

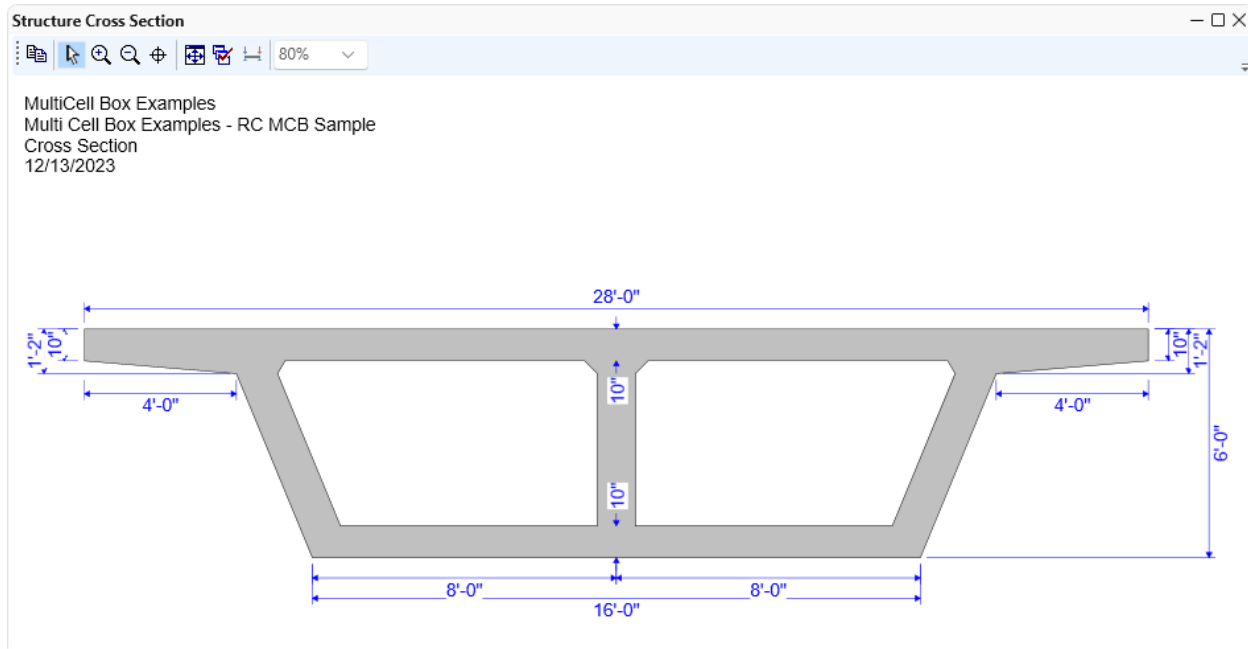
*AASHTOWare BrDR 7.5.0*

---

*Multi-Cell Box Tutorial*

*MCB2 – Reinforced Concrete Multi-Cell Box Example*

## MCB2 – Reinforced Concrete Multi-Cell Box Example



### 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

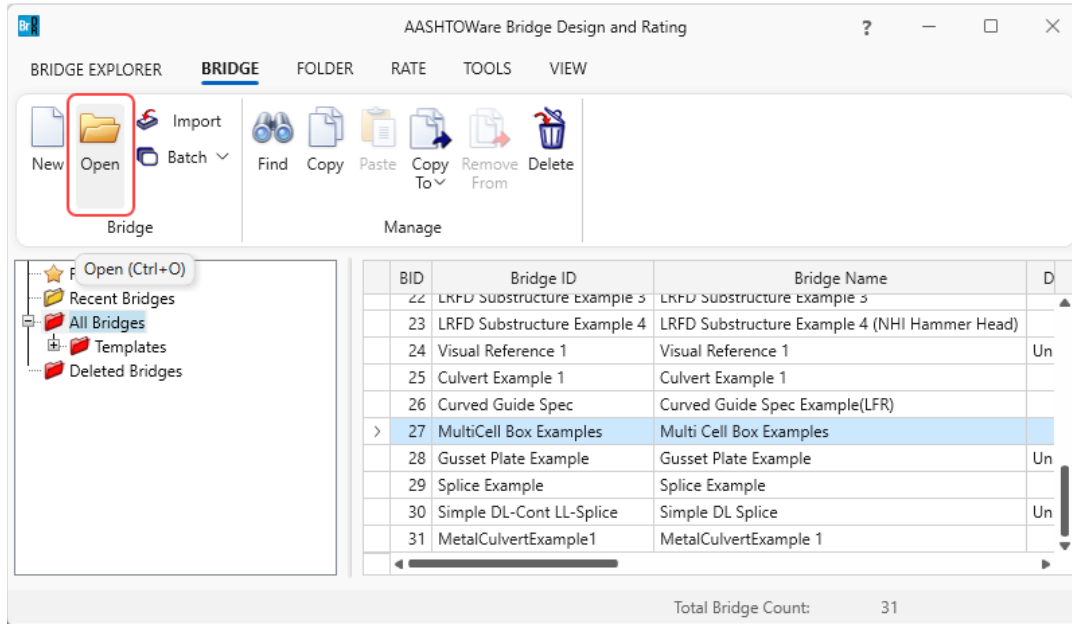
Reinforced concrete multicell box (MCB) superstructures can be analyzed in the following manners:

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

## MCB2 – Reinforced Concrete Multi-Cell Box Example

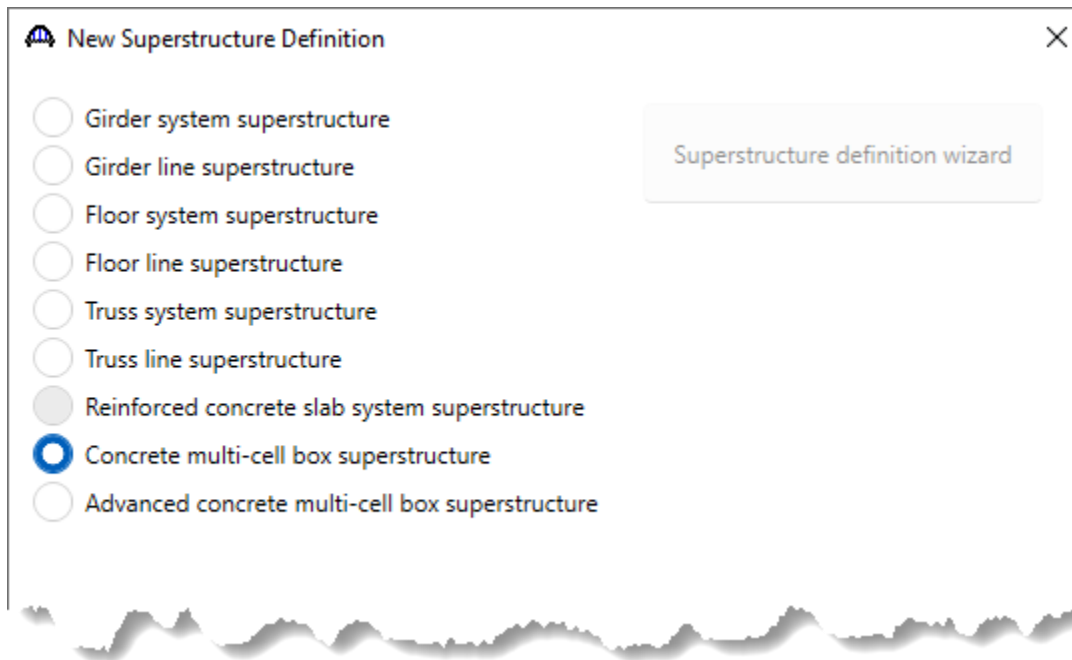
### Slab Reinforcement Data Entry

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.

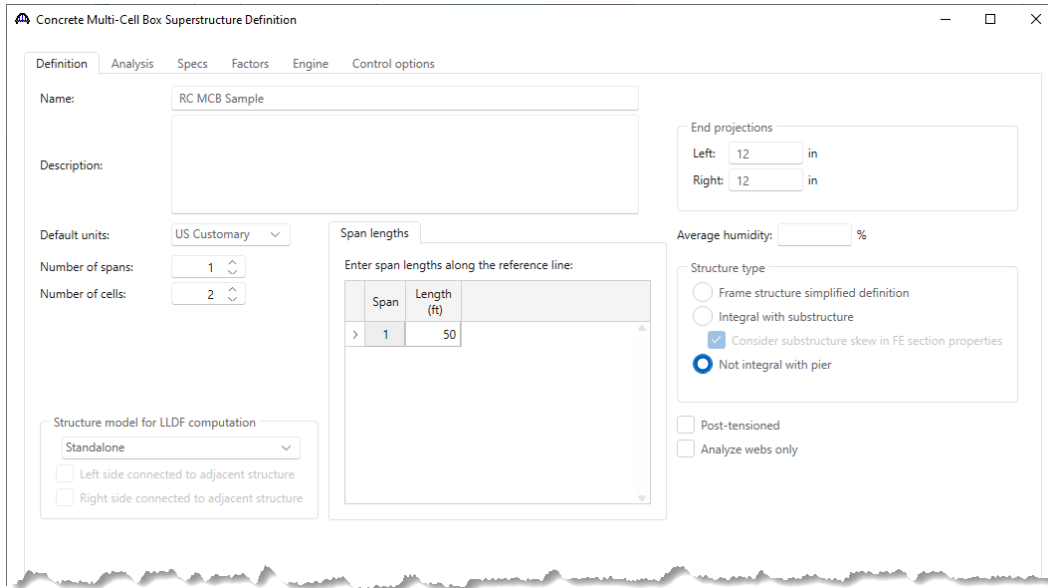


### Concrete Multi-Cell Box Superstructure Definition

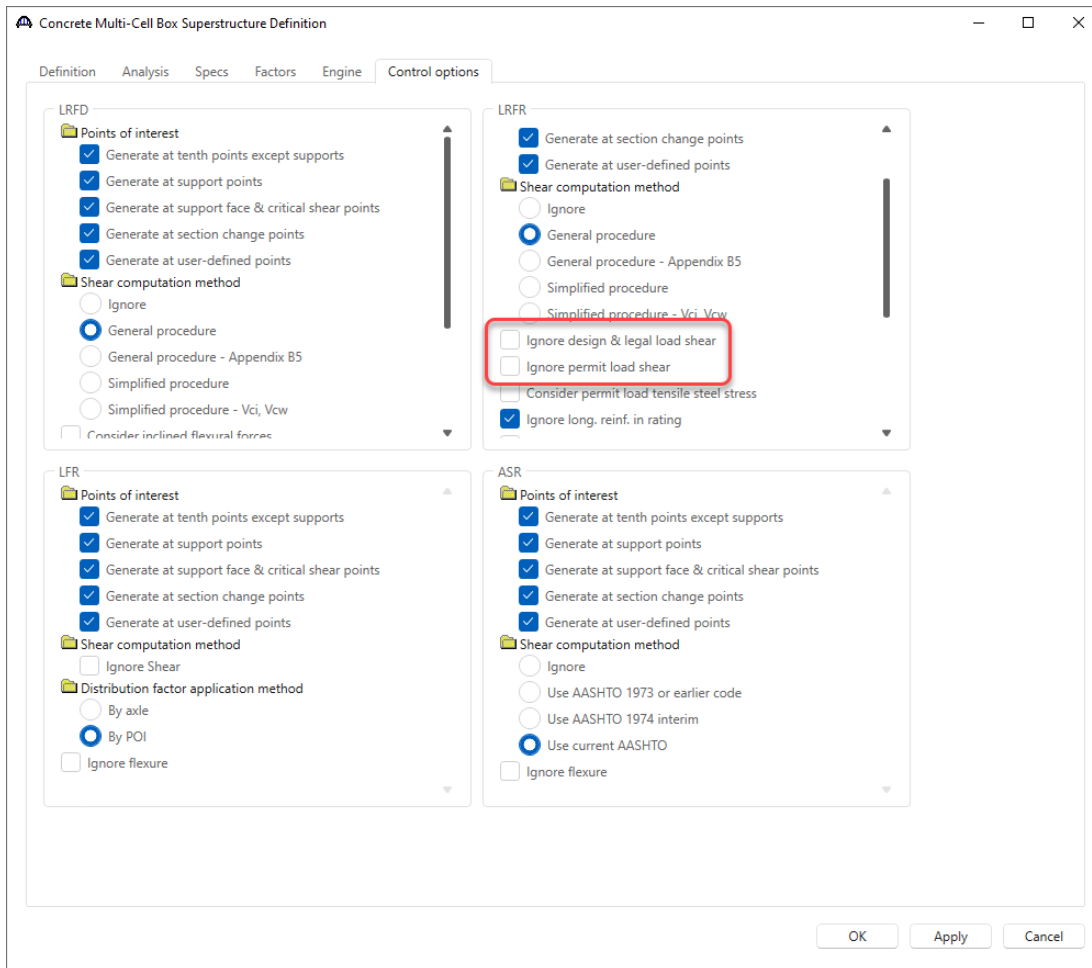
Double click on **SUPERSTRUCTURE DEFINITIONS** folder in the **BWS** tree to start creating a new MCB (Multi-Cell box) superstructure definition. Select **Concrete multi-cell box superstructure** and click **OK**. Be sure to leave **Post-tensioned** unchecked.



# MCB2 – Reinforced Concrete Multi-Cell Box Example



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

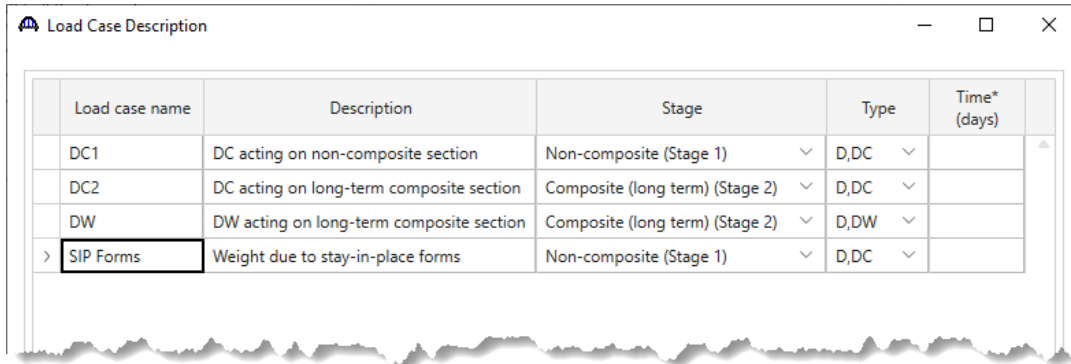


Click **OK** to apply the data and close the window.

## MCB2 – Reinforced Concrete Multi-Cell Box Example

### 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.

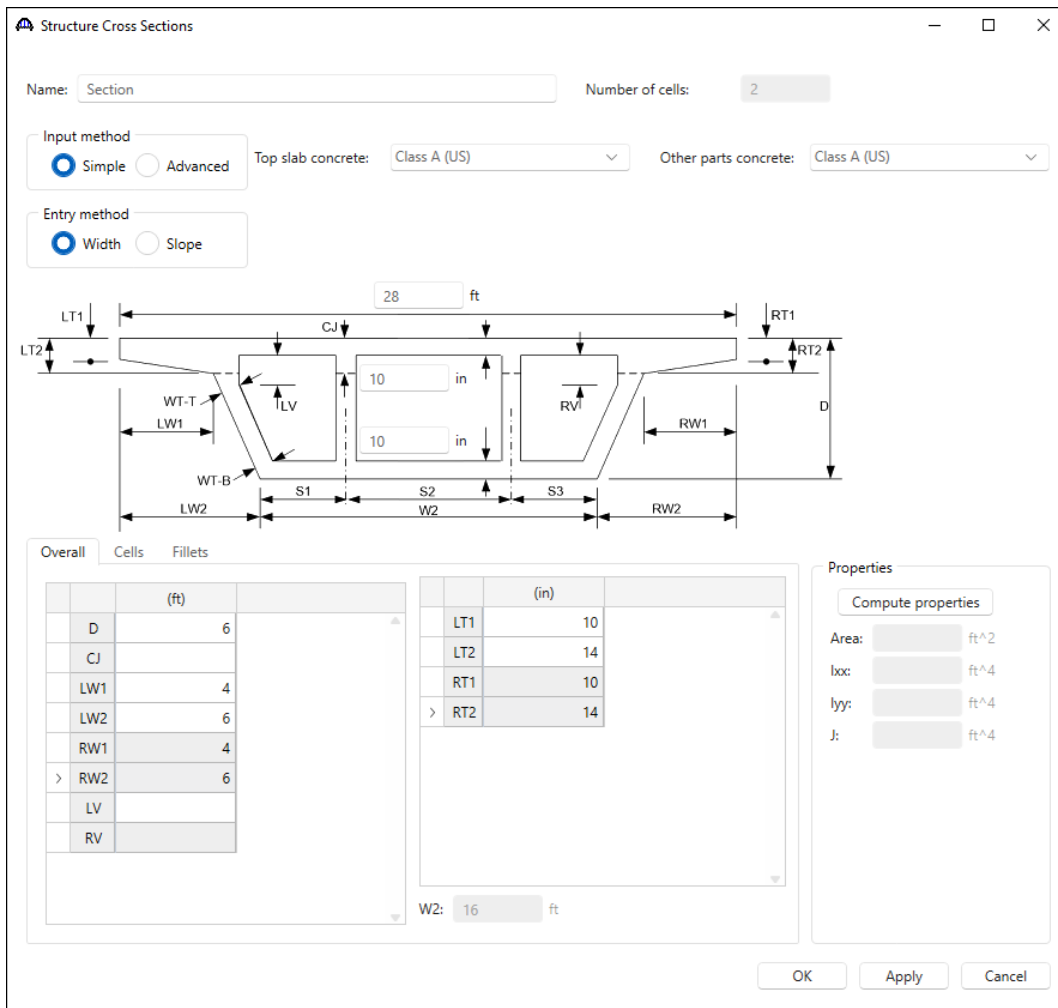


Load case name	Description	Stage	Type	Time* (days)
DC1	DC acting on non-composite section	Non-composite (Stage 1)	D,DC	
DC2	DC acting on long-term composite section	Composite (long term) (Stage 2)	D,DC	
DW	DW acting on long-term composite section	Composite (long term) (Stage 2)	D,DW	
> SIP Forms	Weight due to stay-in-place forms	Non-composite (Stage 1)	D,DC	

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.



Name: Section Number of cells: 2

Input method:  Simple  Advanced Top slab concrete: Class A (US) Other parts concrete: Class A (US)

Entry method:  Width  Slope

Diagram labels: LT1, LT2, CJ, RT1, RT2, WT-T, LW1, WT-B, LW2, LV, S1, S2, S3, W2, RW1, RW2, RV1, D

Overall (ft) table:

	(ft)
D	6
CJ	
LW1	4
LW2	6
RW1	4
> RW2	6
LV	
RV	

Cells (in) table:

	(in)
LT1	10
LT2	14
RT1	10
> RT2	14

W2: 16 ft

Properties: Compute properties Area: ft^2 Ixx: ft^4 Iyy: ft^4 J: ft^4

Buttons: OK Apply Cancel

# MCB2 – Reinforced Concrete Multi-Cell Box Example

Overall Cells Fillets

Top left web thickness:  in W2:  ft

Bottom left web thickness:  in

Cell	S (ft)	Top right web thickness (in)	Bottom right web thickness (in)	Top slab thickness (in)
> 1	8	12	12	10
2	8	12	12	10

Overall Cells Fillets

Location in cells	Exterior web fillet	Interior web fillet	Horiz (in)	Vert (in)
> Top	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	4	4
Bottom	<input type="checkbox"/>	<input type="checkbox"/>		

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

Structure Cross Sections

Name:  Number of cells:

Input method:  Simple  Advanced Top slab concrete:  Other parts concrete:

Entry method:  Width  Slope

Overall Cells Fillets

	(ft)
D	6
CJ	
LW1	4
LW2	6
RW1	4
> RW2	6
LV	
RV	

	(in)
LT1	10
LT2	14
RT1	10
> RT2	14

W2:  ft

Properties

**Compute properties**

Area: 52.1762734 ft<sup>2</sup>

Ixx: 261.1165531 ft<sup>4</sup>

Iyy: 2718.214001 ft<sup>4</sup>

J: 594.804787 ft<sup>4</sup>

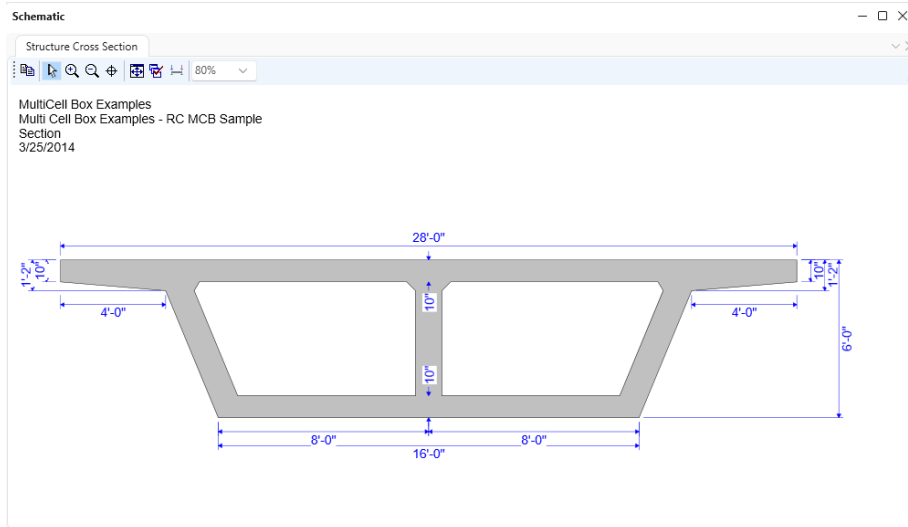
OK Apply Cancel

## MCB2 – Reinforced Concrete Multi-Cell Box Example

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.

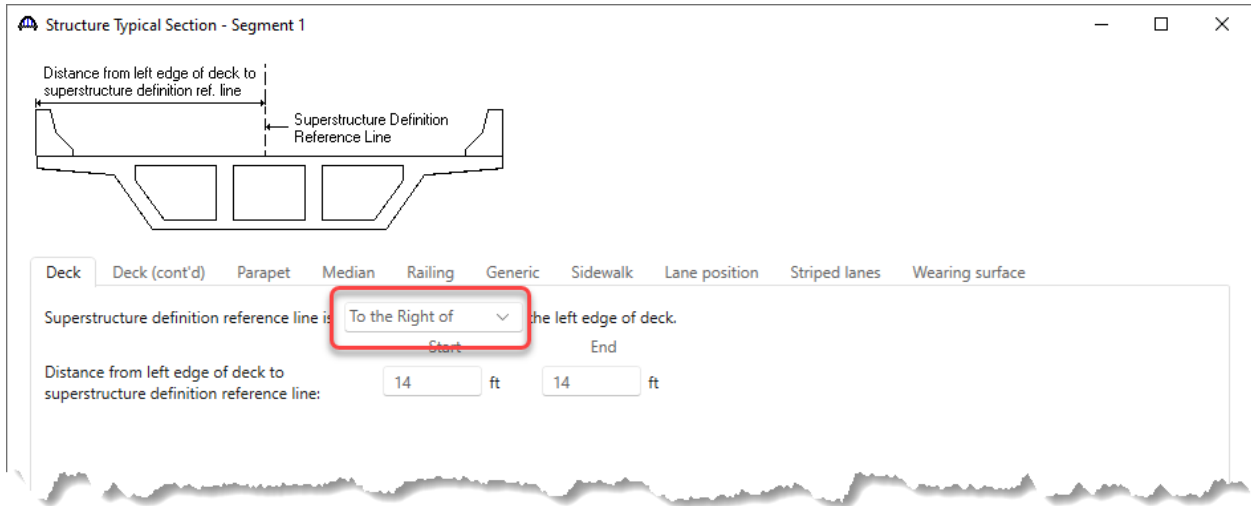
Start section	End section	Depth vary	Solid section	Support number	Start distance (ft)	Length (ft)	End distance (ft)
Section	Section	None	<input checked="" type="checkbox"/>	1	0	3	3
Section	Section	None	<input type="checkbox"/>	1	3	44	47
> Section	Section	None	<input checked="" type="checkbox"/>	1	47	3	50

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

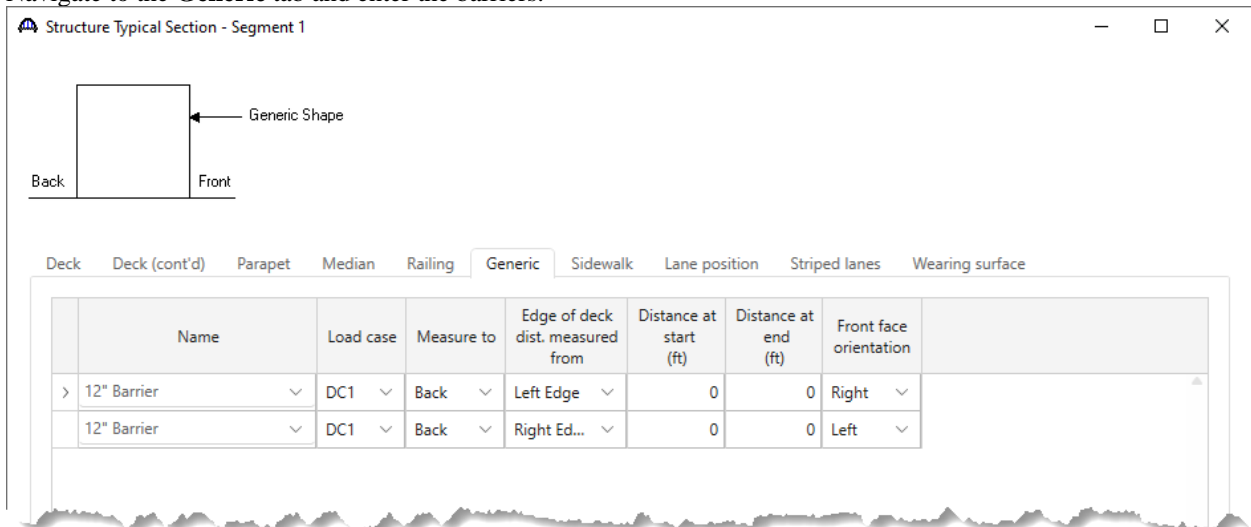
# MCB2 – Reinforced Concrete Multi-Cell Box Example

## 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.





# MCB2 – Reinforced Concrete Multi-Cell Box Example

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

The screenshot shows a software window titled "Structure Typical Section - Segment 1". At the top, there is a diagram of a cross-section of a multi-cell box girder. It shows two travelways, "Travelway 1" and "Travelway 2", separated by a central median. A dashed vertical line represents the "Superstructure Definition Reference Line". Dimensions (A) and (B) are indicated with arrows. (A) is the distance from the left edge of Travelway 1 to the reference line at the start. (B) is the distance from the right edge of Travelway 2 to the reference line at the start. Below the diagram is a tabbed interface with the following tabs: Deck, Deck (cont'd), Parapet, Median, Railing, Generic, Sidewalk, Lane position (selected), Striped lanes, and Wearing surface. The "Lane position" tab contains a table with the following data:

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	-13	13	-13	13

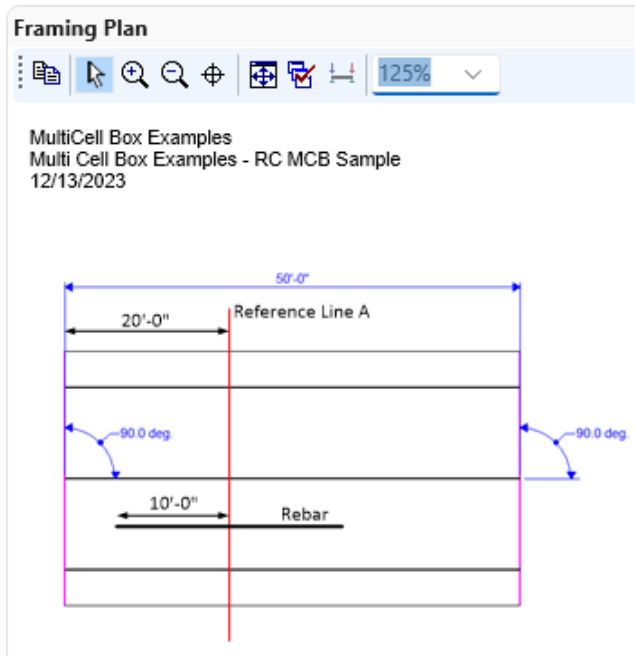
Below the table, there is a section for "LRFD fatigue" with a checkbox for "OverrideTruck fraction" and a text input field for "Lanes available to trucks". A "Compute" button is highlighted with a red box. To the right of the "Compute" button are buttons for "New", "Duplicate", and "Delete". At the bottom right of the window are buttons for "OK", "Apply", and "Cancel".

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

# MCB2 – Reinforced Concrete Multi-Cell Box Example

## 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.

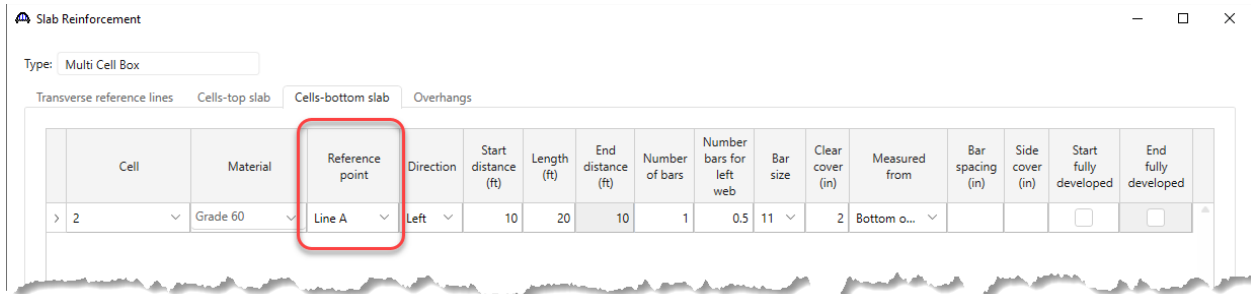


Open the **Slab Reinforcement** window and enter the following reinforcement in the **Transverse reference lines** and **Cells-bottom slab** of the box.

The screenshot shows the 'Slab Reinforcement' window. The 'Type' is set to 'Multi Cell Box'. The 'Transverse reference lines' tab is selected. The 'Input method' is set to 'Distance'. A table below shows the configuration for 'Line A'.

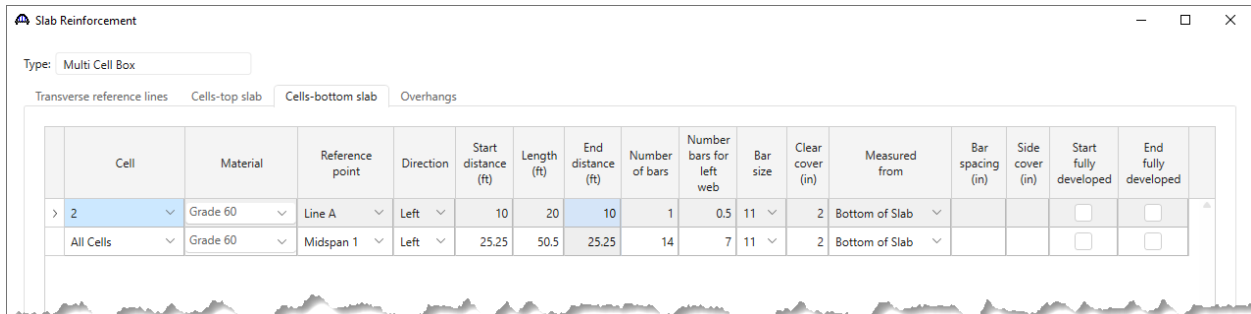
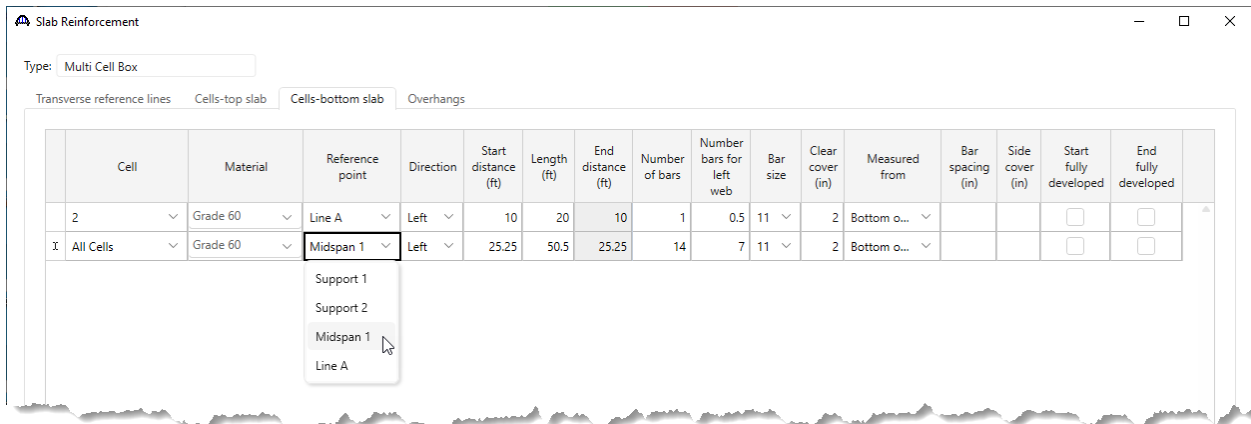
Reference line	Measured from support	Distance along left edge deck (ft)	Distance along right edge deck (ft)
> Line A	1	20	20

# MCB2 – Reinforced Concrete Multi-Cell Box Example



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:



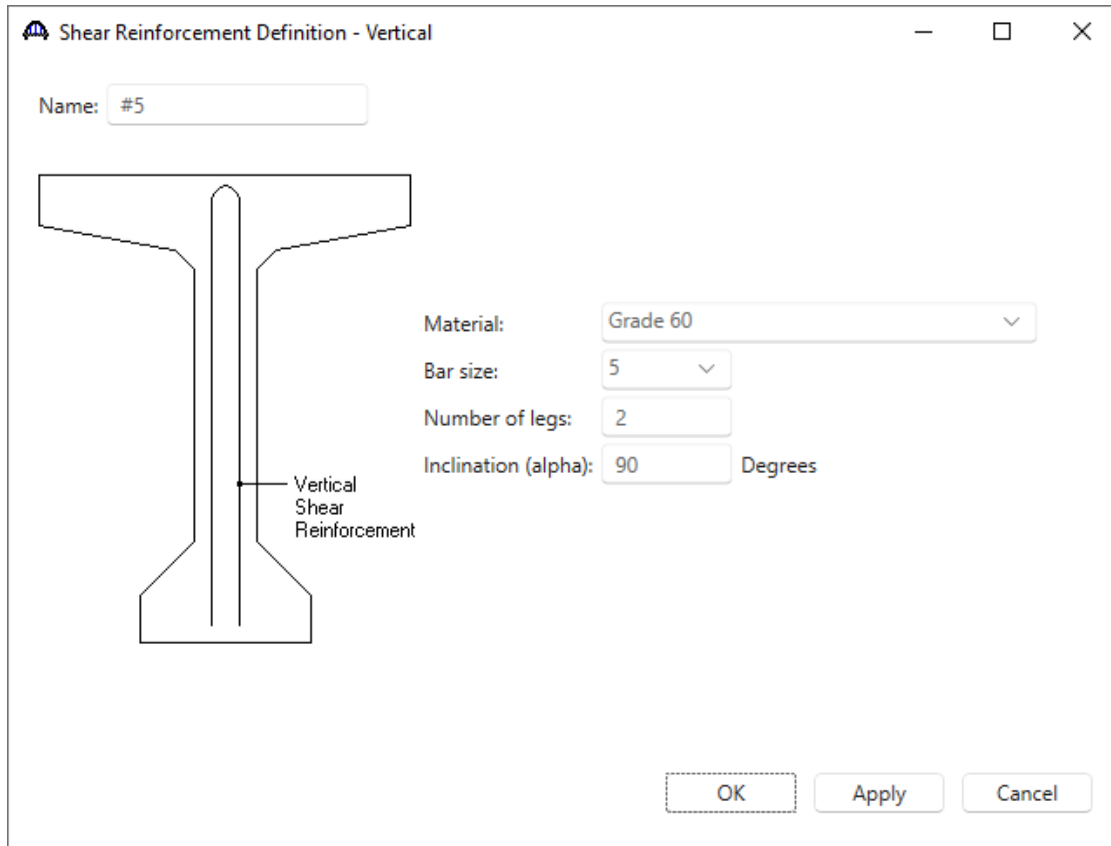
Click **OK** to apply the data and close the window.

## MCB2 – Reinforced Concrete Multi-Cell Box Example

### Stirrup Wizard

#### Shear Reinforcement Definition - Vertical

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



The dialog box titled "Shear Reinforcement Definition - Vertical" contains the following fields and controls:

- Name: #5
- Material: Grade 60
- Bar size: 5
- Number of legs: 2
- Inclination (alpha): 90 Degrees

A diagram of a reinforced concrete beam cross-section is shown on the left, with a label "Vertical Shear Reinforcement" pointing to the stirrups. The "OK" button is highlighted with a dashed border.

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

## MCB2 – Reinforced Concrete Multi-Cell Box Example

### 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.

Stirrup Wizard

Input reference type:  Voids  Centerline bearings

Span: 1 Maximum interior spacing: 24 in

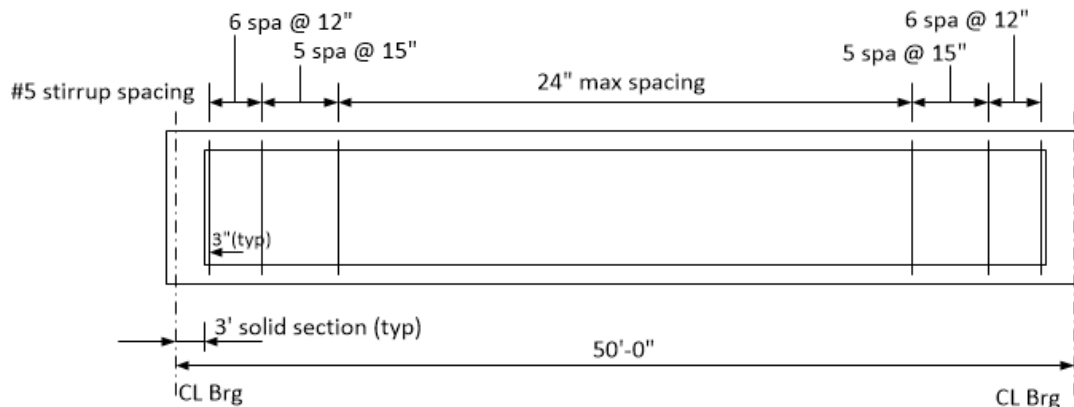
Measured from left end of span  
Start distance: 0 in

Name	Number of spaces	Spacing (in)
> #5	6	12
#5	5	15

Measured from right end of span  
Start distance: 0 in

Name	Number of spaces	Spacing (in)
#5	6	12
> #5	5	15

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.

$$\text{Span length between void faces } L = 50' - 2(3') - 2(0.25) = 43.5'$$

$$\text{Interior Range } L = 43.5' - 2*(6(1.0') + 5(1.25')) = 19.0'$$

$$\text{Number spaces at max spacing} = \text{int}(19.0'/2' \text{ max spacing}) = 9.5$$

## MCB2 – Reinforced Concrete Multi-Cell Box Example

Odd space =  $19.0' - 9 \times 2' = 1.0'$

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 Shear Reinforcement Ranges - WEB2

Input reference type:  Voids  Centerline bearings

Linked with: WEB1

Span ranges

Span: 1

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> #5	0	1	0	0	0
#5	0	6	12	6	6
#5	6	5	15	6.25	12.25
#5	12.25	4	24	8	20.25
#5	20.25	1	18	1.5	21.75
#5	21.75	5	24	10	31.75
#5	31.75	5	15	6.25	38
#5	38	6	12	6	44

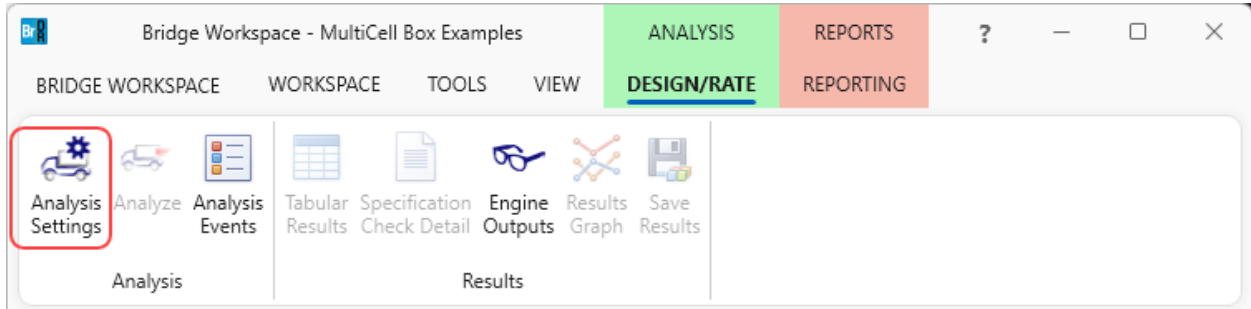
Copy... Stirrup wizard... New Duplicate Delete

OK Apply Cancel

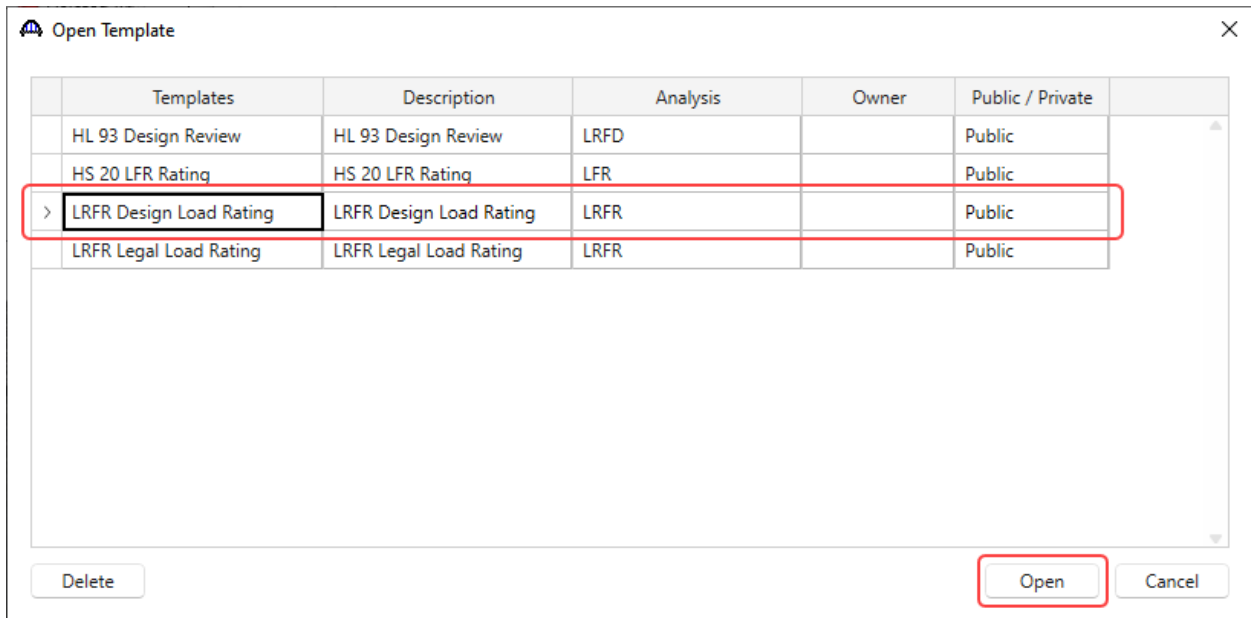
## MCB2 – Reinforced Concrete Multi-Cell Box Example

### Web Analysis

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

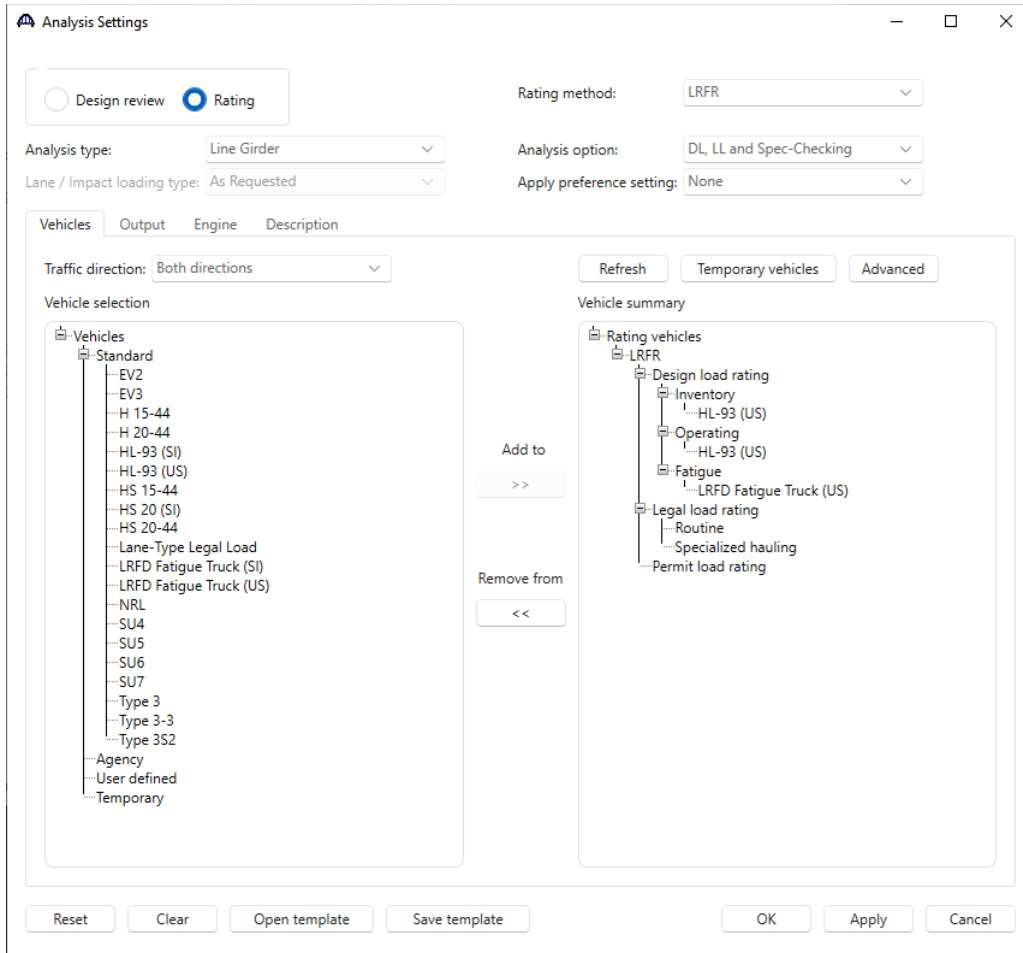


Click on the **Open template** button in the **Analysis Settings** window, select the **LRFR Design Load Rating** from the analysis templates and click **Open**. The full multi-cell box width is analyzed for flexure and shear and then each webline is analyzed for shear.



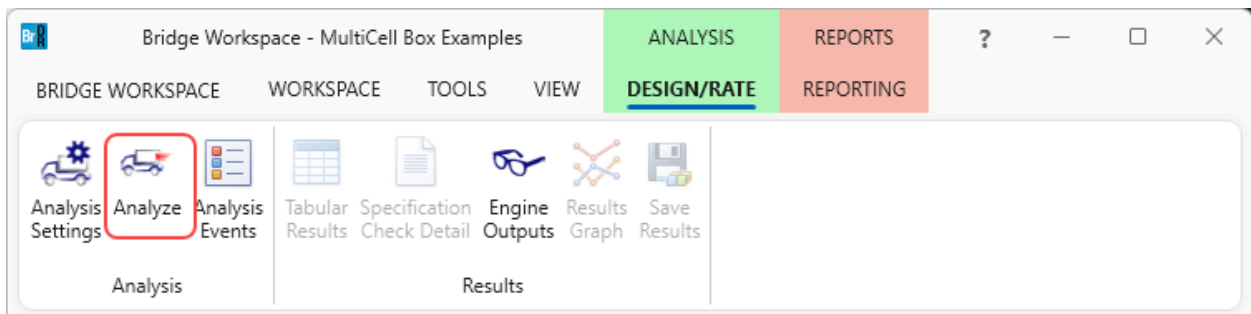
## MCB2 – Reinforced Concrete Multi-Cell Box Example

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.

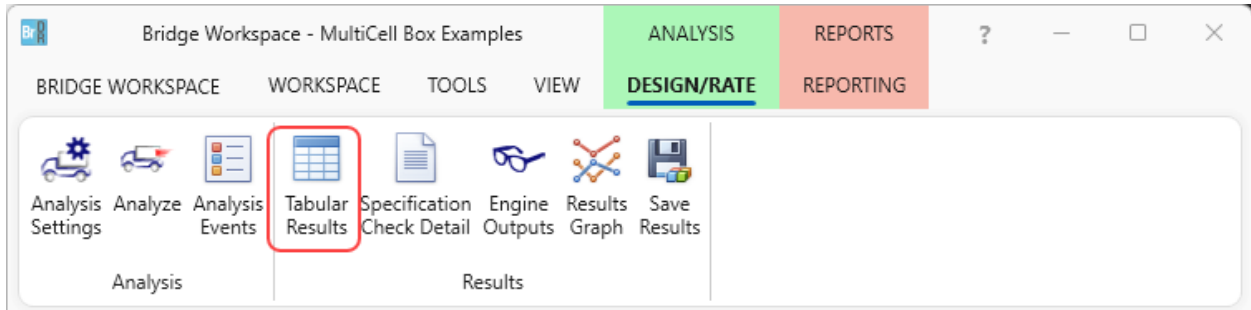




# MCB2 – Reinforced Concrete Multi-Cell Box Example

## 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.



Analysis Results - WEB1

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
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

AASHTO LRFR Engine Version 7.5.0.3001  
Analysis preference setting: None

Close