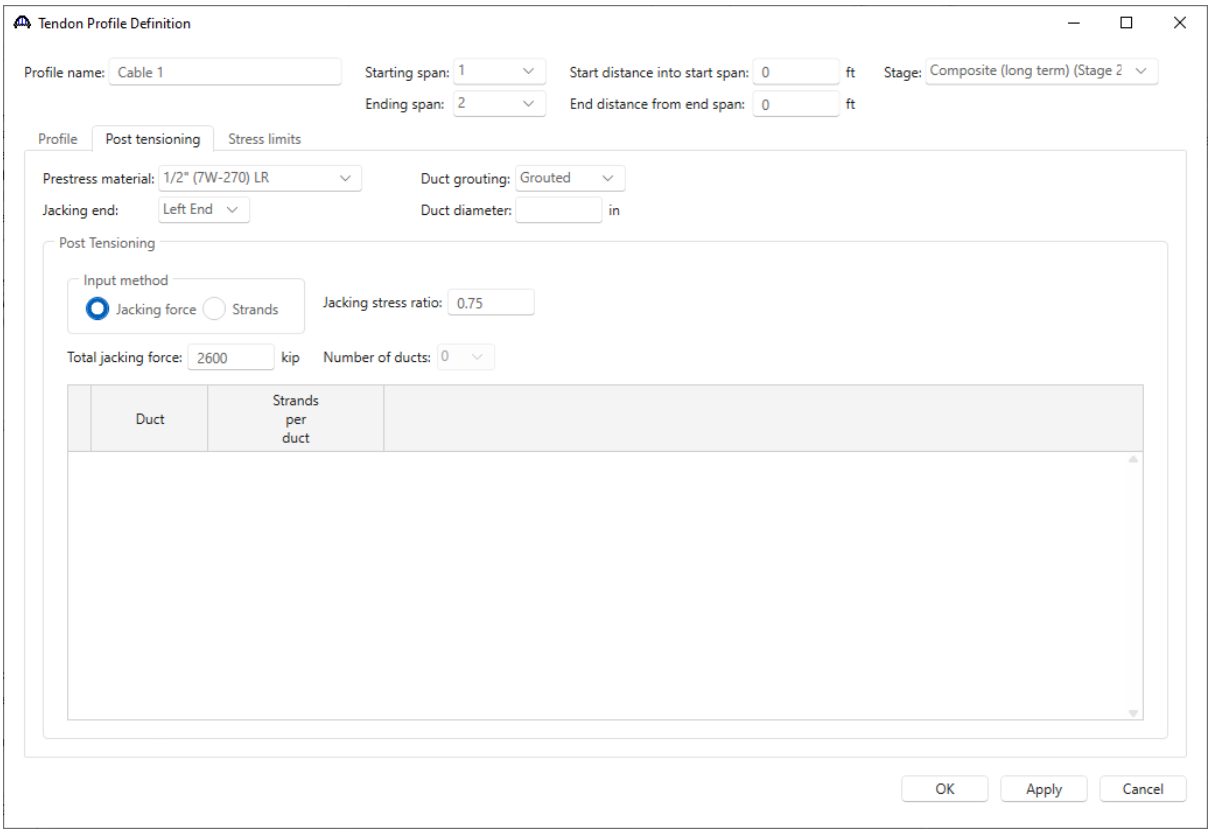


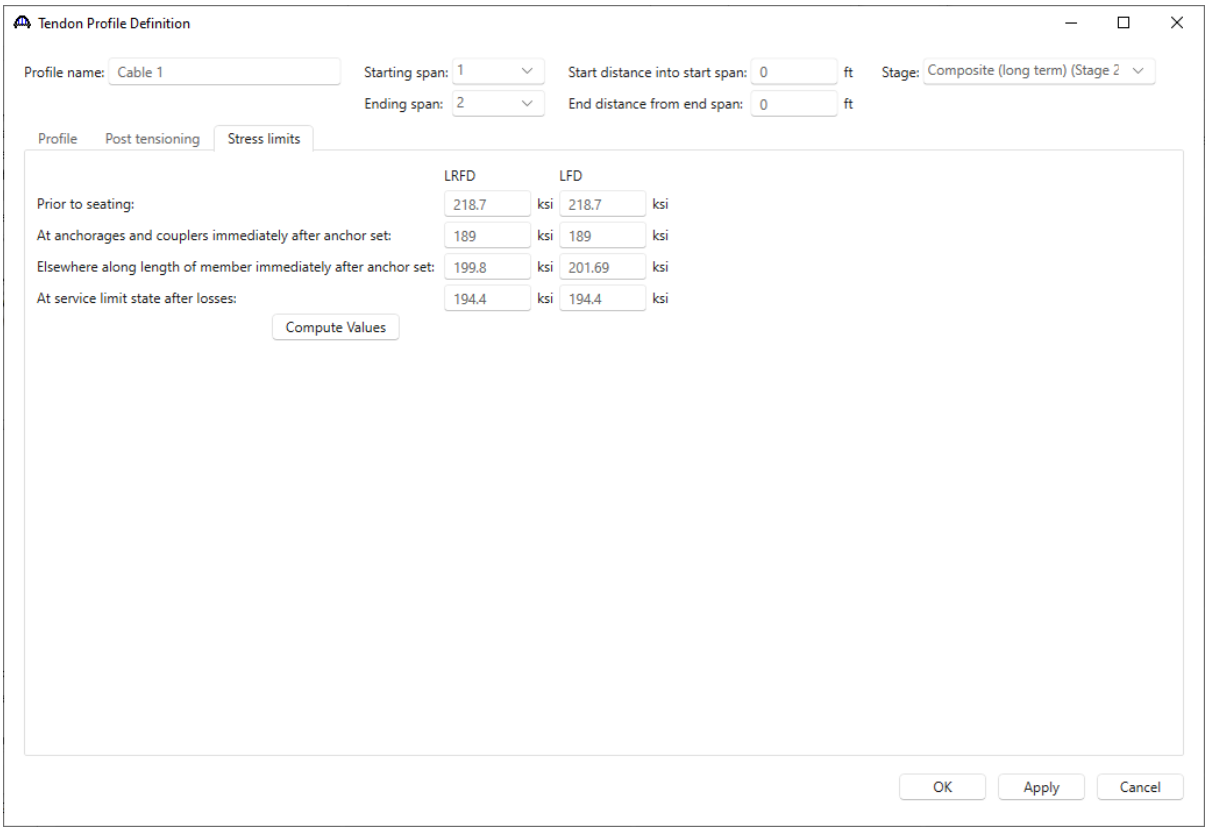


Tendon Profile Definition

Double click on **Tendon Profile Definitions** folder in the **BWS** tree and enter the following data in each tab of this window. The tendons in this example extend only over the first 2 spans. The third span is reinforced concrete.



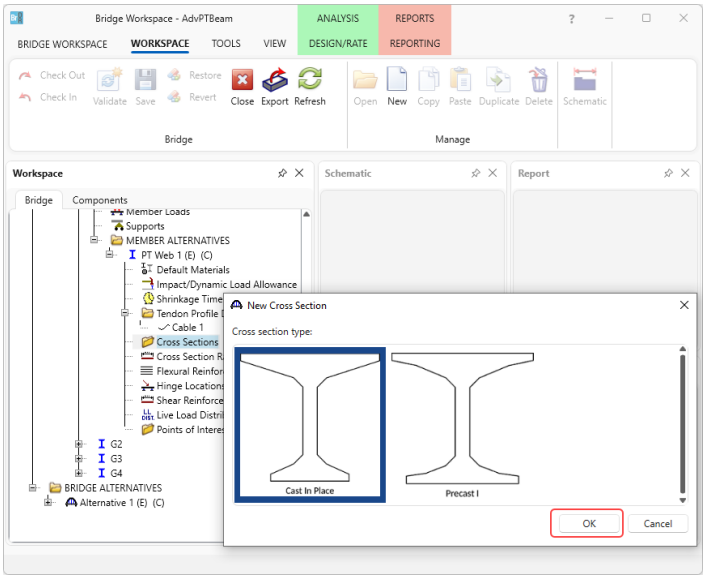




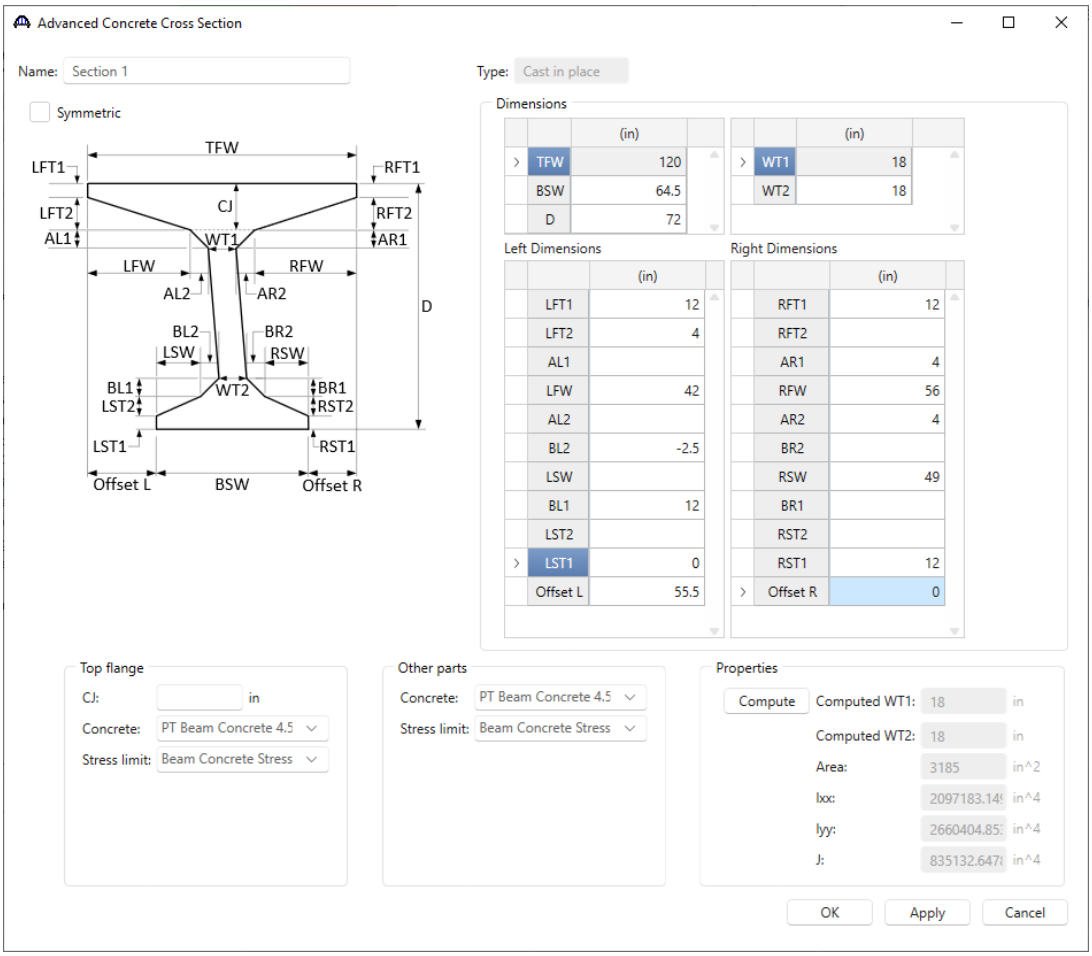
Click **OK** to apply the data and close the window.

Cross Sections

Double click on the **Cross Sections** folder in the **BWS** tree, select **Cast in Place** and click **OK**.



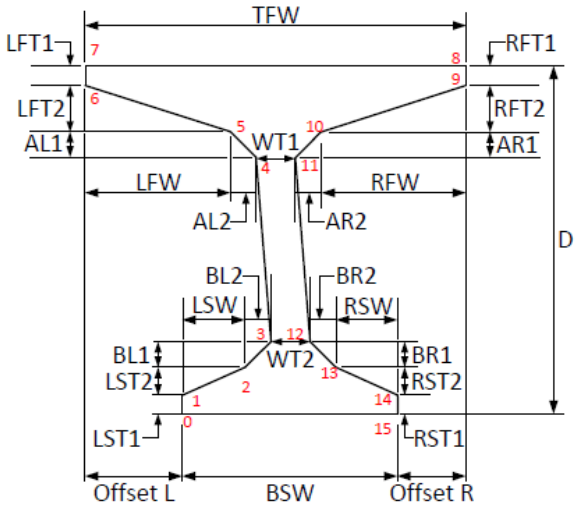
Enter the following data. Click the **Compute** button to validate the section dimensions and compute the section properties. Click **OK** to close the window.



The following rules are considered when creating the cross section from the entered dimensions:

WT1 and **WT2** are not used to locate any points in the cross section. They are used as validation to ensure the computed WT1 and WT2 match the entered values. The shear capacity calculations will use bw = (WT1 + WT2)/2.

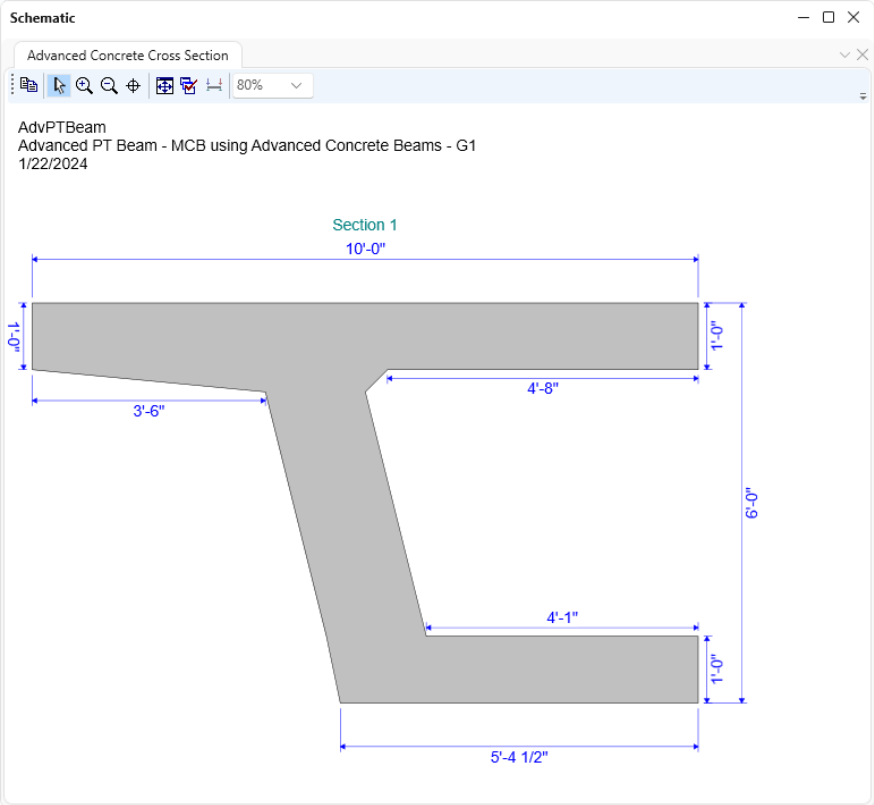
Cross section coordinates are located in the following manner:



Point	X, Y
0	OffsetL, 0
1	OffsetL, LST1
2	OffsetL + LSW, LST1 + LST2
3	OffsetL + LSW + BL2, LST1 + LST2 + BL1
4	LFW + AL2, D – LFT1 - LFT2 - AL1
5	LFW, D – LFT1 - LFT2
6	0, D – LFT1
7	0, D
8	TFW, D
9	TFW, D – RFT1
10	TFW - RFW, D – RFT1 - RFT2
11	TFW – RFW - AR2, D – RFT1 – RFT2 - AR1
12	TFW – OffsetR – RSW – BR2, RST1 + RST2 + BR1
13	TFW – OffsetR – RSW, RST1 + RST2
14	TFW – OffsetR, RST1
15	TFW – OffsetR, 0

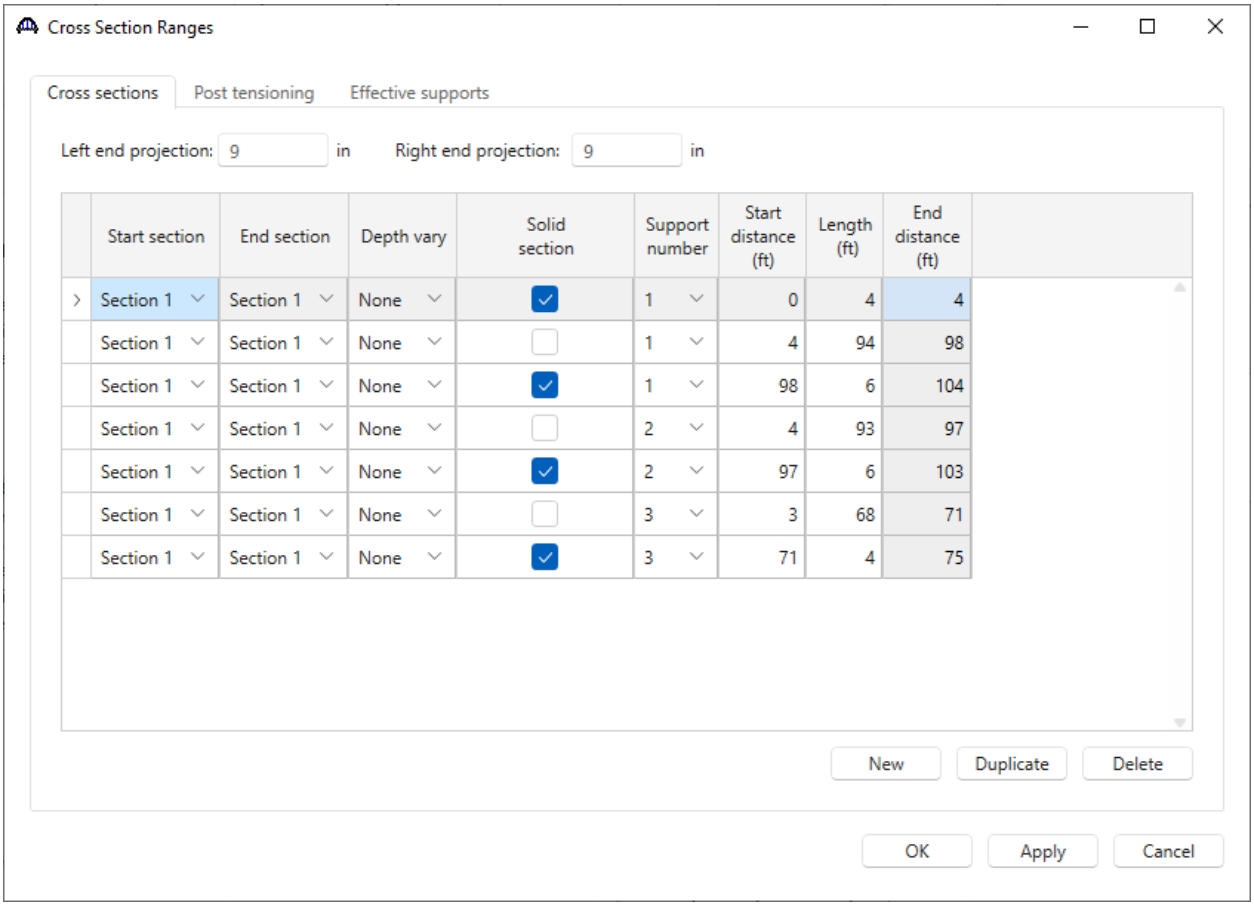
Schematic – Cross Section.

With the **Section 1** cross section selected in the **BWS** tree, click the **Schematic** button from the **WORKSPACE** ribbon. The cross section schematic is shown below:

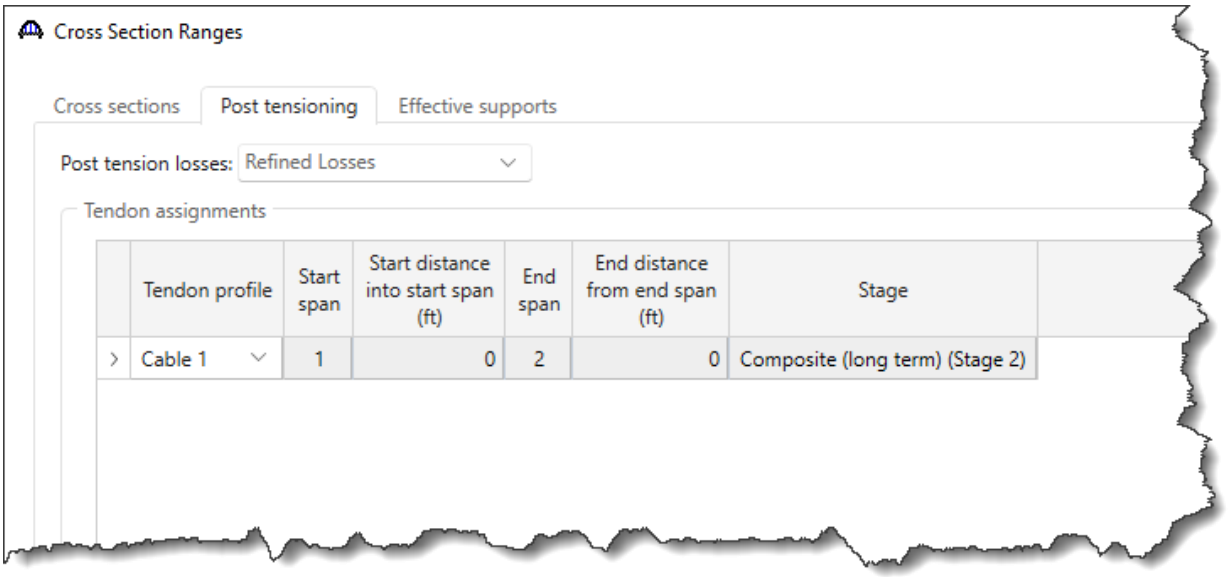


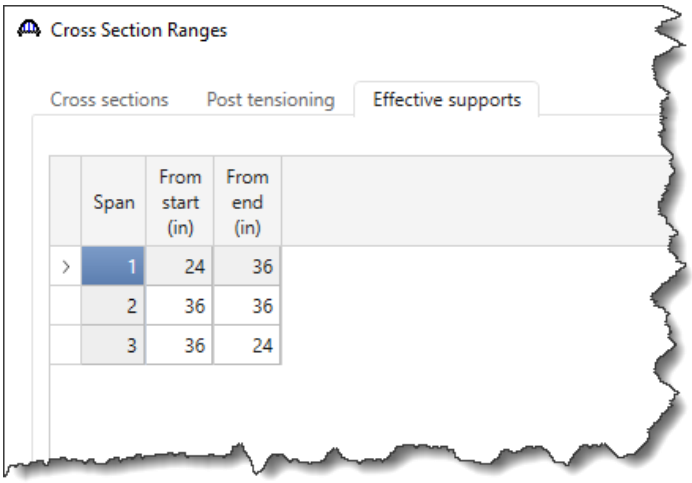
Cross Section Ranges

Open the **Cross Section Ranges** window and enter the following data:



This training example contains a single tendon, but advanced concrete PT beams can have multiple tendons and overlapping tendons.

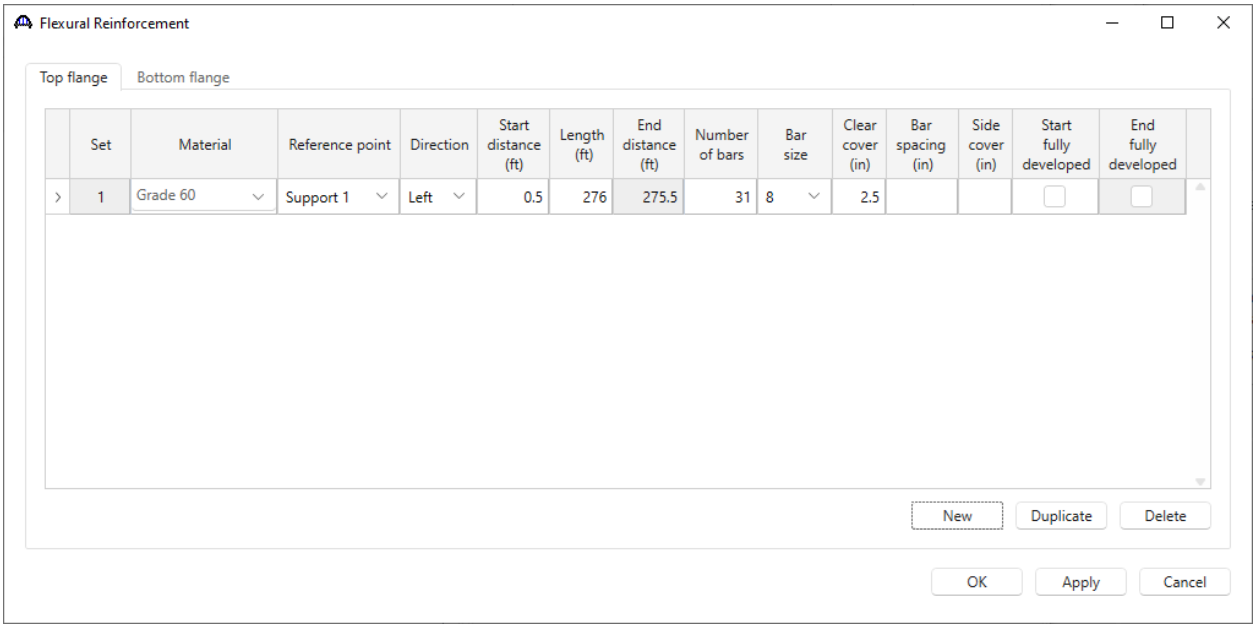


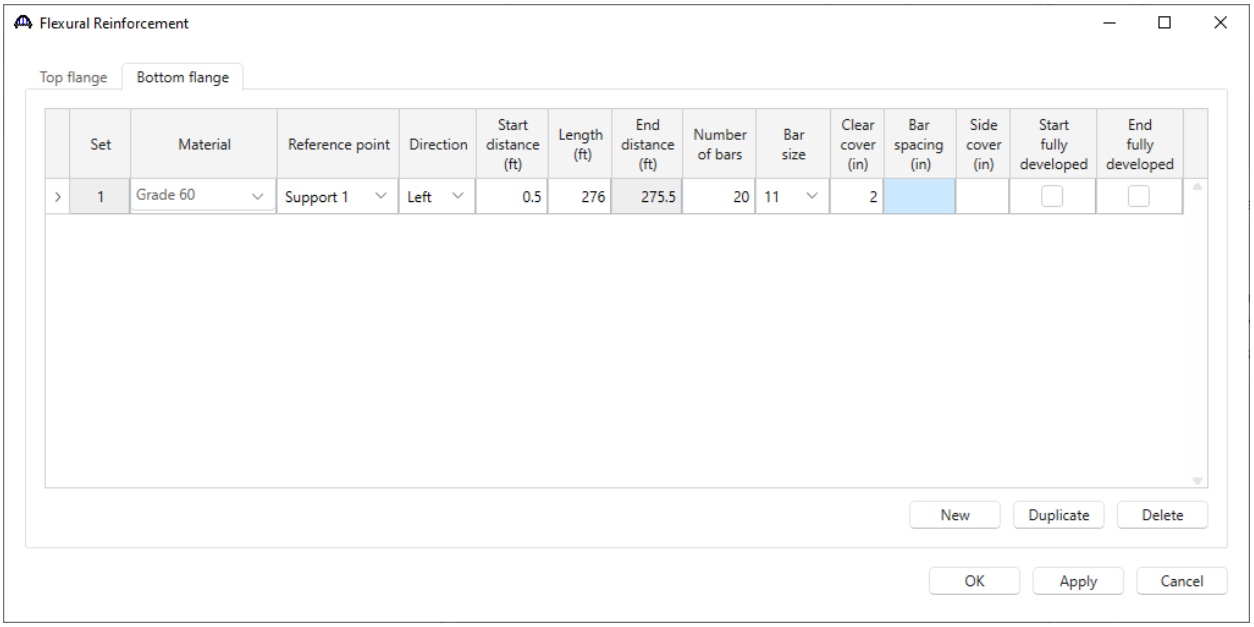


Click **OK** to apply the data and close the window.

Flexural Reinforcement

Enter the following flexural reinforcement in the flanges:

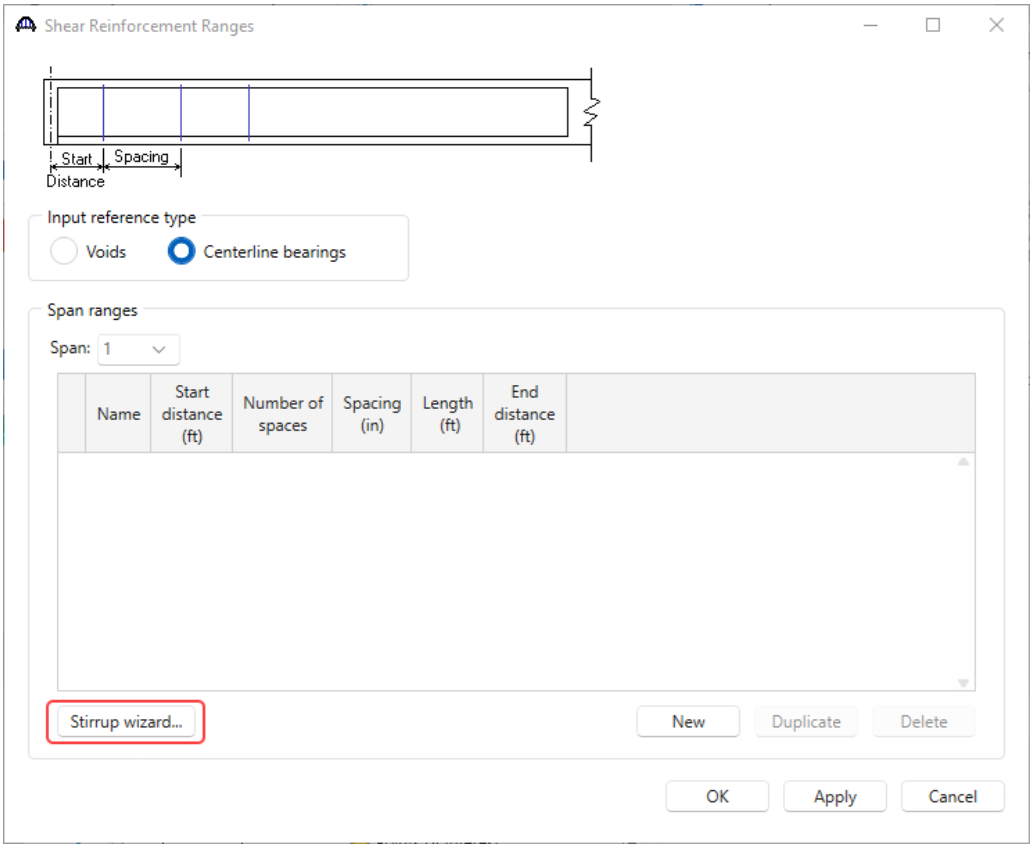




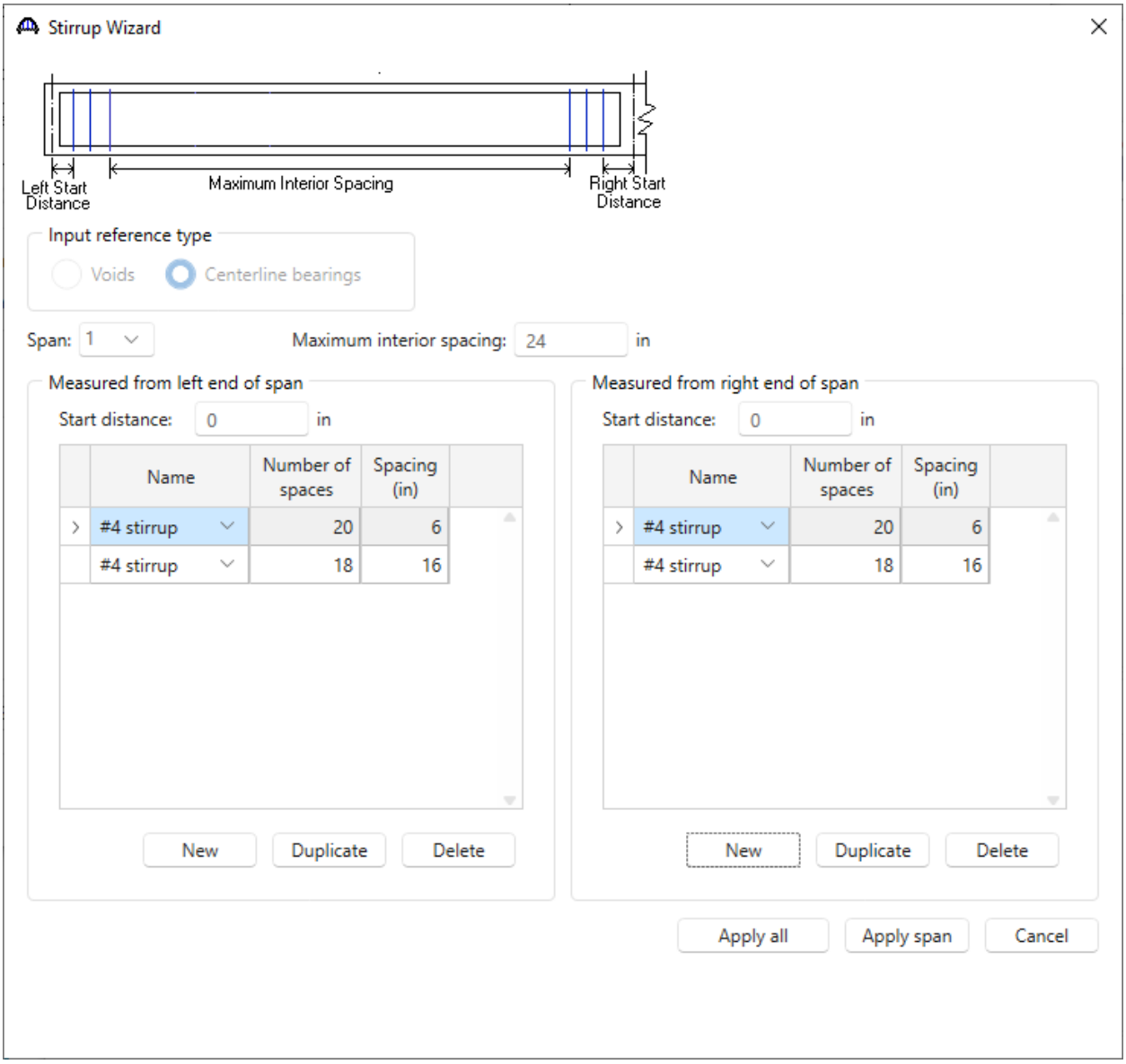
Click **OK** to apply the data and close the window.

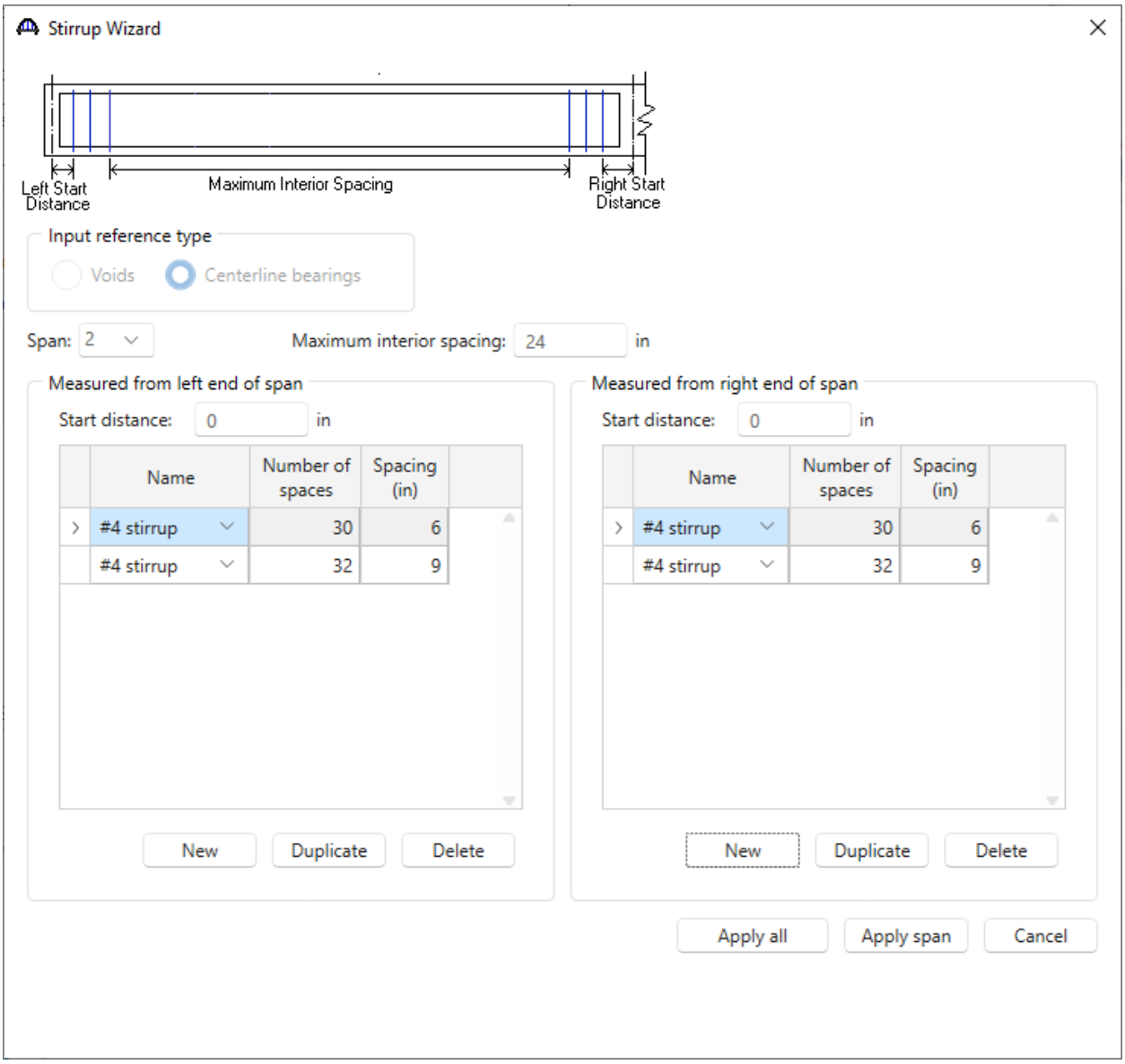
Shear Reinforcement Ranges

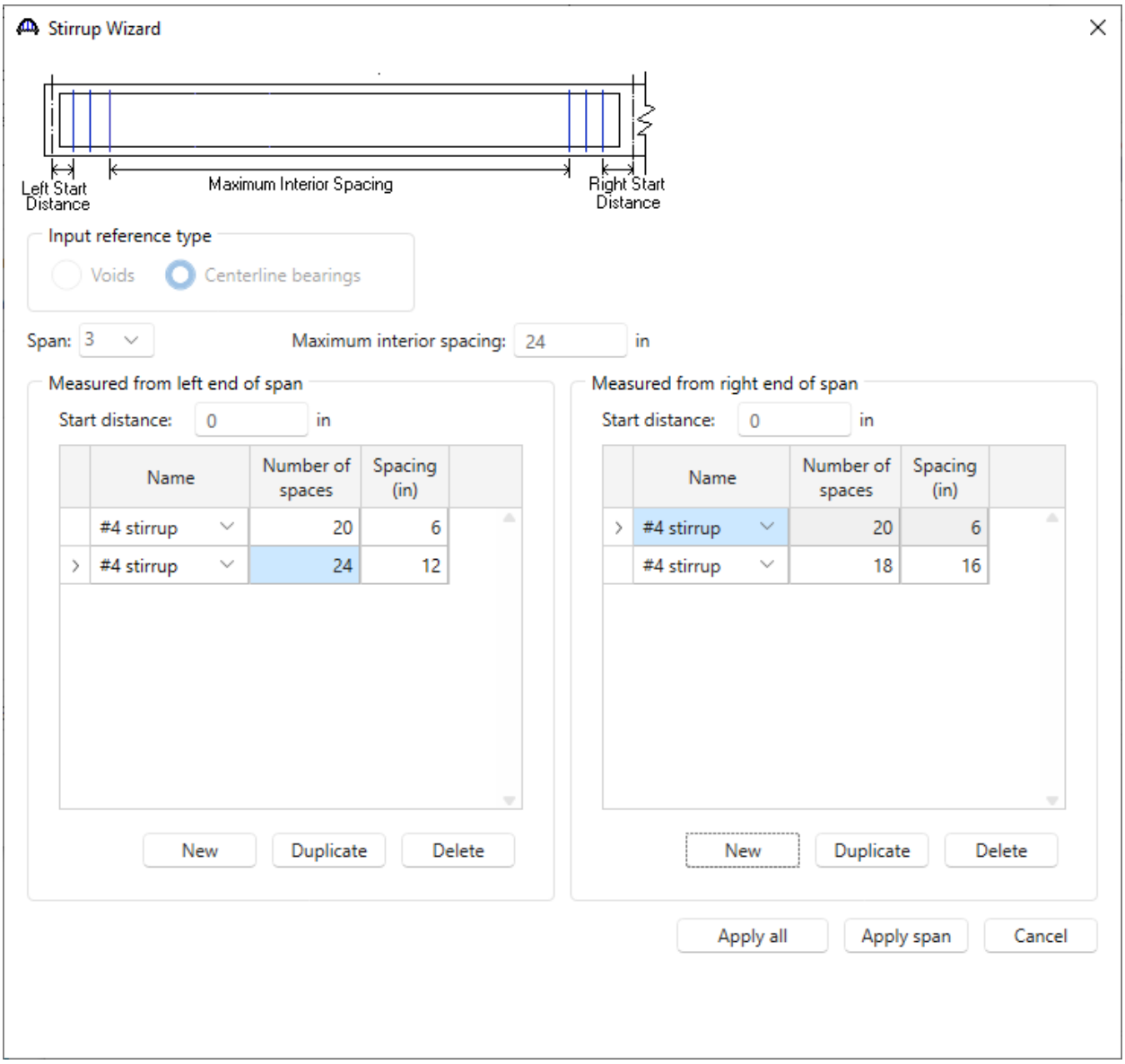
Open the **Shear Reinforcement Ranges** window. Be sure to select **Centerline bearings** as the input type and then click the **Stirrup Wizard** button.



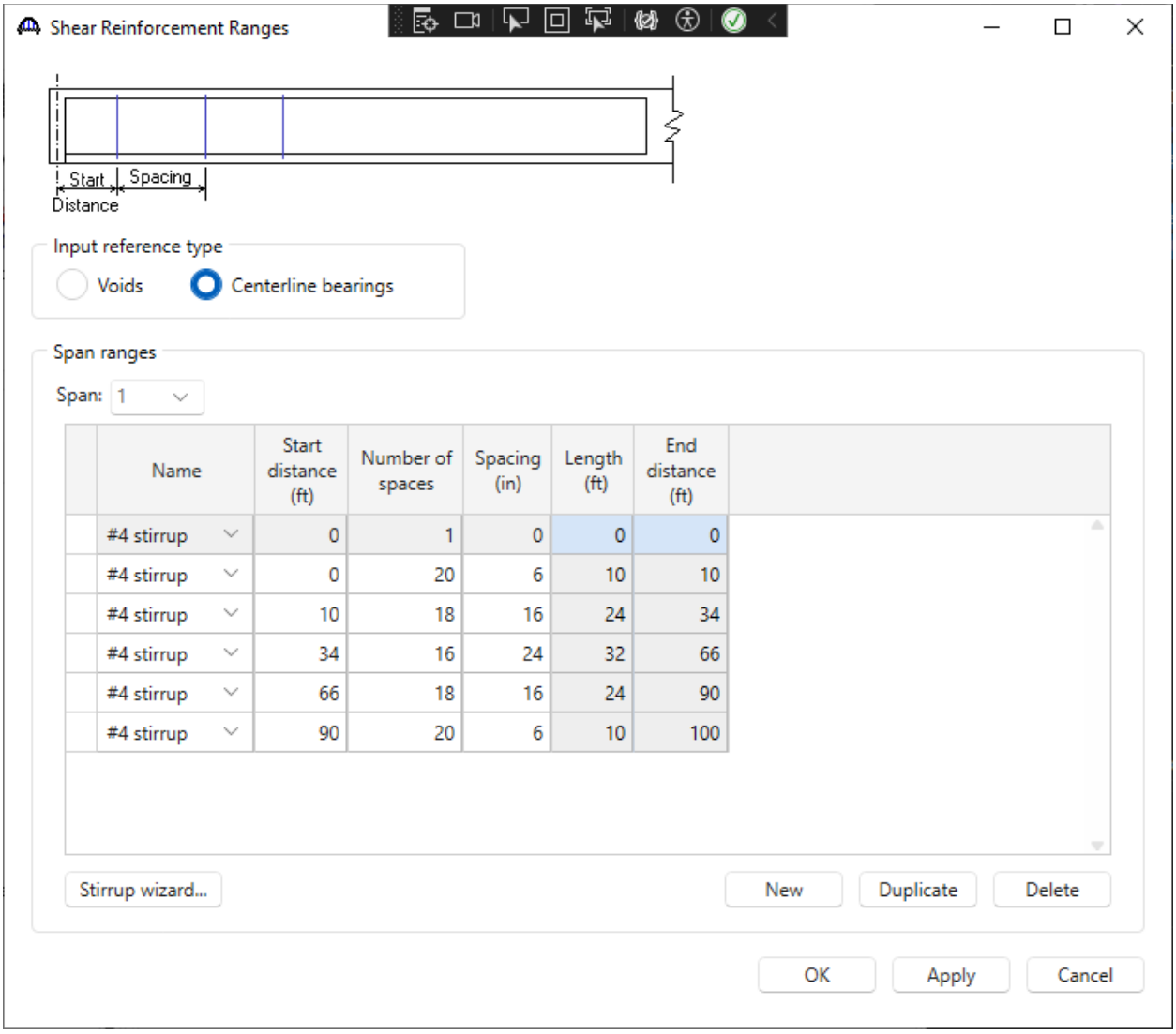
Enter the following data in the **Stirrup Wizard** for each span and then click **Apply All**.

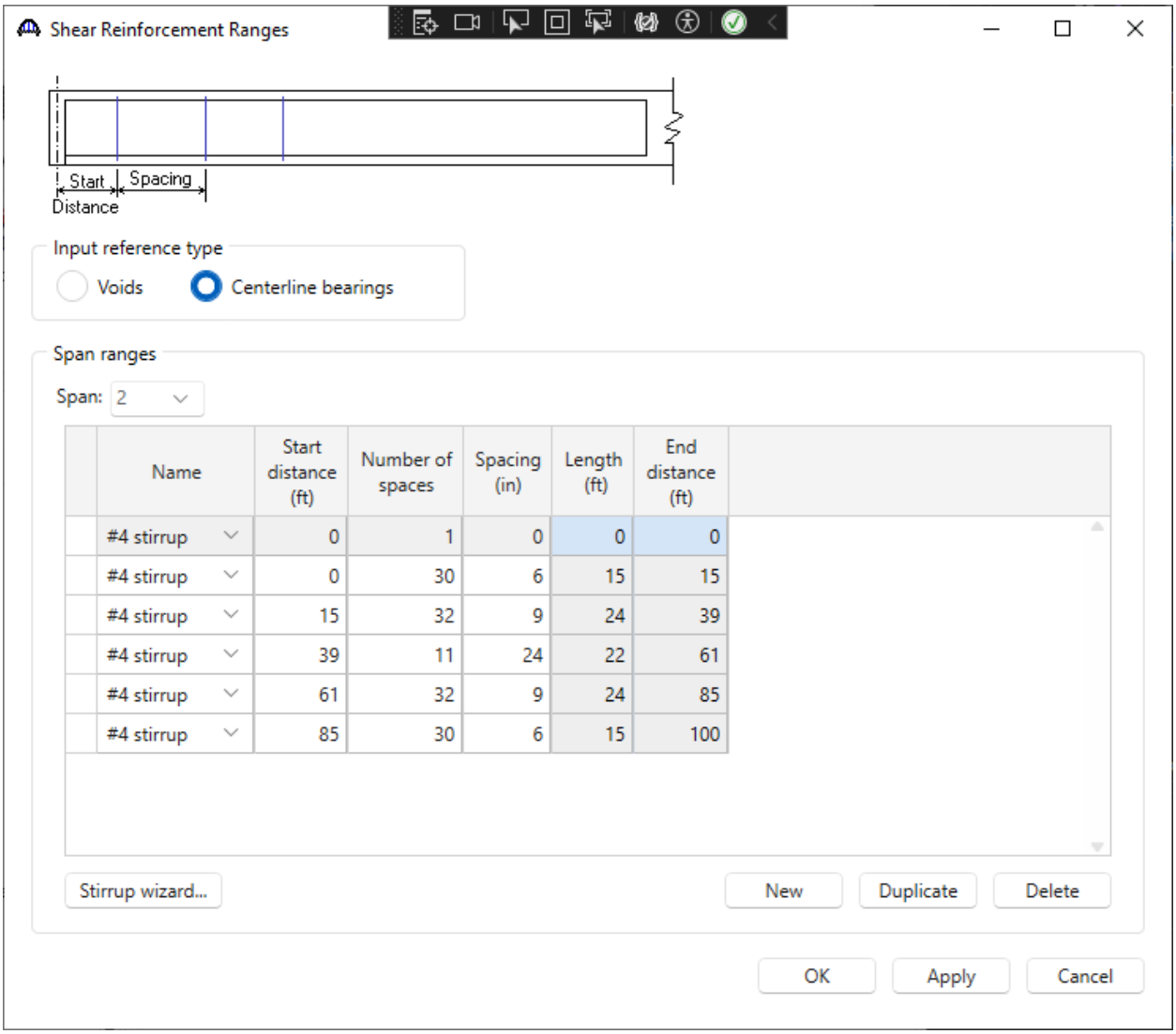


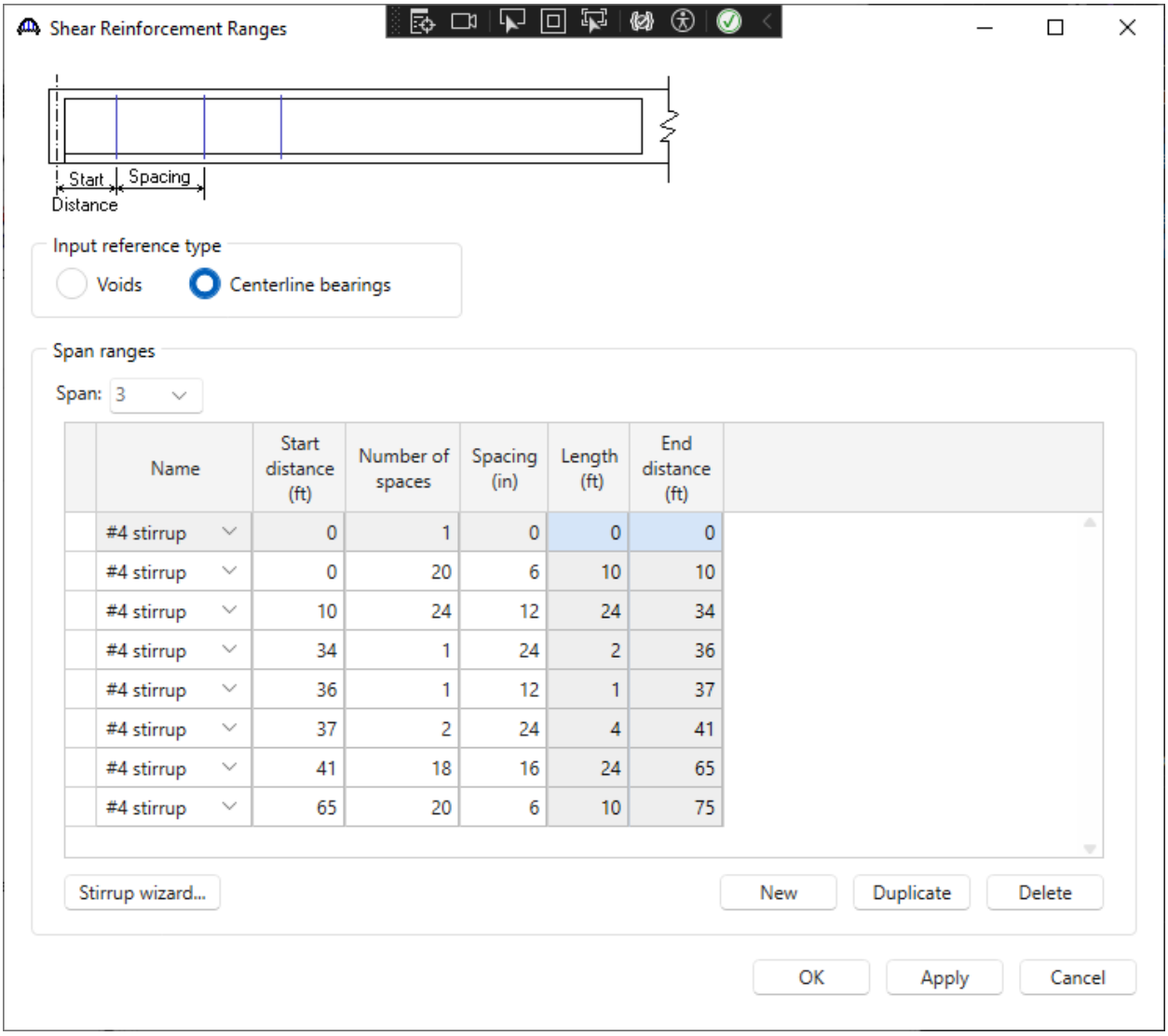

Stirrup Wizard
Left Start Distance
Maximum Interior Spacing
Right Start Distance
Input reference type
Voids
Centerline bearings
Span: 2
Maximum interior spacing: 24 in
Measured from left end of span
Start distance: 0 in
Name
Number of spaces
Spacing (in)
#4 stirrup 30 6
#4 stirrup 32 9
New
Duplicate
Delete
Measured from right end of span
Start distance: 0 in
Name
Number of spaces
Spacing (in)
#4 stirrup 30 6
#4 stirrup 32 9
New
Duplicate
Delete
Apply all
Apply span
Cancel


Stirrup Wizard
Left Start Distance
Maximum Interior Spacing
Right Start Distance
Input reference type
Voids
Centerline bearings
Span: 3
Maximum interior spacing: 24 in
Measured from left end of span
Start distance: 0 in
Name
Number of spaces
Spacing (in)
#4 stirrup 20 6
#4 stirrup 24 12
New
Duplicate
Delete
Measured from right end of span
Start distance: 0 in
Name
Number of spaces
Spacing (in)
#4 stirrup 20 6
#4 stirrup 18 16
New
Duplicate
Delete
Apply all
Apply span
Cancel

The **Shear Reinforcement Ranges** window is updated as shown below.



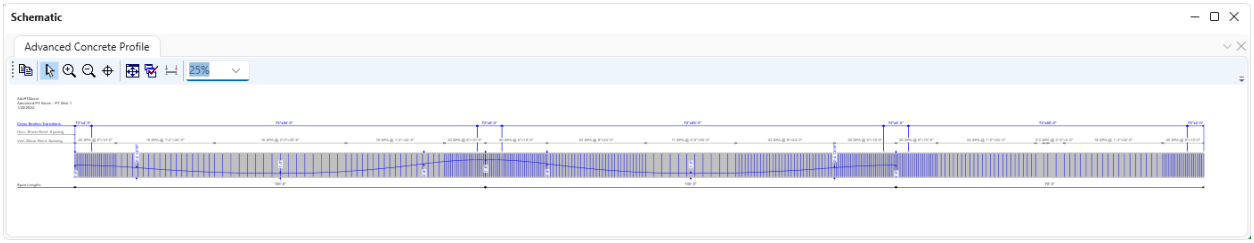

Shear Reinforcement Ranges
Start
Spacing
Distance
Input reference type
Voids
Centerline bearings
Span ranges
Span: 2
Name
Start distance (ft)
Number of spaces
Spacing (in)
Length (ft)
End distance (ft)
#4 stirrup 0 1 0 0 0
#4 stirrup 0 30 6 15 15
#4 stirrup 15 32 9 24 39
#4 stirrup 39 11 24 22 61
#4 stirrup 61 32 9 24 85
#4 stirrup 85 30 6 15 100
Stirrup wizard...
New
Duplicate
Delete
OK
Apply
Cancel



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

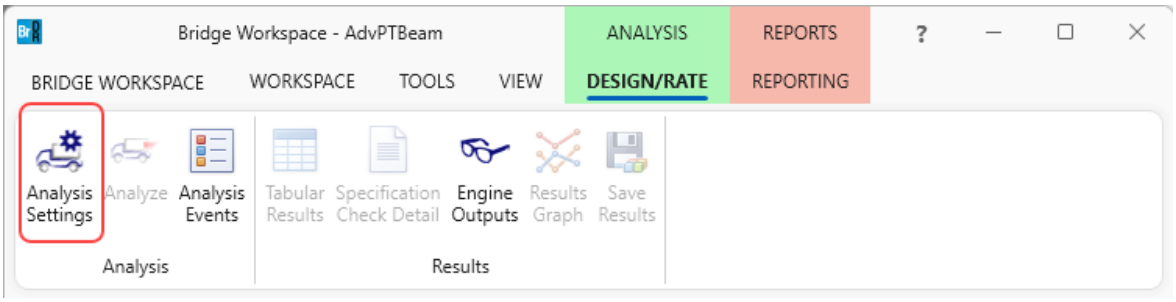
Schematic – Member Alternative

Select **PT Web 1** in the **BWS** tree and click the **Schematic** button on the ribbon to display the girder profile schematic.

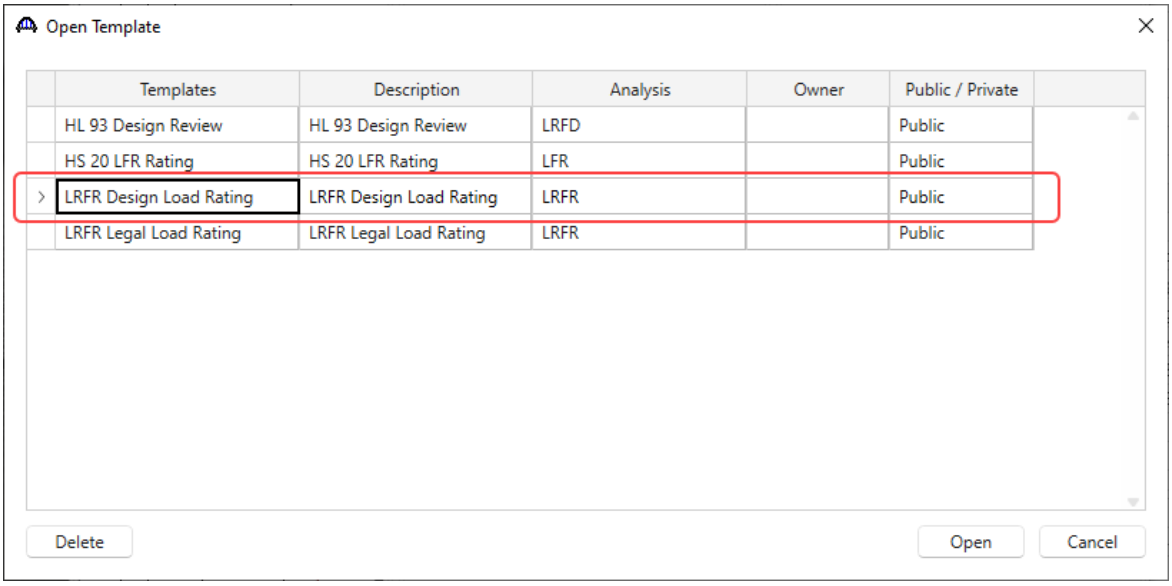


LRFR Analysis

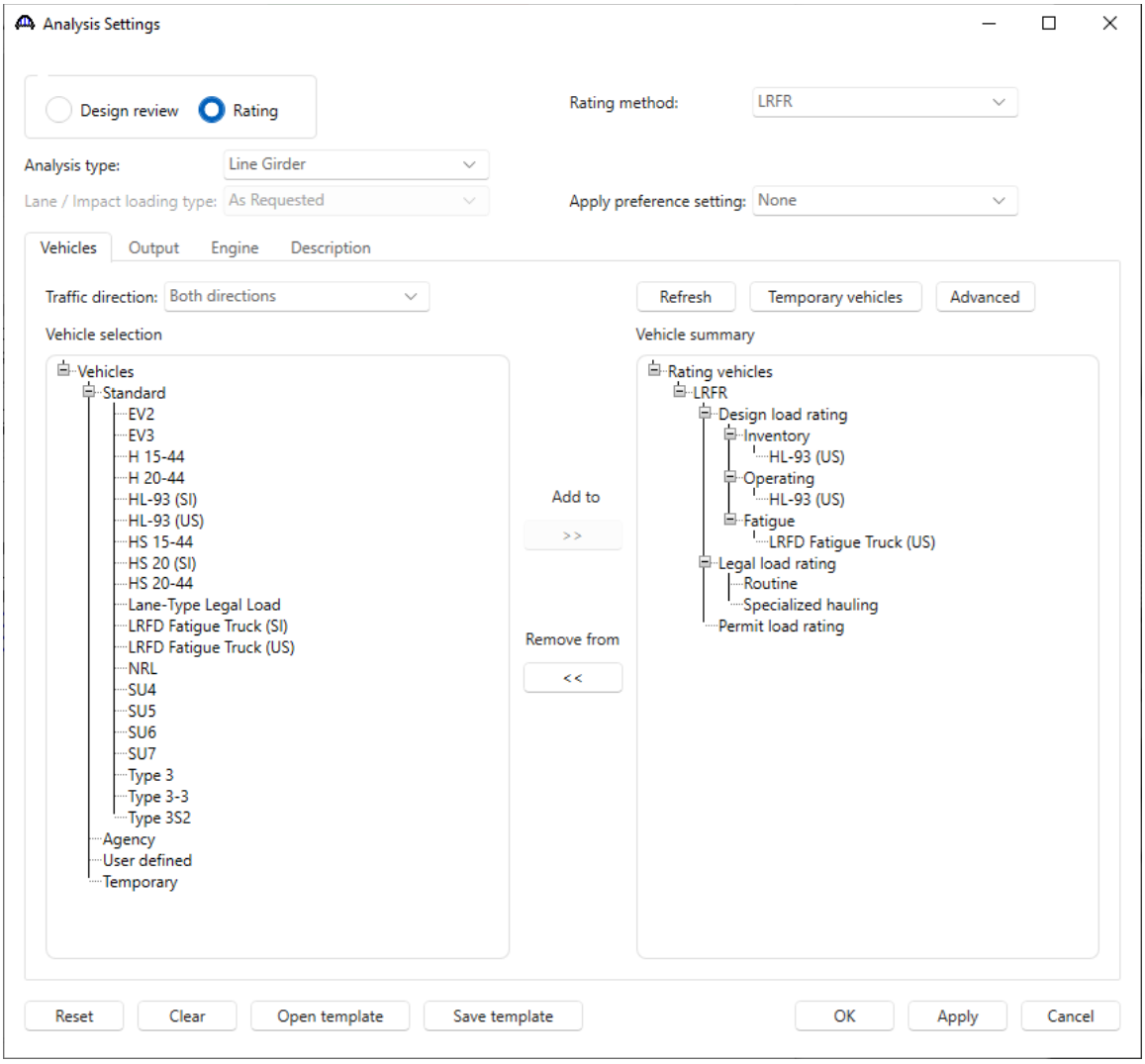
The member alternative can now be analyzed. To perform an LRFR rating, select the **PT Web 1** alternative in the **BWS** tree, open the **ANALYSIS DESIGN/RATE** tab on the ribbon, and select the **Analysis Settings** button.



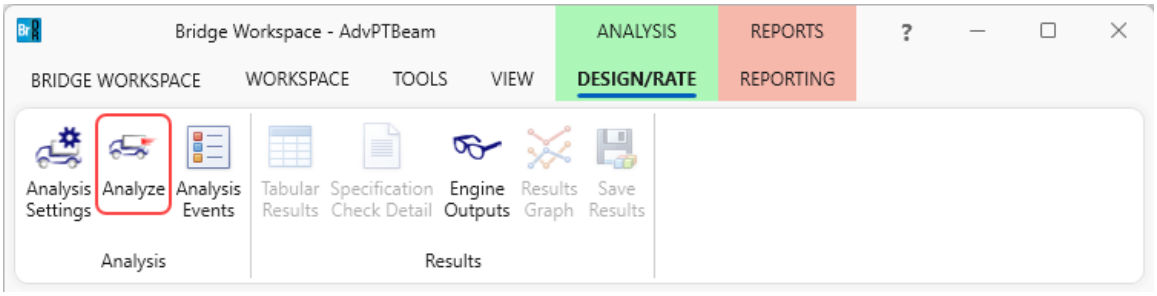
The **Analysis Settings** window will open. Click the **Open template** button and select the **LRFR Design Load Rating** to be used in the rating and click **Open**.



The **Analysis Settings** window will be populated as shown below. Click **OK** to close the window.

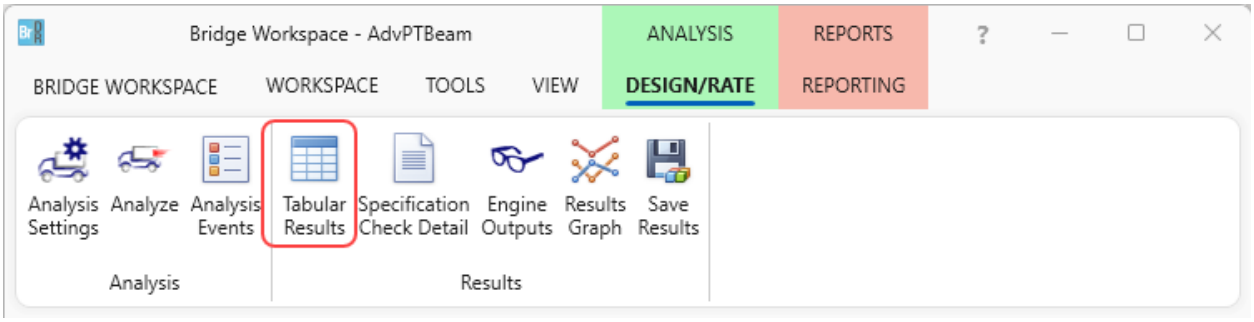


Click **Analyze** on the ribbon to launch the rating.

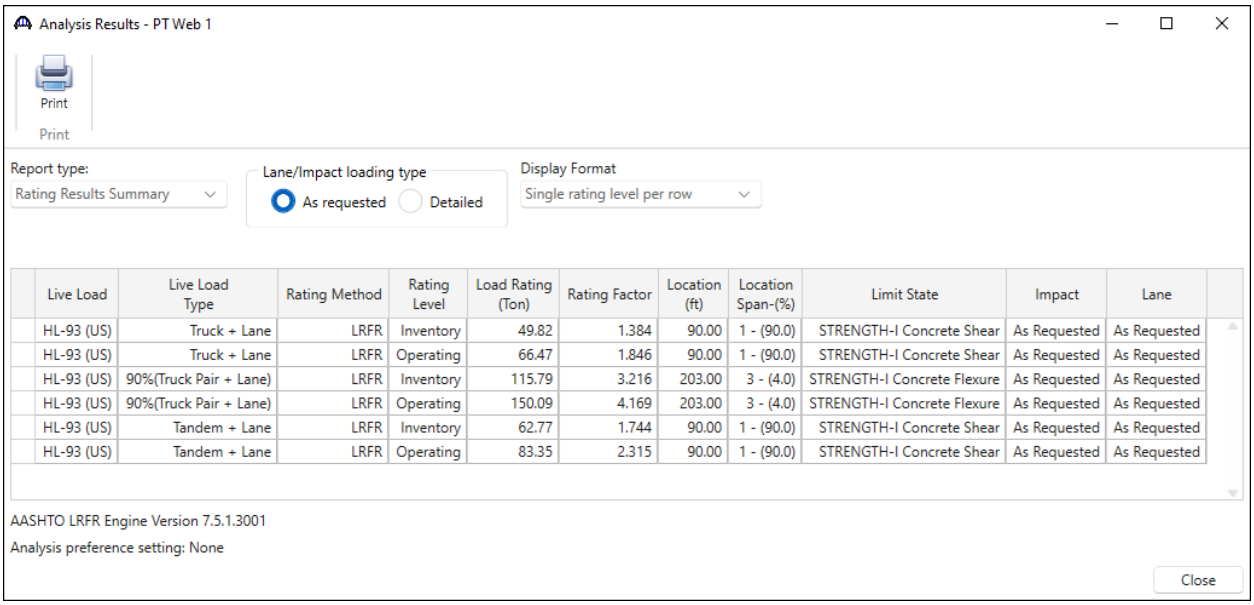


Tabular Results

When the rating is finished results can be reviewed by clicking the **Tabular Results** button on the ribbon.



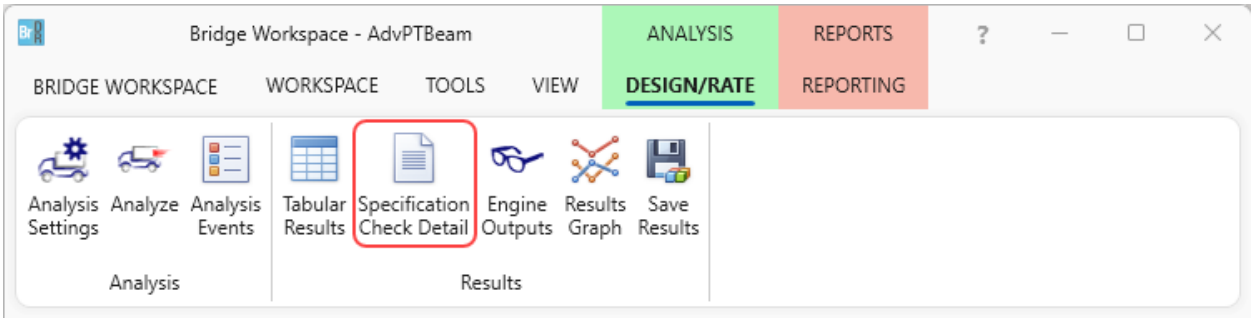
The window shown below will open. Select **Single rating level per row** as the display format to display the output in single rows as shown below.

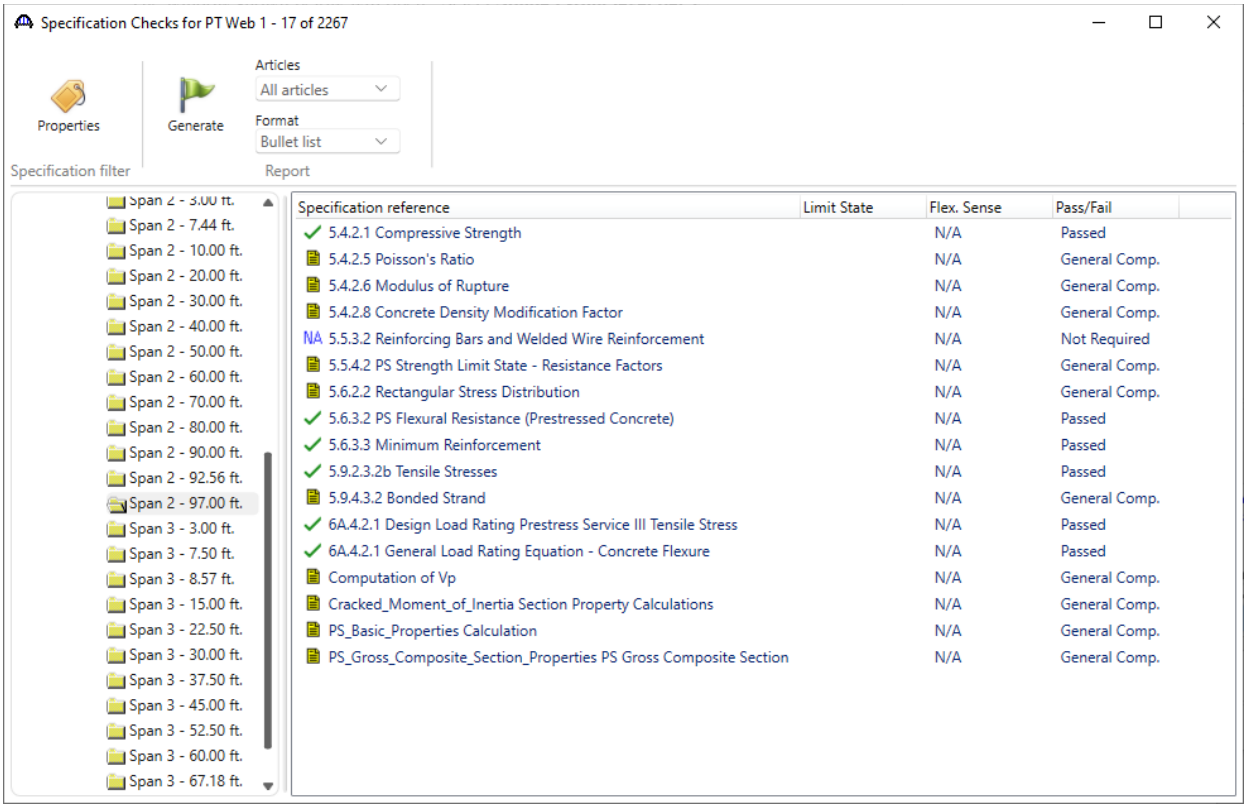


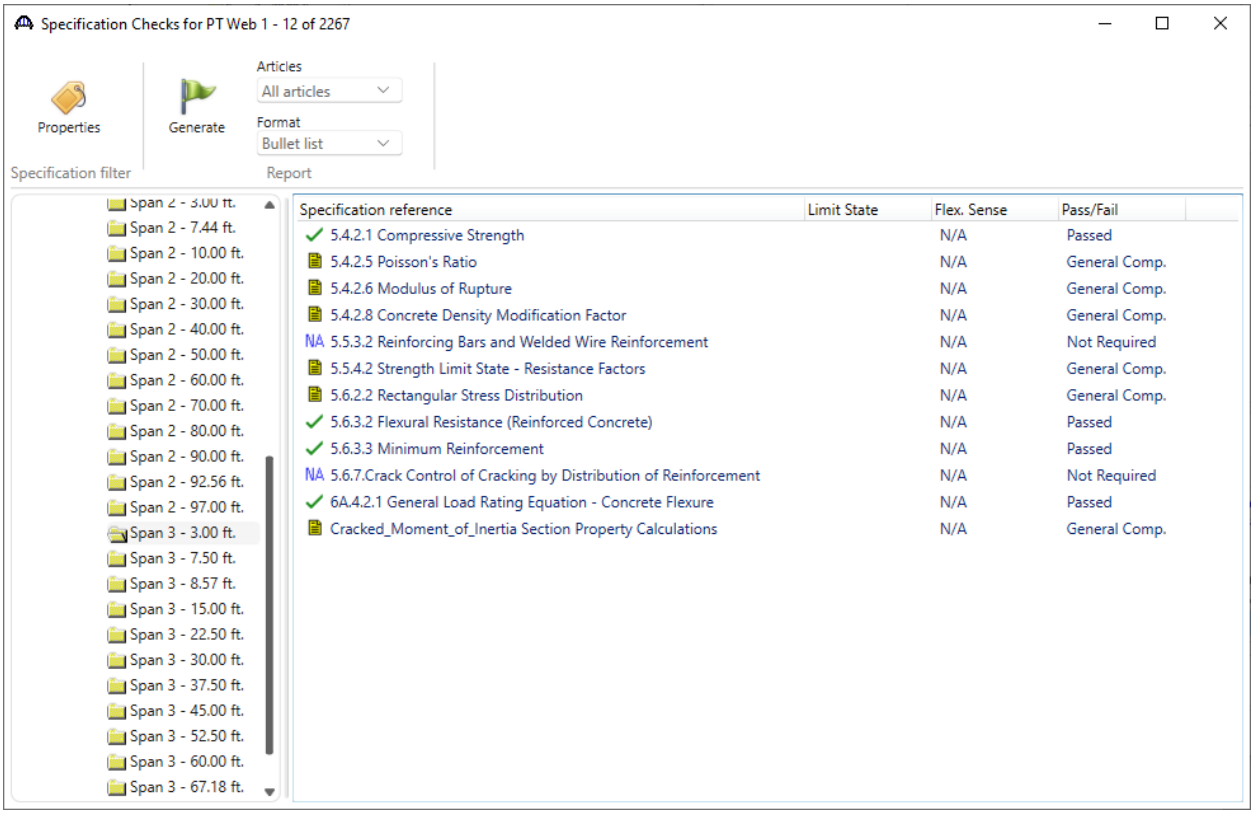
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	49.82	1.384	90.00	1 - (90.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	66.47	1.846	90.00	1 - (90.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	115.79	3.216	203.00	3 - (4.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	150.09	4.169	203.00	3 - (4.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	62.77	1.744	90.00	1 - (90.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	83.35	2.315	90.00	1 - (90.0)	STRENGTH-I Concrete Shear	As Requested	As Requested

Specification Check Detail

Click **Specification Check Detail** on the ribbon to review the detailed spec checks. The tendons in this example stop at pier 2. Examination of the analysis points to the left of this location show post-tension articles being considered while analysis points to the right of this location consider only reinforced concrete articles.






Specification Checks for PT Web 1 - 12 of 2267
Properties
Generate
Articles
All articles
Format
Bullet list
Specification filter
Report
Span 2 - 3.00 ft.
Span 2 - 7.44 ft.
Span 2 - 10.00 ft.
Span 2 - 20.00 ft.
Span 2 - 30.00 ft.
Span 2 - 40.00 ft.
Span 2 - 50.00 ft.
Span 2 - 60.00 ft.
Span 2 - 70.00 ft.
Span 2 - 80.00 ft.
Span 2 - 90.00 ft.
Span 2 - 92.56 ft.
Span 2 - 97.00 ft.
Span 3 - 3.00 ft.
Span 3 - 7.50 ft.
Span 3 - 8.57 ft.
Span 3 - 15.00 ft.
Span 3 - 22.50 ft.
Span 3 - 30.00 ft.
Span 3 - 37.50 ft.
Span 3 - 45.00 ft.
Span 3 - 52.50 ft.
Span 3 - 60.00 ft.
Span 3 - 67.18 ft.
Specification reference
Limit State
Flex. Sense
Pass/Fail
5.4.2.1 Compressive Strength N/A Passed
5.4.2.5 Poisson's Ratio N/A General Comp.
5.4.2.6 Modulus of Rupture N/A General Comp.
5.4.2.8 Concrete Density Modification Factor N/A General Comp.
NA 5.5.3.2 Reinforcing Bars and Welded Wire Reinforcement N/A Not Required
5.5.4.2 Strength Limit State - Resistance Factors N/A General Comp.
5.6.2.2 Rectangular Stress Distribution N/A General Comp.
5.6.3.2 Flexural Resistance (Reinforced Concrete) N/A Passed
5.6.3.3 Minimum Reinforcement N/A Passed
NA 5.6.7.Crack Control of Cracking by Distribution of Reinforcement N/A Not Required
6A.4.2.1 General Load Rating Equation - Concrete Flexure N/A Passed
Cracked_Moment_of_Inertia Section Property Calculations N/A General Comp.