AASHTOWare BrDR 7.5.0

Advanced Concrete Beam Tutorial 1

Simple Span Advanced Concrete RC I Beam Example

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AASHTOWare Bridge Design and Rating Training

AC1 – Advanced Concrete RC I Beam Example

Topics Covered:

- Advanced Concrete RC Member Alternatives
- Effective supports and critical shear locations (applies to all concrete member alternatives in BrDR, not just advanced concrete)
- LRFR Rating

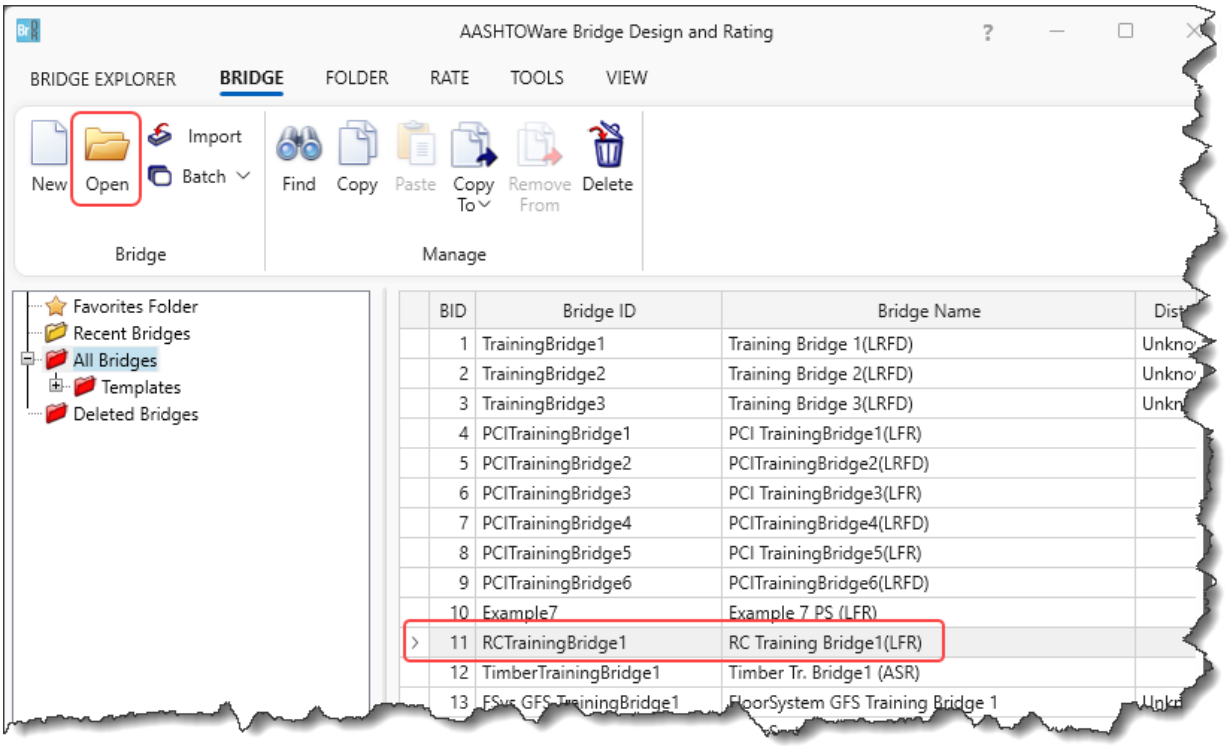
Overview of Advanced Concrete Beam features:

- Advanced concrete beams implemented in BrDR version 7.1.0 in September 2021
- Advanced concrete RC: LRFD/LRFR/LFR/ASR
- 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

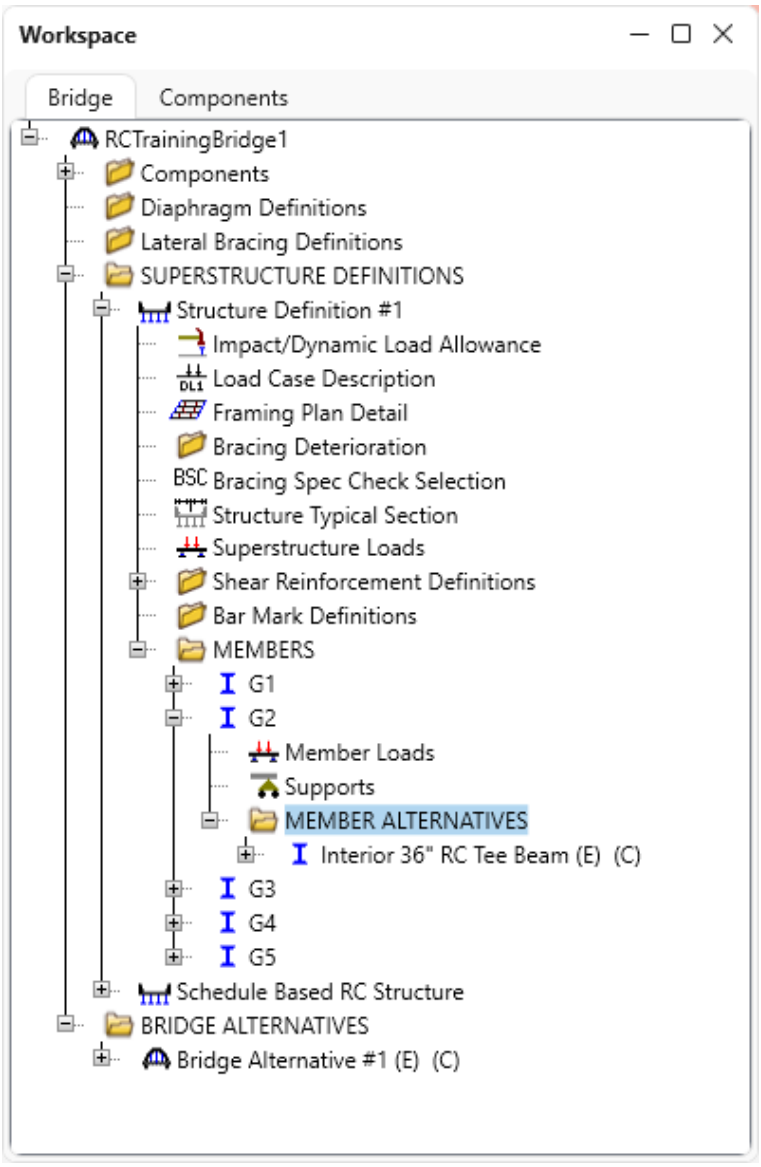
This tutorial describes the data entry for a reinforced concrete I beam with schedule based reinforcement using the Advanced Concrete beam alternative in BrDR version 7.5.

Advanced Concrete RC Member Alternatives

Open the **Bridge Workspace** for **BID 11** in the sample database delivered with BrDR as shown below.



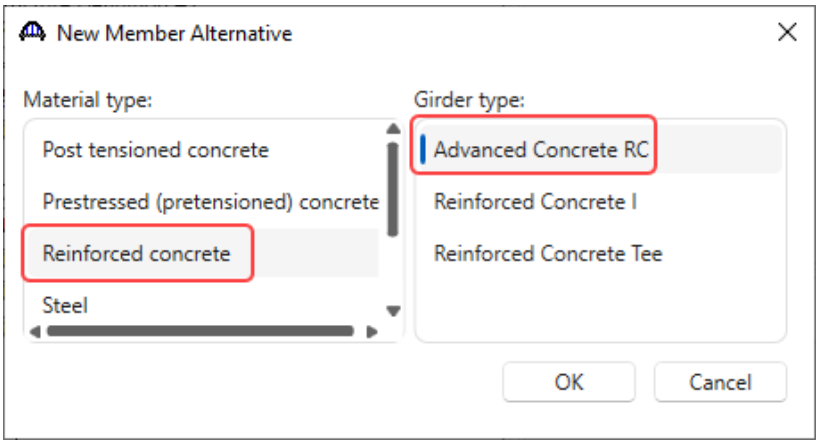
Expand the **Bridge Workspace (BWS)** tree to show the member alternative for **G2** in the first superstructure definition:



Member **G2** already contains a cross-section based RC Tee beam member alternative. In this training example, a new advanced concrete RC I beam member alternative will be created where the beam shape is defined by cross sections, but the reinforcement is entered in a schedule based fashion.

Member Alternatives

Double click on the **MEMBER ALTERNATIVES** tree node for member **G2** to open the following window to create a new member alternative.



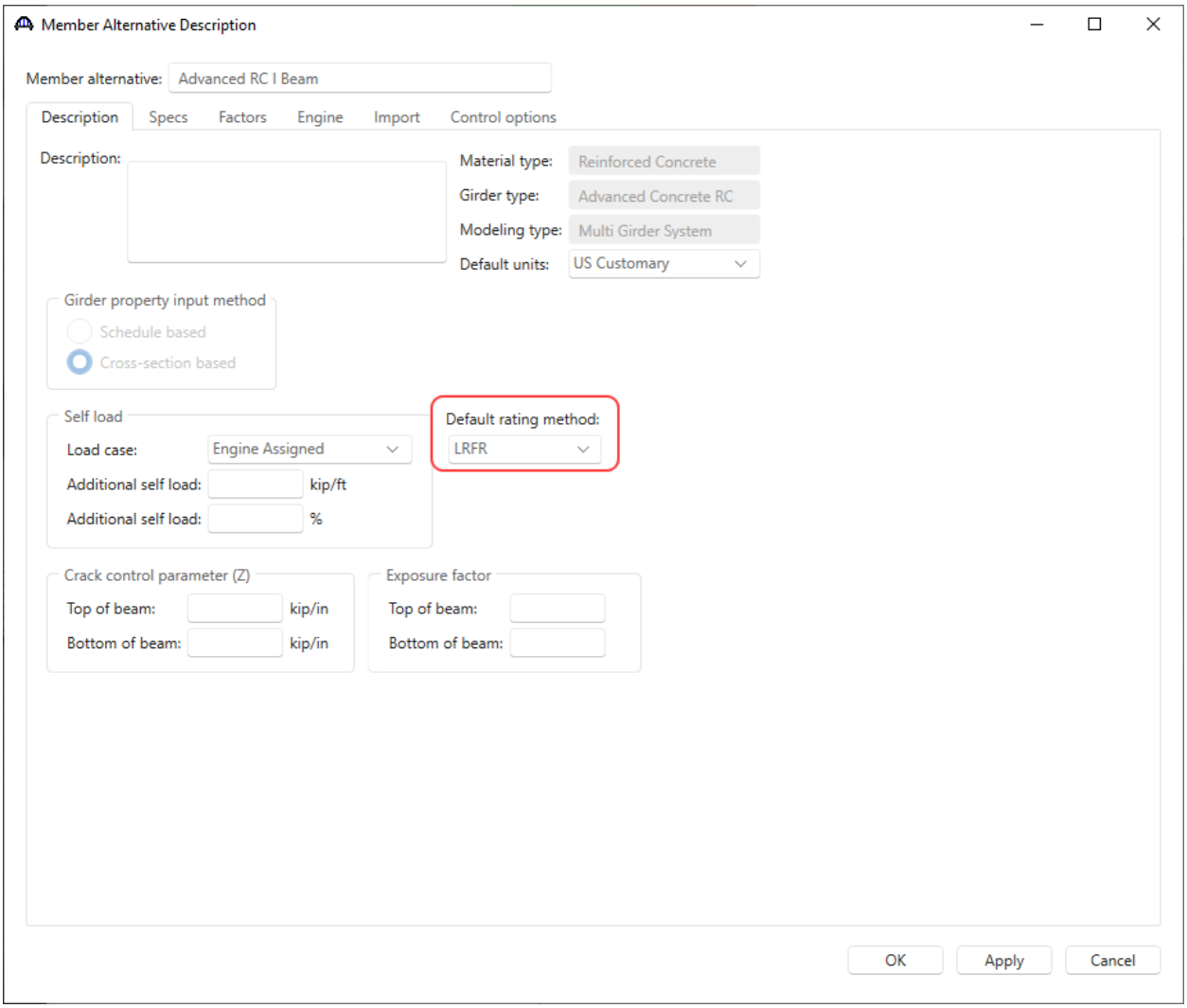
For **Reinforced concrete** material type, there are 3 girder types available.

The **Reinforced Concrete I** girder type is a cross-section based reinforced concrete member. With a cross-section based RC member alternative, the cross sections are assumed to contain fully developed reinforcement. The AASHTO engines will not compute the reinforcement development lengths for cross-section based RC member alternatives. The user is responsible for determining the development lengths of the longitudinal reinforcement and entering the appropriate developed percentage of reinforcement in each cross section.

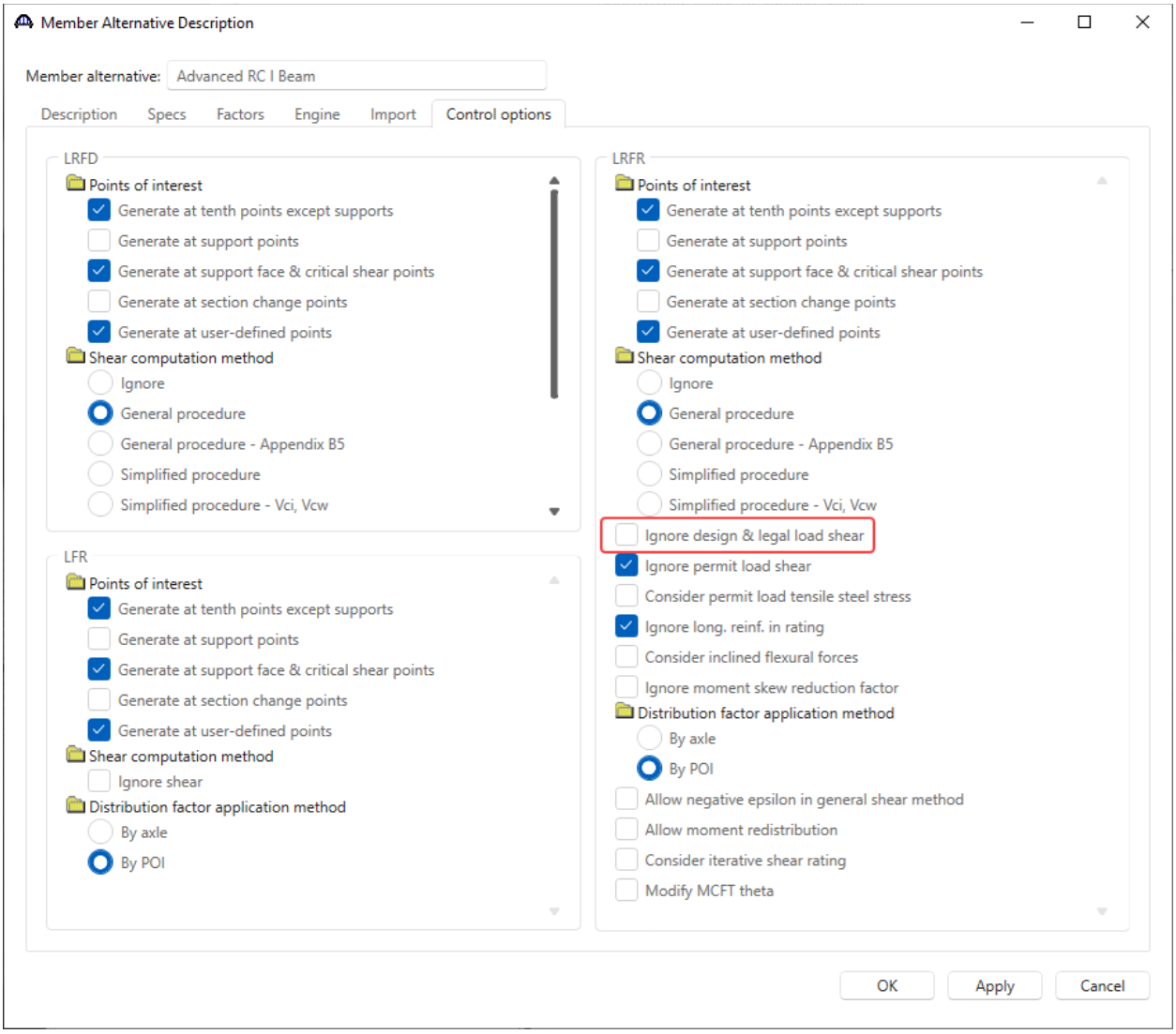
Selecting the **Advanced Concrete RC** girder type permits the creation of a reinforced concrete I beam where cross sections are used to describe the beam shape, but the reinforcement is entered as a schedule. Entering the reinforcement in a schedule fashion will allow the AASHTO engines to compute the reinforcement development lengths and determine the developed percentage of reinforcement at each analysis point.

Select **Reinforced concrete** and **Advanced Concrete RC**. Click **OK** to close this window and create the new member alternative.

The **Member Alternative Description** window will open as shown below. Enter a name for the member alternative and switch the default rating method to **LRFR**. The default rating method set here is the method that will be used if **Member Alternative** is selected as the rating method on the **Analysis Settings** window.

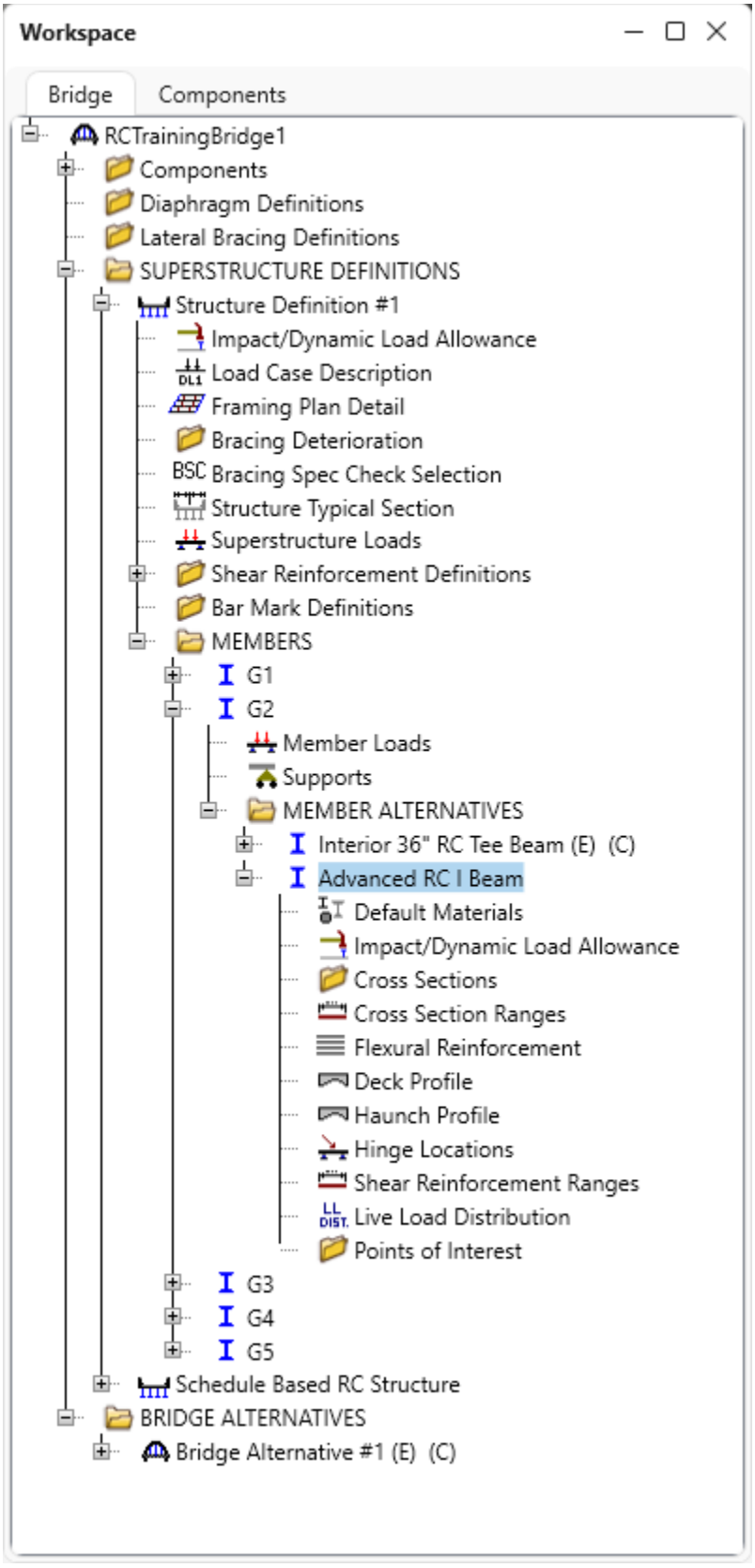


Navigate to the **Control options** tab and uncheck the **Ignore design & legal load shear** checkbox for **LRFR**. Note that the **Points of interest** selection does not include support points but does include support face & critical shear points. Support points are the centerline of bearing locations. The centerline of bearing is considered as the support face unless an **Effective Support location** is entered in the **Cross Section Ranges: Effective supports** tab. This will be discussed again later in this example.



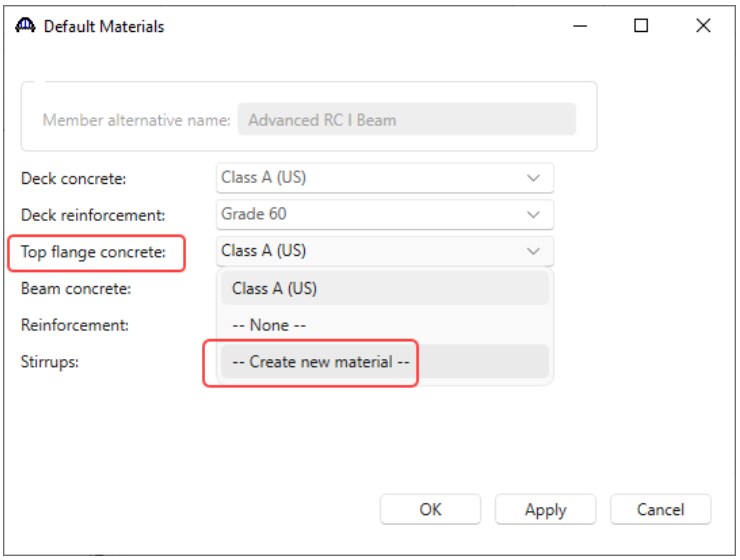
Click **OK** to apply the data and close the window.

The partially expanded **BWS** tree is shown below.

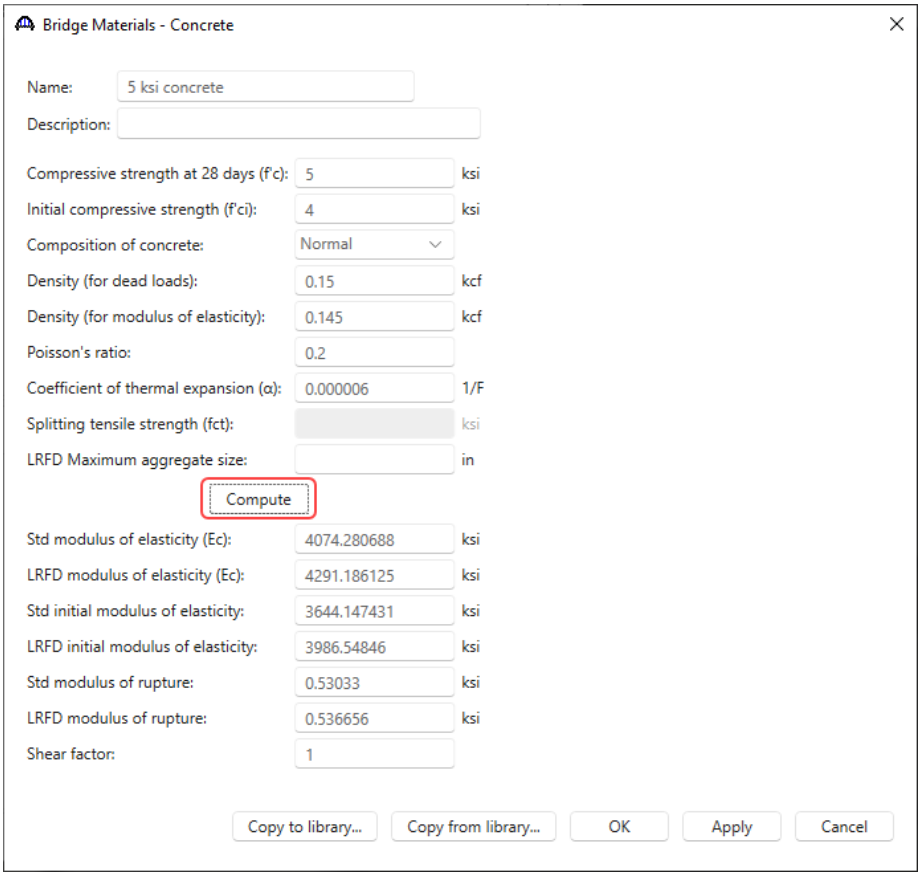


Default Materials

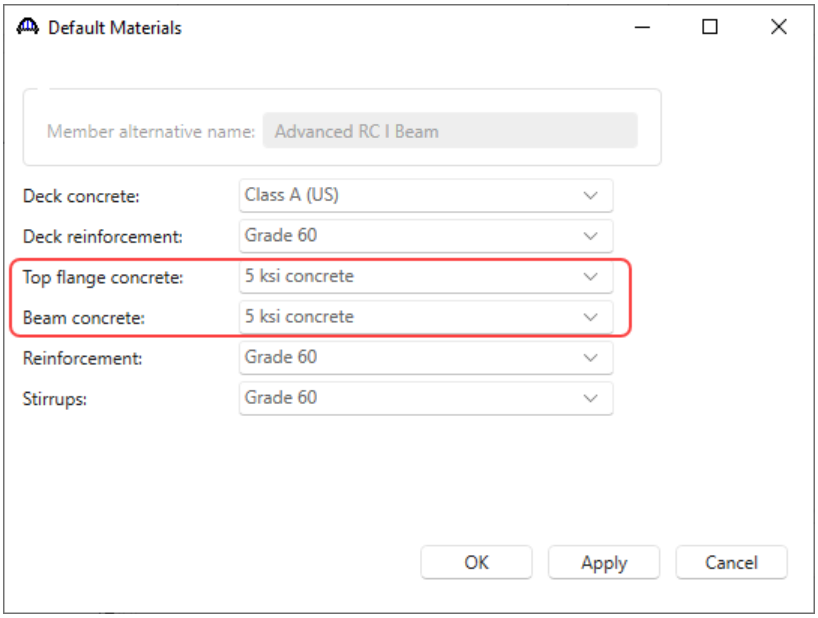
Open the **Default Materials** window. Select the **Top flange concrete** and click on the **Create new material** option.



Enter the following data down to the **Compute** button. Click the **Compute** button to have the remaining data calculated.



Click **OK** to apply the data and close the window. This will create a new concrete material for this bridge.

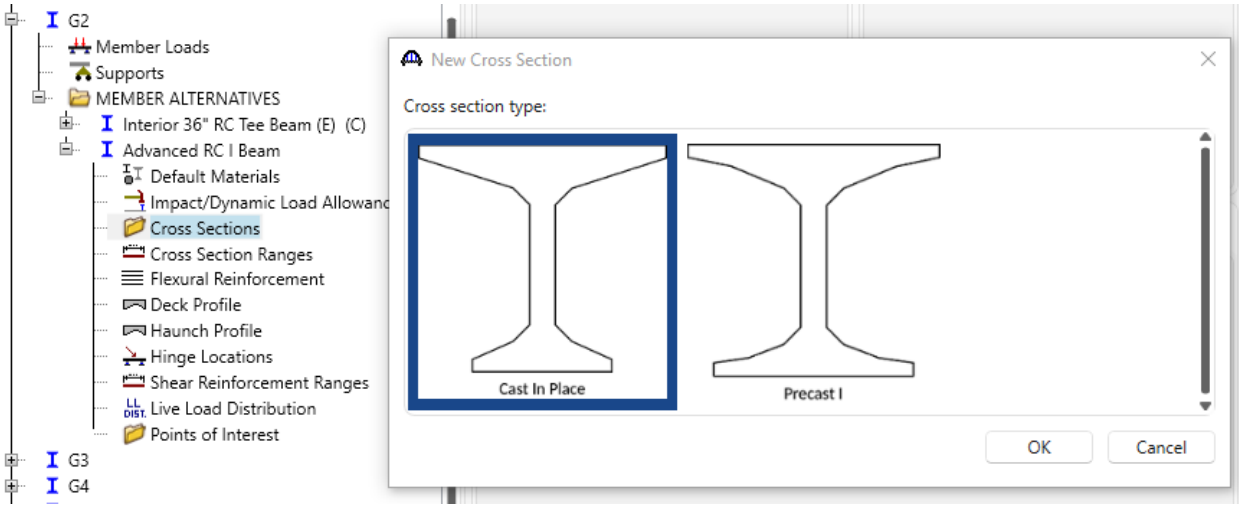


Select this new **5 ksi concrete** as the default **Beam concrete** as well. Click **OK**. Now the 5 ksi concrete will be the default top flange and beam material when a new cross section is created.

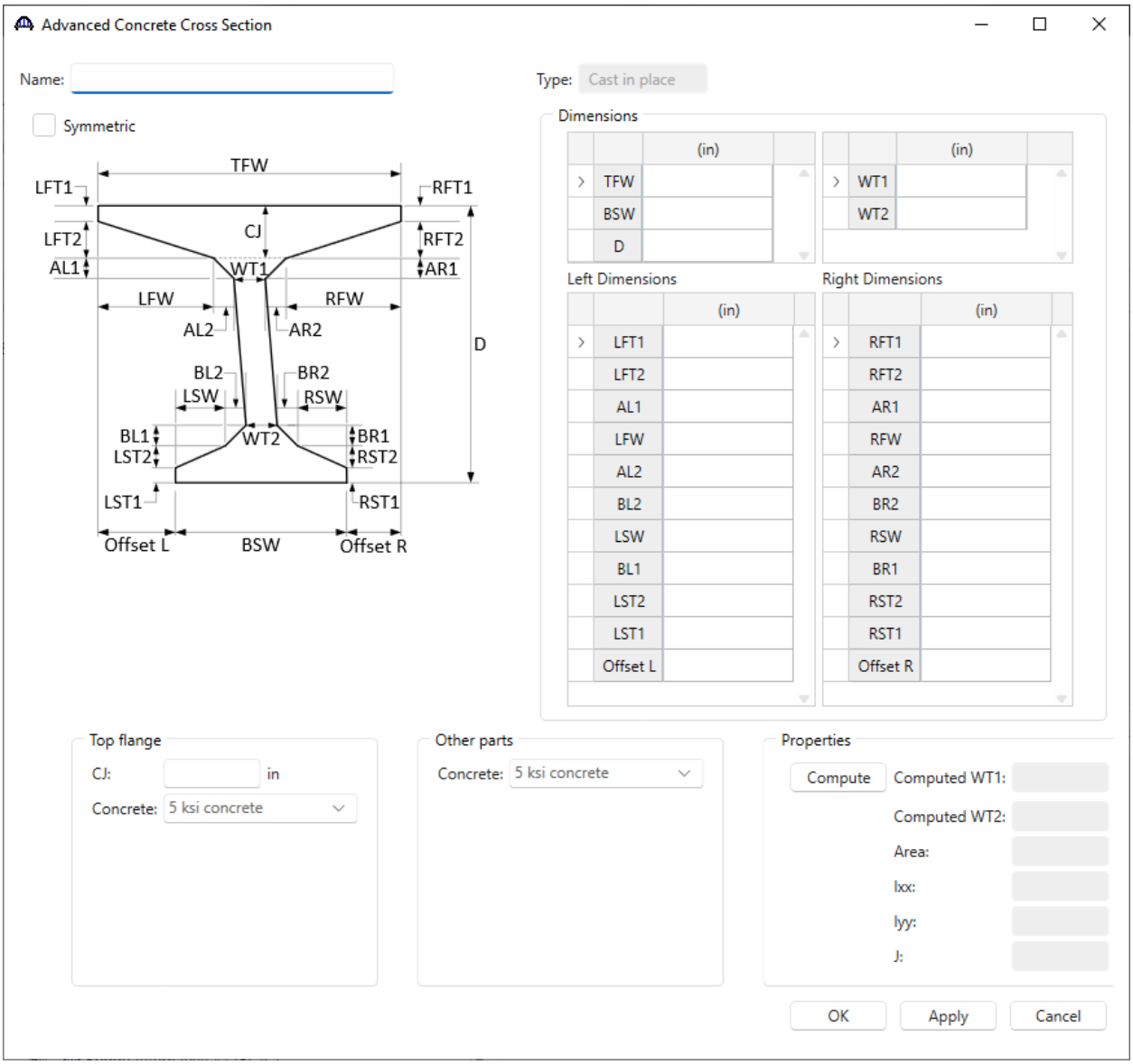
Cross Sections

Double click on the **Cross Sections** folder in the tree. The **Cast In Place** cross section type is a robust cross section that allows the entry of a wide variety of cross sections including non-symmetric sections. The **Precast I** cross section type permits copying the cross section dimensions from a PS I beam shape in the Library or BWS. Once copied, any dimension can be modified as needed. For this example, the dimensions will be input and not copied from the library.

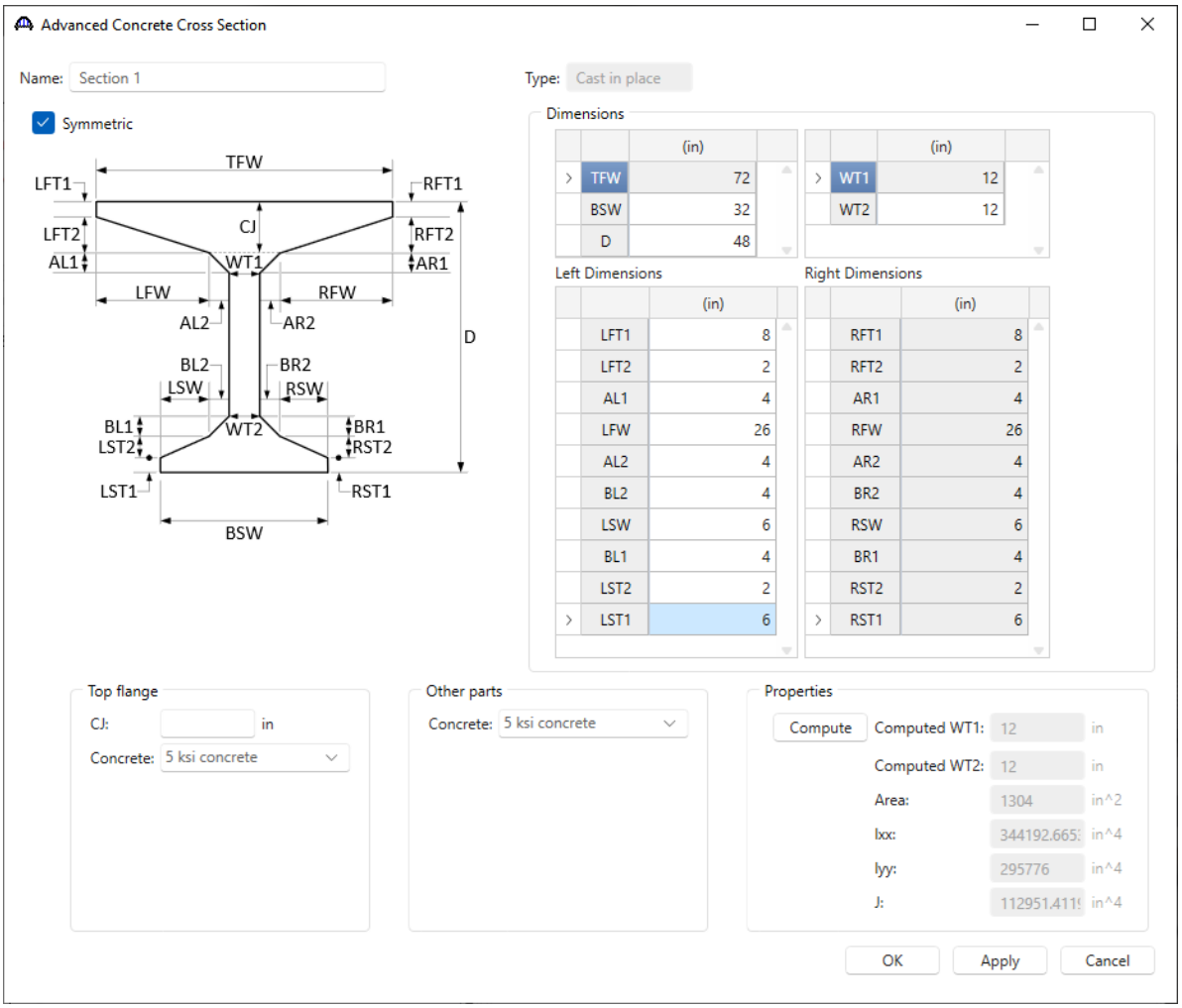
Select **Cast In Place** and click **OK**.



The following window appears:



Check the **Symmetric** checkbox and enter the following data. Click the **Compute** button to compute the section properties.

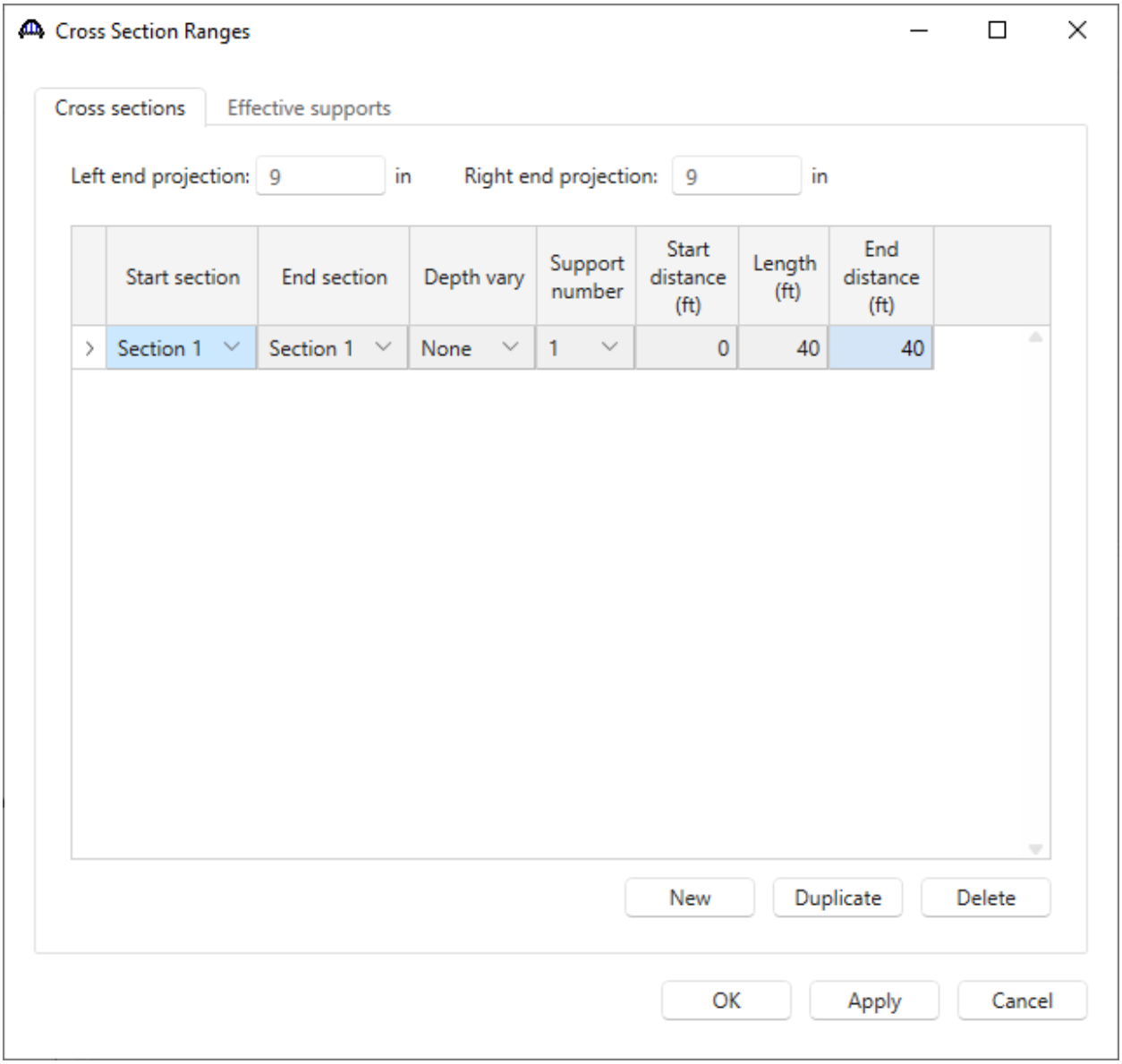


Click **OK** to apply the data and close the window.

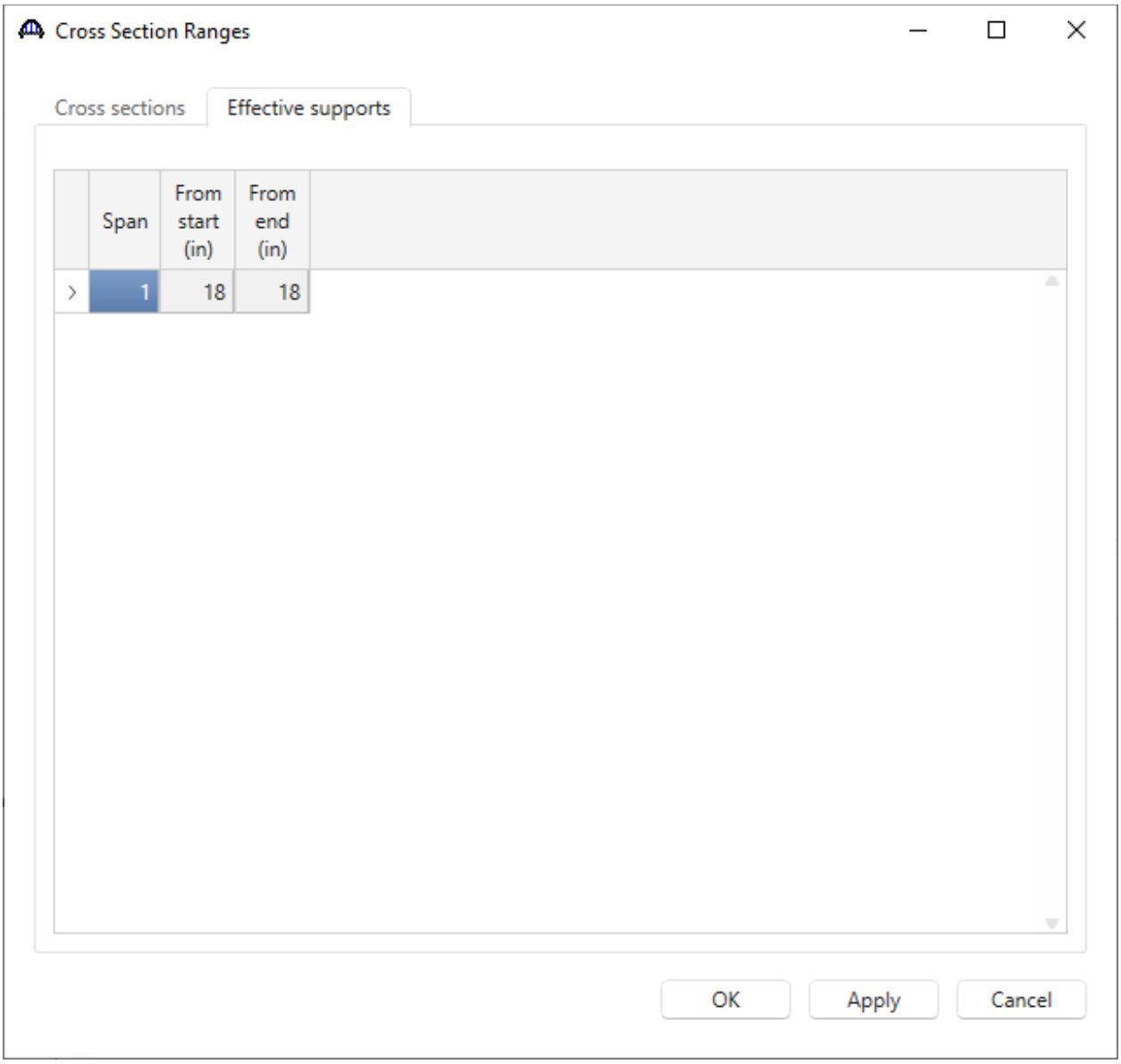
Cross Section Ranges

Open the **Cross Section Ranges** window and enter the data shown below. Be sure to enter the left and right end projections. These projections are the extension of the beam beyond the first and last centerline of bearings in the structure. Entering this data will permits the entry of longitudinal reinforcement as per the design plans starting and ending in this region. This will allow the AASHTO engines to compute a small percentage of reinforcement developed at the centerline of bearings. Having reinforcement developed at the centerline of bearings is required to compute the LFD/ASD critical shear distance d and LRFD/LRFR critical shear distance d_v if spec checking is performed at the support points. If this information is not available, the reinforcement can be specified as being fully developed in the **Flexural Reinforcement** window that will be examined shortly.

In this example, spec checking is not performed at the support points, but this topic is explained in detail to help users gain a fuller understanding of the program.



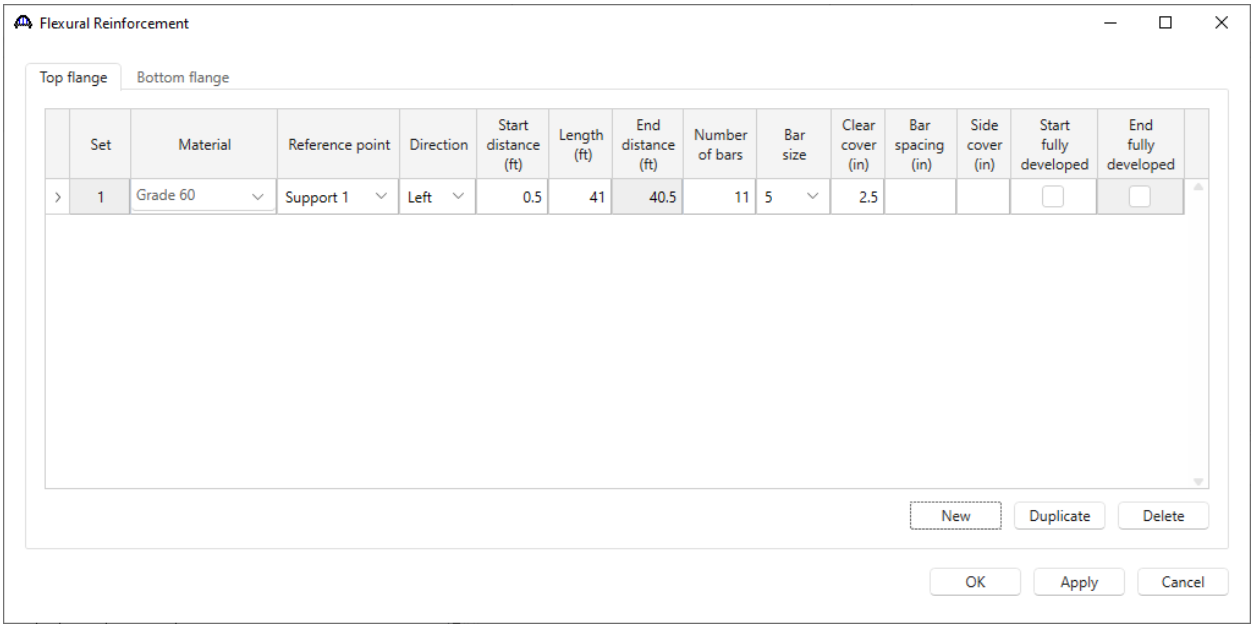
Switch to the **Effective Supports** tab and enter the following data. This tab allows the shifting of the analysis point at the centerline of bearing to the location entered in the table. The critical shear distance is then measured from this effective support location. The critical shear distance will be computed in the flexural resistance article at the effective support location based on the cross section properties and developed reinforcement at that location.

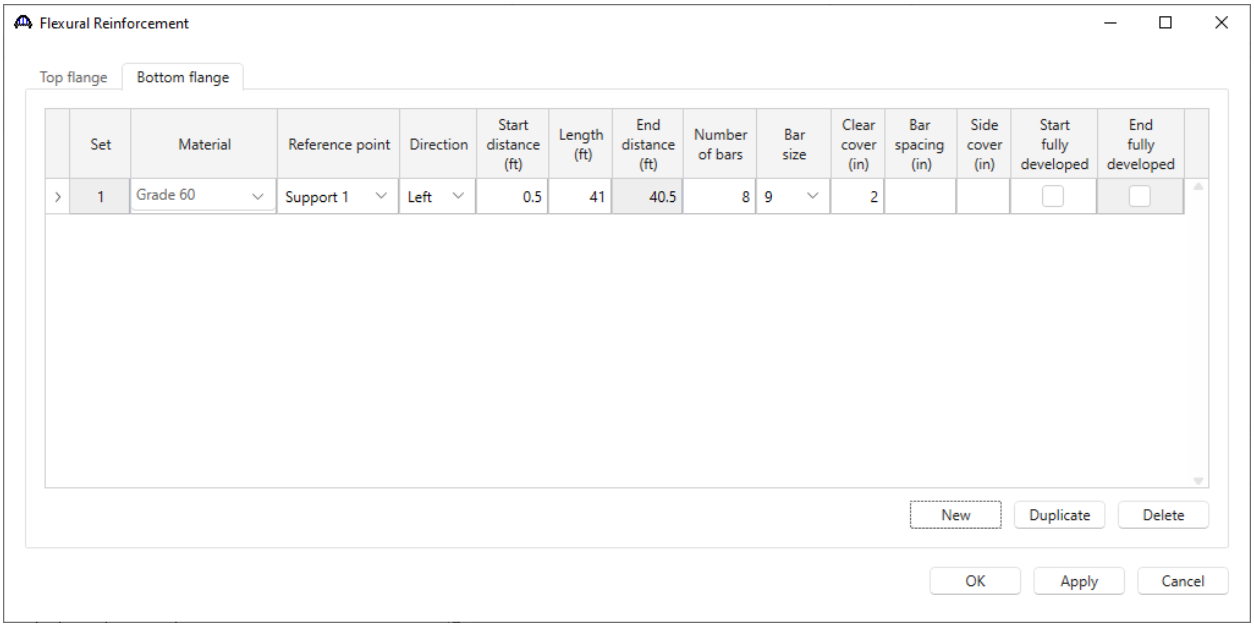


Click **OK** to apply the data and close the window.

Flexural Reinforcement

Open the **Flexural Reinforcement** window and enter the following data in each of its tabs:

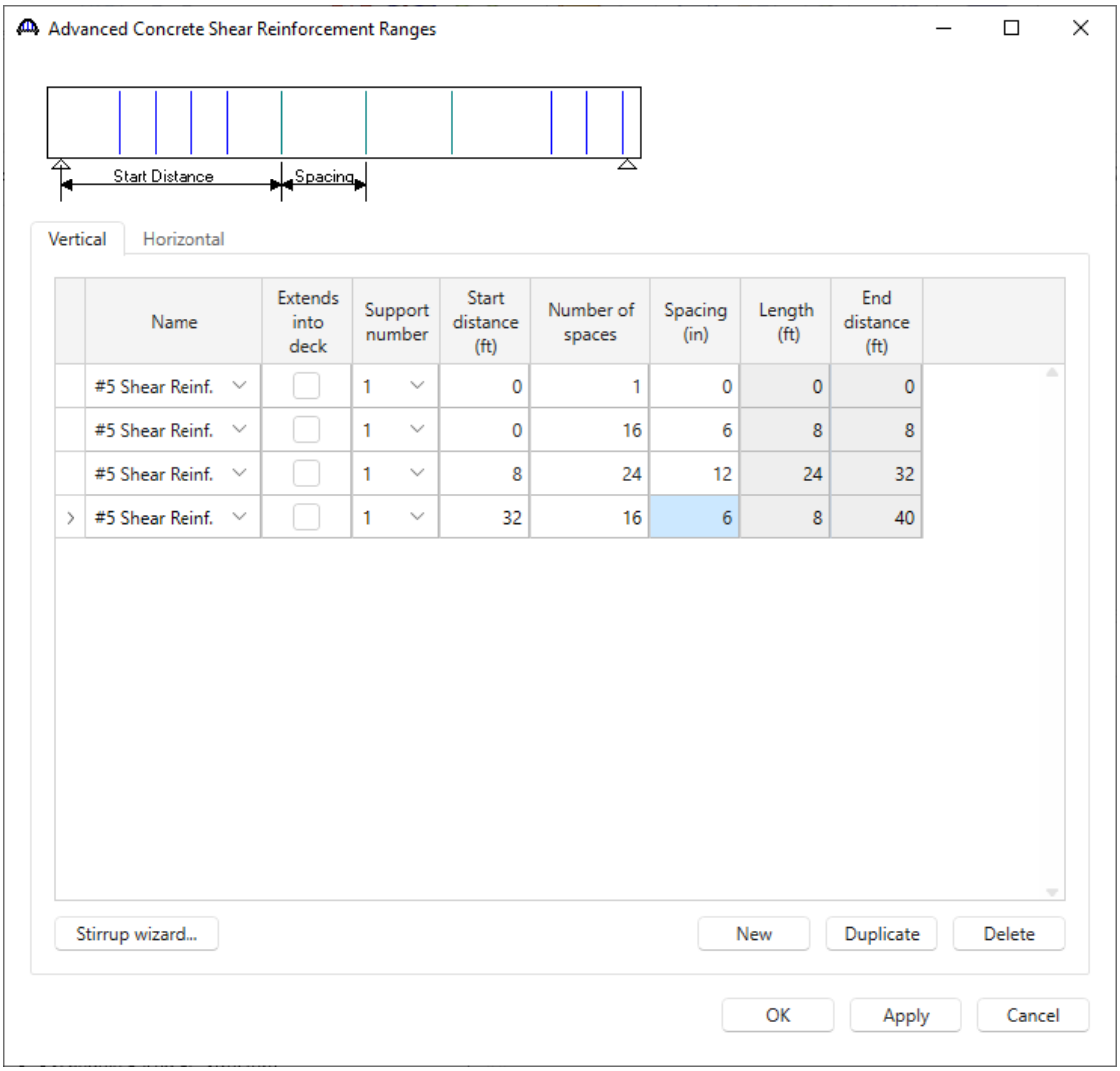




Click **OK** to apply the data and close the window.

Advanced Concrete Shear Reinforcement Ranges

The BWS tree contains a **Deck Profile** window and a **Haunch Profile** window to provide the greatest flexibility in defining a member alternative. This example does not contain a reinforced concrete deck so these windows will be skipped. Open the **Shear Reinforcement Ranges** window and enter the following data.

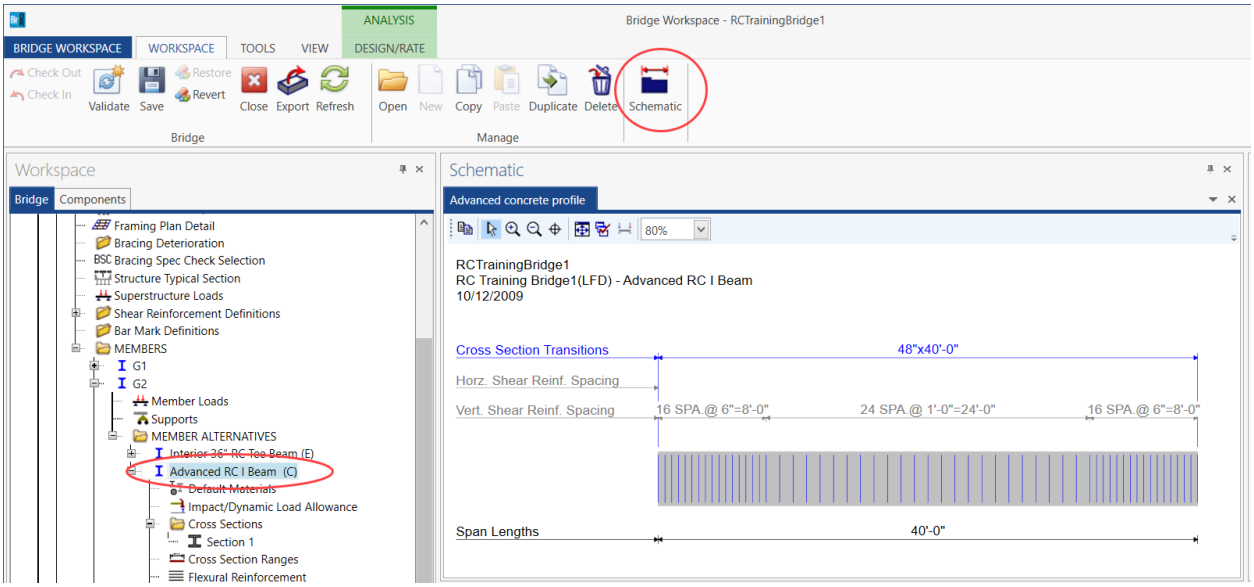


Click **OK** to apply the data and close the window.

Note, in this example, no data will be entered on the **Live Load Distribution** window and instead allow the AASHTO engine to compute the live load distribution factors during the analysis.

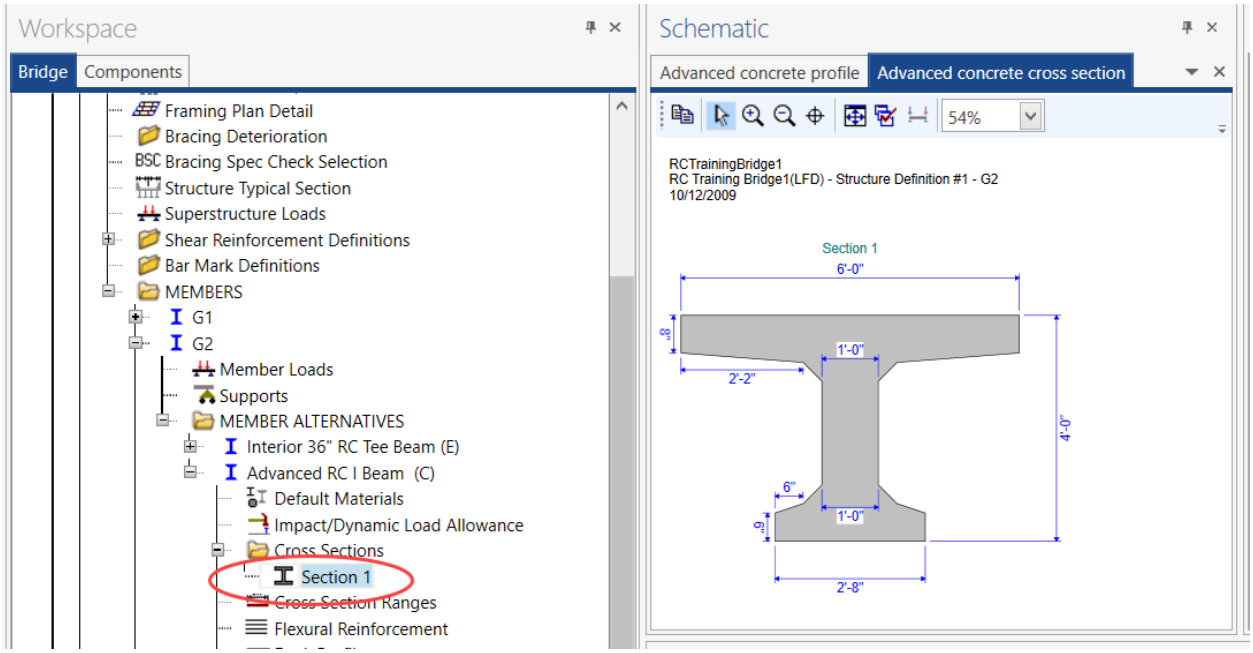
Schematic – Member alternative

With member alternative **Advanced RC I Beam** selected in the BWS tree, click on the **Schematic** button from the **WORKSPACE** ribbon as shown below to view the schematic.



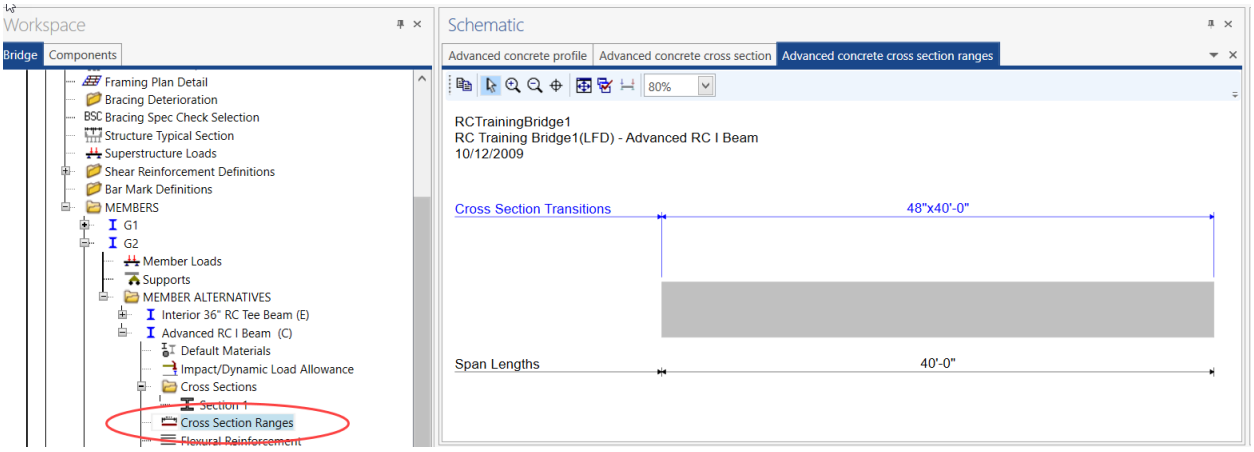
Schematic – Cross Section

Similarly, the schematic of the cross section can be viewed by clicking on the **Schematic** button from the **WORKSPACE** ribbon with **Section 1** selected in the **BWS** tree.

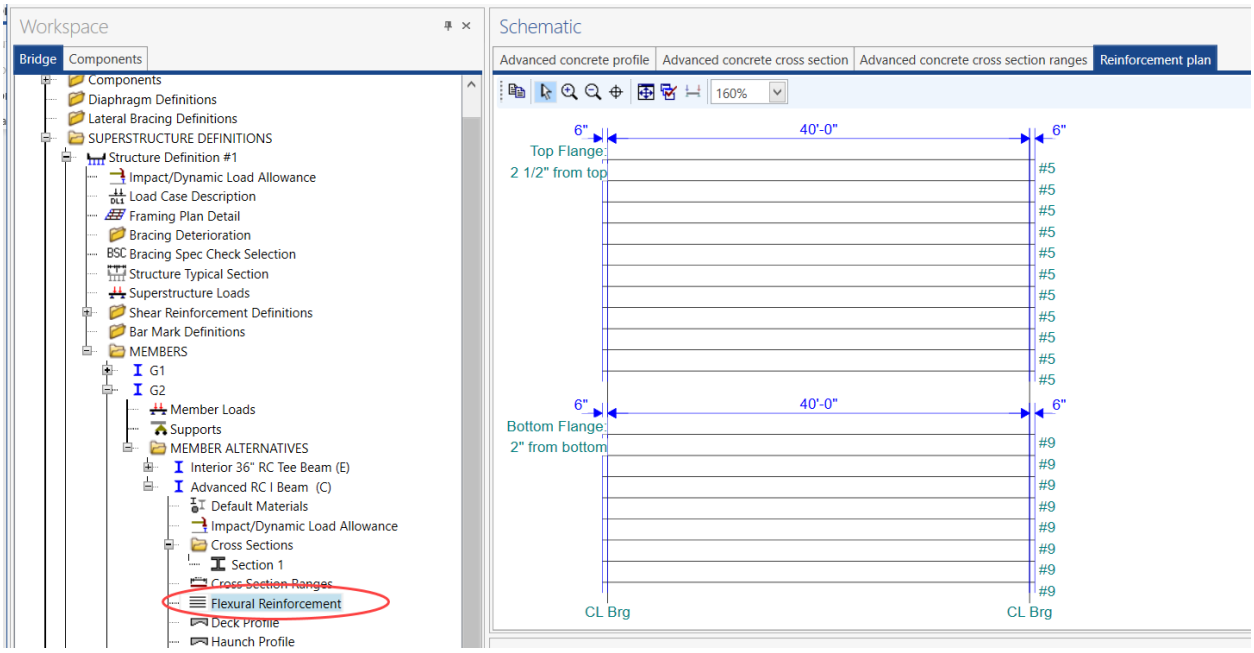


Similarly, the following schematics are available for advanced concrete beams.

Schematic – Cross Section Ranges

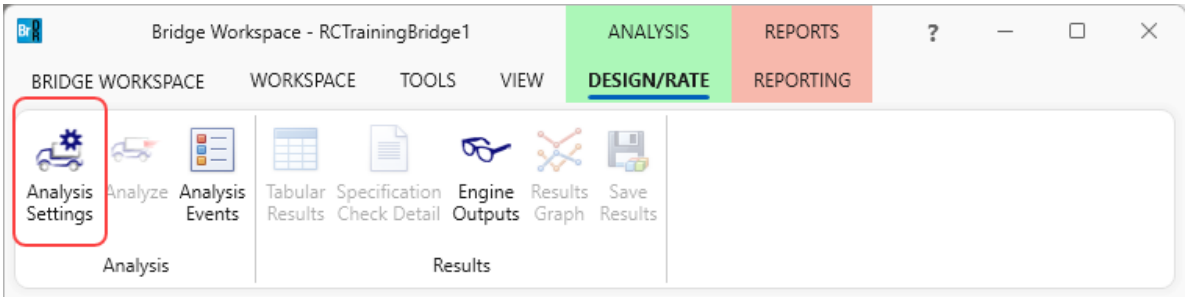


Schematic – Flexural Reinforcement

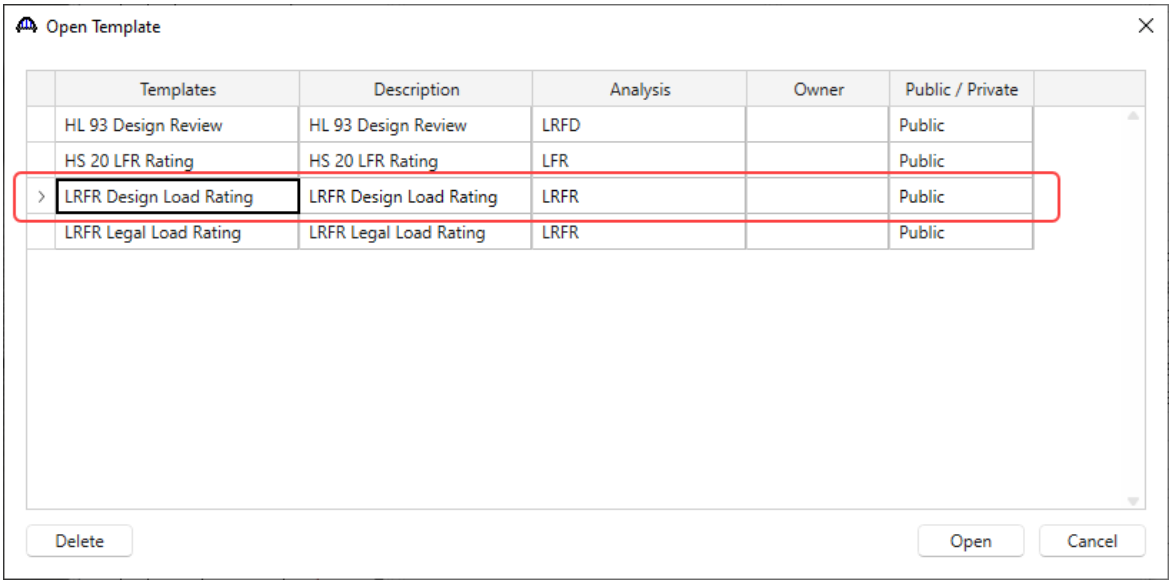


LRFR Analysis

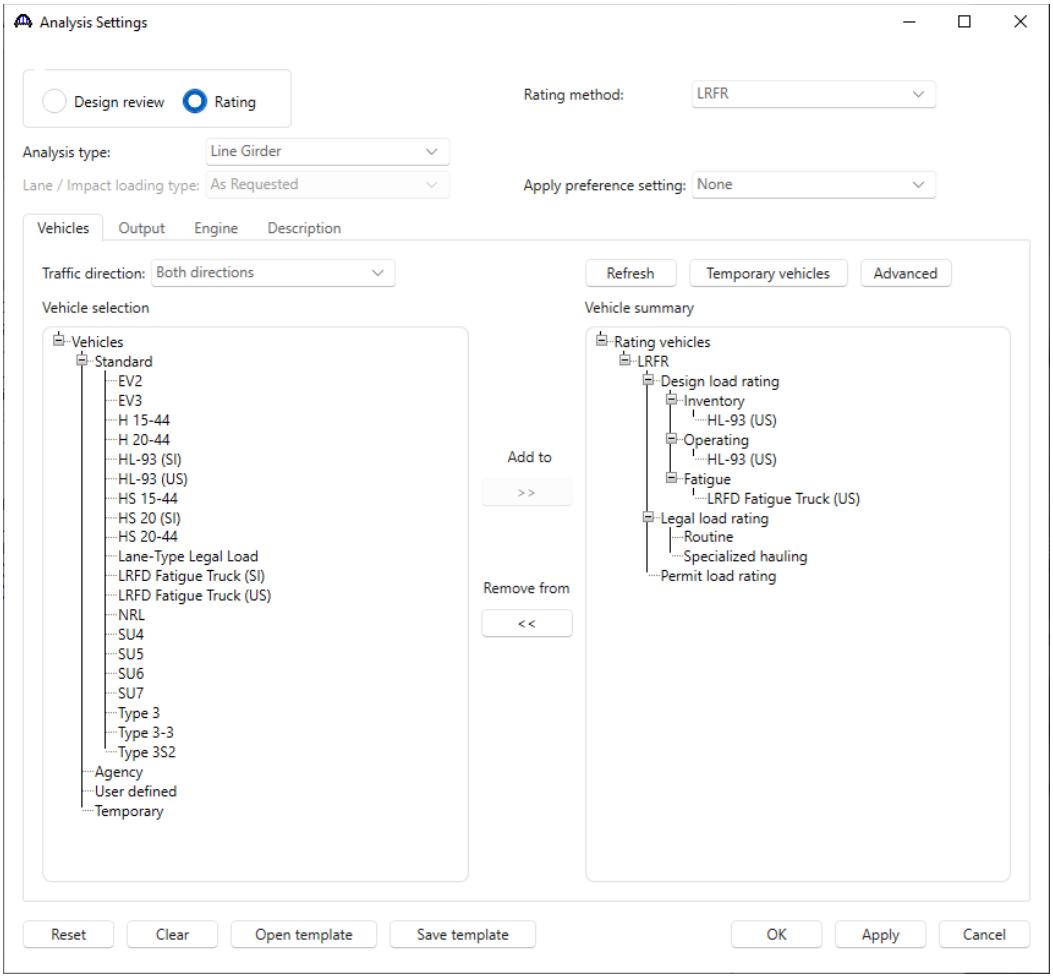
The member alternative can now be analyzed. To perform an LRFR rating, select the **Advanced RC I Beam** alternative in the BWS tree, open the **ANALYSIS DESIGN/RATE** tab on the ribbon, and select the **Analysis Settings** button.



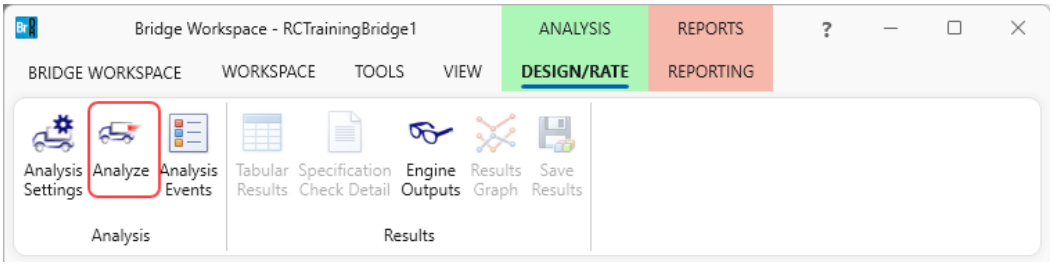
The **Analysis Settings** window will open. Click the **Open template** button and select the **LRFR Design Load Rating** to be used in the rating and click **Open**.



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

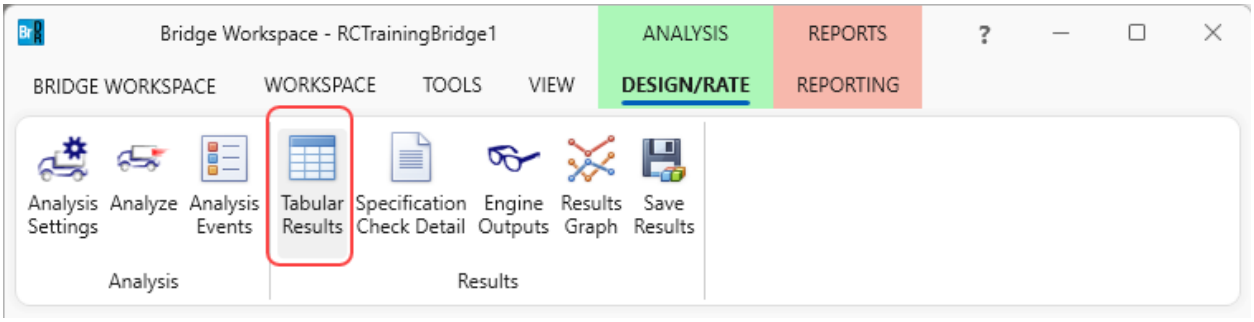


Click **Analyze** on the ribbon to launch the rating.

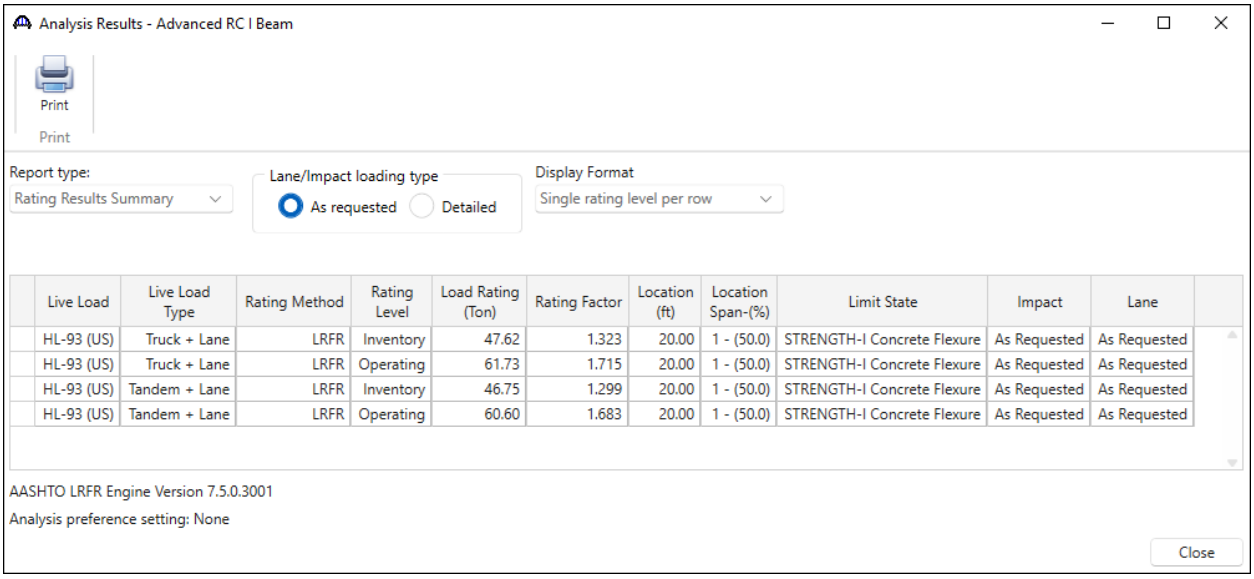


Tabular Results

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

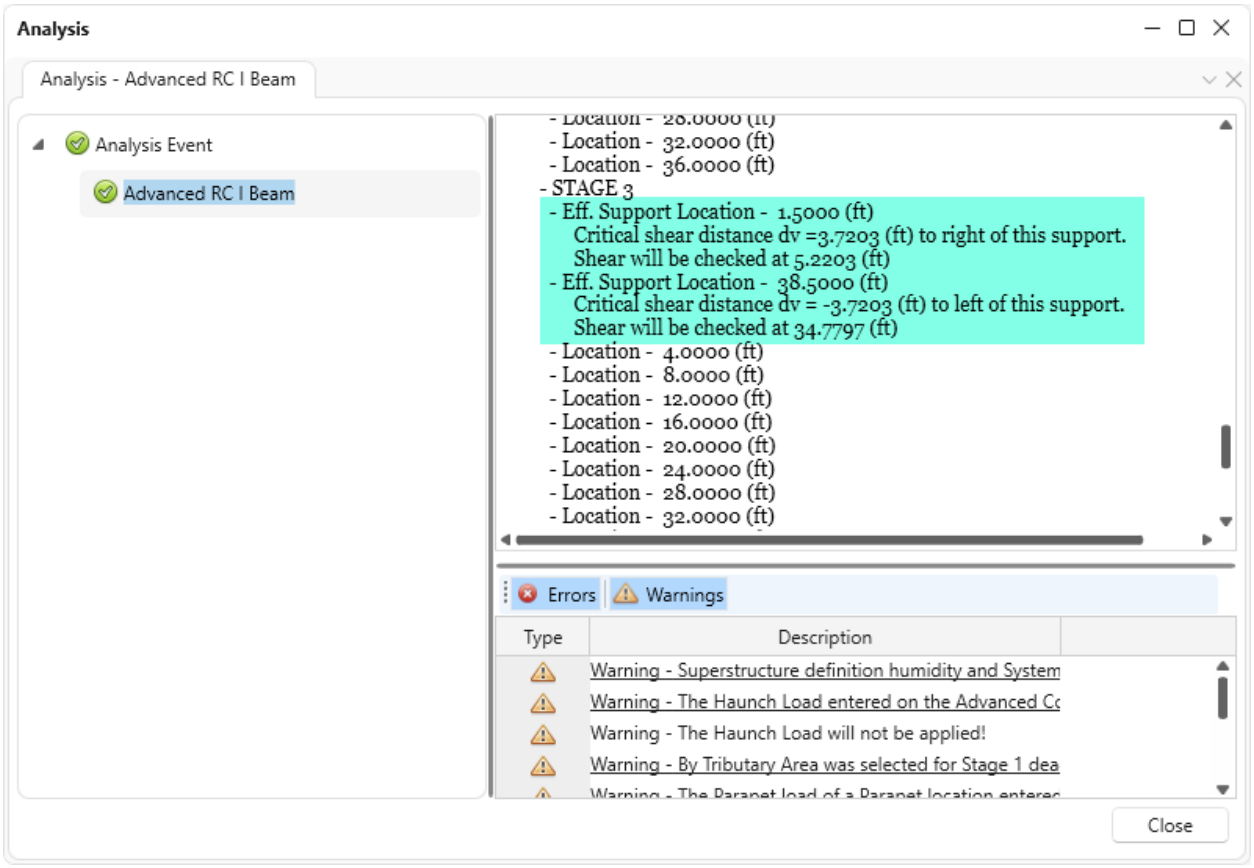


The window shown below will open. Select **Single rating level per row** as the display format to display the output in single rows as shown below. Other Report Types such as **Dead Load** and **Live Load** analysis results can also be viewed in this window.



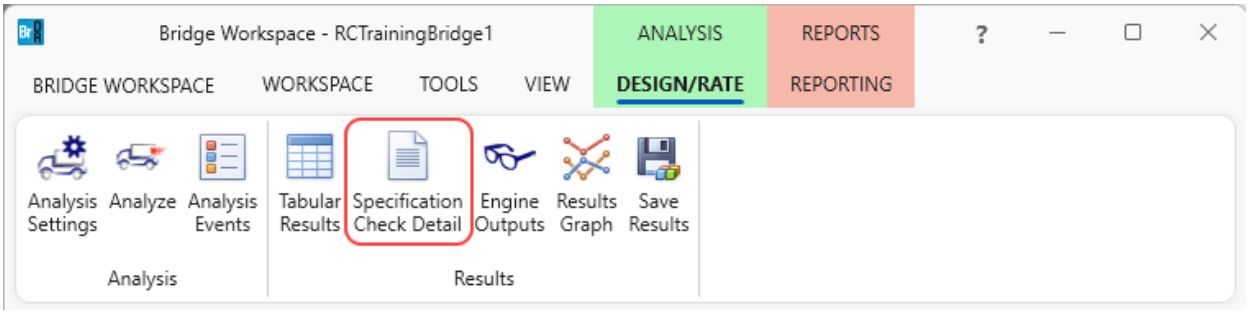
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	47.62	1.323	20.00	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	61.73	1.715	20.00	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	46.75	1.299	20.00	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	60.60	1.683	20.00	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested

Review the **Analysis Progress** log shown below. The **Effective Support** locations that were entered are listed first in the report of analysis points. The critical shear distance dv is measured from these effective support locations as shown below.

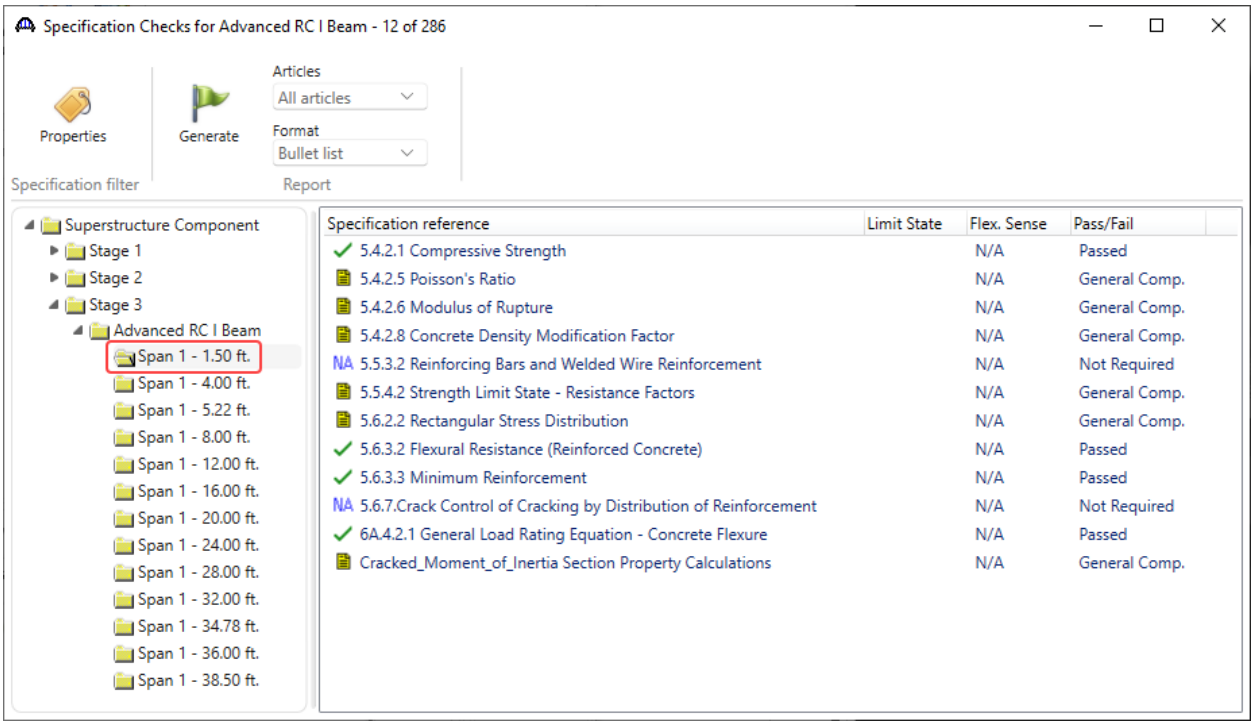


Specification Check Detail

Click **Specification Check Detail** on the ribbon to review the detailed spec checks.



Note that the 0’ and 40’ locations are not included in the spec checking. That is because data was entered for the effective supports. The first point spec checked is located at the effective support location at 1.5’. Only flexural articles are evaluated at this point. The critical shear distance d_v is computed from this location.



Scrolling through the analysis points shows that shear does not get evaluated until the analysis point at 5.22'. Shear is then evaluated at analysis points until we reach the critical shear location at 34.78' at the right end of the beam.