

AASHTOWare BrR 6.8

Multicell Box LFR Tutorial

MCB3 - Post-Tensioned Multicell Box LFR Example

MCB3 - Post-Tensioned Multicell Box LFR Example

Topics Covered

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

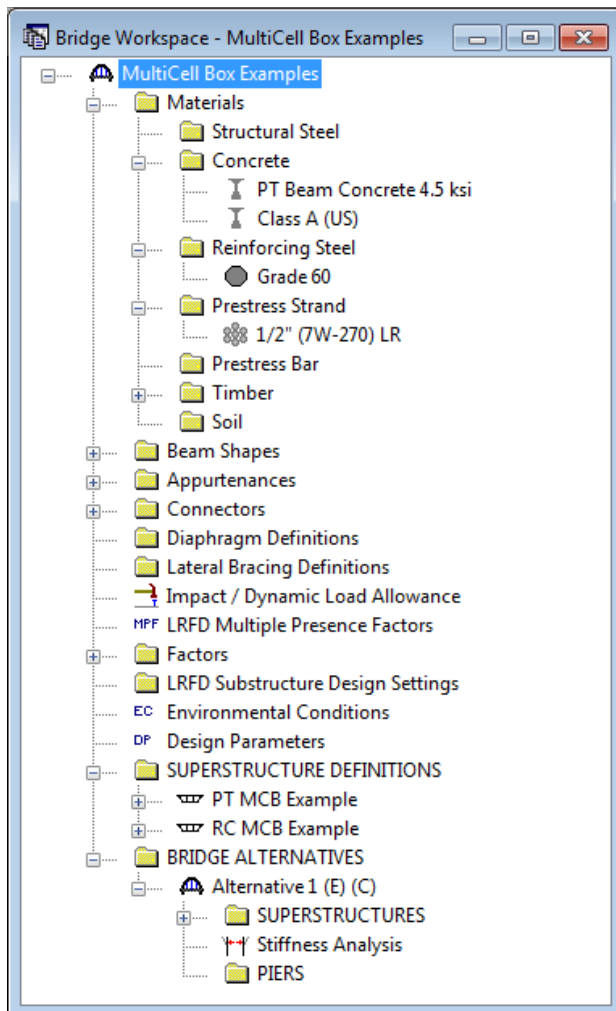
This example describes entering a post-tensioned multicell box superstructure into AASHTOWare BrR. The superstructure is not integral with the substructure.

Analysis Methods

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

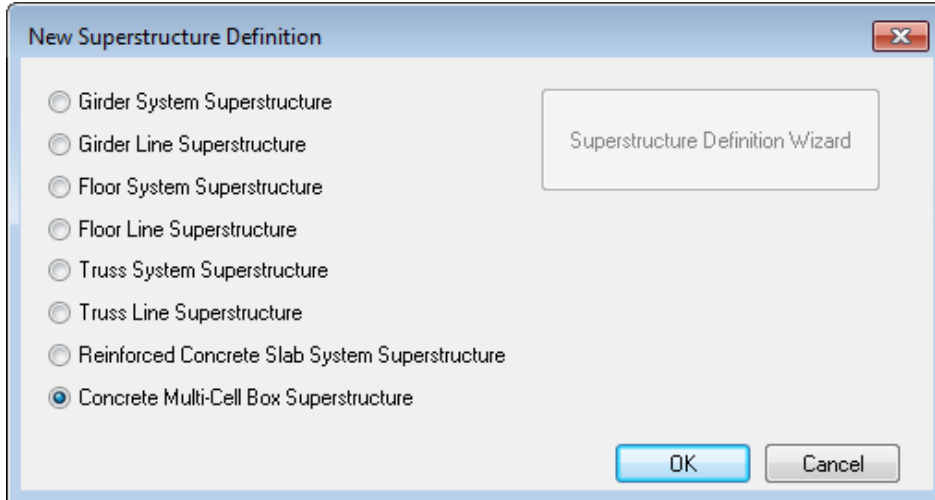
- LFR and LRFR
- Full box section including each individual weblane

Open bridge BID 27 'MultiCell Box Examples' in the sample database.

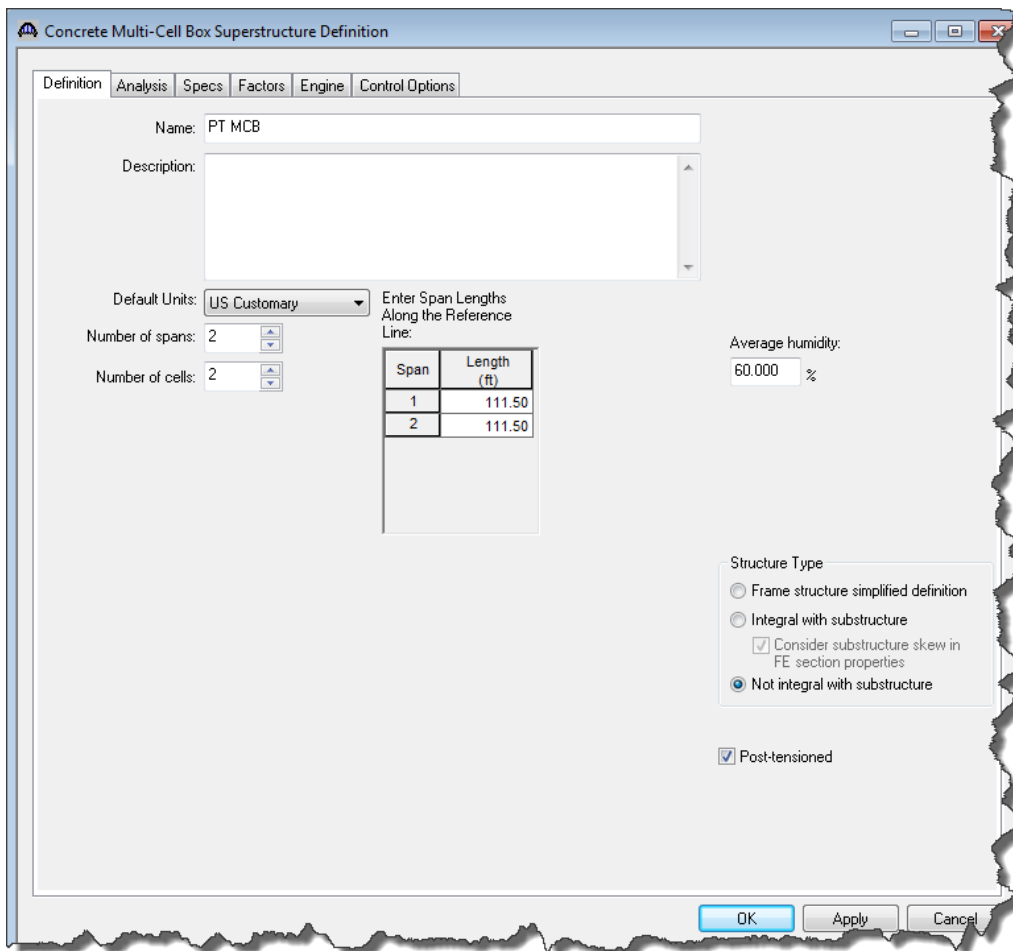


Create a new MCB (multicell box) superstructure definition.

MCB3 - Post-Tensioned Multicell Box LFR Example



Enter the following data for the superstructure definition. Select the 'Post-tensioned' checkbox. This will display the PT windows in the user interface.



MCB3 - Post-Tensioned Multicell Box LFR Example

Open the Load Case Description window and use the 'Add Default...' 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	

Create a stress limit for the beam concrete.

Name:

Description:

Concrete Material:

	LFD	LRFD
Initial allowable compression:	<input type="text" value="2.400"/> ksi	<input type="text" value="2.600"/> ksi
Initial allowable tension:	<input type="text" value="0.190"/> ksi	<input type="text" value="0.190"/> ksi
Final allowable compression:	<input type="text" value="2.700"/> ksi	<input type="text" value="2.700"/> ksi
Final allowable tension:	<input type="text" value="0.403"/> ksi	<input type="text" value="0.403"/> ksi
Final allowable DL compression:	<input type="text" value="1.800"/> 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="1.800"/> ksi	<input type="text" value="1.800"/> ksi

OK Apply Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

Create the following Lump Sum losses.

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

MCB3 - Post-Tensioned Multicell Box LFR Example

Create the following structure cross section.

The screenshot shows the 'Structure Cross Section' software interface. At the top, the window title is 'Structure Cross Section'. Below the title bar, there are several input fields and dropdown menus:

- Name: Section 1
- Number of cells: 2
- Input Method: Simple (selected), Advanced
- Entry Method: Width (selected), Slope
- Top slab concrete: PT Beam Concrete 4.5 ksi
- Other parts concrete: PT Beam Concrete 4.5 ksi
- Top slab stress limit: Beam Stress Limit
- Other parts stress limit: Beam Stress Limit

The central part of the interface is a cross-section diagram of a multicell box girder. The total width is 30.000 ft. The diagram shows two cells, each 12.000 ft wide (W2 = 24.000 ft). The top slab thickness is 8.000 in. The bottom web thickness is 14.000 in. The overall depth is D = 4.000 ft. The center-to-center spacing between cells is S = 12.000 ft. The diagram also shows various fillet dimensions: LW1 = 3.000 ft, LW2 = 3.000 ft, RW1 = 3.000 ft, RW2 = 3.000 ft, LV = 1.000 ft, and RV = 1.000 ft. The top left and right fillet radii are LT1 = 8.000 ft and RT1 = 8.000 ft, respectively. The bottom left and right fillet radii are LT2 = 12.000 ft and RT2 = 12.000 ft. The center-to-center spacing between fillets is CJ = 0.667 ft. The fillet thicknesses are WT-T and WT-B.

Below the diagram, there are two tables:

Overall		Cells		Fillet	
	(ft)		(in)		(in)
D	4.000	LT1	8.000		
CJ	0.667	LT2	12.000		
LW1	3.000	RT1	8.000		
LW2	3.000	RT2	12.000		
RW1	3.000				
RW2	3.000				
LV	1.000				
RV	1.000				

W2 = 24.000 ft

On the right side, there is a 'Properties' section with a 'Compute Properties' button and the following fields:

- Area = [] ft²
- Ixx = [] ft⁴
- Iyy = [] ft⁴
- J = [] ft⁴

At the bottom, there are 'OK', 'Apply', and 'Cancel' buttons.

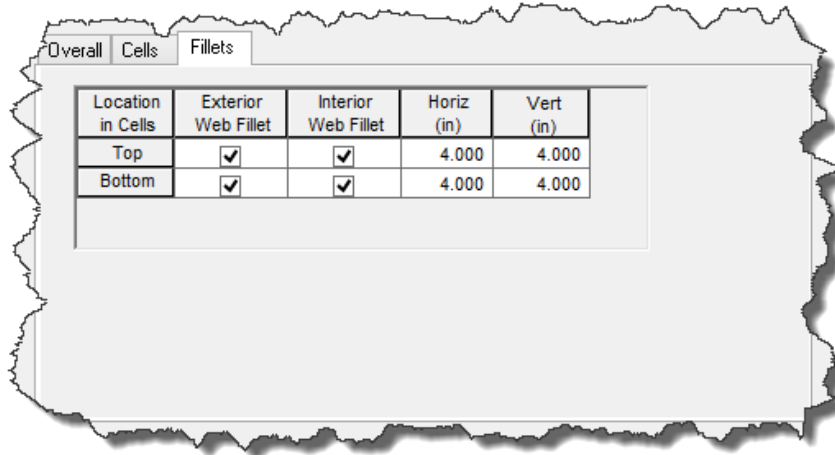
This is a close-up view of the 'Cells' tab in the software interface. It shows the following input fields:

- Top left web thickness: 14.000 in
- Bottom left web thickness: 14.000 in
- W2 = 24.000 ft

Below these fields is a table with the following data:

Cell	S (ft)	Top Right Web Thickness (in)	Bottom Right Web Thickness (in)	Top Slab Thickness (in)
1	12.000	14.000	14.000	8.000
2	12.000	14.000	14.000	8.000

MCB3 - Post-Tensioned Multicell Box LFR Example



Now that all of the dimensions are entered, click the 'Compute Properties' button.

Structure Cross Section

Name: Section 1 Number of cells: 2

Input Method: Simple Advanced
 Entry Method: Width Slope

Top slab concrete: PT Beam Concrete 4.5 ksi Other parts concrete: PT Beam Concrete 4.5 ksi
 Top slab stress limit: Beam Stress Limit Other parts stress limit: Beam Stress Limit

Diagram labels: LT1, LT2, WT-T, LW1, WT-B, LW2, S1, S2, S3, W2, W1, W2, RV, RW1, RW2, RT1, RT2, D, CJ, LV, RV, 30.000 ft, 8.000 in, 8.000 in.

	(ft)
D	4.000
CJ	0.667
LW1	3.000
LW2	3.000
RW1	3.000
RW2	3.000
LV	1.000
RV	1.000

	(in)
LT1	8.000
LT2	12.000
RT1	8.000
RT2	12.000

W2 = 24.000 ft

Properties

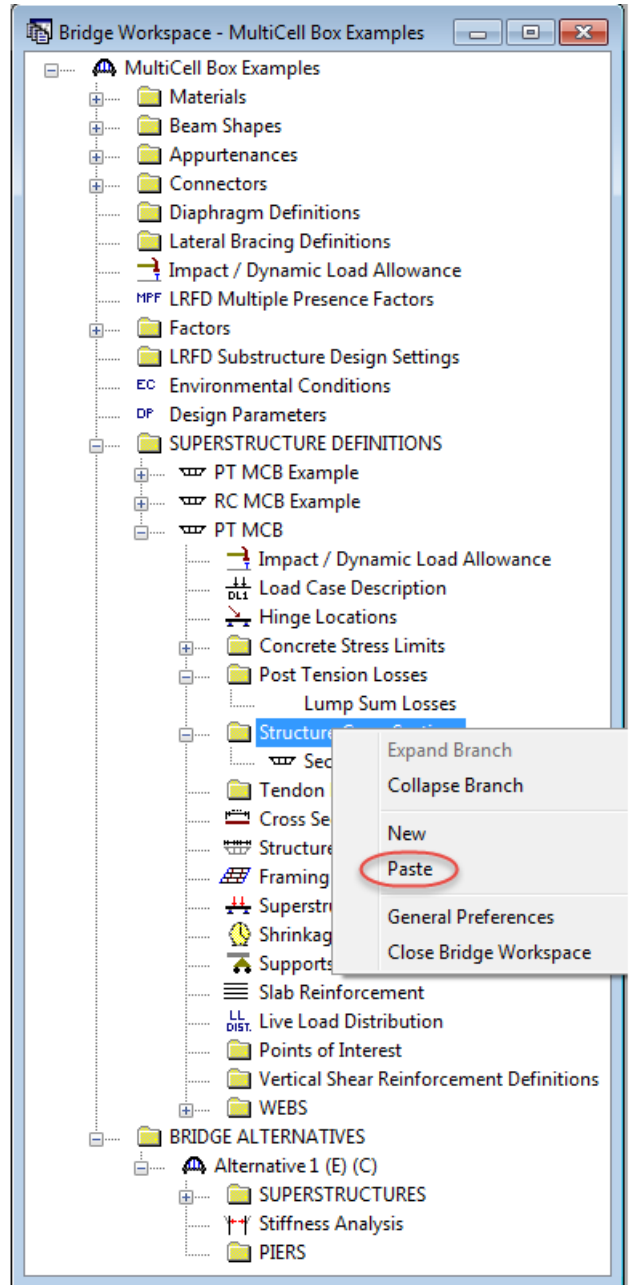
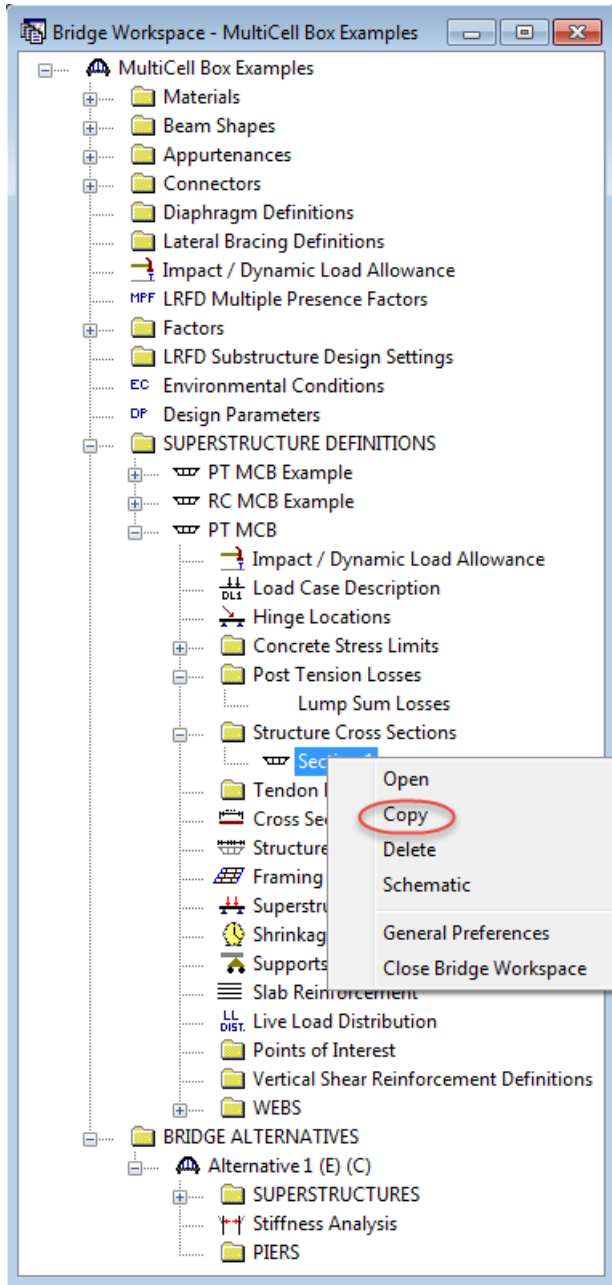
Compute Properties

Area = 46.778 ft²
 Ixx = 107.7004 ft⁴
 Iyy = 3275.2227 ft⁴
 J = 312.2257 ft⁴

OK Apply Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

Make a copy of this cross section by using the right-click menu.



MCB3 - Post-Tensioned Multicell Box LFR Example

Rename the new cross section and revise the depth to 8 ft.

Structure Cross Section

Name: Section 2 Number of cells: 2

Input Method: Simple Advanced
 Entry Method: Width Slope

Top slab concrete: PT Beam Concrete 4.5 ksi Other parts concrete: PT Beam Concrete 4.5 ksi
 Top slab stress limit: Beam Stress Limit Other parts stress limit: Beam Stress Limit

Overall Cells Fillets

	(ft)
D	8.000
CJ	0.667
LW1	3.000
LW2	3.000
RW1	3.000
RW2	3.000
LV	1.000
RV	1.000

	(in)
LT1	8.000
LT2	12.000
RT1	8.000
RT2	12.000

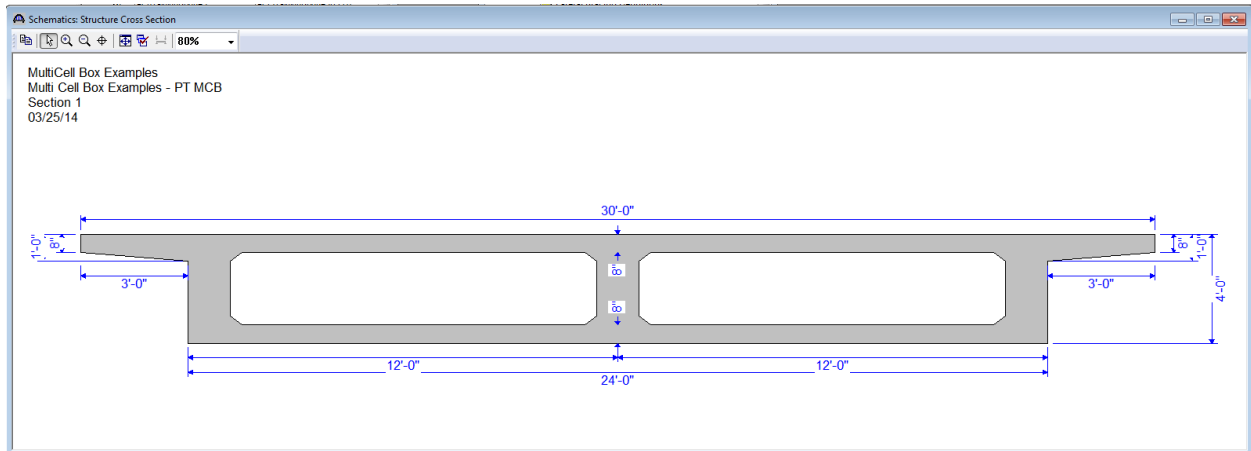
W2 = 24.000 ft

Properties

Compute Properties

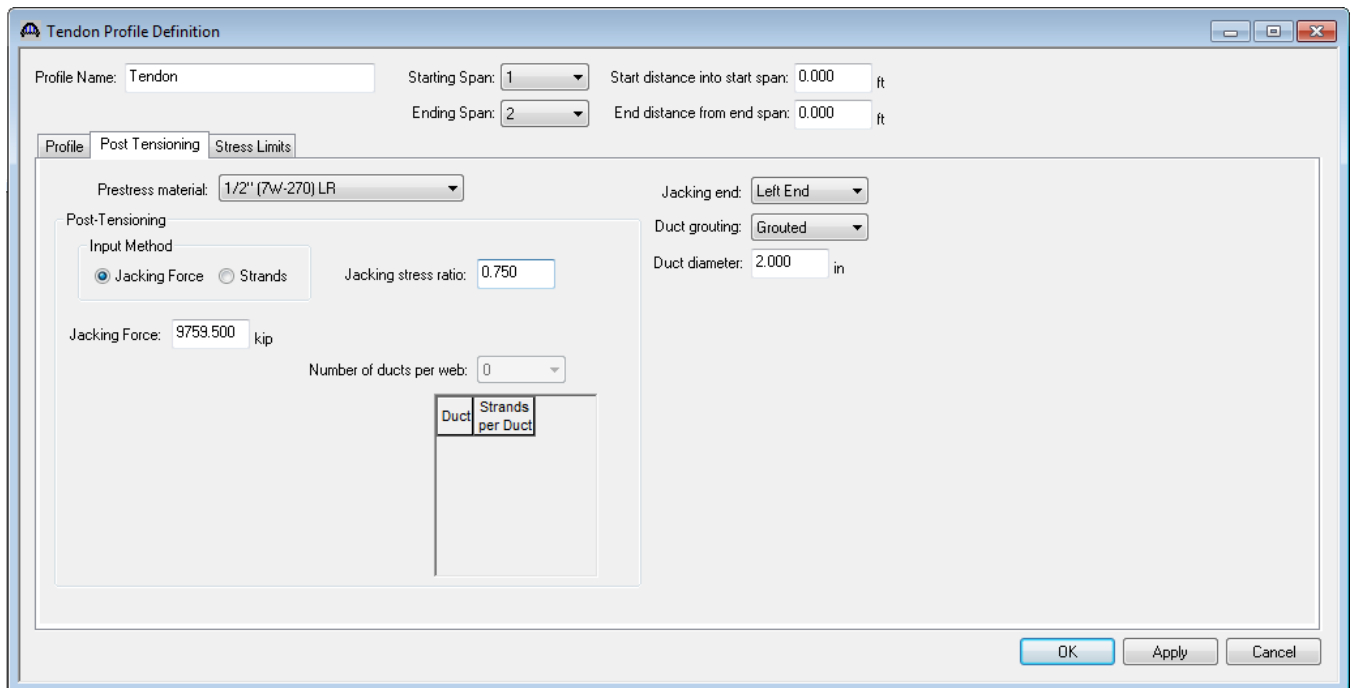
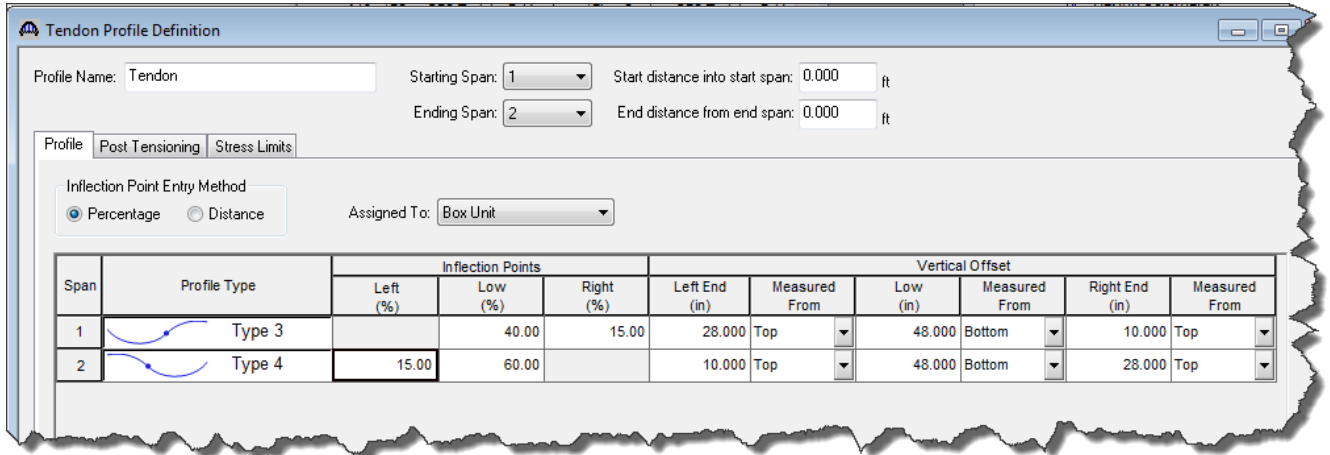
Area = 60.778 ft²
 I_{xx} = 581.4940 ft⁴
 I_{yy} = 4493.3200 ft⁴
 J = 1383.3550 ft⁴

OK Apply Cancel



MCB3 - Post-Tensioned Multicell Box LFR Example

Create the following tendon profile.



MCB3 - Post-Tensioned Multicell Box LFR Example

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**

	LRFD	LFD
Prior to seating:	<input type="text" value="218.700"/> ksi	<input type="text" value="201.690"/> ksi
At anchorages and couplers immediately after anchor set:	<input type="text" value="189.000"/> ksi	<input type="text" value="202.500"/> ksi
Elsewhere along length of member immediately after anchor set:	<input type="text" value="199.800"/> ksi	<input type="text" value="189.000"/> ksi
At service limit state after losses:	<input type="text" value="194.400"/> ksi	<input type="text" value="194.400"/> ksi

Open the Cross Section Range Properties window and assign the cross sections as follows.

Cross Section Ranges

Cross Sections | Post Tensioning | Effective Supports

Left end projection: in Right end projection: in

Start Section	End Section	Depth Vary	Solid Section	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
Section 1	Section 1	None	<input checked="" type="checkbox"/>	1	0.000	1.000	1.000
Section 1	Section 2	Parabolic	<input type="checkbox"/>	1	1.000	107.500	108.500
Section 2	Section 2	None	<input checked="" type="checkbox"/>	1	108.500	6.000	114.500
Section 2	Section 1	Parabolic	<input type="checkbox"/>	2	3.000	107.500	110.500
Section 1	Section 1	None	<input checked="" type="checkbox"/>	2	110.500	1.000	111.500

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Post Tension Losses:

Tendon Assignments

Tendon Profile	Start Span	Start Distance into Start Span (ft)	End Span	End Distance from End Span (ft)
Tendon	1	0.000	2	0.000

Buttons: New, Delete, OK, Apply, Cancel

Effective supports allow you 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.

Span	From Start (in)	From End (in)
1		36.000
2	36.000	

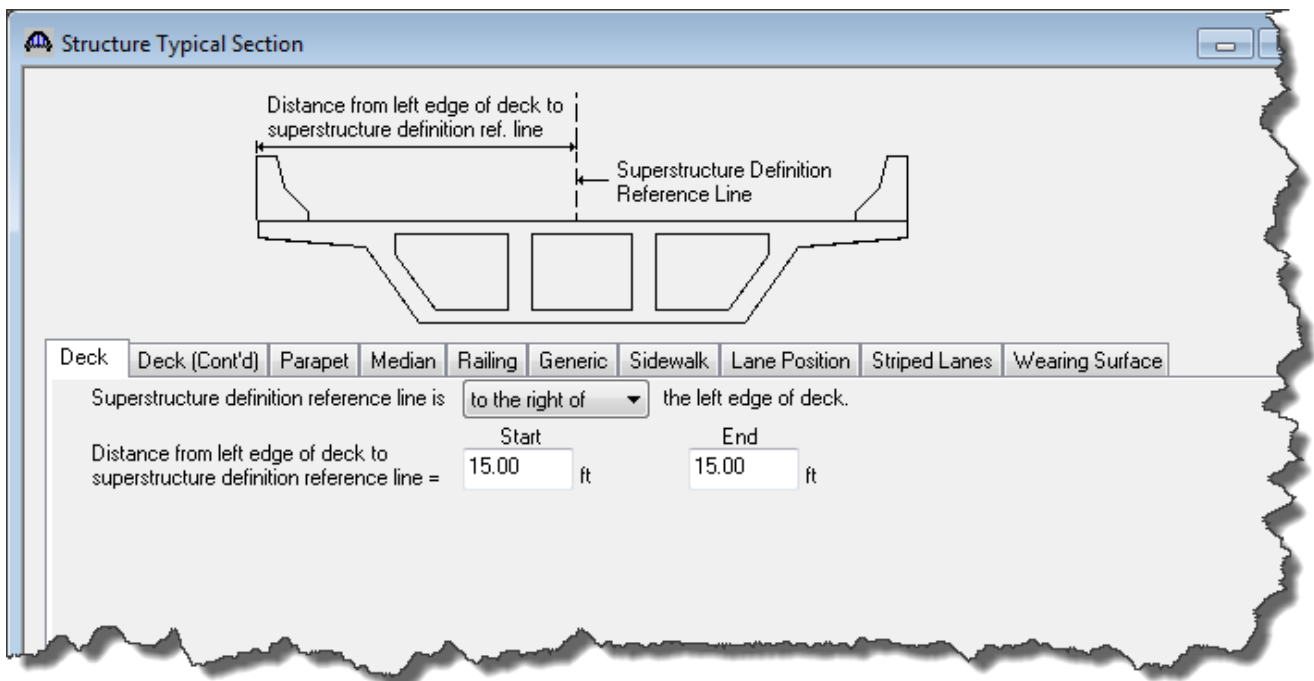
Buttons: OK, Apply, Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

Select 'Cross Section Range Properties' in the BWS tree and open the following Schematic from the toolbar.



Open the Structure Typical Section window and locate the superstructure definition reference line as follows.



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Enter the following data for the structural overlay. The overlay is applied in the self load DC load case.

Distance from left edge of deck to superstructure definition ref. line

Superstructure Definition Reference Line

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Sacrificial wear thickness: in

Structural overlay density: kcf

Structural overlay thickness: in

Top slab crack control parameter: kip/in

Bottom slab crack control parameter: kip/in

Sustained modular ratio factor:

Bottom slab exposure factor:

Top slab exposure factor:

Inside void slab exposure factor:

Inside void slab crack control parameter: kip/in

OK Apply Cancel

Enter the barriers.

Generic Shape

Back Front

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
12" Barrier	DC1	Back	Left Edge	0.00	0.00	Right
12" Barrier	DC1	Back	Right Edge	0.00	0.00	Left

MCB3 - Post-Tensioned Multicell Box LFR Example

Use the Compute button to enter the following lane positions.

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	-14.00	14.00	-14.00	14.00

LRFD Fatigue
 Lanes available to trucks:
 Override Truck fraction:

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'.

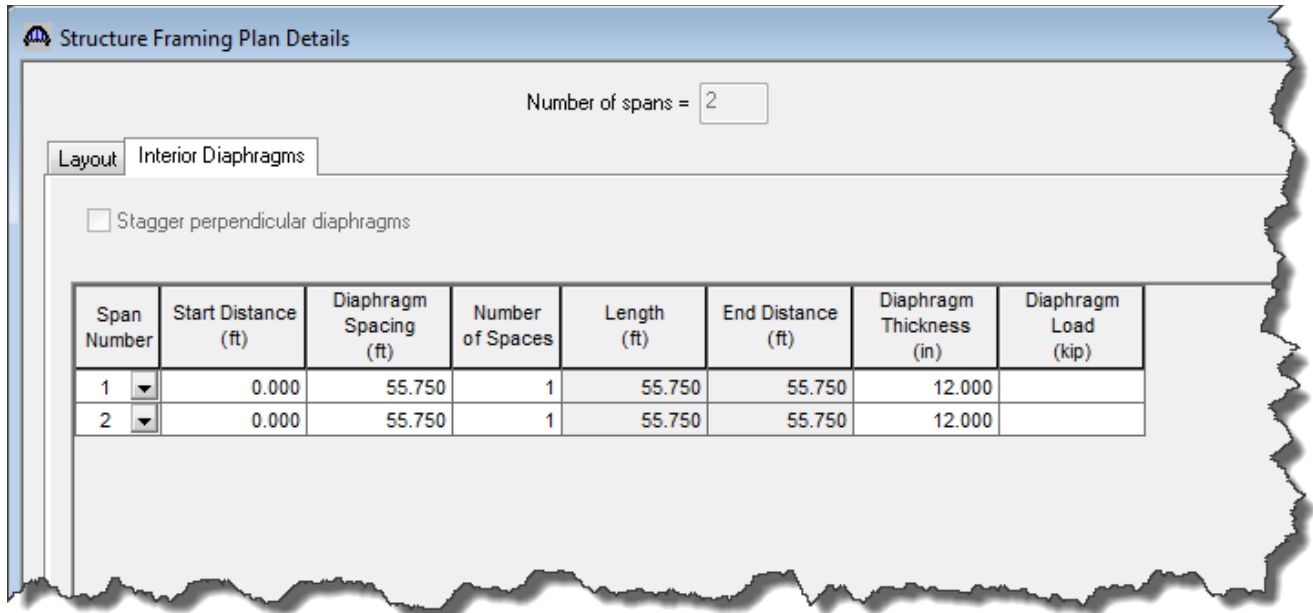
MultiCell Box Examples
 Multi Cell Box Examples - PT MCB
 03/25/14

28'-0"

Travelway 1

MCB3 - Post-Tensioned Multicell Box LFR Example

Enter the following diaphragm locations on the Framing Plan Details 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.



Structure Framing Plan Details

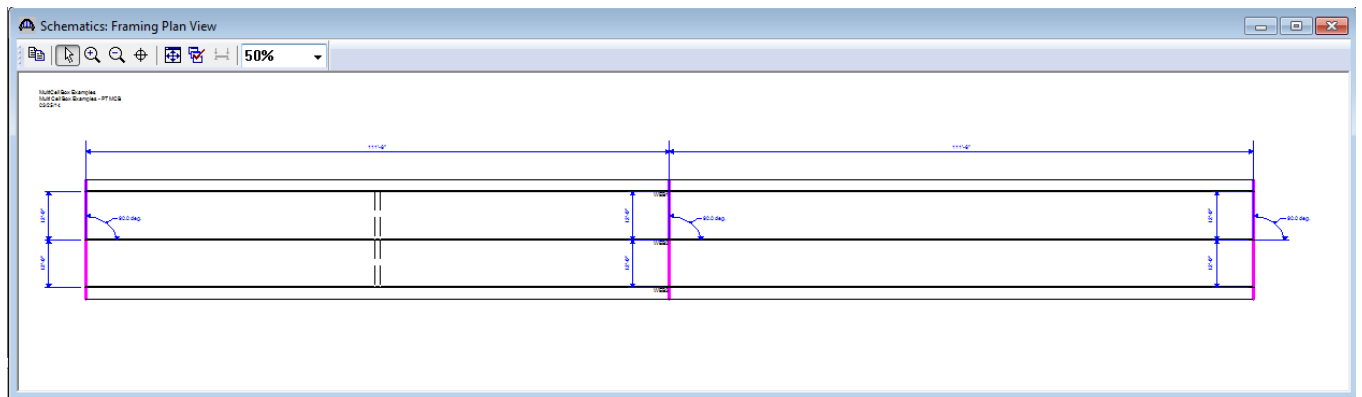
Number of spans = 2

Layout Interior Diaphragms

Stagger perpendicular diaphragms

Span Number	Start Distance (ft)	Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)	Diaphragm Thickness (in)	Diaphragm Load (kip)
1	0.000	55.750	1	55.750	55.750	12.000	
2	0.000	55.750	1	55.750	55.750	12.000	

The Framing Plan schematic appears as follows.



MCB3 - Post-Tensioned Multicell Box LFR Example

Full beam multicell box live load distribution factors is 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 sum of all the web distribution factors are used as the beam distribution factors.

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

Standard live load distribution factors for entire beam using the 'Compute from Typical Section' button.

Standard LFRD

Distribution Factor Input Method

Use Simplified Method Use Advanced Method Use Advanced Method with 1994 Guide Specs

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

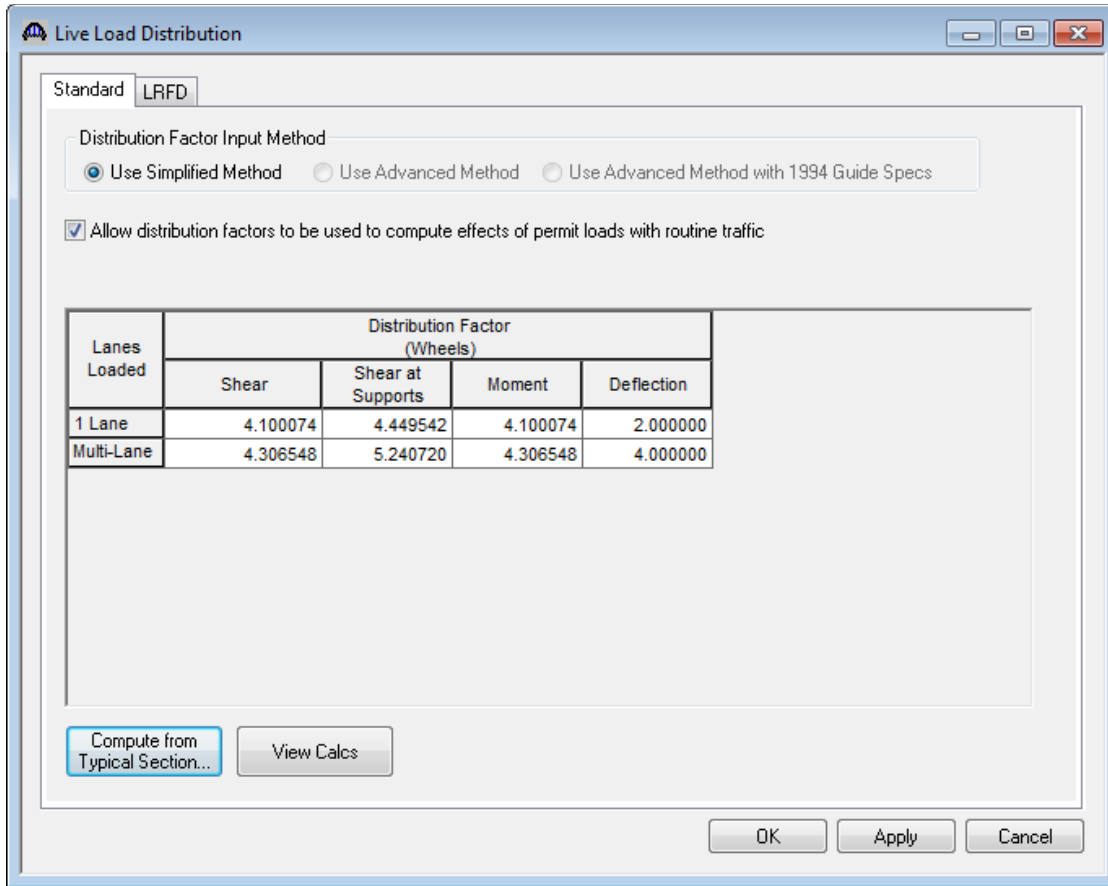
Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane				
Multi-Lane				

Compute from Typical Section... View Calcs

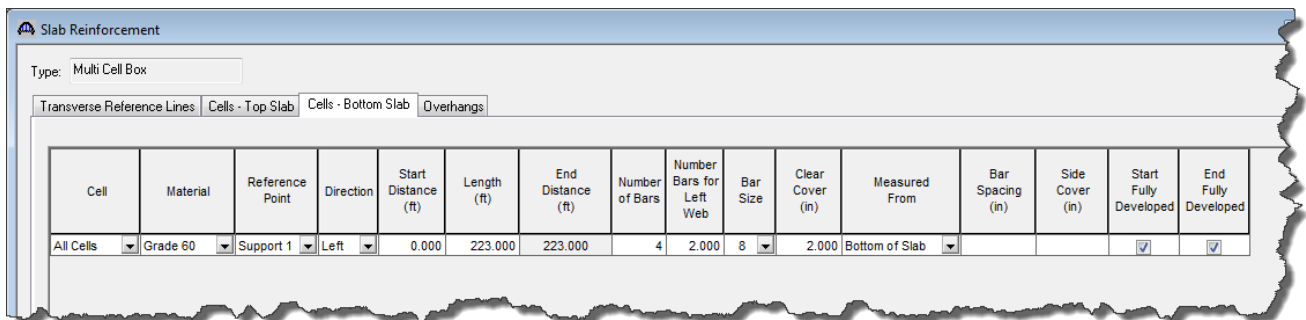
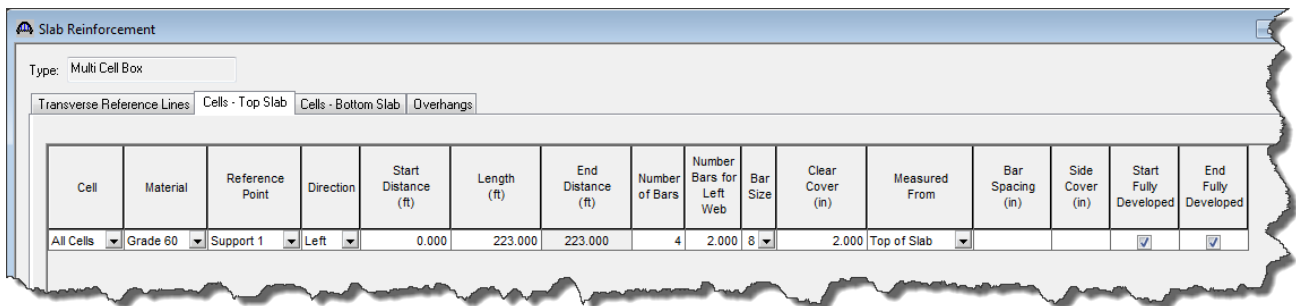
OK Apply Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

The computed Live Load Distribution window is shown below.

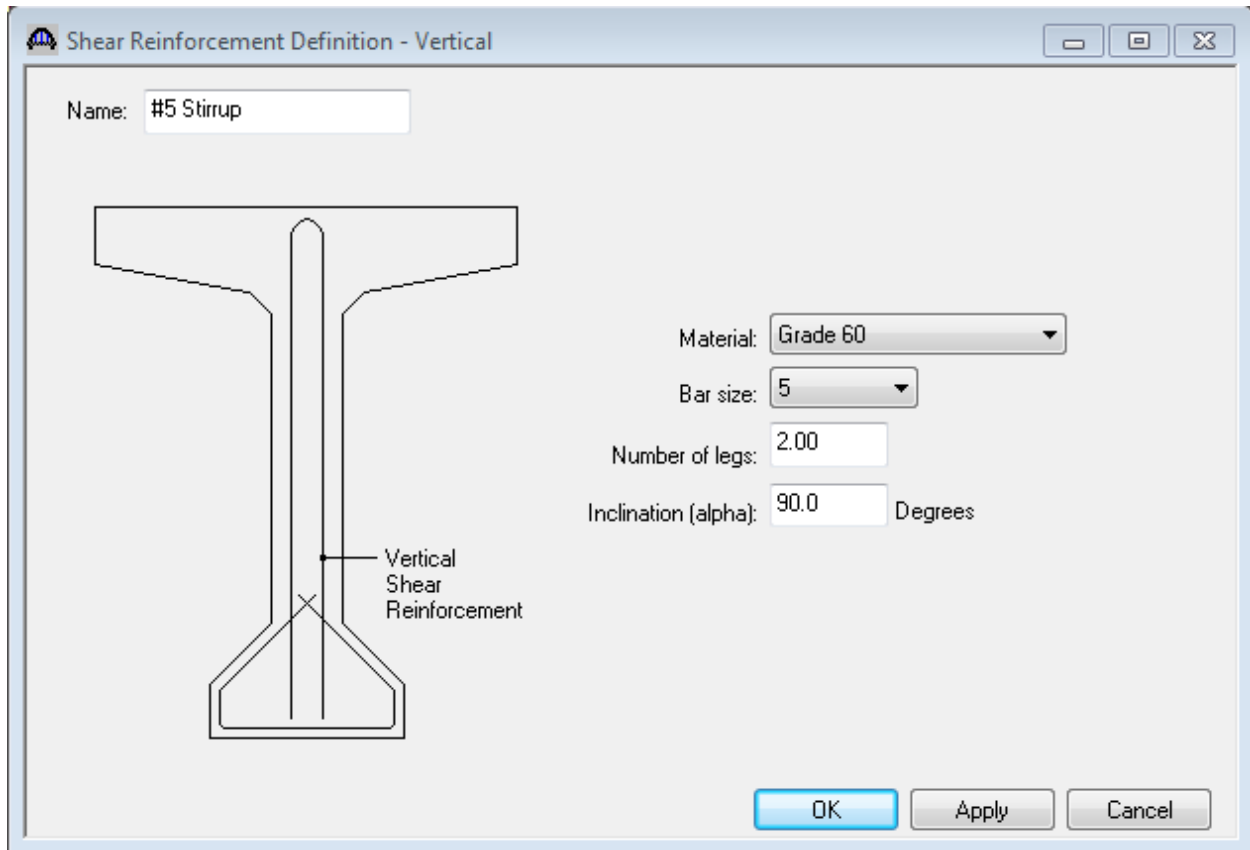


Enter the following reinforcement in the top and bottom slabs of the box.



MCB3 - Post-Tensioned Multicell Box LFR Example

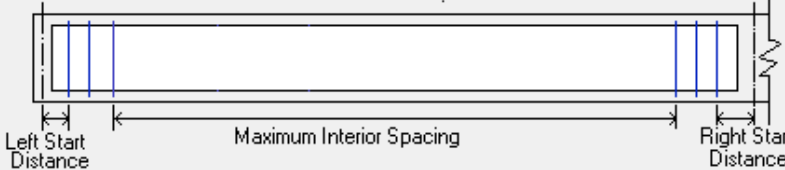
Create the following stirrup definition.



MCB3 - Post-Tensioned Multicell Box LFR Example

Open the Web 1 Shear Reinforcement Ranges window. Select the input reference type as 'Centerline of Bearings'. Click the Stirrup Wizard button and enter the following data.

Stirrup Wizard



Input Reference Type

Voids Centerline Bearings

Span: 1 Maximum interior spacing: 18.0000 in

Measured From Left End of Span

Start distance: 15.0000 in

Name	Number of Spaces	Spacing (in)
#5 Stirrup	12	6.000
#5 Stirrup	12	9.000
#5 Stirrup	12	14.000

Measured From Right End of Span

Start distance: 39.0000 in

Name	Number of Spaces	Spacing (in)
#5 Stirrup	18	5.000
#5 Stirrup	18	7.000
#5 Stirrup	24	9.000

Buttons: New Duplicate Delete (for both tables)

Buttons: Apply All Apply Span Cancel Help

MCB3 - Post-Tensioned Multicell Box LFR Example

Select 'Span 2' in the Wizard and enter similar data for Span 2.

Stirrup Wizard

Left Start Distance Maximum Interior Spacing Right Start Distance

Input Reference Type
 Voids Centerline Bearings

Span: 2 Maximum interior spacing: 18.0000 in

Measured From Left End of Span Measured From Right End of Span

Start distance: 39.0000 in Start distance: 15.0000 in

Name	Number of Spaces	Spacing (in)
#5 Stirrup	18	5.000
#5 Stirrup	18	7.000
#5 Stirrup	24	9.000

Name	Number of Spaces	Spacing (in)
#5 Stirrup	12	6.000
#5 Stirrup	12	9.000
#5 Stirrup	12	14.000

New Duplicate Delete New Duplicate Delete

Apply All Apply Span Cancel Help

Click the 'Apply All' button to create the stirrup ranges for each span.

MCB3 - Post-Tensioned Multicell Box LFR Example

Span 1 will show the following data.

Web Shear Reinforcement Ranges - Web 1

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	1.250000	1	0.000000	0.000	1.250
#5 Stirrup	1.250000	12	6.000000	6.000	7.250
#5 Stirrup	7.250000	12	9.000000	9.000	16.250
#5 Stirrup	16.250000	12	14.000000	14.000	30.250
#5 Stirrup	30.250000	13	18.000000	19.500	49.750
#5 Stirrup	49.750000	1	18.000000	1.500	51.250
#5 Stirrup	51.250000	14	18.000000	21.000	72.250
#5 Stirrup	72.250000	24	9.000000	18.000	90.250
#5 Stirrup	90.250000	18	7.000000	10.500	100.750
#5 Stirrup	100.750000	18	5.000000	7.500	108.250

Copy... Stirrup Wizard... New Duplicate Delete

OK Apply Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

Open the Web 2 Shear Reinforcement Ranges window. Select 'Web 1' in the 'Link With' field. The data from Web 1 will appear in this window as read only. If data is changed in the Web 1 Shear Reinforcement Ranges window in the future, those changes will be reflected in this window. Do the same for Web 3, linking it to Web 1.

Web Shear Reinforcement Ranges - Web 2

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	1.250	1	0.000	0.000	1.250
#5 Stirrup	1.250	12	6.000	6.000	7.250
#5 Stirrup	7.250	12	9.000	9.000	16.250
#5 Stirrup	16.250	12	14.000	14.000	30.250
#5 Stirrup	30.250	13	18.000	19.500	49.750
#5 Stirrup	49.750	1	18.000	1.500	51.250
#5 Stirrup	51.250	14	18.000	21.000	72.250
#5 Stirrup	72.250	24	9.000	18.000	90.250
#5 Stirrup	90.250	18	7.000	10.500	100.750
#5 Stirrup	100.750	18	5.000	7.500	108.250

Copy... Stirrup Wizard... New Duplicate Delete

OK Apply Cancel

MCB3 - Post-Tensioned Multicell Box LFR Example

We can now sit on our superstructure definition in the BWS tree and launch an LFR analysis. The full multicell box width is analyzed for flexure and shear and then each weblines is analyzed for shear. The Analysis Results window shows the critical rating factors considering the full box and each weblines.

Analysis Results - PT MCB

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-(%)	Element Name	Limit State	Impact	Lane
HS 20-44	Lane	LFD	Inventory	9.98	0.277	66.90	1 - (60.0)	PT MCB	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Lane	LFD	Operatin	21.44	0.596	66.90	1 - (60.0)	PT MCB	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	8.97	0.249	66.90	1 - (60.0)	PT MCB	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operatin	7.04	0.196	114.50	2 - (2.7)	PT MCB	Design Shear - Concrete	As Requested	As Requested

AASHTO LFR Engine Version 6.8.0.3001
Analysis Preference Setting: None

Close

Spec check details are available for the full box and each weblines.

Specification Checks for PT MCB - 504 of 3208

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

Specification Reference

- ✓ 6B.5.3.3 PS Concrete Compressive Stress
- ✓ 6B.5.3.3 PS Concrete Tensile Stress
- ✓ 6B.5.3.3 PS Flexure Rating
- 6B.5.3.3 PS Moment Capacity
- ✓ 6B.5.3.3 PS Shear Rating
- ✓ 6B.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
- 9.20.1.3 Nominal Shear Capacity
- 9.20.2.1 Shear Strength Provided by Concrete
- 9.20.2.2 Shear Strength Provided by Concrete
- 9.20.2.3 Shear Strength Provided by Concrete
- 9.20.2.5 Shear Strength Provided by Concrete