

AASHTOWare BrDR 7.5.0

Multi-Cell Box LFR Tutorial

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Topics Covered

- Post-tensioned concrete multicell box data entry
- Live load distribution factor calculations
- LFR analysis and results

This example describes entering a post-tensioned multicell box superstructure into AASHTOWare BrDR. The superstructure is not integral with the substructure.

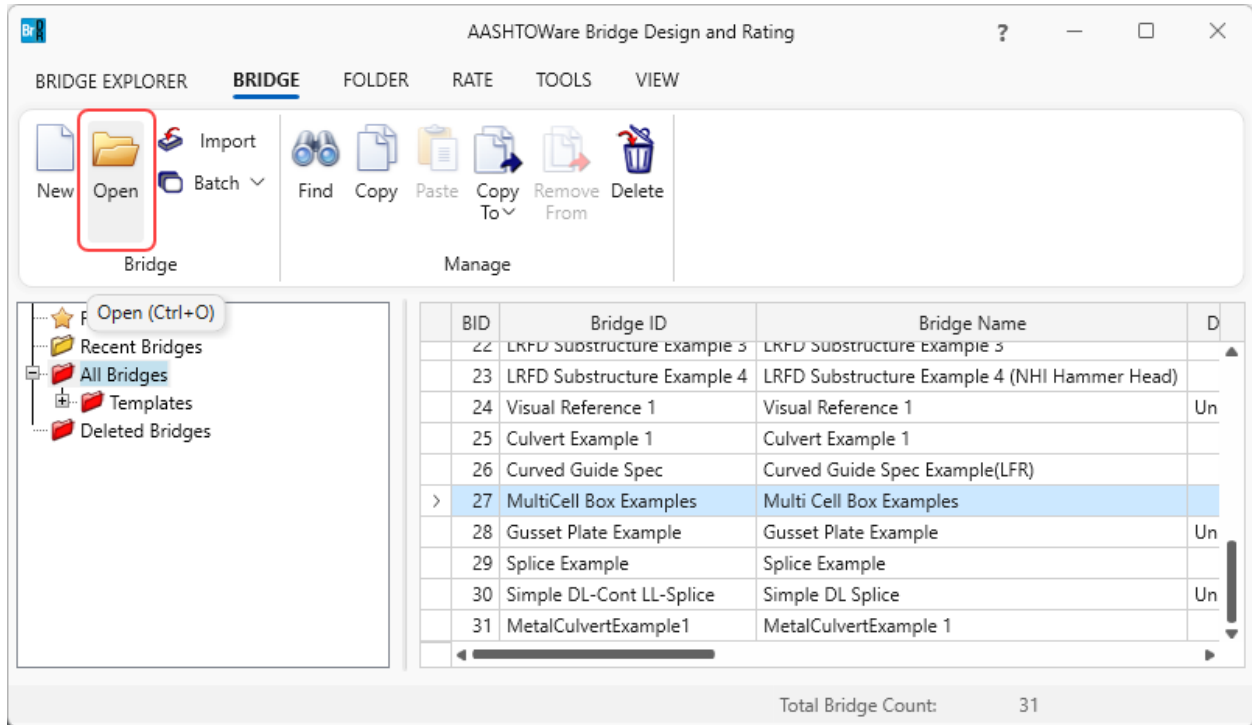
Analysis Methods

Post-tensioned concrete multicell box (MCB) superstructures can be analyzed in the following ways:

- LFR and LRFR
- Full box section including each individual weblane

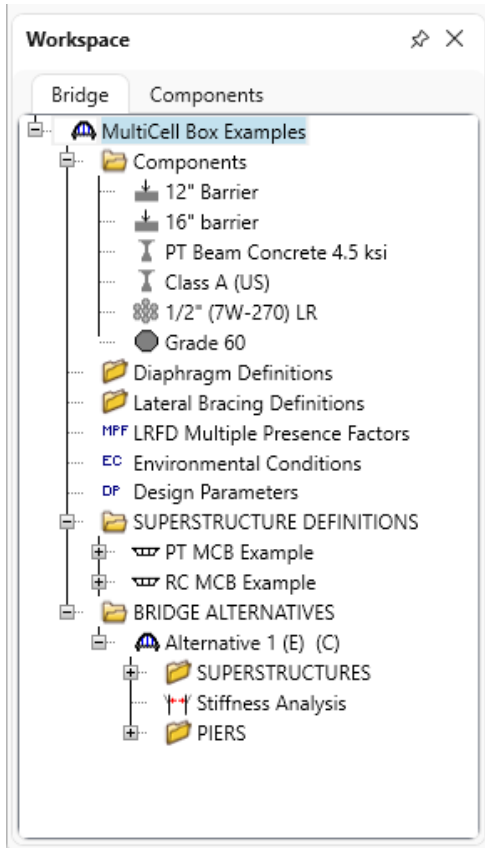
Post-Tensioned Concrete Multi-Cell Box Data Entry

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.



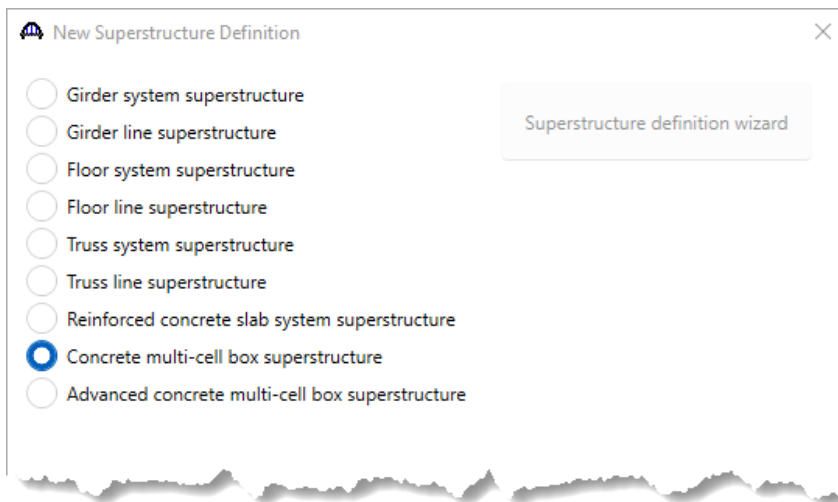
MCB3 – Post-Tensioned Multi-Cell Box LFR Example

The partially expanded **Bridge Workspace (BWS)** tree is shown below.



Superstructure Definitions

Create a new MCB (multicell box) superstructure definition. Click on **Superstructure Definitions** in the **BWS** to open the **New Superstructure Definition** window. Select Concrete multi-cell box superstructure and click **OK**.



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Concrete Multi-Cell Box Superstructure Definition

Enter the following data for the superstructure definition. Select the **Post-tensioned** checkbox. This will display the **PT** windows in the **BWS** tree.

Concrete Multi-Cell Box Superstructure Definition

Definition Analysis Specs Factors Engine Control options

Name: PT MCB

Description:

Default units: US Customary

Number of spans: 2

Number of cells: 2

Span lengths

Enter span lengths along the reference line:

Span	Length (ft)
1	111.5
> 2	111.5

Structure model for LLDF computation

Standalone

Left side connected to adjacent structure

Right side connected to adjacent structure

End projections

Left: 12 in

Right: 12 in

Average humidity: 60 %

Structure type

Frame structure simplified definition

Integral with substructure

Consider substructure skew in FE section prop

Not integral with pier

Post-tensioned

Analyze webs only

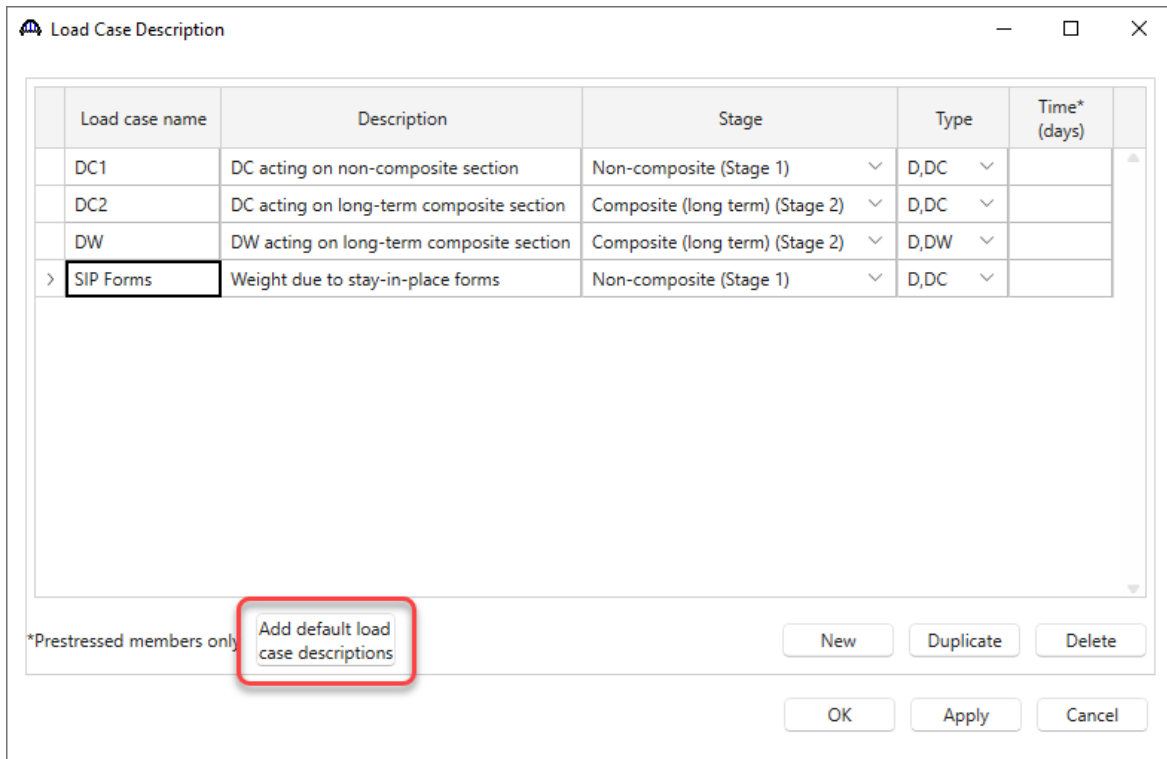
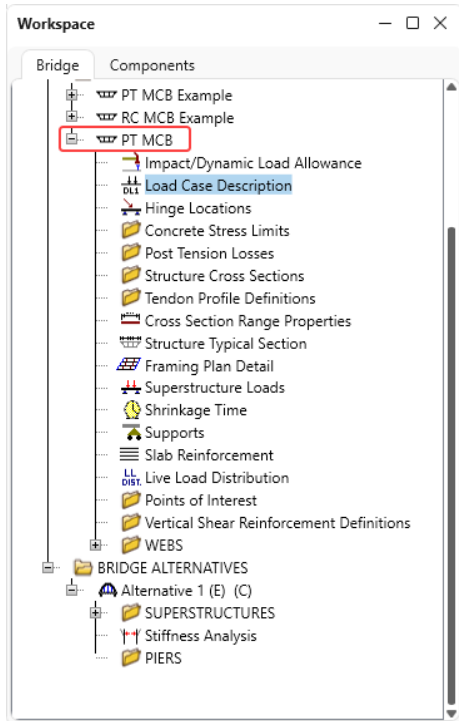
OK Apply Cancel

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Load Case Description

Expand the newly added superstructure definition **PT MCB** 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.

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Concrete Stress Limits

Double click on the **Concrete Stress Limits** folder in the **BWS** tree and enter a **Name, Concrete material** and click the **Compute** button to fill the stress limit data for the beam concrete.

Stress Limit Sets - Concrete

Name:

Description:

Corrosion condition:

Final allowable tension stress limit coef. (US) override:

Concrete material:

Compute

	LFD		LRFD	
Initial allowable compression:	<input type="text" value="2.4"/>	ksi	<input type="text" value="2.6"/>	ksi
Initial allowable tension:	<input type="text" value="0.1897367"/>	ksi	<input type="text" value="0.1896"/>	ksi
Final allowable compression:	<input type="text" value="2.7"/>	ksi	<input type="text" value="2.7"/>	ksi
Final allowable tension:	<input type="text" value="0.4030509"/>	ksi	<input type="text" value="0.4030509"/>	ksi
Final allowable DL compression:	<input type="text" value="1.8"/>	ksi	<input type="text" value="2.025"/>	ksi
Final allowable slab compression:	<input type="text"/>	ksi	<input type="text"/>	ksi
Final allowable compression: (LL+1/2(Pe+DL))	<input type="text" value="1.8"/>	ksi	<input type="text" value="1.8"/>	ksi

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

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Post Tension Losses

Double click on the **Post Tension Losses** folder in the **BWS** tree and select the **Lump Sum** Loss method.

Post Tension Losses

Name:

Loss method:

Anchor set: in

Coefficient of friction:

Wobble coefficient: per ft

P/S transfer stress ratio:

Transfer time: Hours

Age at deck placement: Days

Final age: Days

Lump sum losses

Initial loss: ksi

Final loss: ksi

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Structure Cross Sections

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

Overall | Cells | Fillets

	(ft)
D	4
CJ	0.667
LW1	3
LW2	3
RW1	3
RW2	3
LV	1
RV	1

	(in)
LT1	8
LT2	12
RT1	8
RT2	12

W2: 24 ft

Properties

Compute properties

Area: ft²

Ixx: ft⁴

Iyy: ft⁴

J: ft⁴

OK Apply Cancel

Overall | Cells | Fillets

Top left web thickness: 14 in W2: 24 ft

Bottom left web thickness: 14 in

Cell	S (ft)	Top right web thickness (in)	Bottom right web thickness (in)	Top slab thickness (in)
1	12	14	14	8
2	12	14	14	8

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Overall					
Cells					
Fillet					
	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 checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	4	4

Now that all the dimensions are entered, click the **Compute properties** button.

Structure Cross Sections

Name: Section 1 Number of cells: 2

Input method: Simple Advanced Top slab concrete: PT Beam Concrete 4.5 ksi Other parts concrete: PT Beam Concrete 4.5 ksi

Entry method: Width Slope Top slab stress limit: Beam Stress Limit Other parts stress limit: Beam Stress Limit

30 ft

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

Overall					
Cells					
Fillet					
	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 checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	4	4

Properties

Compute properties

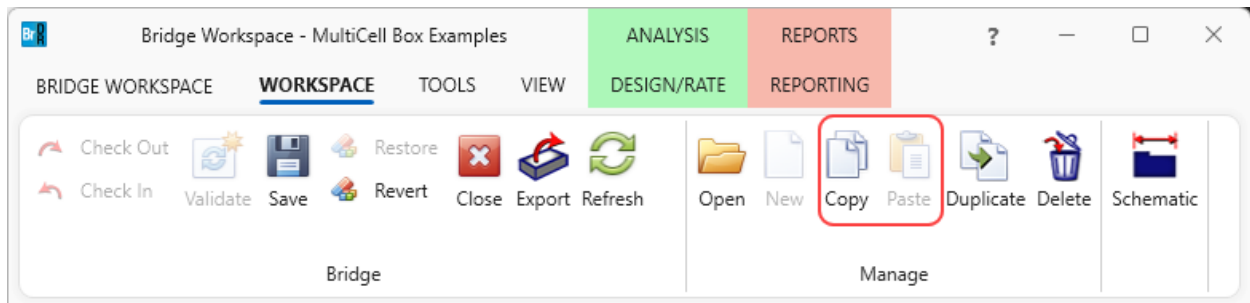
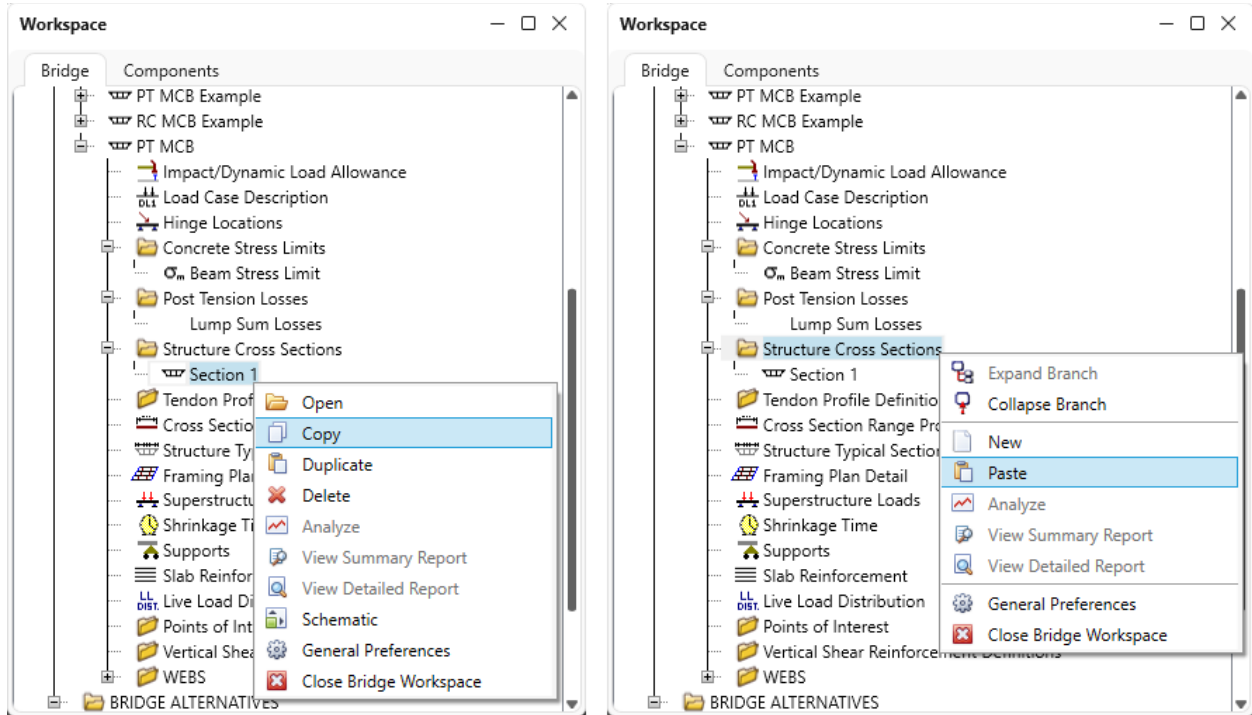
Area: 46.7777778 ft²
 Ixx: 107.700434 ft⁴
 Iyy: 3275.222734 ft⁴
 J: 312.225668 ft⁴

OK Apply Cancel

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Create another cross section by copying **Section 1** and making edits to it. To copy, select **Section 1**, right-click and select **Copy** (or click on the **Copy** button from the **Manage** group of the **WORKSPACE** ribbon). Now select **Structure Cross Sections** folder, right-click and select **Paste** (or click on the **Paste** button from the **Manage** group of the **WORKSPACE** ribbon).



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Now double click on the copied cross section to open its window. Rename the new cross section to **Section 2**, revise the depth to 8' and click on the **Compute properties** button as shown below.

Structure Cross Sections

Name: **Section 2** Number of cells: 2

Input method: Simple Advanced

Top slab concrete: PT Beam Concrete 4.5 ksi Other parts concrete: PT Beam Concrete 4.5 ksi

Entry method: Width Slope

Top slab stress limit: Beam Stress Limit Other parts stress limit: Beam Stress Limit

30 ft

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

Overall (ft):

	(ft)
D	8
CJ	0.667
LW1	3
LW2	3
RW1	3
RW2	3
LV	1
RV	1

Cells (in):

	(in)
LT1	8
LT2	12
RT1	8
RT2	12

W2: 24 ft

Properties:

Compute properties

Area: 60.7777778 ft²

lxx: 581.4939731 ft⁴

lyy: 4493.319951 ft⁴

J: 1383.355021 ft⁴

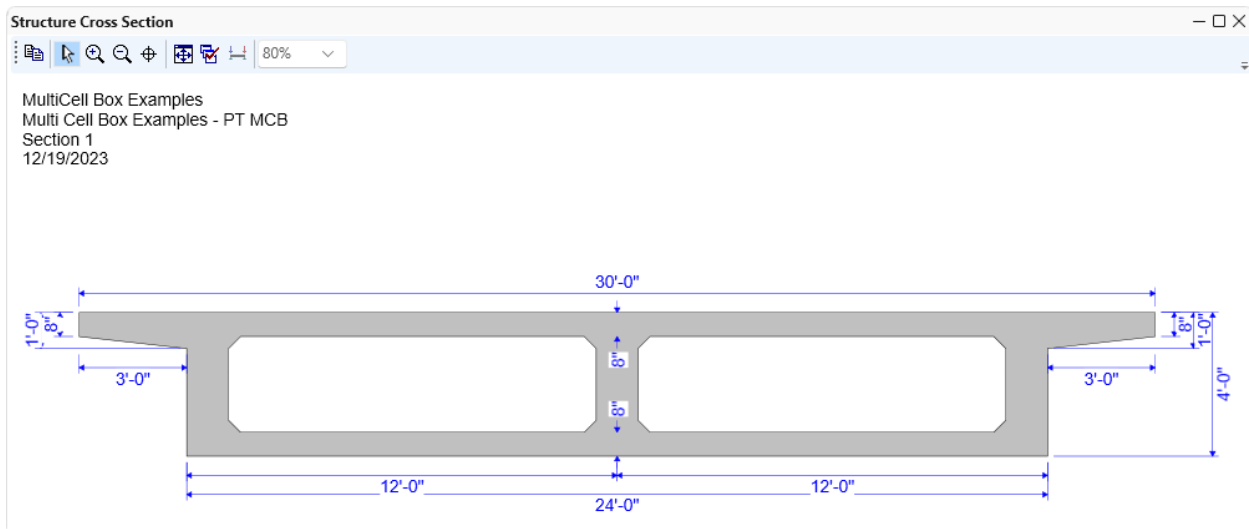
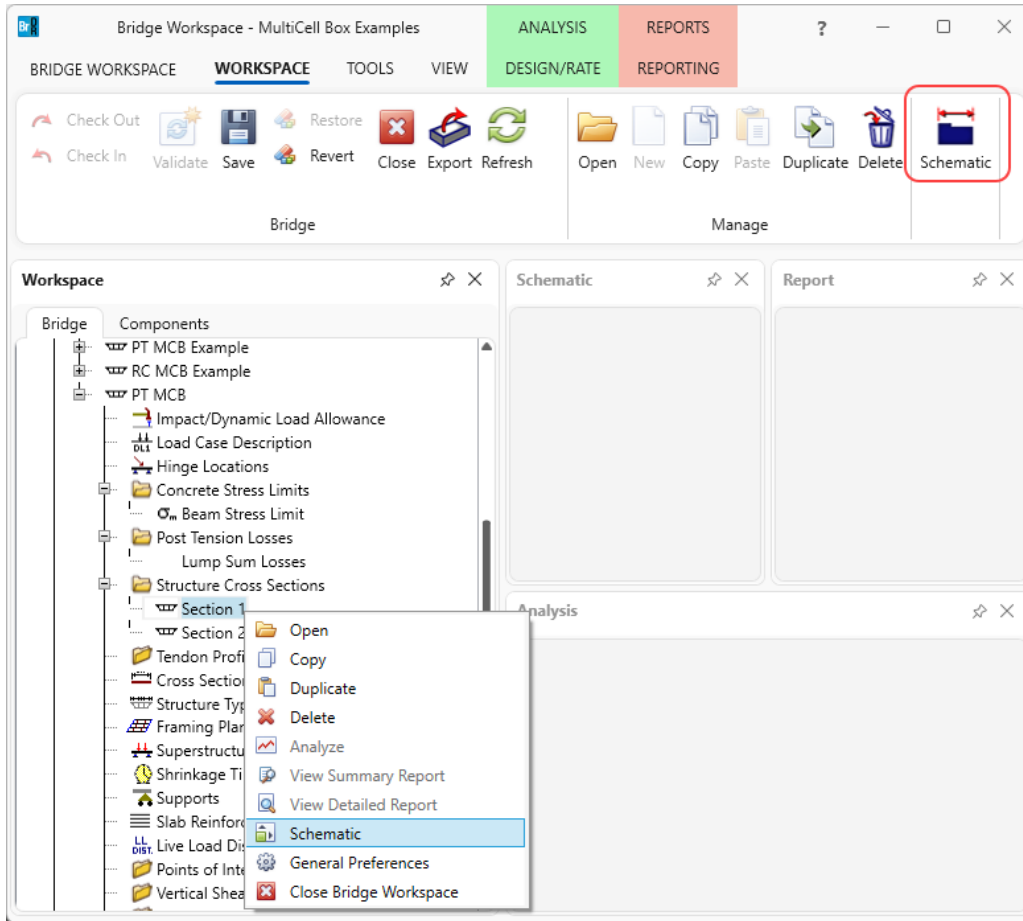
OK Apply Cancel

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

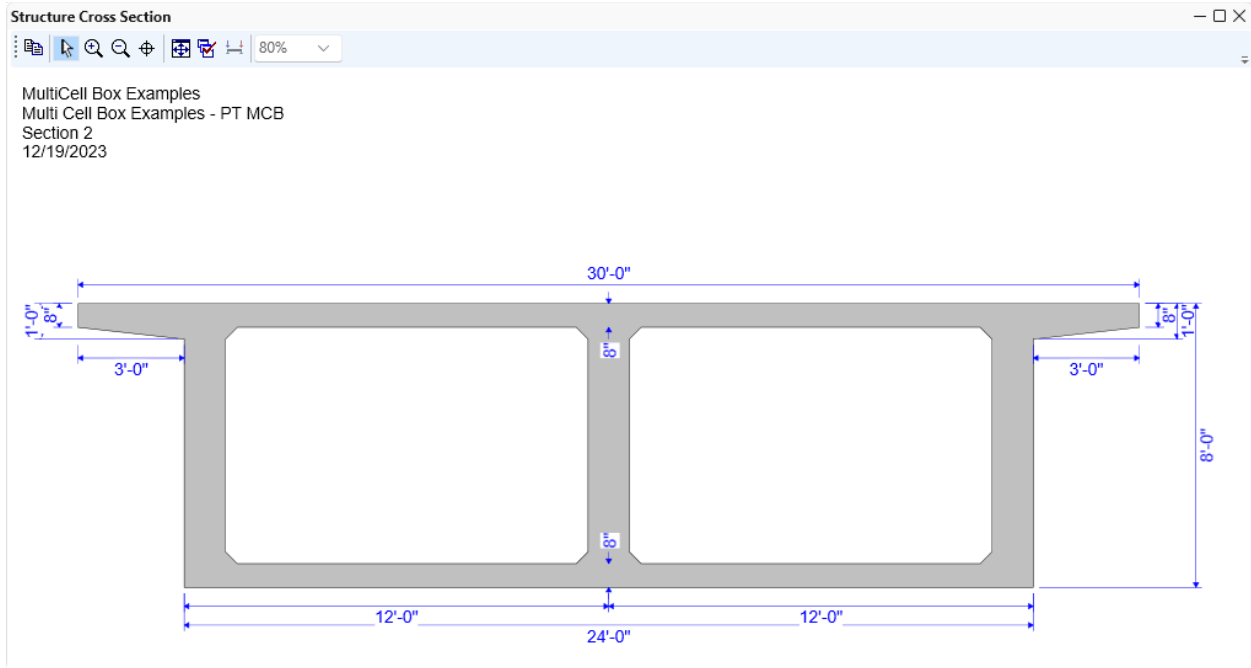
Schematic – Section 1

With **Section 1** 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.



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Similarly, schematic for **Section 2** is shown below.



Tendon Profile Definitions – Profile tab

Double click on the **Tendon Profile Definition** folder in the **BWS** tree and create the following tendon profile.

Enter the data shown below for the 3 tabs.

Tendon Profile Definition

Profile name: Starting span: Ending span: Start distance into start span: ft End distance from end span: ft

Profile | Post tensioning | Stress limits

Inflection point entry method: Percentage Distance Assigned to:

Span	Profile type	Inflection points			Vertical offset					
		Left (%)	Low (%)	Right (%)	Left end (in)	Measured from	Low (in)	Measured from	Right end (in)	Measured from
1	Type 3		40	15	28	Top	48	Bottom	10	Top
2	Type 4	15	60		10	Top	48	Bottom	28	Top

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Tendon Profile Definition

Profile name: Tendon Starting span: 1 Ending span: 2 Start distance into start span: 0 ft End distance from end span: 0 ft

Profile Post tensioning Stress limits

Prestress material: 1/2" (7W-270) LR Duct grouting: Grouted
 Jacking end: Left End Duct diameter: 2 in

Post tensioning

Input method
 Jacking force Strands Jacking stress ratio: 0.75

Total jacking force: 9759.5 kip Number of ducts per web: 0
 Distribute equally

Web	Percentage (%)	Duct	Strands per duct
WEB1	33.333333		
WEB2	33.333333		
WEB3	33.333333		

Click the **Compute Values** button followed by **OK** to apply the data and close the window.

Tendon Profile Definition

Profile name: Tendon Starting span: 1 Ending span: 2 Start distance into start span: 0 ft End distance from end span: 0 ft

Profile Post tensioning Stress limits

	LRFD	LFD
Prior to seating:	218.7 ksi	218.7 ksi
At anchorages and couplers immediately after anchor set:	189 ksi	189 ksi
Elsewhere along length of member immediately after anchor set:	199.8 ksi	201.69 ksi
At service limit state after losses:	194.4 ksi	194.4 ksi

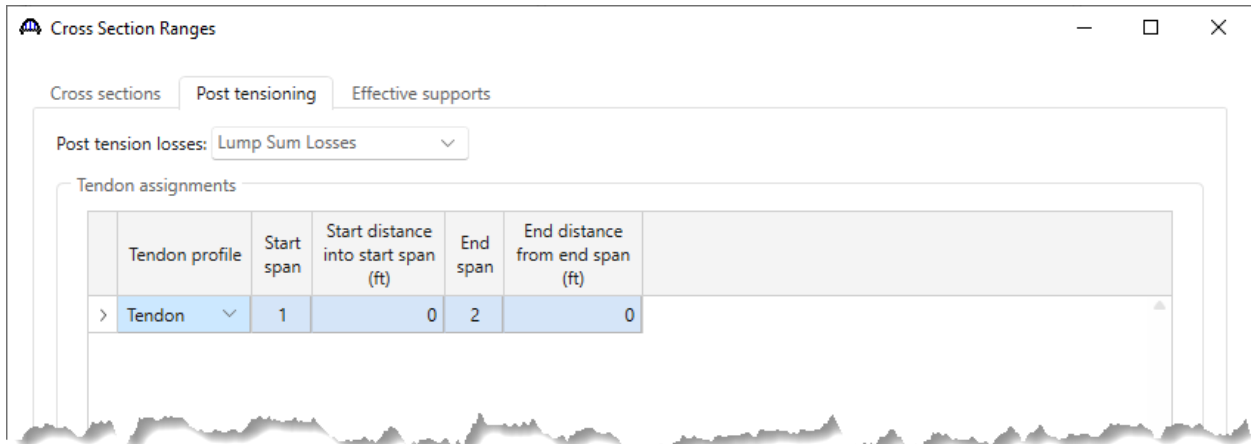
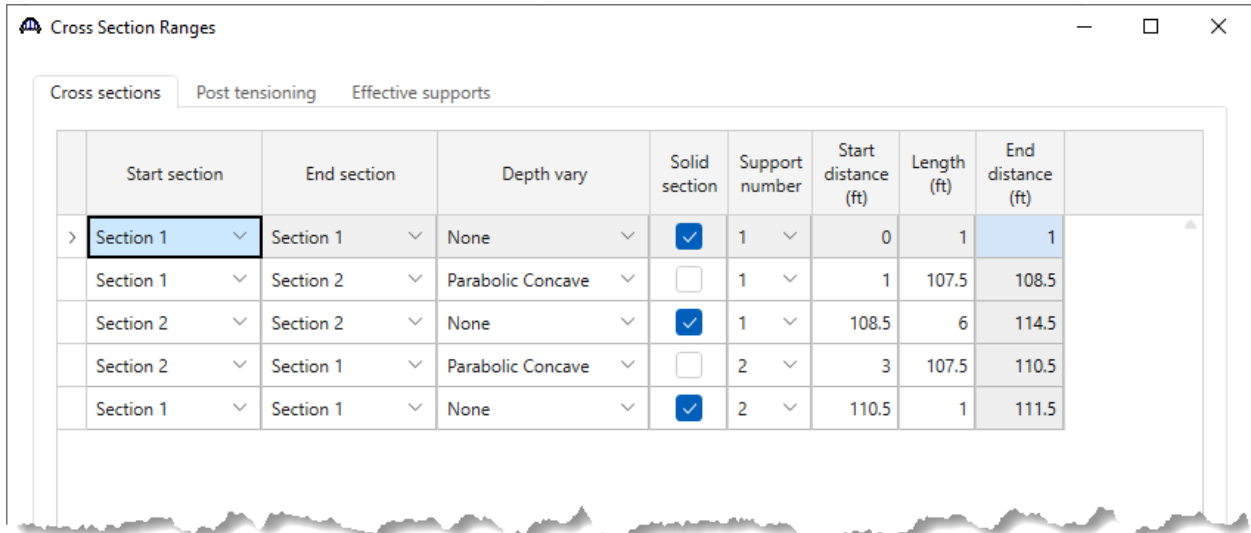
Compute Values

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Cross Section Ranges

Double click on the **Cross Section Range Properties** node in the **BWS** tree and assign the cross sections as shown below.



Effective supports allow to shift the specification check point at the centerline of the support to the location entered below. Shear will be checked at a distance d_v from the location entered below.

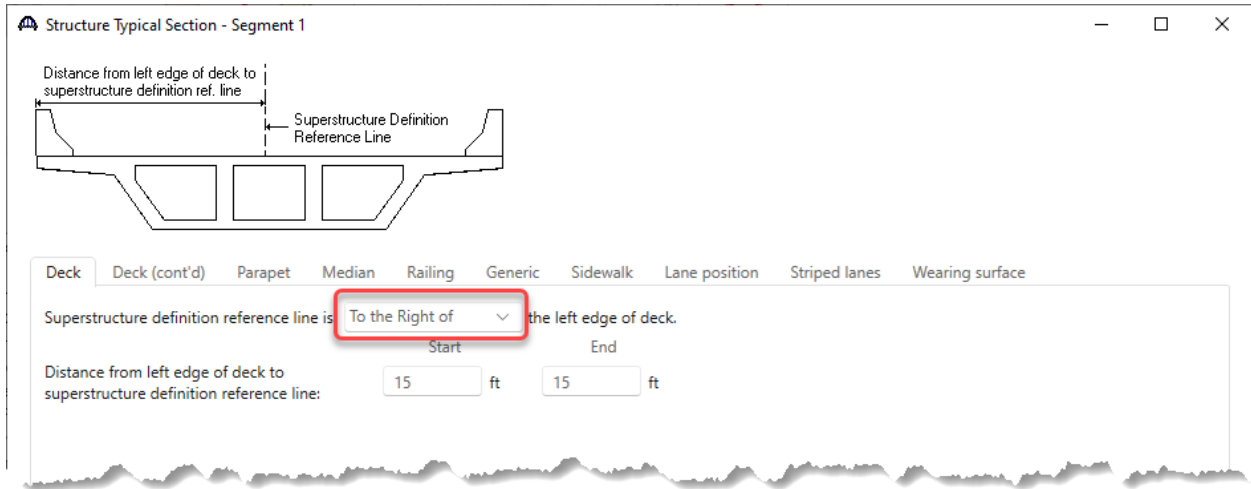


Click **OK** to apply the data and close the window.

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

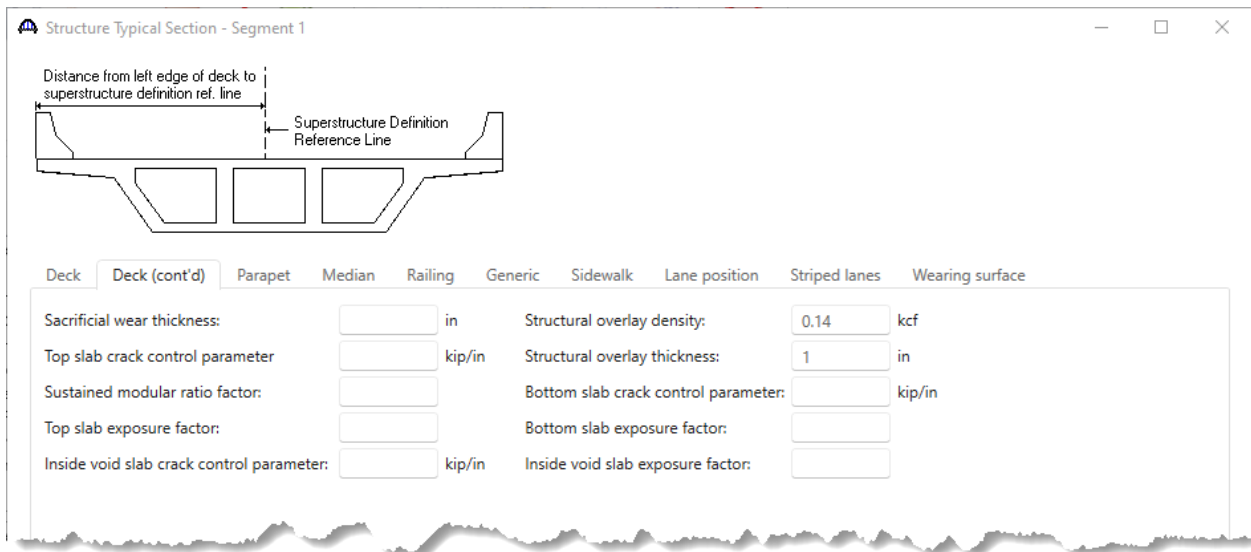
Structure Typical Section – Deck tab

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



Structure Typical Section – Deck (cont'd) tab

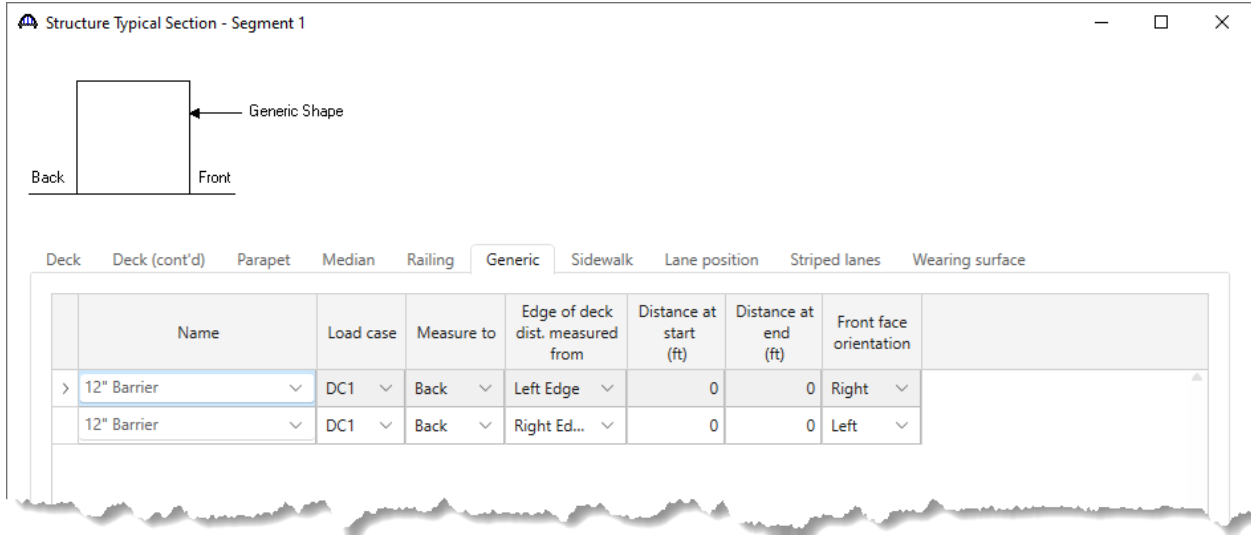
Enter the following data for the **Structural overlay density and thickness**. The overlay is applied in the self load DC load case.



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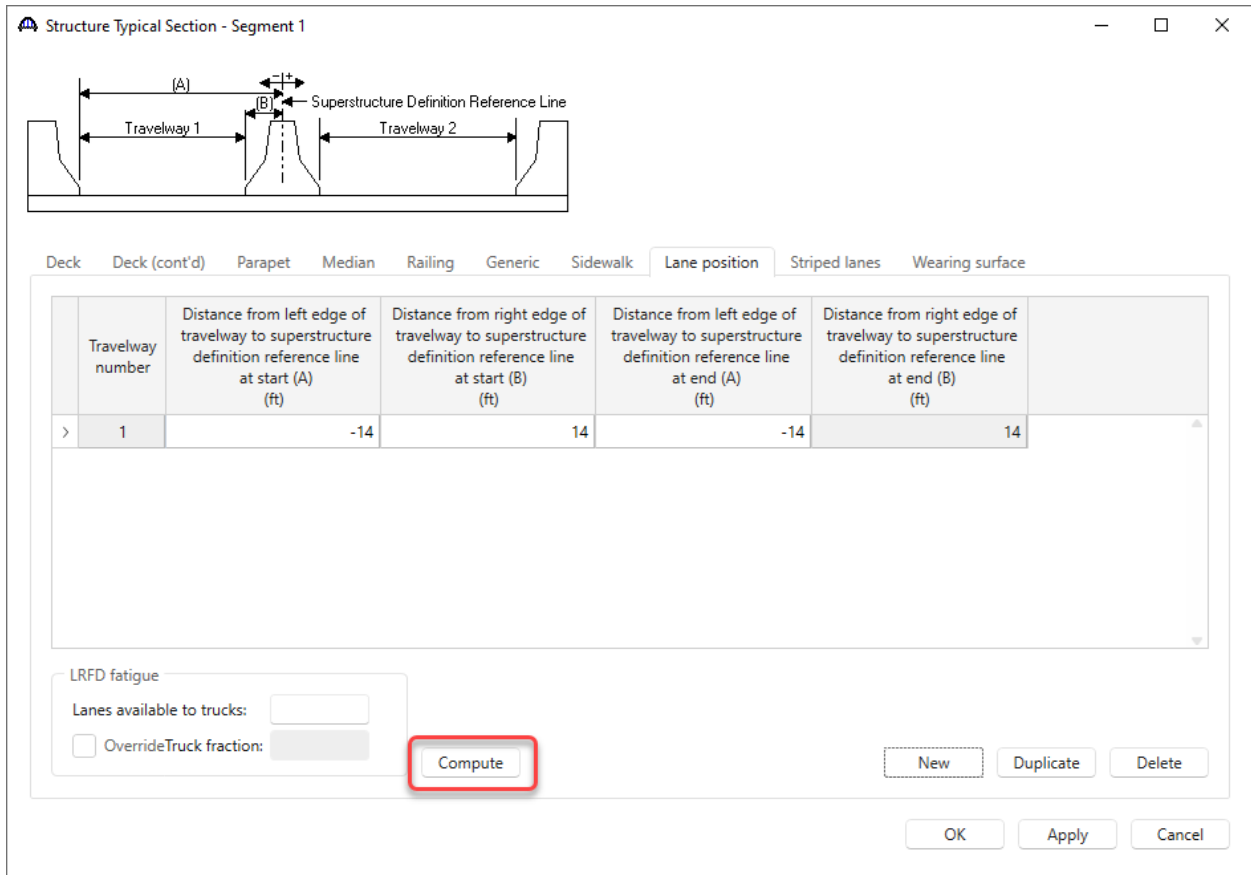
Structure Typical Section – Generic tab

Enter the barriers.



Structure Typical Section – Lane position tab

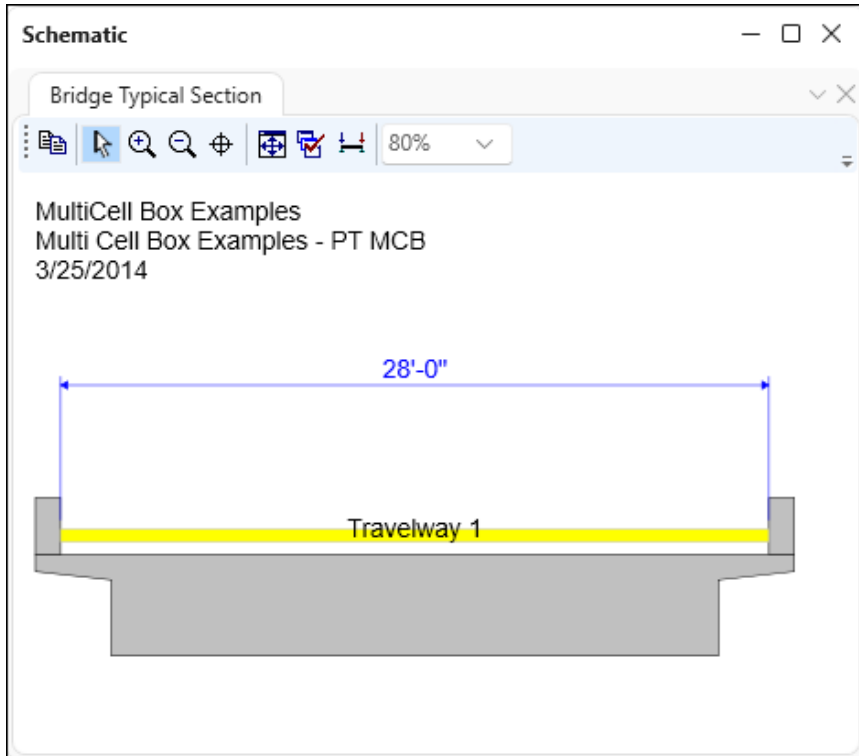
Use the **Compute** button to enter the following lane positions then click **OK** to apply the data and close the window.



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

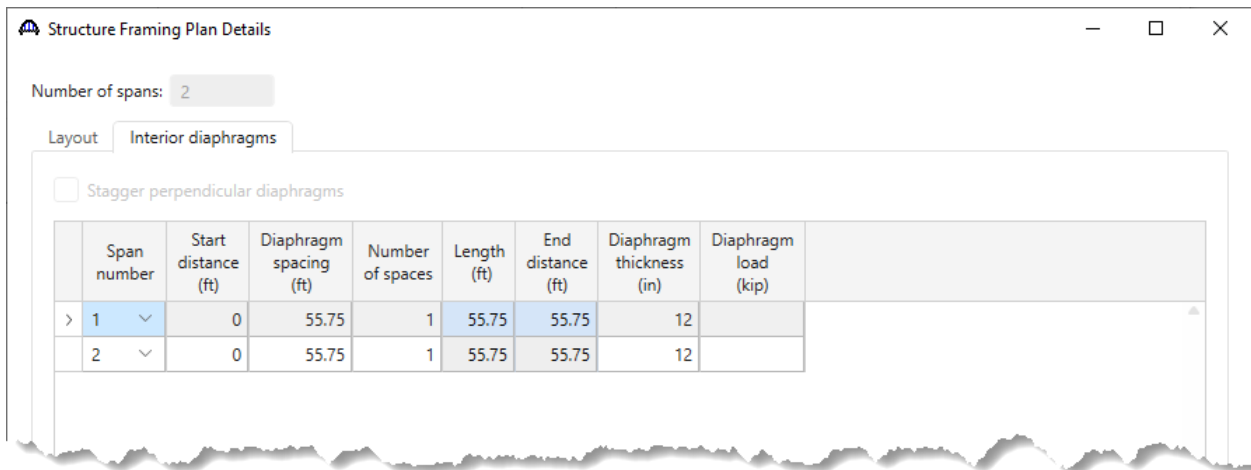
Structure Typical Section - Schematic

The **Schematic** for the **Structure Typical Section** will appear as follows. The webs are not visible in the schematic because the cross section at the start of the structure was marked as ‘Solid’.



Framing Plan Detail – Interior diaphragms tab

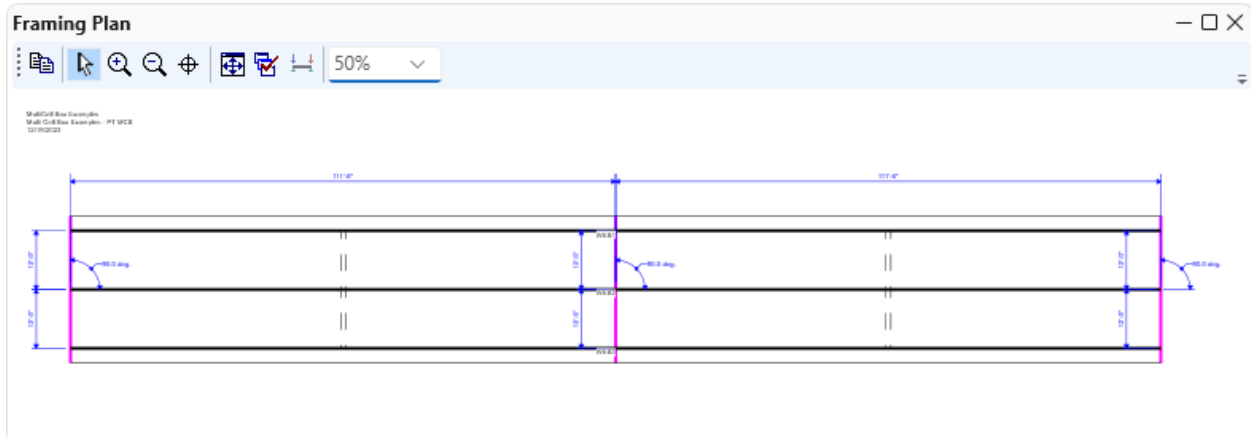
Enter the following diaphragm locations on the **Framing Plan Detail** window. The diaphragms only contribute to the dead load on the structure. They do not provide a structural role in the box analysis. Enter the **diaphragm thickness** and the AASHTO engine will compute diaphragm load based on the box cross section properties and diaphragm thickness.



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

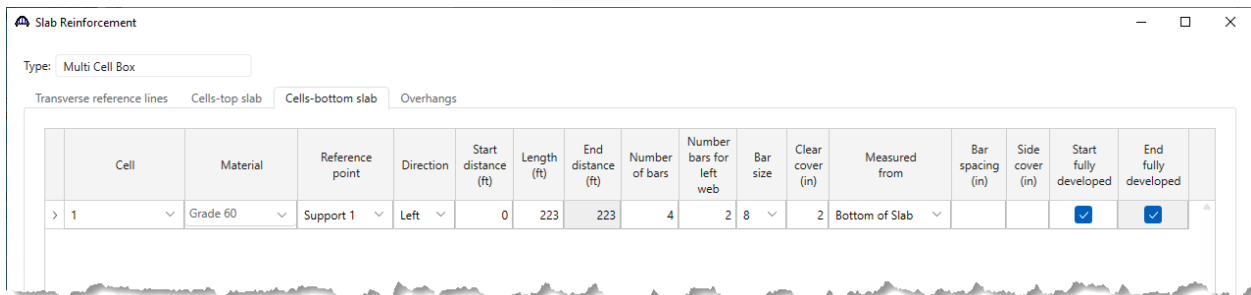
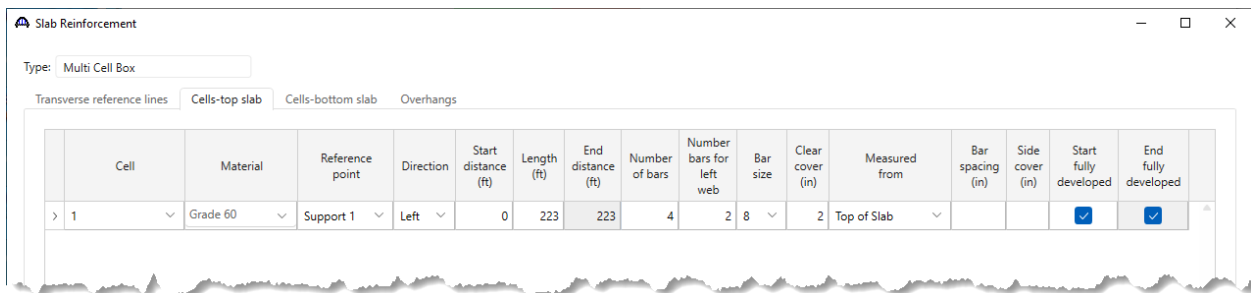
Framing Plan Detail - Schematic

With **Framing Plan Details** node selected in the **BWS** tree, click on the **Schematic** button from the **WORKSPACE** ribbon (or right click and select **Schematic**) to view the framing plan.



Slab Reinforcement

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



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Live Load Distribution

Full beam multicell box live load distribution factors is the sum of each web live load distribution factors. If user has entered the live load distribution factors for each web, the beam distribution factors will be the sum of the user entered distribution factors.

If the web distribution factors are empty, each web distribution factors are computed and the sum of all the web distribution factors are used as the beam distribution factors.

If both beam and web distribution factors are not entered or computed, the program computes the distribution factors during the analysis.

Standard live load distribution factors for entire beam using the **Compute from typical section** button.

Live Load Distribution

Standard LFRD

Distribution factor input method

Use simplified method Use advanced method

Computed date:

Allow distribution factors to be used to compute effects of permit loads with routine traffic

Lanes loaded	Distribution factor (wheels)			
	Shear	Shear at supports	Moment	Deflection
> 1 Lane				
Multi-lane				

Compute from typical section... View calcs

OK Apply Cancel

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

The computed **Live Load Distribution** window is shown below.

Lanes loaded	Distribution factor (wheels)			
	Shear	Shear at supports	Moment	Deflection
> 1 Lane	4.1000744	4.6513754	4.1000744	2
Multi-lane	4.3065476	5.467465	4.3065476	4

Vertical Shear Reinforcement Definitions

Create the following stirrup definition.

Name: #5 Stirrup

Material: Grade 60

Bar size: 5

Number of legs: 2

Inclination (alpha): 90 Degrees

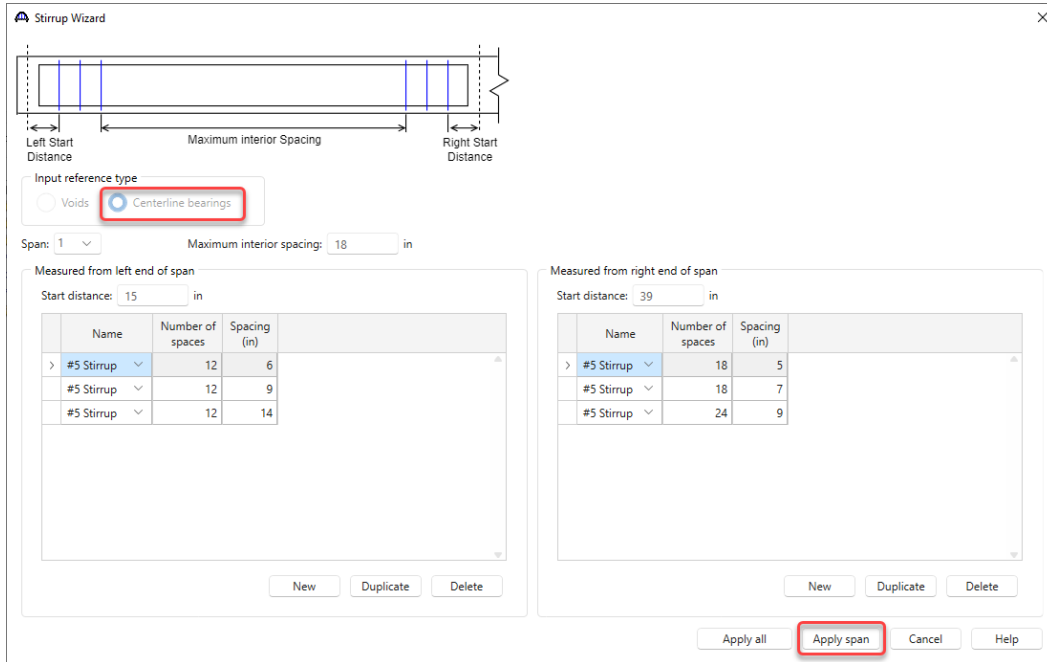
Vertical Shear Reinforcement

OK Apply Cancel

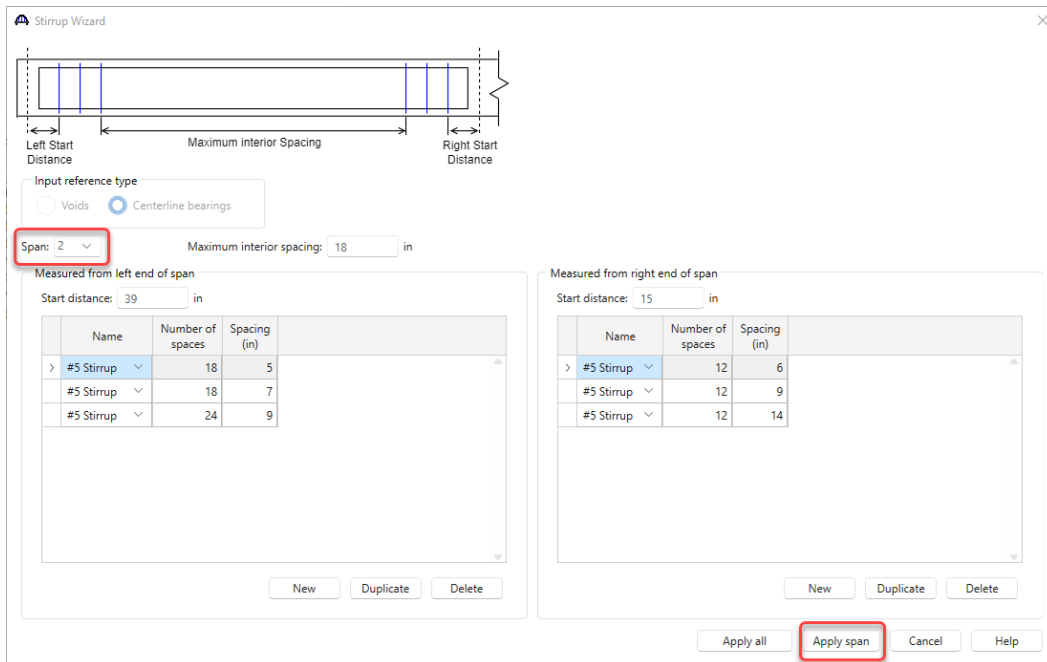
MCB3 – Post-Tensioned Multi-Cell Box LFR Example

WEB1 – Shear Reinforcement Ranges

Expand **WEBS** folder -> **WEB1** and double click on the **Shear Reinforcement Ranges** node. Select the input reference type as **Centerline bearings**. Click the **Stirrup wizard** button and enter the following data.



Select **Span 2** in the Wizard and enter the following data followed by clicking **Apply span**.



Click the **Apply all** button to create the stirrup ranges for each span as shown below.

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Span 1 will show the following data.

Web Shear Reinforcement Ranges - WEB1

Input reference type: Voids Centerline bearings

Linked with: None

Span ranges

Span: 1

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
#5 Stirrup	1.25	1	0	0	1.25
#5 Stirrup	1.25	12	6	6	7.25
#5 Stirrup	7.25	12	9	9	16.25
#5 Stirrup	16.25	12	14	14	30.25
#5 Stirrup	30.25	13	18	19.5	49.75
#5 Stirrup	49.75	1	18	1.5	51.25
#5 Stirrup	51.25	14	18	21	72.25
#5 Stirrup	72.25	24	9	18	90.25
#5 Stirrup	90.25	18	7	10.5	100.75
#5 Stirrup	100.75	18	5	7.5	108.25

Buttons: Copy..., Stirrup wizard..., New, Duplicate, Delete, OK, Apply, Cancel

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

MCB3 – Post-Tensioned Multi-Cell Box LFR Example

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 Stirrup	0.25	1	0	0	0.25
	#5 Stirrup	0.25	12	6	6	6.25
	#5 Stirrup	6.25	12	9	9	15.25
	#5 Stirrup	15.25	12	14	14	29.25
>	#5 Stirrup	29.25	13	18	19.5	48.75
	#5 Stirrup	48.75	1	18	1.5	50.25
	#5 Stirrup	50.25	14	18	21	71.25
	#5 Stirrup	71.25	24	9	18	89.25
	#5 Stirrup	89.25	18	7	10.5	99.75
	#5 Stirrup	99.75	18	5	7.5	107.25

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

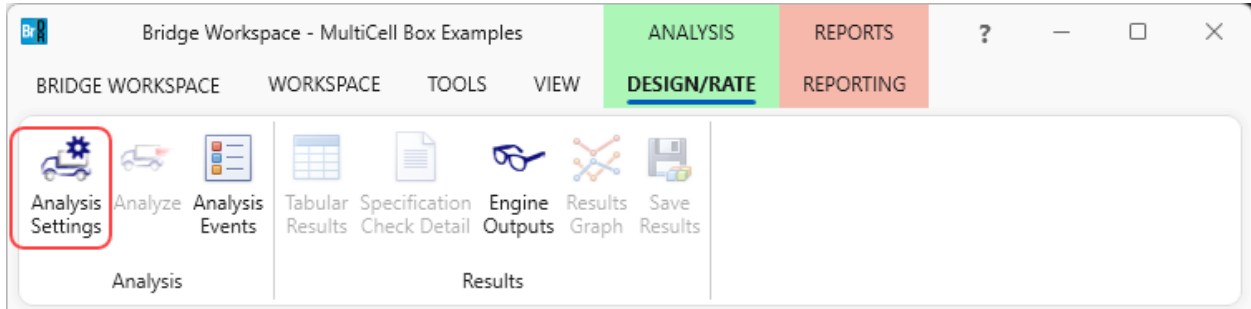
OK Apply Cancel

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

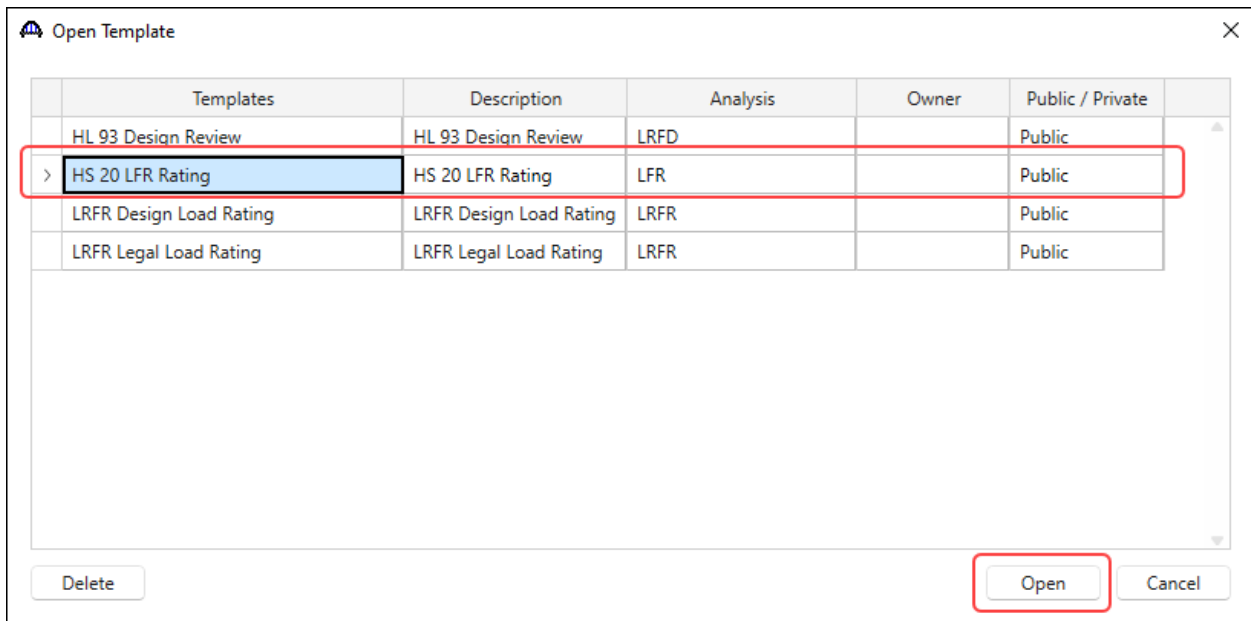
MCB3 – Post-Tensioned Multi-Cell Box LFR Example

LFR Analysis and Results

To run an LFR analysis on the **PT MCB** superstructure definition, click on the **Analysis Settings** window from the **Analysis** group of the **DESIGN/RATE** ribbon.

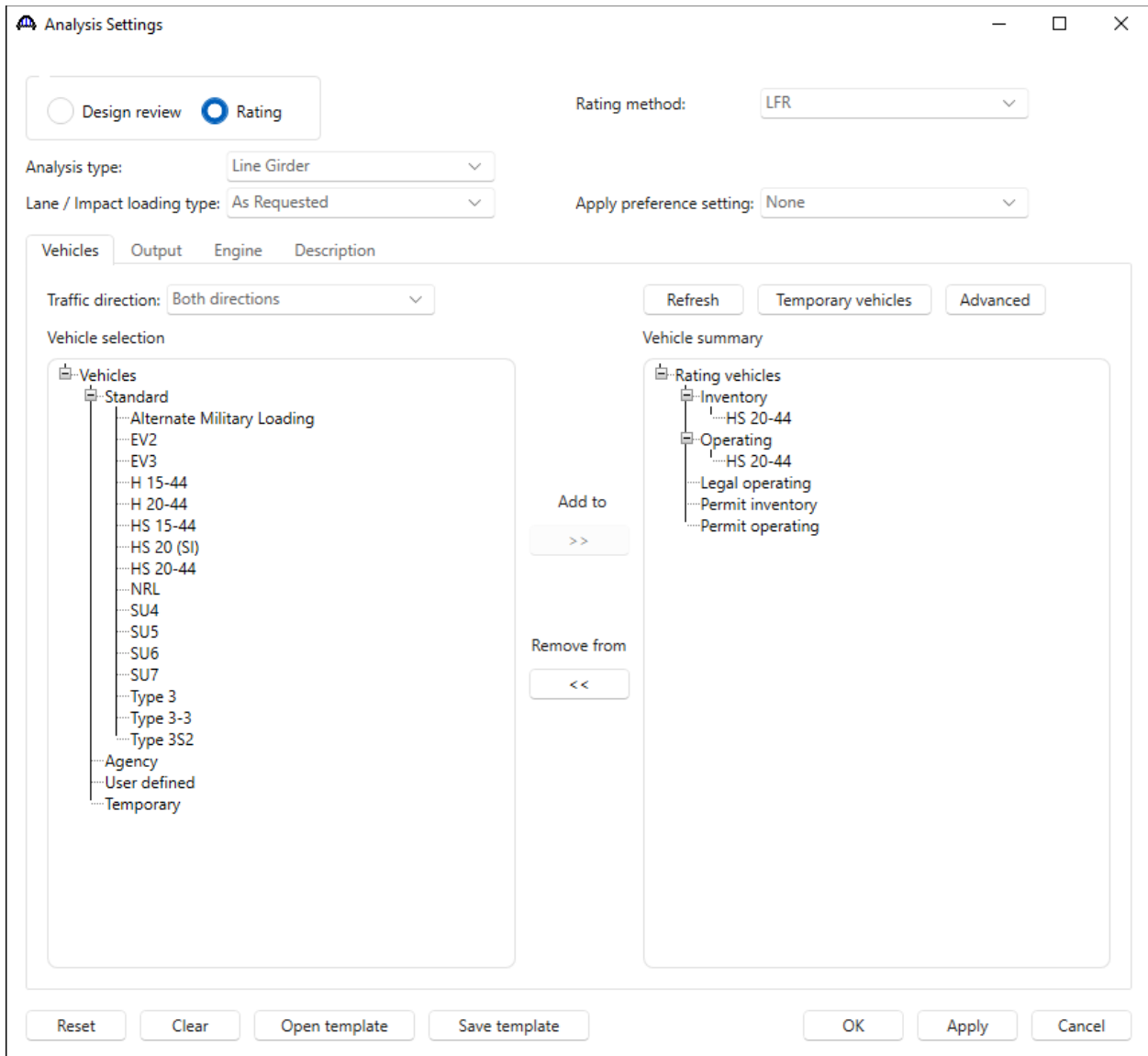


Click on the **Open template** button in the **Analysis Settings** window, select the **HS 20 LFR Rating** from the analysis templates and click **Open**.



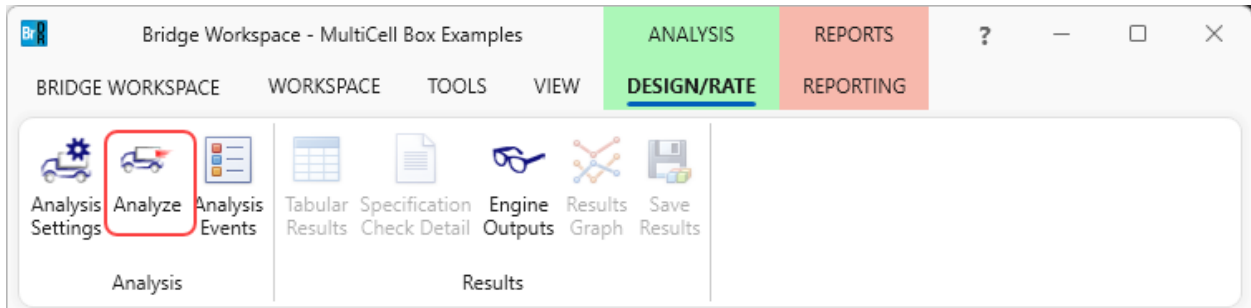
MCB3 – Post-Tensioned Multi-Cell Box LFR Example

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



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

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

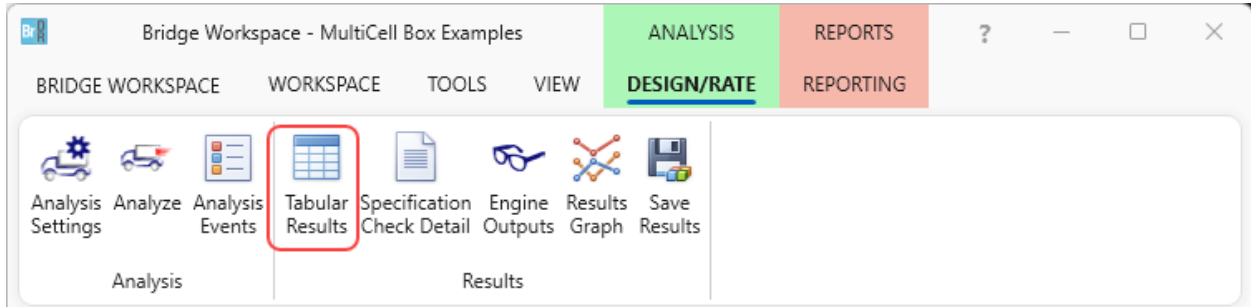


MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Tabular Results

The full multicell box width is analyzed for flexure and shear and then each weblane is analyzed for shear.

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 weblane.



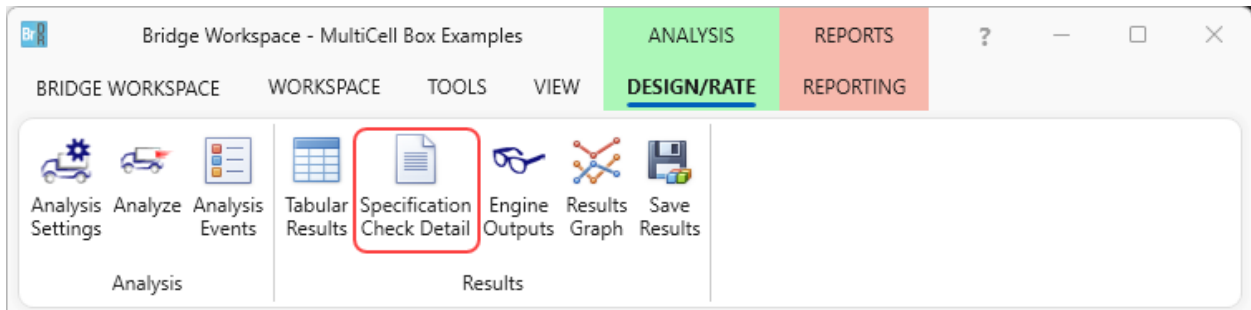
The screenshot shows the 'Analysis Results - PT MCB' window. It includes a 'Print' button, 'Report type' dropdown (Rating Results Summary), 'Lane/Impact loading type' radio buttons (As requested selected, Detailed unselected), and 'Display Format' dropdown (Single rating level per row). Below is a table with the following data:

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Element Name	Limit State	Impact	Lane
HS 20-44	Axle Load	LFR	Inventory	4.40	0.122	114.50	2 - (2.7)	WEB3	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Axle Load	LFR	Operating	8.36	0.232	114.50	2 - (2.7)	WEB3	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Inventory	12.82	0.356	114.50	2 - (2.7)	WEB3	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Operating	17.59	0.489	114.50	2 - (2.7)	WEB3	Design Shear - Concrete	As Requested	As Requested

At the bottom, it says 'AASHTO LFR Engine Version 7.5.0.3001' and 'Analysis preference setting: None'. A 'Close' button is in the bottom right corner.

Specification Check Detail

Select the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon for the full box and each weblane Spec check details.



MCB3 – Post-Tensioned Multi-Cell Box LFR Example

Specification Checks for PT MCB - 644 of 1360

Articles: All articles

Format: Bullet list

Specification filter

- Superstructure Component
 - Prestress Calculations
 - Stage 1
 - Stage 2
 - Stage 3
 - PT MCB**
 - WEB1
 - WEB2
 - WEB3

Report

Specification reference

- ✓ 68.5.3.3 PS Concrete Compressive Stress
- ✓ 68.5.3.3 PS Concrete Tensile Stress
- ✓ 68.5.3.3 PS Flexure Rating
- 68.5.3.3 PS Moment Capacity
- ✓ 68.5.3.3 PS Shear Rating
- ✓ 68.5.3.3 PS Steel Tensile Stress
- 8.16.2.7 Design Assumptions
- 9.15.2.3 Concrete - Cracking Stress
- ✓ 9.17 Flexural Strength
- 9.18.2.1 Ductility Limits - Minimum Steel
- 9.20 Consider Shear from Torsion
- 9.20 Effective Shear
- 9.20.1.3 Nominal Shear Capacity
- 9.20.2.1 Shear Strength Provided by Concrete