Multi-Cell Box Tutorial

MCB2 – Reinforced Concrete Multi-Cell Box Example

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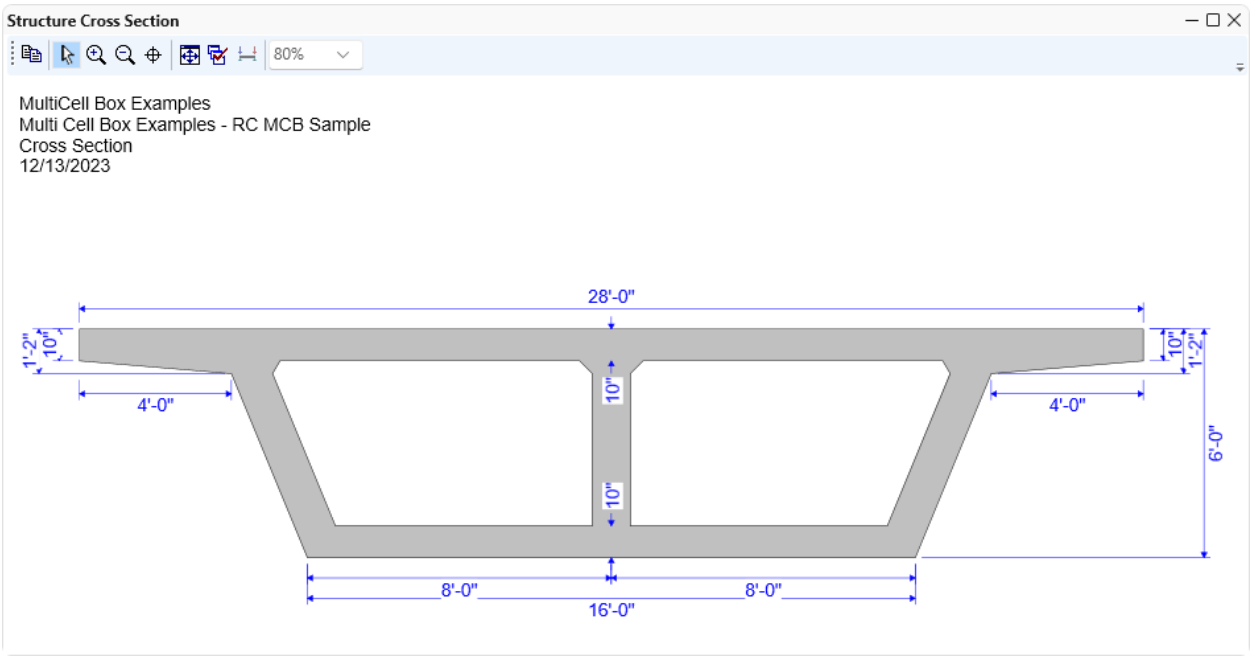


Topics Covered

- Analysis Methods
- Slab Reinforcement Data Entry
- Stirrup Wizard
- Web analysis

The data entry for a reinforced concrete multicell box superstructure is very similar to that for a post-tensioned multicell box. Example "MCB1-PT MCB Example" describes in detail the process to define a PT multicell box. This example will focus on a few details for data entry.

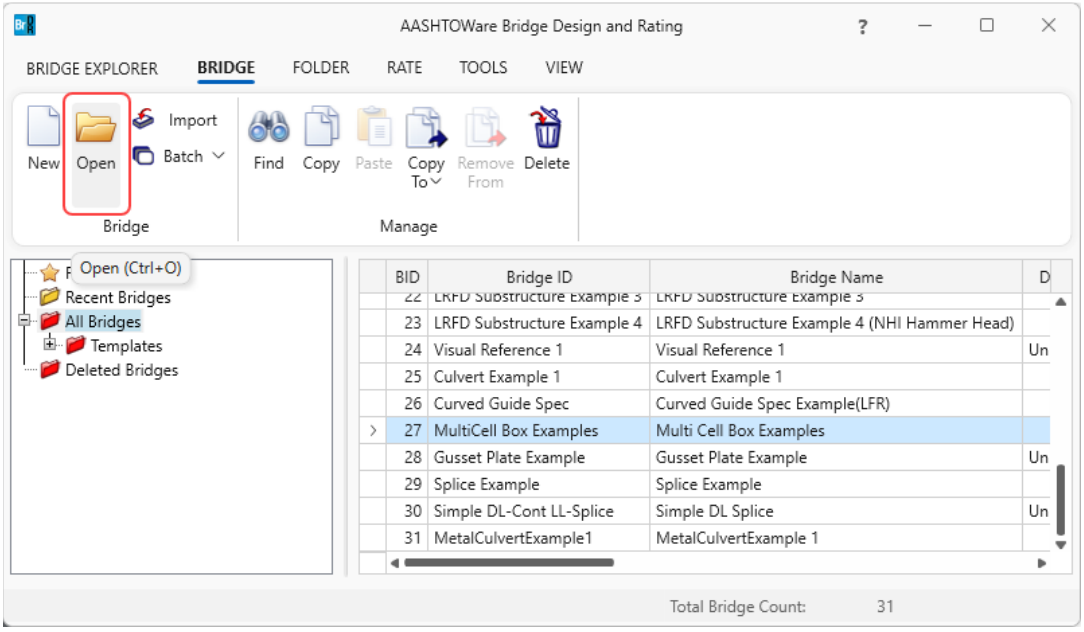
Analysis Methods

Reinforced concrete multicell box (MCB) superstructures can be analyzed in the following manners:

- LRFD, LRFR and LFR
- Full box section including each individual webline
- Single webline

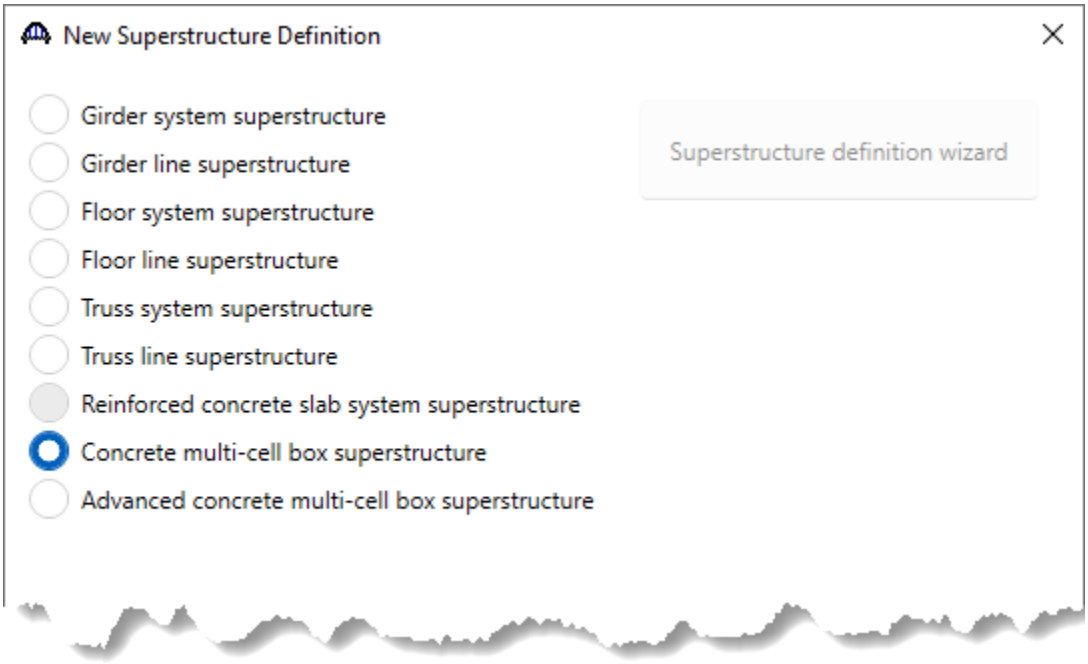
Slab Reinforcement Data Entry

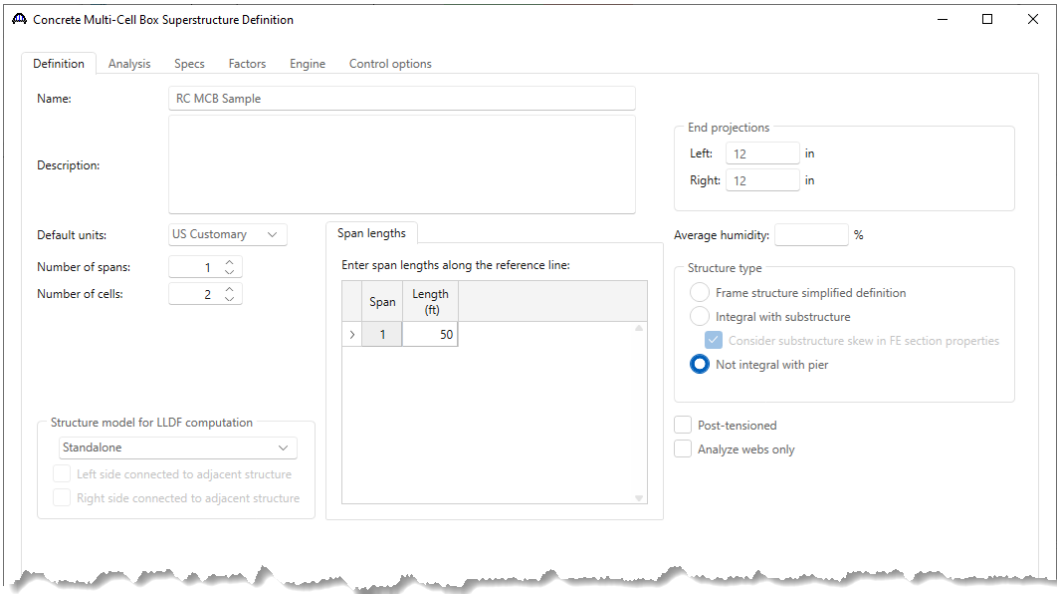
From the Bridge Explorer, click on the bridge **BID 27 MultiCell Box Examples** in the sample database and select **Open** from the **Bridge** group of the **BRIDGE** ribbon to open this bridge as shown below.



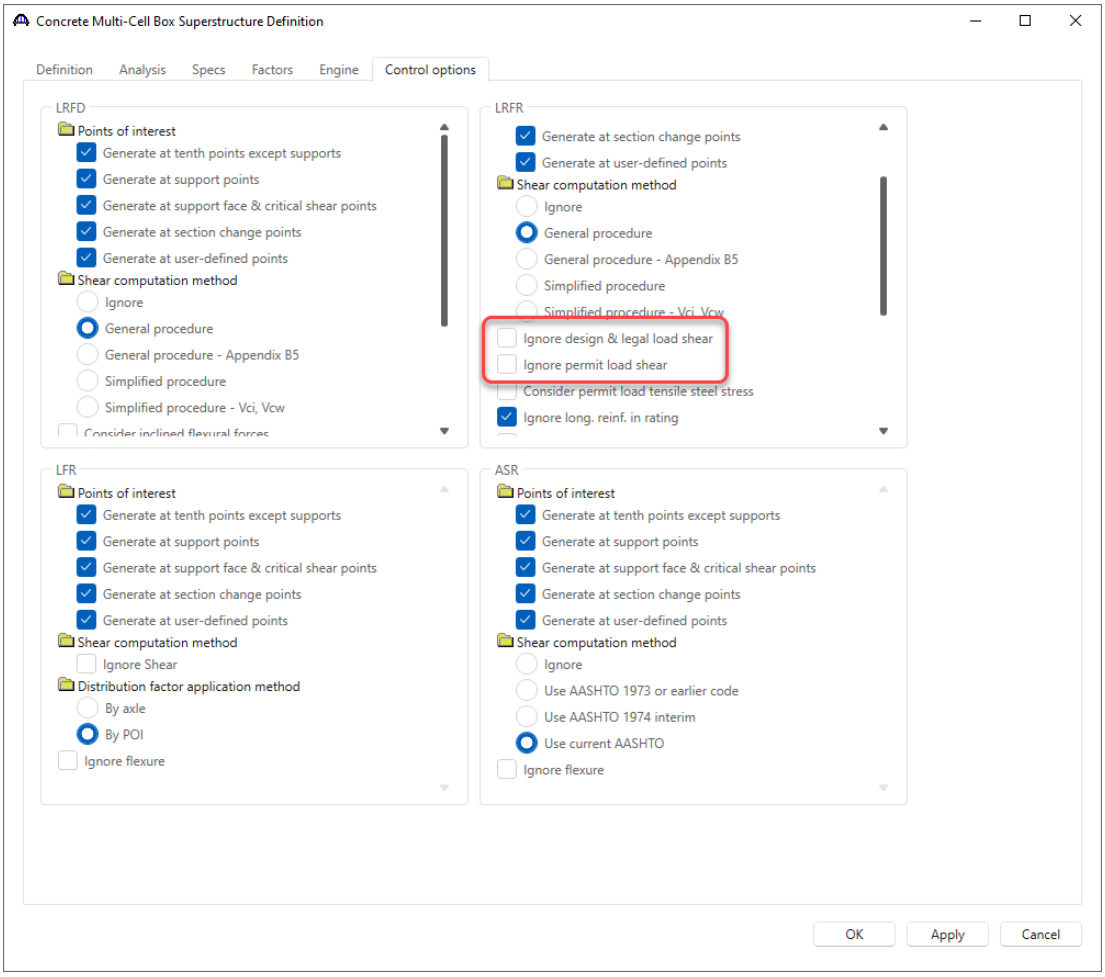
Concrete Multi-Cell Box Superstructure Definition

Double click on **SUPERSTRUCTURE DEFINITIONS** folder in the **BWS** tree to start creating a new MCB (Multi-Cell box) superstructure definition. Select **Concrete multi-cell box superstructure** and click **OK**. Be sure to leave **Post-tensioned** unchecked.





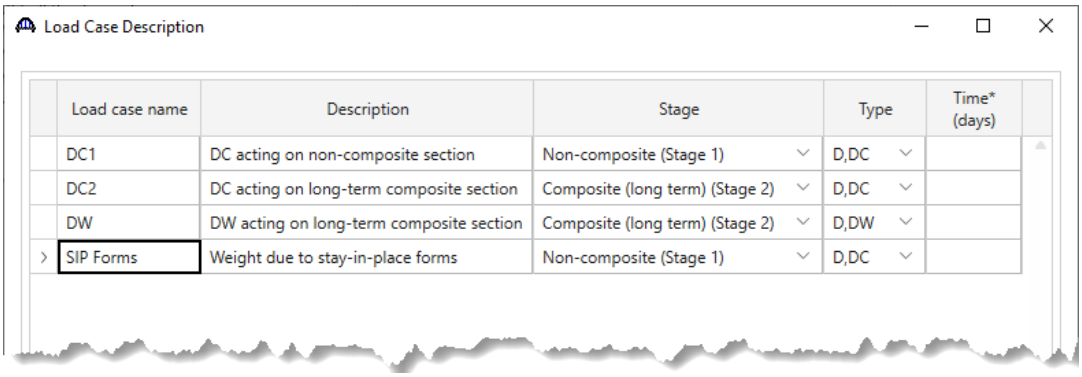
Navigate to the **Control options** tab of this window and uncheck the LRFR **Ignore shear** checkboxes.



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

Load Case Description

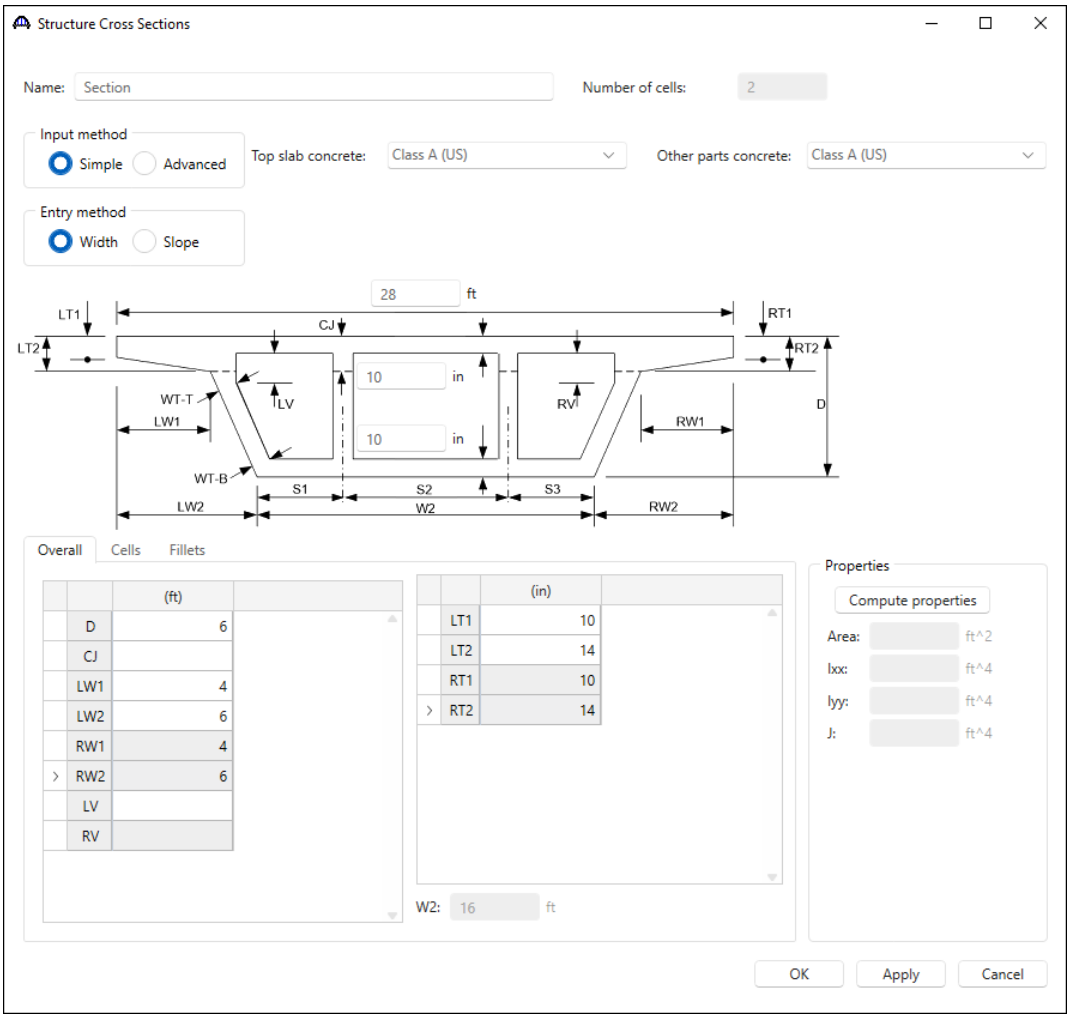
Expand the newly added superstructure definition **RC MCB Sample** folder in the **BWS** tree and double click on the **Load Case Description** node. Use the **Add default load case descriptions** button to create the following load cases.

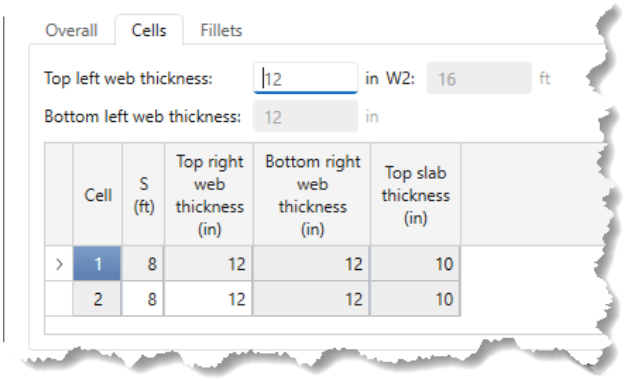


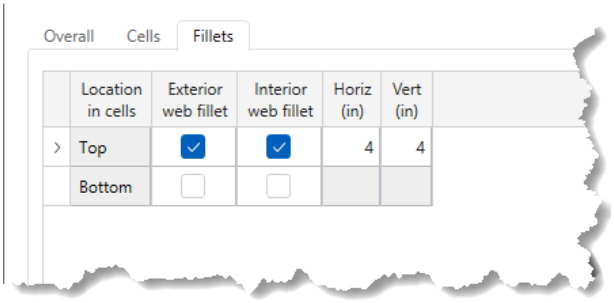
Click **OK** to apply the data and close the window.

Structure Cross Sections

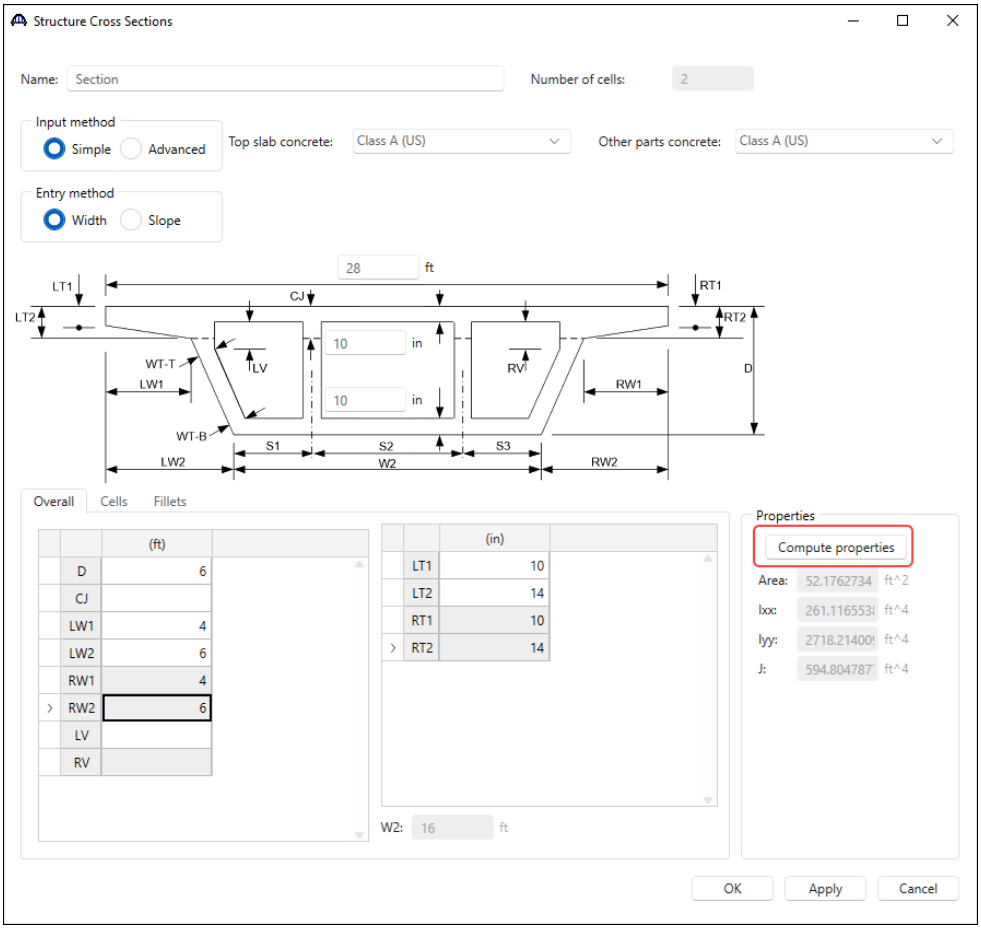
Double click on the **Structure Cross Sections** folder in the **BWS** tree and enter the following data.







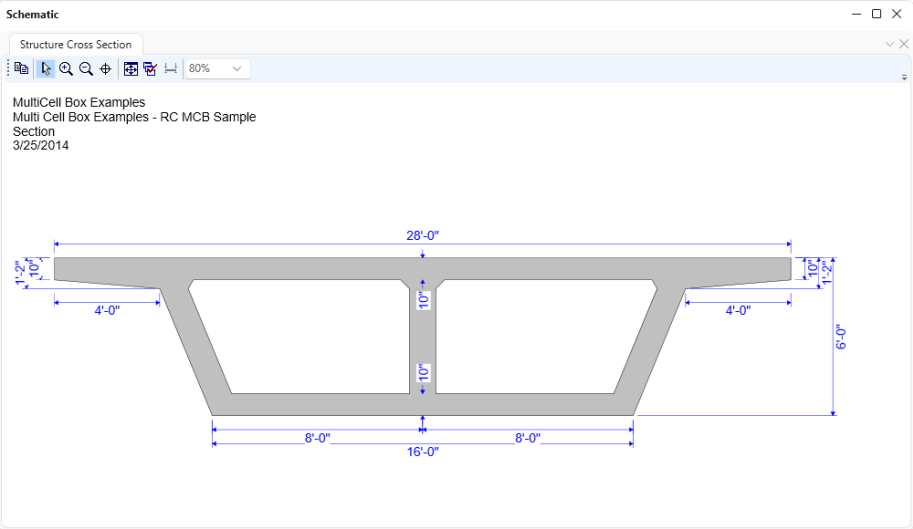
Click on the **Compute properties** button. The updated **Structure Cross Sections** window is shown below.



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

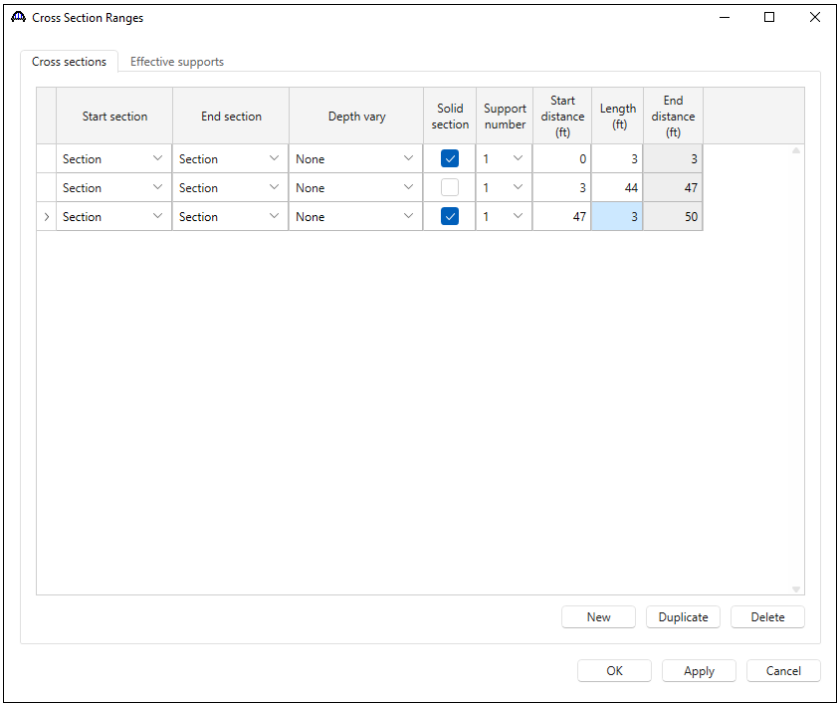
Structure Cross Section – Schematic

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



Cross Section Ranges

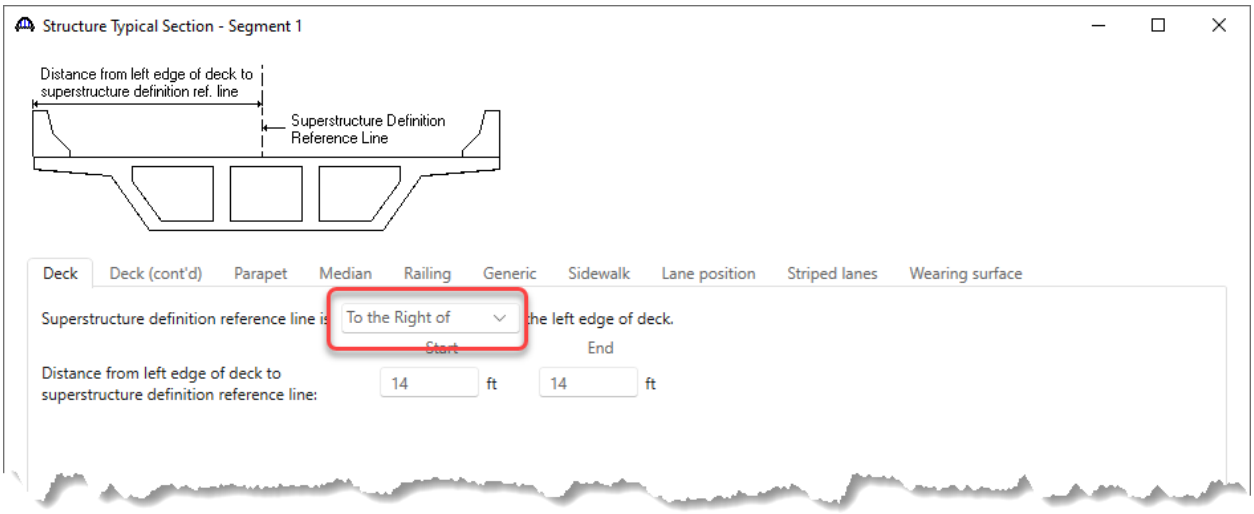
Double click on the **Cross Section Range Properties** node in the **BWS** tree and assign the cross section to the length of the superstructure as shown below.



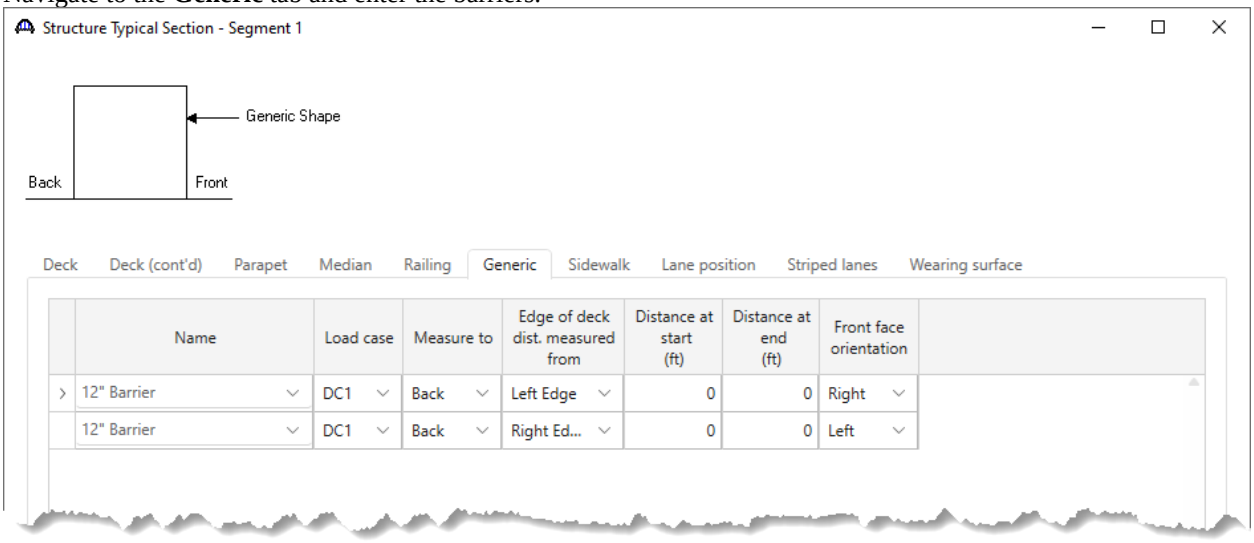
Click **OK** to apply the data and close the window.

Structure Typical Section

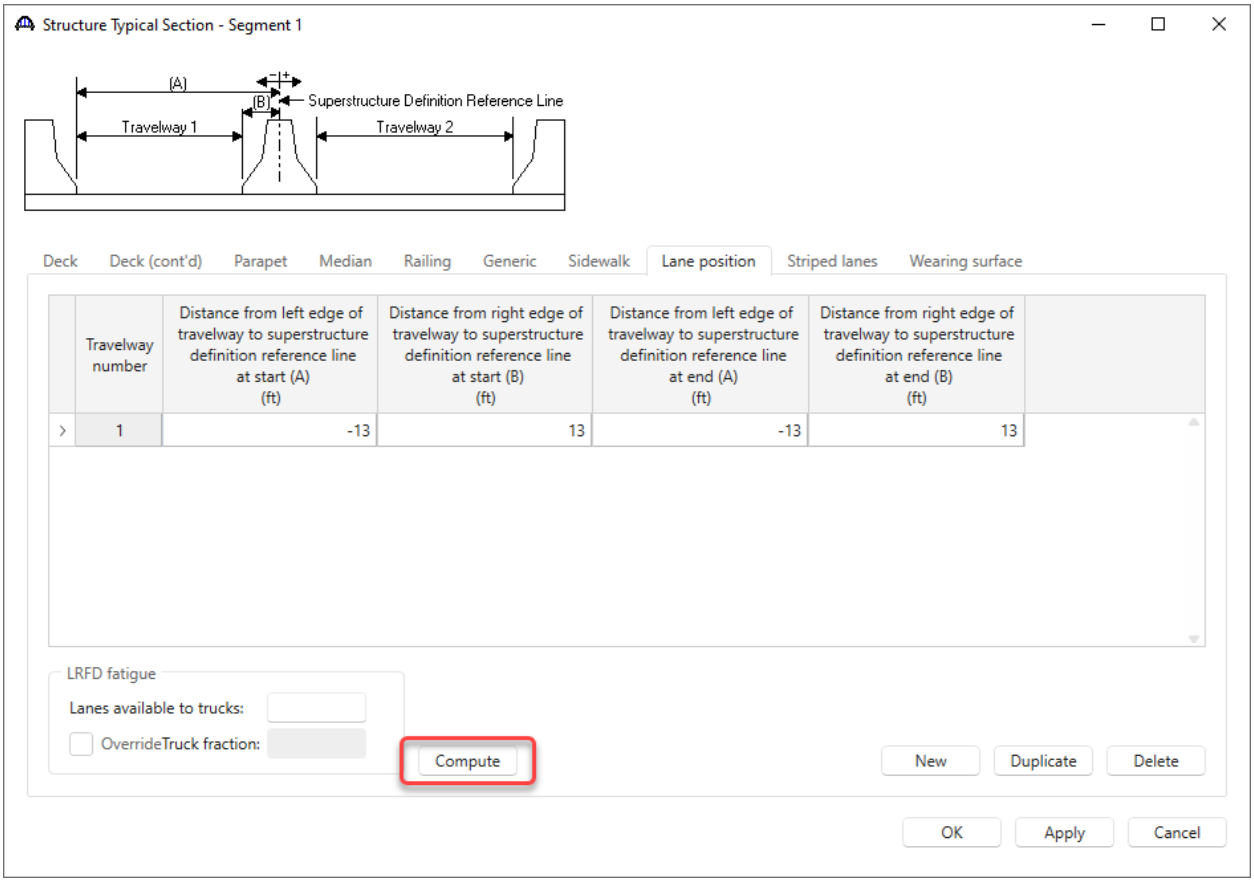
Double click on the **Structure Typical Section** node in the **BWS** tree and locate the superstructure definition reference line as follows.



Navigate to the **Generic** tab and enter the barriers.



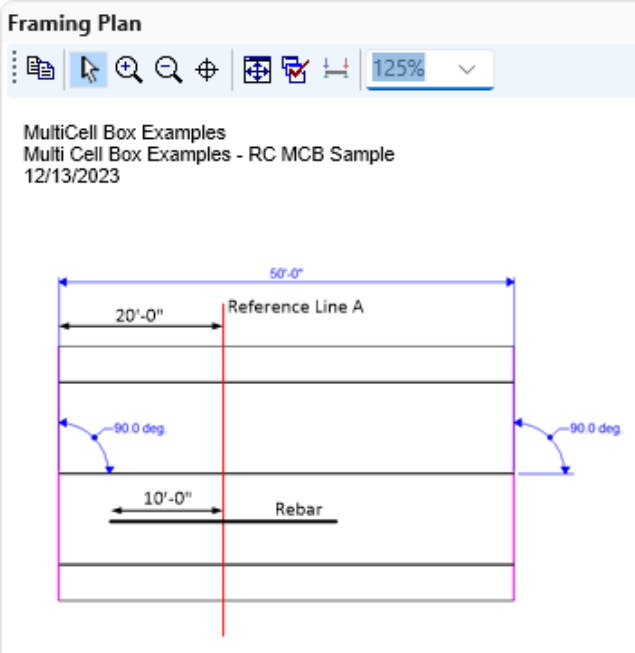
In the **Lane position** tab, use the **Compute** button to enter the lane positions.



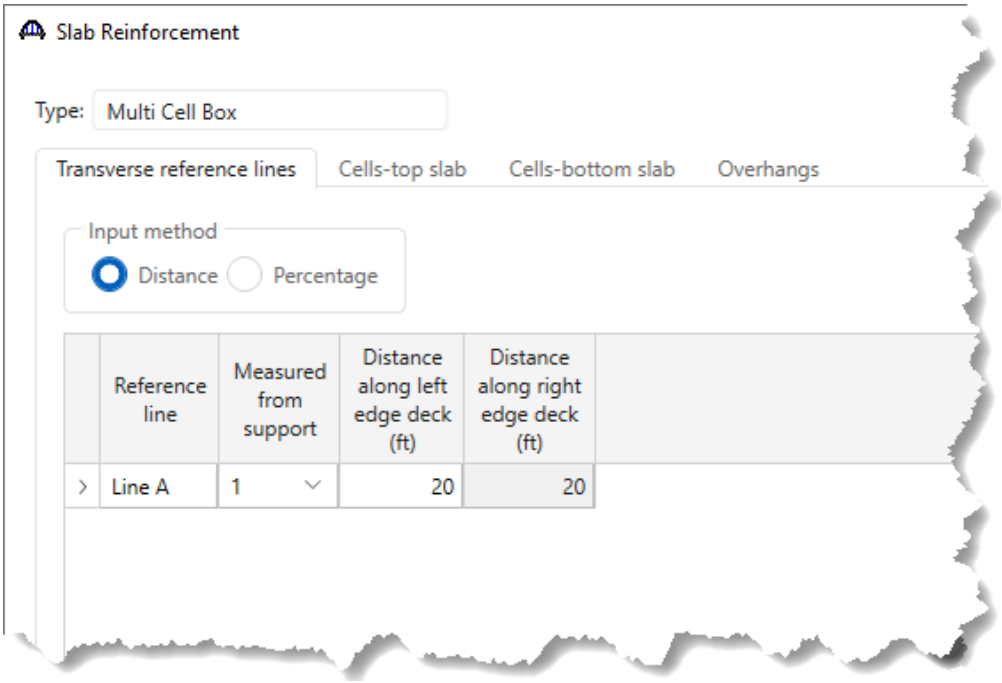
Click **OK** to apply the data and close the window.

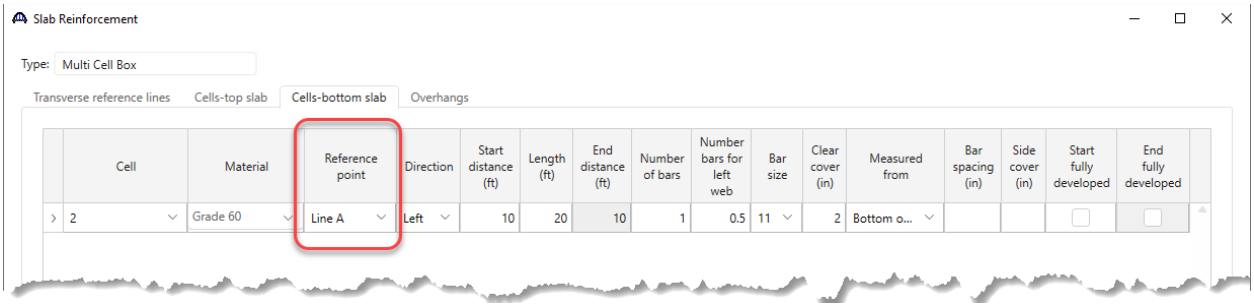
Slab Reinforcement

Slab reinforcement can be located in several ways for multi-cell boxes. One way is for the user to create user defined transverse reference lines from which to locate the reinforcement. A user defined reference line is shown in the following sketch.



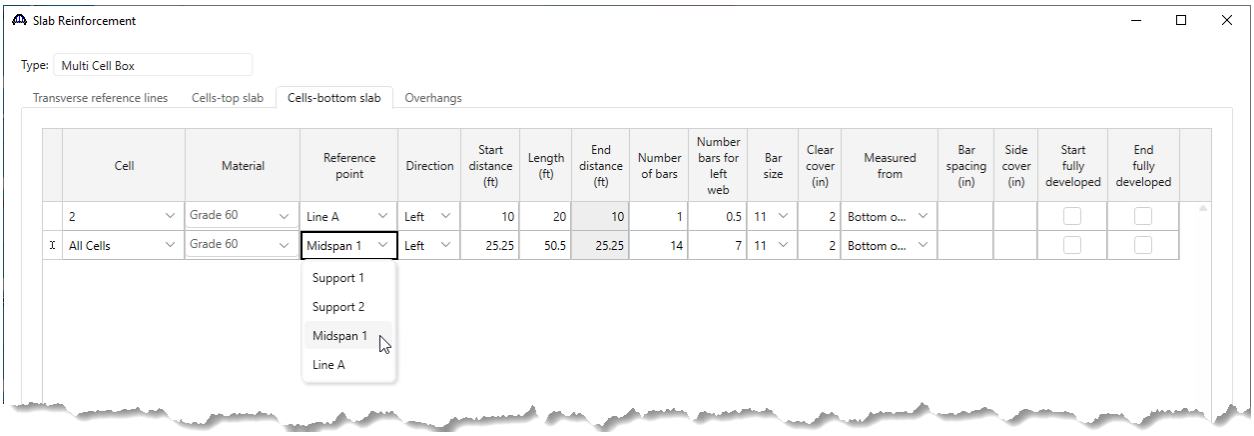
Open the **Slab Reinforcement** window and enter the following reinforcement in the **Transverse reference lines** and **Cells-bottom slab** of the box.

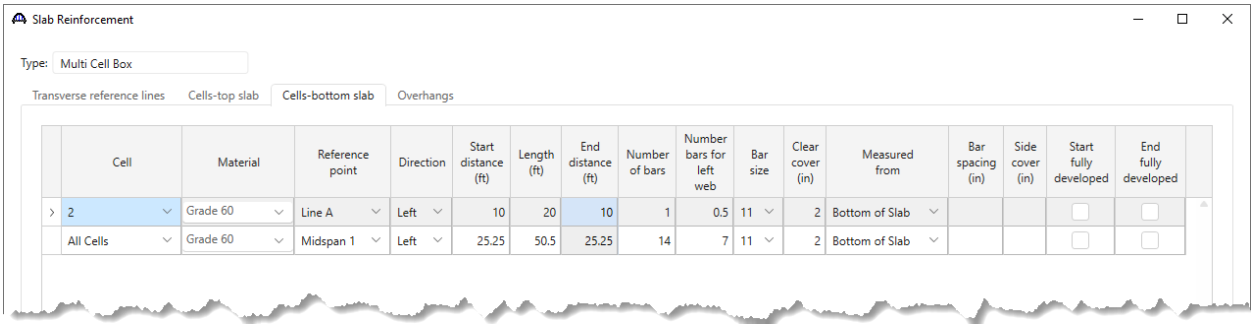




The start distance for this bar is located 10’ to the left of the reference Line A.

Another way to reference reinforcement in a MCB is from the middle of a span:



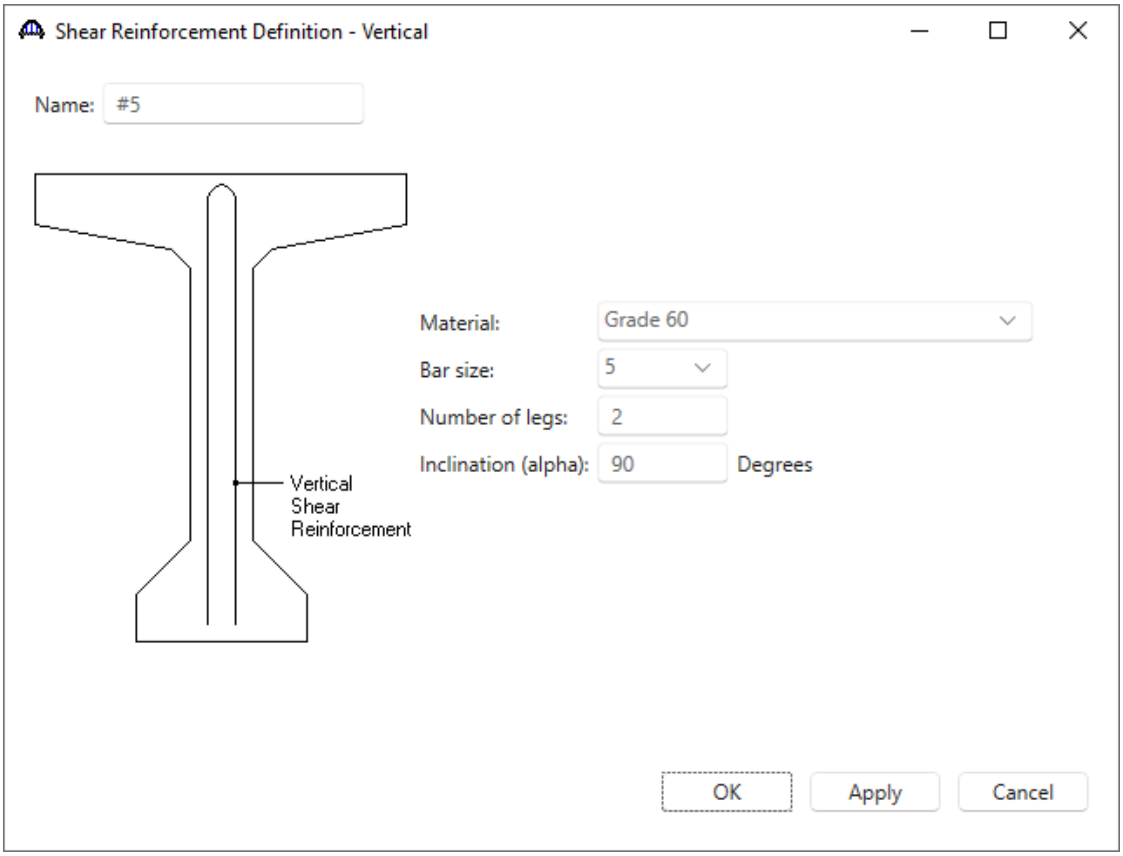


Click **OK** to apply the data and close the window.

Stirrup Wizard

Shear Reinforcement Definition - Vertical

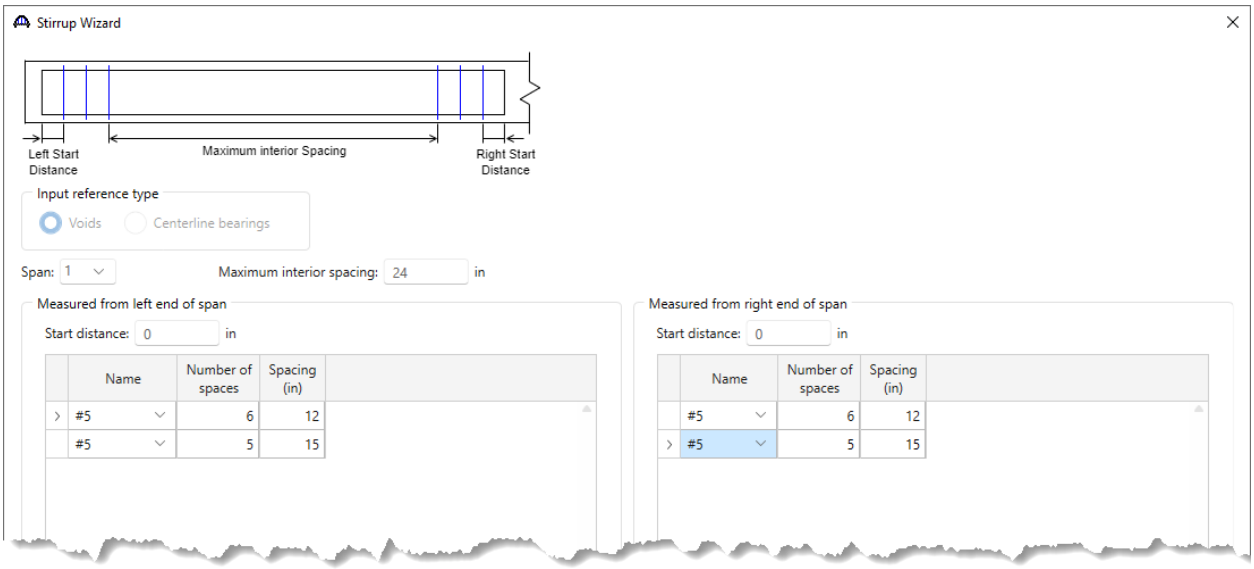
Open the **Vertical Shear Reinforcement Definitions** window and create the following stirrup definition.



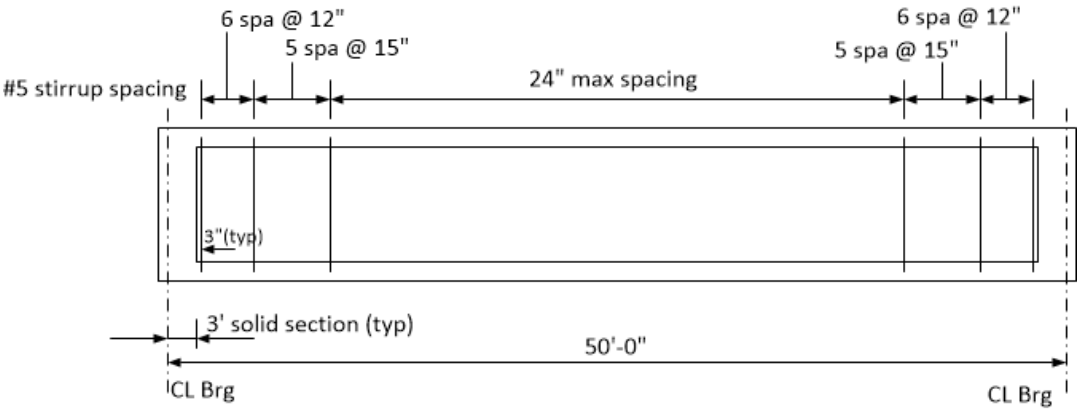
Click **OK** to apply the data and close the window.

WEB1 – Shear Reinforcement Ranges

Expand **WEBS** folder -> **WEB1** and double click on the **Shear Reinforcement Ranges** node. Select the input reference type as **Voids**. Click the **Stirrup wizard** button and enter the following data. Open the **WEB1 Shear Reinforcement Ranges** window and use the **Stirrup Wizard** to enter the following data.



Click the **Apply all** button, the stirrup ranges will be created as follows. Consider the following typical sketch from a set of design drawings.



During construction the region for the interior stirrups may have been divided into a number of equal spaces each less than 24" or the stirrups may have been placed at 24" max with one spacing less than 24". Since the actual stirrup placement is not known for sure, the conservative approach is taken to locate the stirrups. The stirrups are placed at the 24" max with an odd space less than 24" placed at the center of the span where the shear is the lowest.

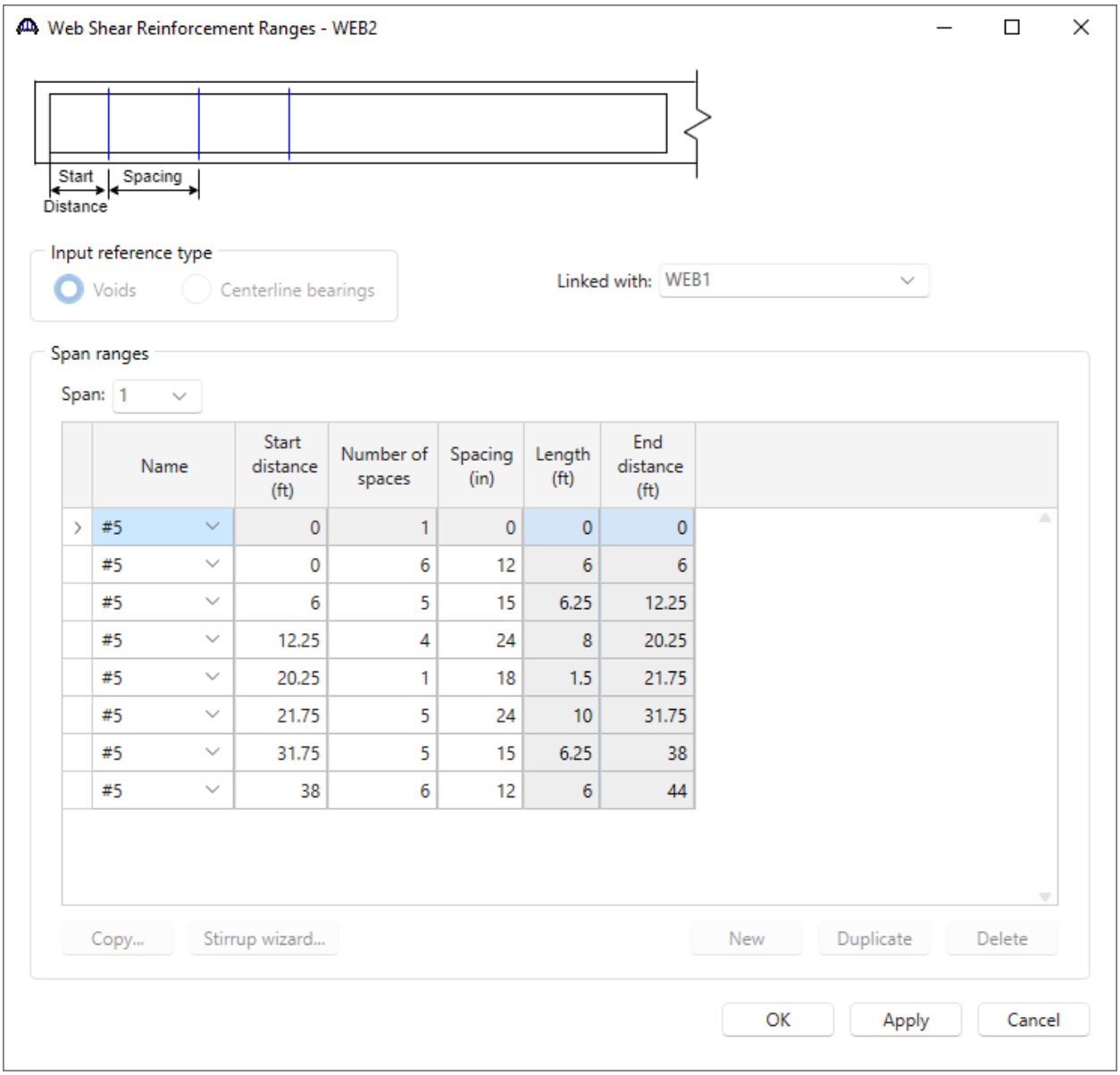
Span length between void faces L = 50' – 2(3')-2(0.25) = 43.5'
Interior Range L = 43.5' – 2*(6(1.0') + 5(1.25')) = 19.0'
Number spaces at max spacing = int(19.0'/2' max spacing) = 9.5

Odd space = 19.0’ – 9*2’ = 1.0’

Odd space is positioned near the middle of the span.

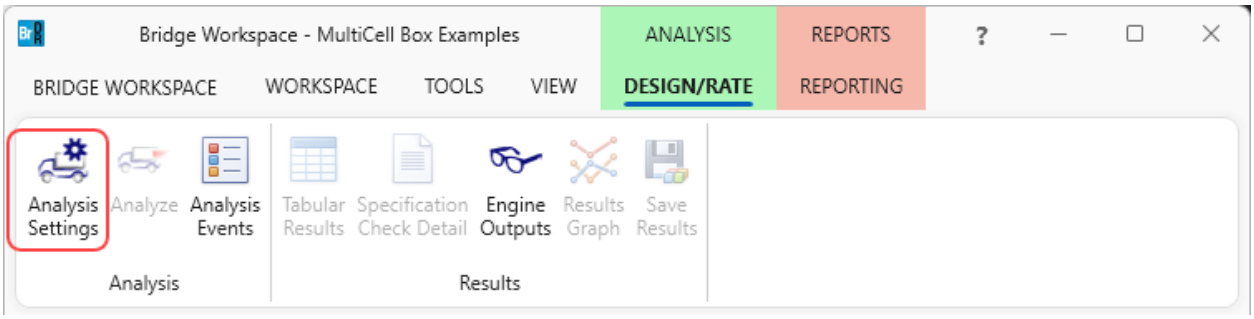
WEB2 - Shear Reinforcement Ranges

Expand the **WEB2** folder and double click on the **Shear Reinforcement Ranges** node. Select **WEB1** in the **Linked with** field. The data from **WEB1** will appear in this window as read only. If data is changed in the **WEB1 Shear Reinforcement Ranges** window in the future, those changes will be reflected in this window. Do the same for **WEB3**, linking it to **WEB1**.

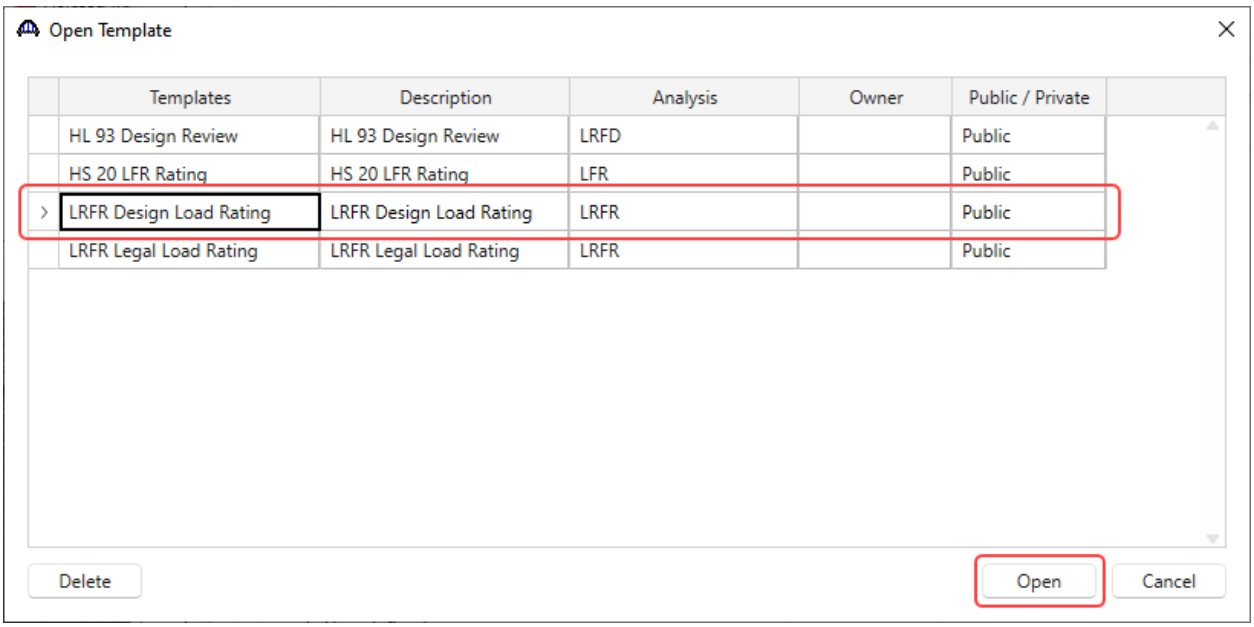


Web Analysis

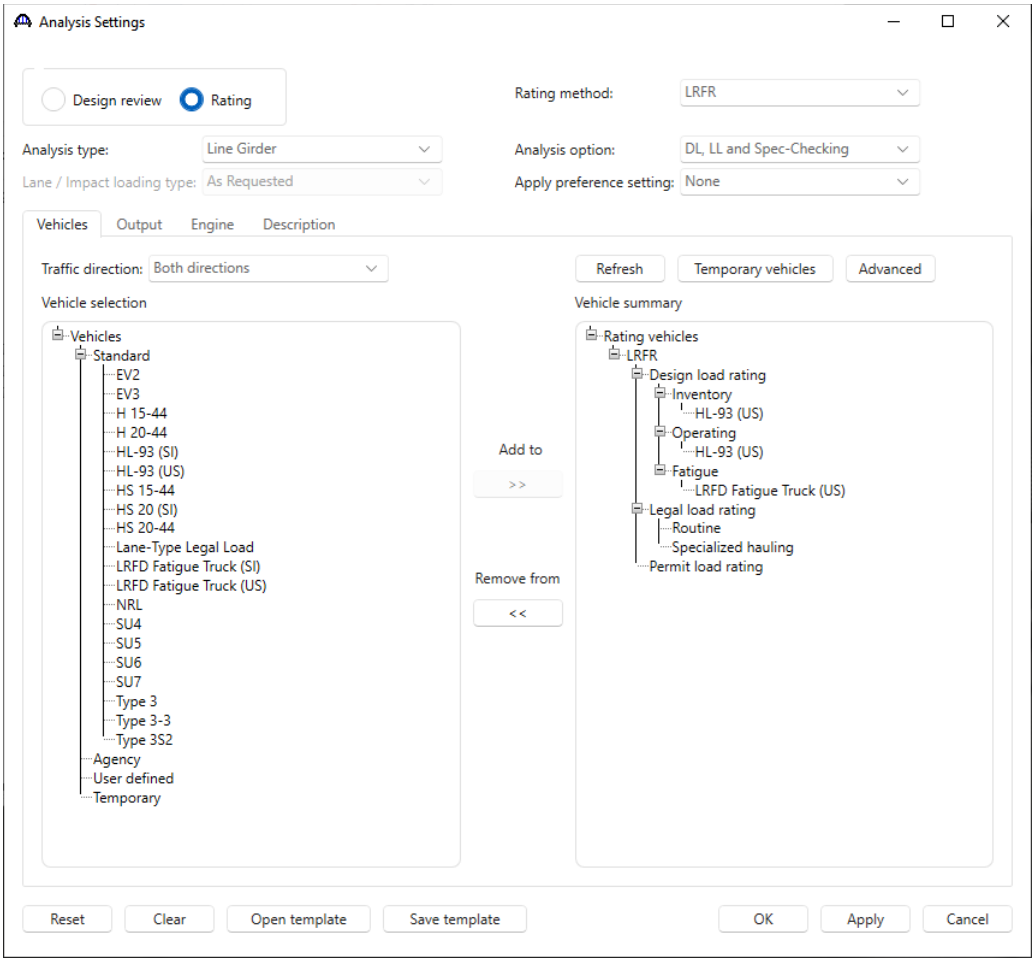
To run an LRFR analysis on **WEB1**, click on the **Analysis Settings** window from the **Analysis** group of the **DESIGN/RATE** ribbon.



Click on the **Open template** button in the **Analysis Settings** window, select the **LRFR Design Load Rating** from the analysis templates and click **Open**. The full multi-cell box width is analyzed for flexure and shear and then each webline is analyzed for shear.

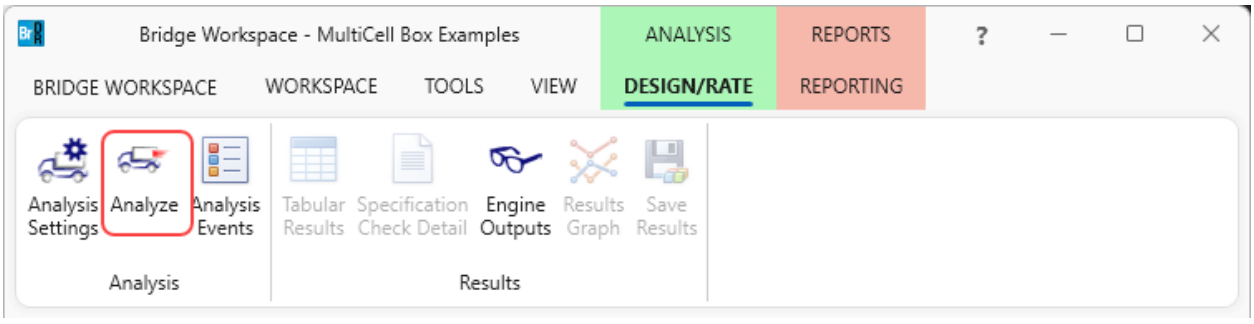


The updated **Analysis Settings** window is shown below.



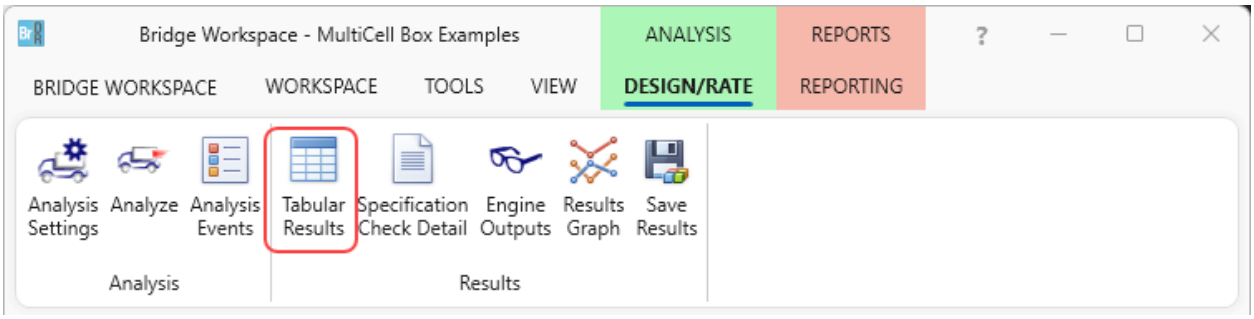
Click **OK** to apply the settings and close the window.

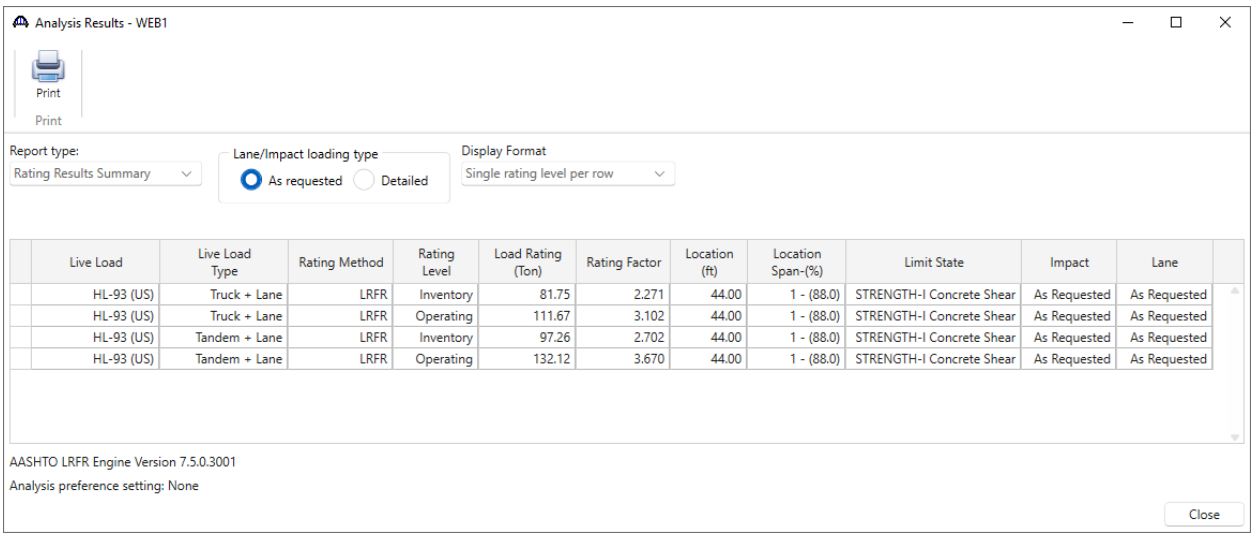
With **WEB1** selected in the **BWS** tree, click on the **Analyze** button from the **Analysis** group of the **DESIGN/RATE** ribbon.



Tabular Results

Once the analysis is complete, click on the **Tabular Results** button from the **Results** group of the **DESIGN/RATE** ribbon. The **Analysis Results** window shows the critical rating factors considering the full box and each webline.





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	81.75	2.271	44.00	1 - (88.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	111.67	3.102	44.00	1 - (88.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	97.26	2.702	44.00	1 - (88.0)	STRENGTH-I Concrete Shear	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	132.12	3.670	44.00	1 - (88.0)	STRENGTH-I Concrete Shear	As Requested	As Requested