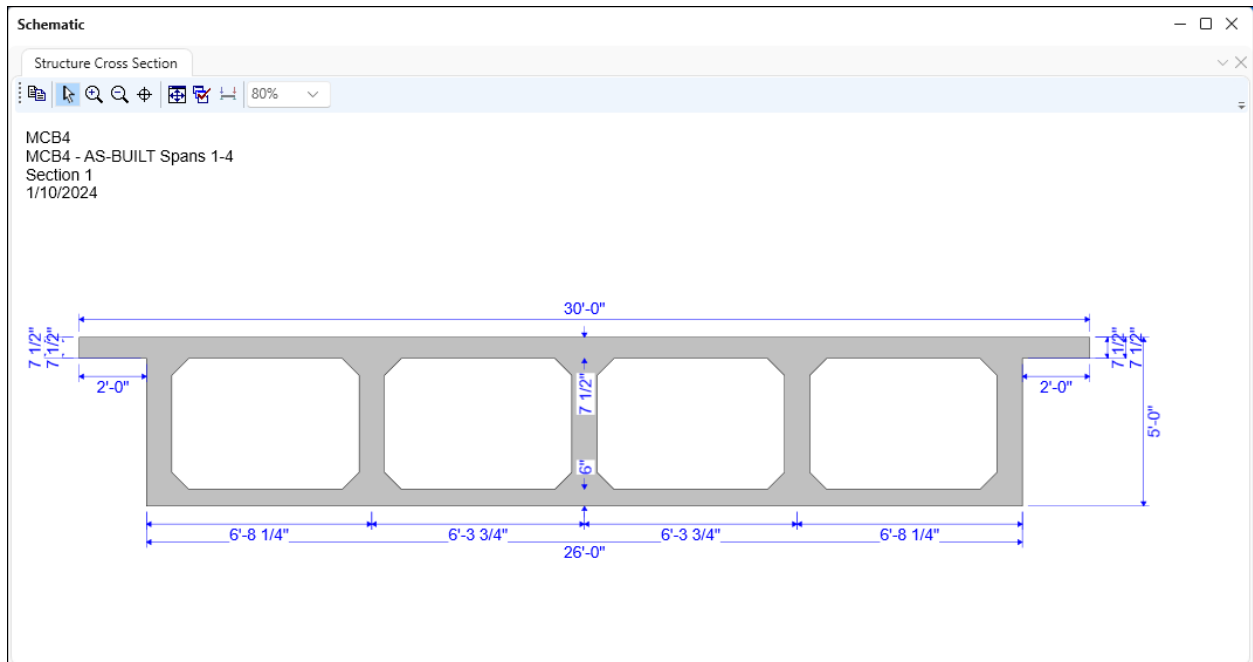


AASHTOWare BrDR 7.5.0

Multi-Cell Box Tutorial

MCB4 – RC MCB Integral with Pier Example

MCB4 – RC MCB Integral with Pier Example



Topics Covered

- Analysis Methods
- Comments and Assumptions
- Data Entry
- Structure Typical Section
- Structure Framing Plan Details
- Slab Reinforcement Data Entry
- Vertical Shear Reinforcement Data Entry
- Bridge Alternatives
- Pier Data Entry
- Foundation Alternatives
- Analysis and results

Analysis Methods

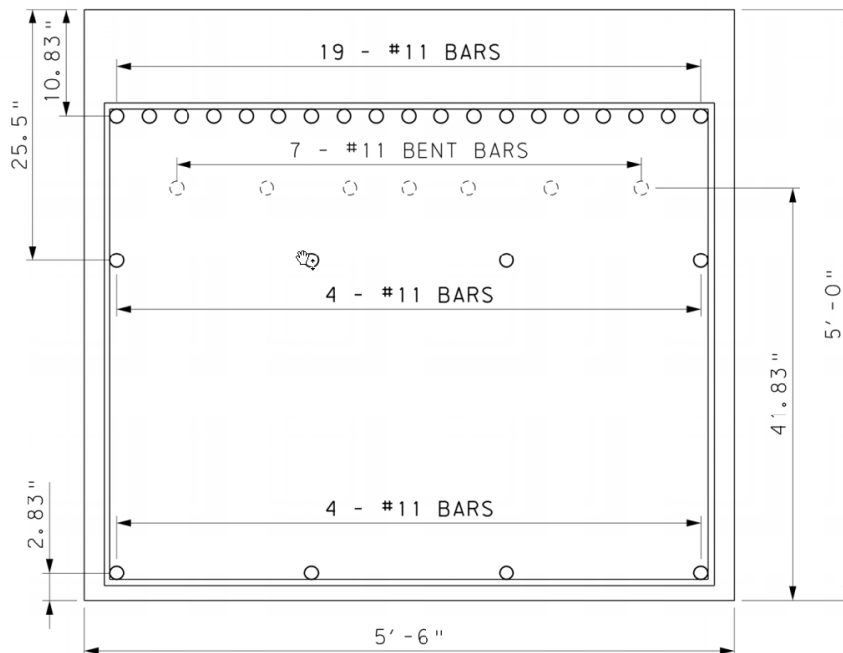
Reinforced concrete multi-cell box (MCB) superstructures can be analyzed in the following ways:

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

MCB4 – RC MCB Integral with Pier Example

Comments and Assumptions

- Based on the year built, 1963, information contained in the design plans, and the AASHTO Manual for Bridge Evaluation:
 - Concrete compressive strength = 3 ksi ($f_c = 1.2$ ksi)
 - Reinforcing steel yield strength = 40 ksi ($f_s = 20$ ksi)
 - Structural Steel Yield Strength = 36 ksi
 - Pile size = 10BP42
- ADTT = 500
- Integral wearing surface = 0.0 in.
- Use approximate longitudinal deck rebar spacing.
- Use the following section to determine pier cap straight flexural reinforcement:

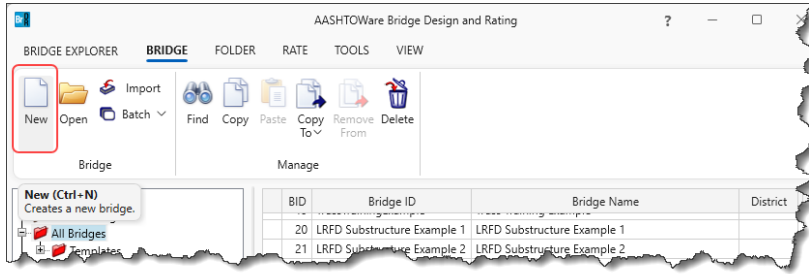


- Web shear reinforcement (S1 – S3 bars) are #5 bars.
- Top of footing elevation = 332.96 ft. for all piers.
- Finished ground line elevation = 335.00 ft. for all piers.
- Bottom of footing elevation = 328.71 ft. for all piers
- 30'-0" long piles with 1'-0" embedment
- Assume pile fixity elevation = 318.71 ft.
- Assume pile downdrag force = 0 kip
- Use the maximum shaft height for all piers (27 ft.)
- Soil density = 120 kcf
- Factored bearing resistance of soil = 15 ksf

MCB4 – RC MCB Integral with Pier Example

Data Entry

From the **Bridge Explorer**, use the **New** button to create a new bridge and enter the following data.



New Bridge

Bridge ID: NBI structure ID (8):

Template
 Bridge completely defined

Bridge Workspace View
 Superstructures
 Culverts
 Substructures

Description | Description (cont'd) | Alternatives | Global reference point | Traffic | Custom agency fields

Name: Year built:

Description:

Location: Length: ft

Facility carried (7): Route number:

Feat. intersected (6): Mi. post:

Default units:

Bridge ID: NBI structure ID (8): Bridge completely defined

Bridge Workspace View
 Superstructures
 Culverts
 Substructures

Description | Description (cont'd) | Alternatives | Global reference point | Traffic | Custom agency fields

Truck PCT: %

ADT:

Directional PCT: %

Recent ADTT:

Design ADTT:

Exp. annual ADTT growth rate:

Fatigue importance factor:

Importance factor override

(ADTT)_S:

(ADTT)_SPRESENT:

(ADTT)_SLIMIT:

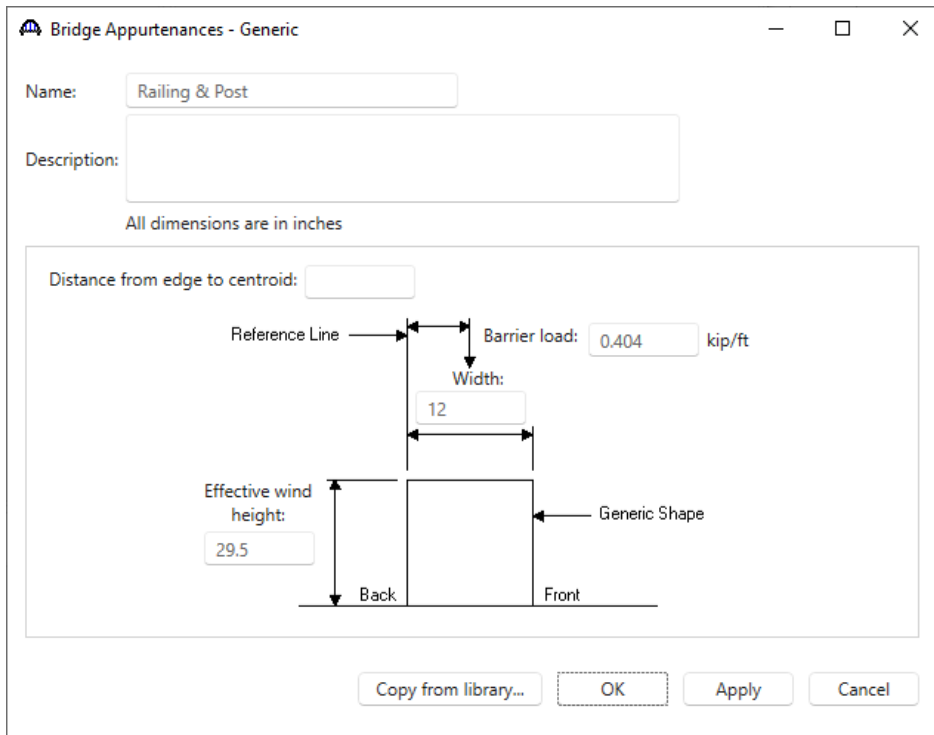
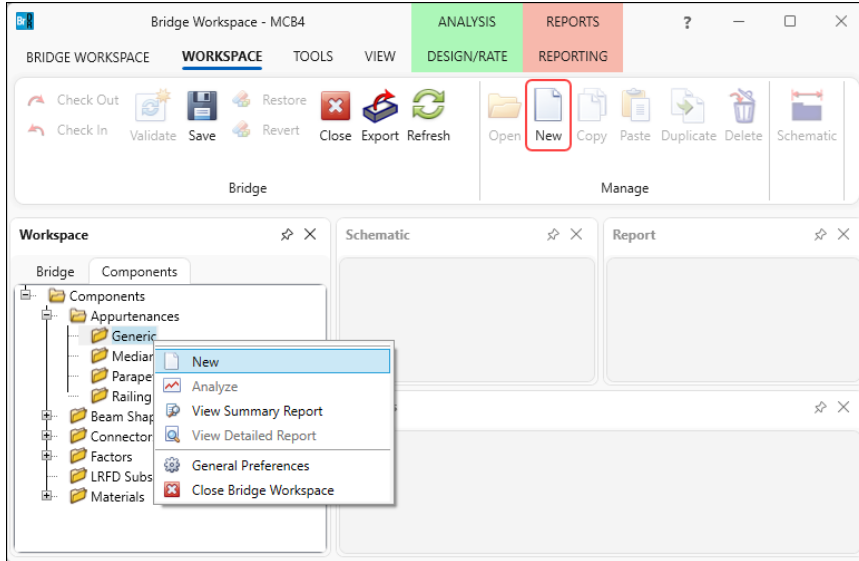
Click **OK** to apply the data and close the window.

MCB4 – RC MCB Integral with Pier Example

Now begin adding the **Components** required to build the bridge model. Navigate to the **Components** tab of the **Bridge Workspace (BWS)**.

Bridge Appurtenances – Generic tab

Expand the **Appurtenances** tree and double click on the **Generic** folder (or right click and select **New** or click on the **New** button from the **Manage** group of the **WORKSPACE** ribbon) to define a generic barrier as shown below.

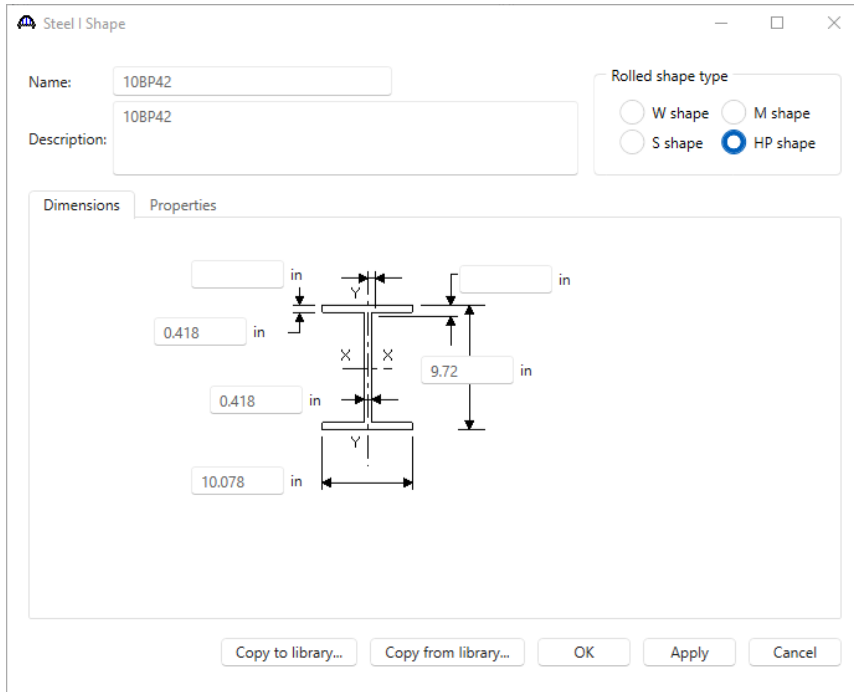


Click **OK** to apply the data and close the window.

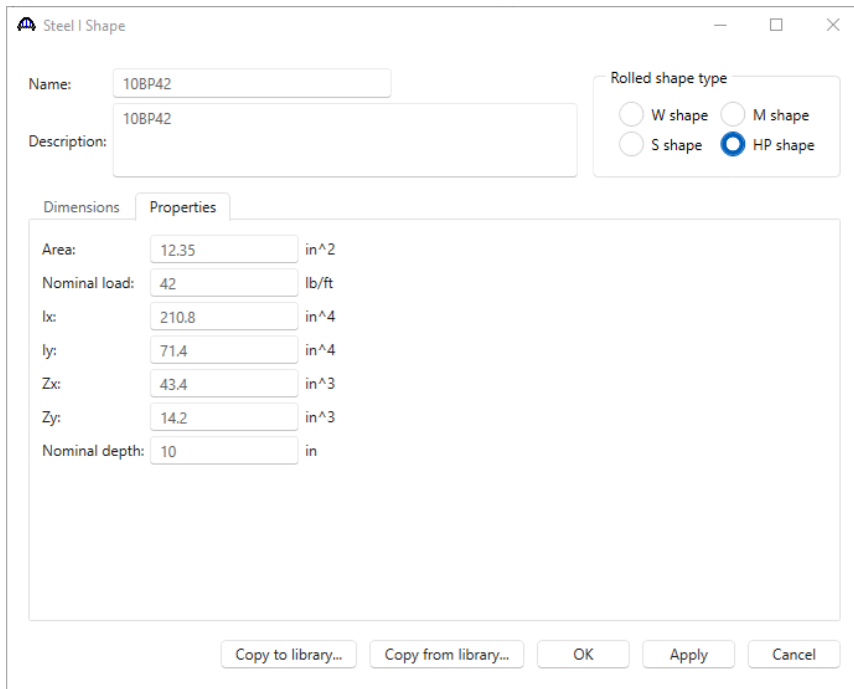
MCB4 – RC MCB Integral with Pier Example

Beam Shapes - Steel I Shape

The **10PB42** Steel Shape for the footing pile is not in the library so it will have to be created. Expand the **Beam Shapes** folder, **Steel Shapes** and double click **Steel Shapes - I Shapes** and enter the following data.



Navigate to the **Properties** tab of this window and enter the data as shown below.



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

MCB4 – RC MCB Integral with Pier Example

LRFD Substructure Design Settings

Define substructure design settings by double clicking **LRFD Substructure Design Settings** and click **Copy from library...** button. Select **Final Design Setting (US)** and click **OK**.

Library Data: LRFD Substructure Design Settings

Name	Description	Library	Units	Preliminary	Final
Final Design Setting (SI)	Final Design Setting (SI)	Standard	SI / Metric	False	True
> Final Design Setting (US)	Final Design Setting (US)	Standard	US Customary	False	True
Preliminary Design Setting (SI)	Preliminary Design Setting (SI)	Standard	SI / Metric	True	False
Preliminary Design Setting (US)	Preliminary Design Setting (US)	Standard	US Customary	True	False

Name: Final Design Setting (US)
Description: Final Design Setting (US)

Design setting type:
 Preliminary
 Final

Limit states: Vehicles Substructure loading

Analysis method type	Analysis module	Spec version	Factors
LRFD	AASHTO LRFD	LRFD 5th 2010i	2010 AASHTO LRFD Specifications

Choose the limit states to be included in the analysis:

- STRENGTH-I
- STRENGTH-II
- STRENGTH-III
- STRENGTH-IV
- STRENGTH-V
- SERVICE-I
- SERVICE-II
- SERVICE-III
- SERVICE-IV

Dynamic load allowance

Fatigue and fracture limit states: 15 %
All other limit states: 33 %

Copy from library... OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example

Bridge Materials - Concrete

To add a new concrete material, expand the **Materials** folder and double click on **Concrete** in the tree. The window shown below will open. Enter the values shown below. Use the **Compute** button to fill in the lower portion of the window.

Name:	3 ksi
Description:	Class B cement concrete
Compressive strength at 28 days (f'c):	3 ksi
Initial compressive strength (f'ci):	
Composition of concrete:	Normal
Density (for dead loads):	0.15 kcf
Density (for modulus of elasticity):	0.145 kcf
Poisson's ratio:	0.2
Coefficient of thermal expansion (α):	0.000006 1/F
Splitting tensile strength (fct):	
LRFD Maximum aggregate size:	
Compute	
Std modulus of elasticity (Ec):	3155.924251 ksi
LRFD modulus of elasticity (Ec):	3625.494616 ksi
Std initial modulus of elasticity:	
LRFD initial modulus of elasticity:	
Std modulus of rupture:	0.410792 ksi
LRFD modulus of rupture:	0.415692 ksi
Shear factor:	1

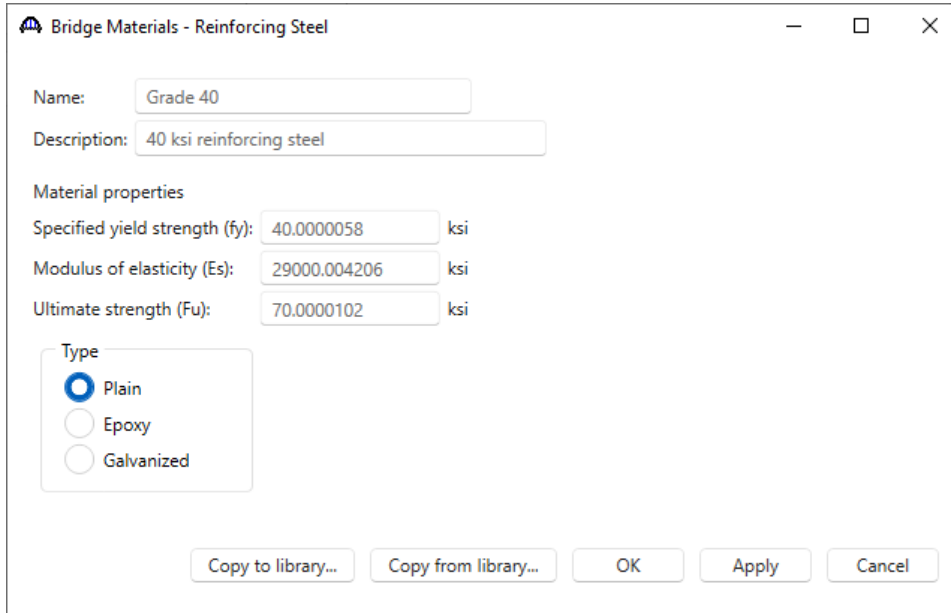
Copy to library... Copy from library... OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example

Bridge materials – Reinforcing Steel

To add a new reinforcing steel material, double click on **Reinforcing Steel** in the tree and click on **Copy from library...** button. Select the **Grade 40** reinforcing steel and click **OK**. The selected material properties are copied to the **Bridge Materials – Reinforcing Steel** window as shown below.



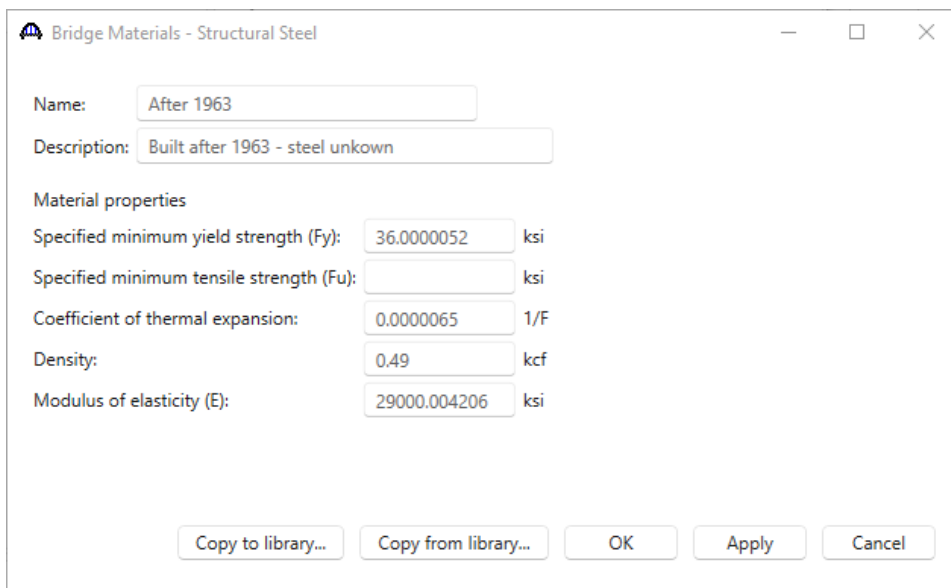
The screenshot shows a dialog box titled "Bridge Materials - Reinforcing Steel". It contains the following fields and options:

- Name: Grade 40
- Description: 40 ksi reinforcing steel
- Material properties:
 - Specified yield strength (fy): 40.0000058 ksi
 - Modulus of elasticity (Es): 29000.004206 ksi
 - Ultimate strength (Fu): 70.0000102 ksi
- Type: Plain (selected), Epoxy, Galvanized
- Buttons: Copy to library..., Copy from library..., OK, Apply, Cancel

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

Bridge Materials – Structural Steel

To add a new structural steel material, double click on **Structural Steel** in the tree and click on **Copy from library...** button. Select the **After 1963** material and click **OK**. The selected material properties are copied to the **Bridge Materials – Structural Steel** window as shown below.



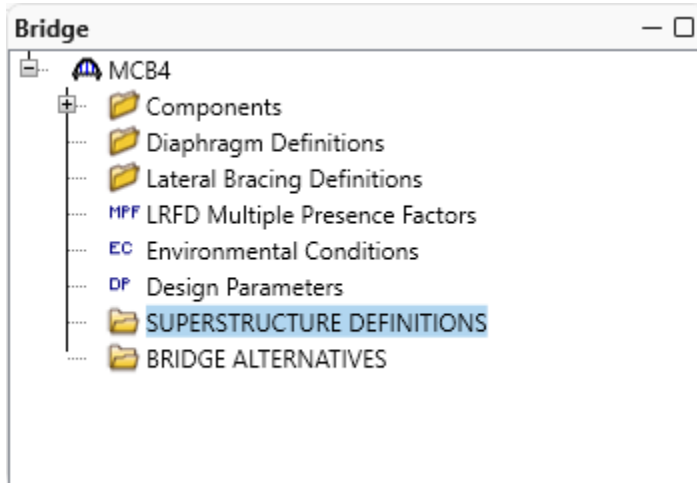
The screenshot shows a dialog box titled "Bridge Materials - Structural Steel". It contains the following fields and options:

- Name: After 1963
- Description: Built after 1963 - steel unknown
- Material properties:
 - Specified minimum yield strength (Fy): 36.0000052 ksi
 - Specified minimum tensile strength (Fu): ksi
 - Coefficient of thermal expansion: 0.0000065 1/F
 - Density: 0.49 kcf
 - Modulus of elasticity (E): 29000.004206 ksi
- Buttons: Copy to library..., Copy from library..., OK, Apply, Cancel

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

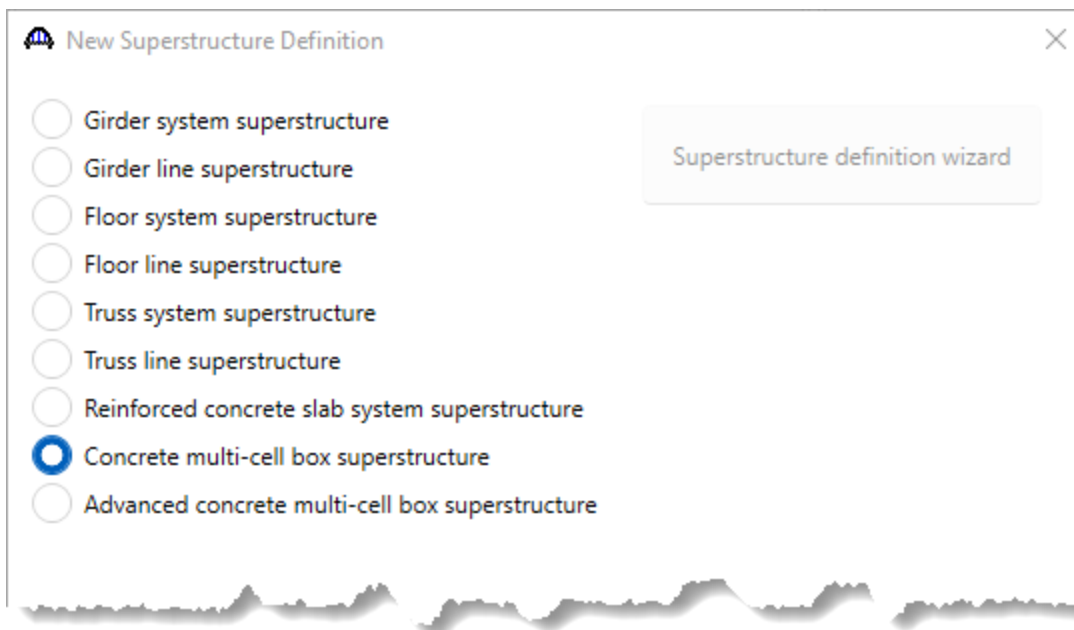
MCB4 – RC MCB Integral with Pier Example

Navigate back to the **Bridge** tab of the **BWS** tree. The partially expanded tree is shown below.



New Superstructure Definition

Create a new concrete multi-cell box superstructure definition by double clicking the **SUPERSTRUCTURE DEFINITIONS** folder. Select **Concrete multi-cell box superstructure** and click **OK**.



MCB4 – RC MCB Integral with Pier Example

Concrete Multi-Cell Box Superstructure Definition

Enter data as shown below. Be sure to leave make the superstructure **Integral with substructure** and that the **Post-tensioned** box is unchecked.

Concrete Multi-Cell Box Superstructure Definition

Definition Analysis Specs Factors Engine Control options

Name: AS-BUILT Spans 1-4

Description:

Default units: US Customary

Number of spans: 4

Number of cells: 4

Span lengths Integral piers

Enter span lengths along the reference line:

Span	Length (ft)
1	57.25
2	80
3	80
4	57.25

End projections
Left: 6 in
Right: 6 in

Average humidity: %

Structure type
 Frame structure simplified definition
 Integral with substructure
 Consider substructure skew in FE section properties
 Not integral with pier

Structure model for LLDF computation
Standalone

Left side connected to adjacent structure
 Right side connected to adjacent structure

Post-tensioned
 Analyze webs only

Concrete Multi-Cell Box Superstructure Definition

Definition Analysis Specs Factors Engine Control options

Name: AS-BUILT Spans 1-4

Description:

Default units: US Customary

Number of spans: 4

Number of cells: 4

Span lengths Integral piers

Frame connections:

Support	Integral
1	<input type="checkbox"/>
2	<input checked="" type="checkbox"/>
3	<input checked="" type="checkbox"/>
4	<input checked="" type="checkbox"/>
5	<input type="checkbox"/>

End projections
Left: 6 in
Right: 6 in

Average humidity: %

Structure type
 Frame structure simplified definition
 Integral with substructure
 Consider substructure skew in FE section properties
 Not integral with pier

Structure model for LLDF computation
Standalone

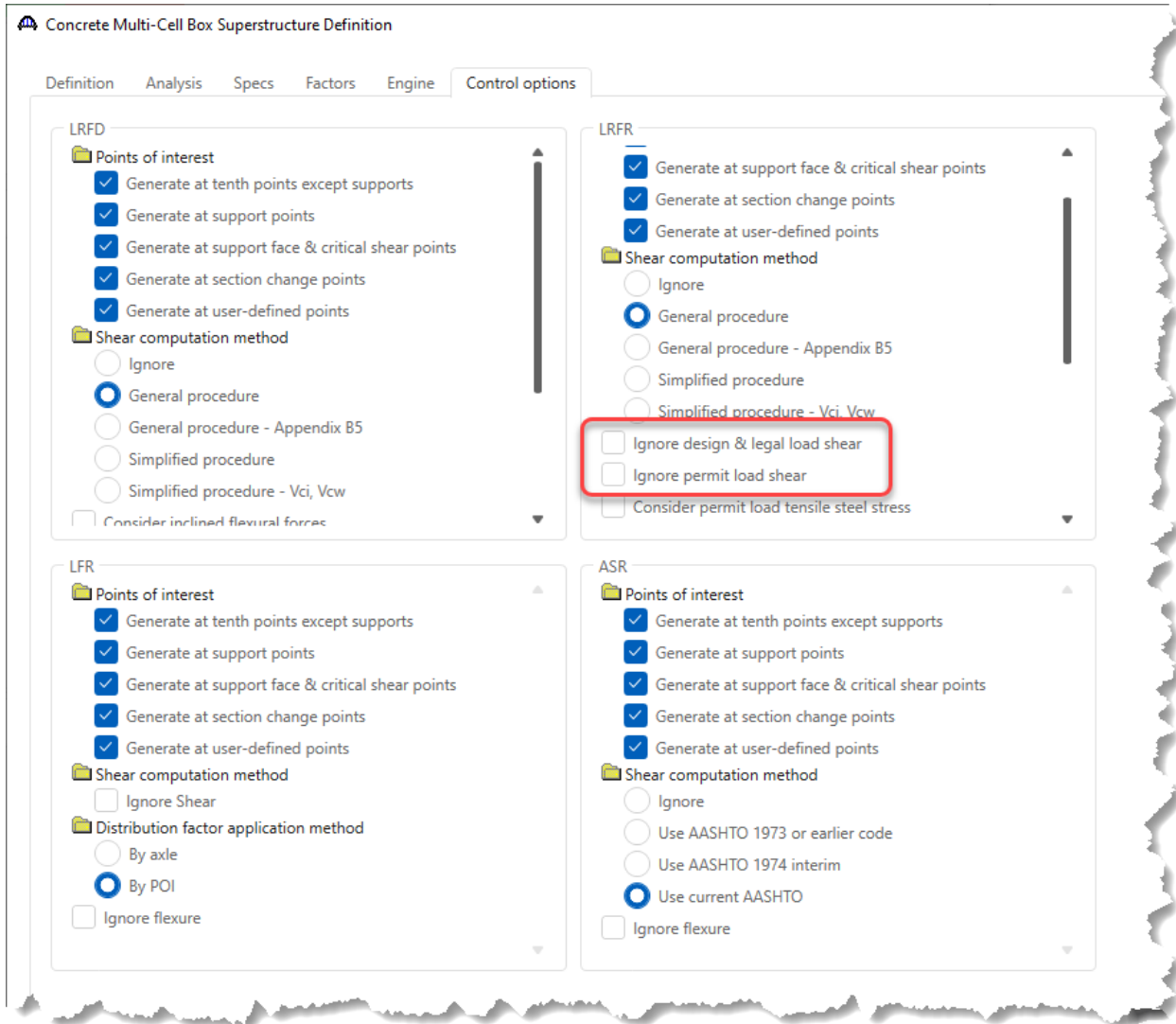
Left side connected to adjacent structure
 Right side connected to adjacent structure

Post-tensioned
 Analyze webs only

MCB4 – RC MCB Integral with Pier Example

Concrete Multi-Cell Box Superstructure Definition – Control options tab

Navigate to the **Control options** tab. Uncheck the LRFr **Ignore shear** checkboxes.



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

MCB4 – RC MCB Integral with Pier Example

Load case Description

Expand the newly created superstructure definition and double click **Load Case Description** and create default load cases. Use the **Add default load case descriptions** button. Load cases are populated as shown below.

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 the **Structure Cross Sections** folder and create the following cross section by entering the values shown.

Structure Cross Sections

Name: Section 1 Number of cells: 4

Input method: Simple Advanced Top slab concrete: 3 ksi Other parts concrete: 3 ksi

Entry method: Width Slope

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

	(ft)
> D	5
CJ	1.125
LW1	2
LW2	2
RW1	2
RW2	2
LV	
RV	

	(in)
> LT1	7.5
LT2	7.5
RT1	7.5
RT2	7.5

W2: 26 ft

Properties: Compute properties

Area: ft²

Ixx: ft⁴

Iyy: ft⁴

J: ft⁴

Buttons: OK Apply Cancel

MCB4 – RC MCB Integral with Pier 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	6.6875	9	9	7.5
	2	6.3125	9	9	7.5
	3	6.3125	9	9	7.5
	4	6.6875	9	9	7.5

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"/>	6	6
	Bottom	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	6	6

MCB4 – RC MCB Integral with Pier Example

With all the data entered click the **Compute properties** button to see the window below then click **OK** to apply this data and close the window.

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	5
CJ	1.125
LW1	2
LW2	2
RW1	2
RW2	2
LV	
RV	

	(in)
> LT1	7.5
LT2	7.5
RT1	7.5
RT2	7.5

W2: ft

Properties

Area: ft²

Ixx: ft⁴

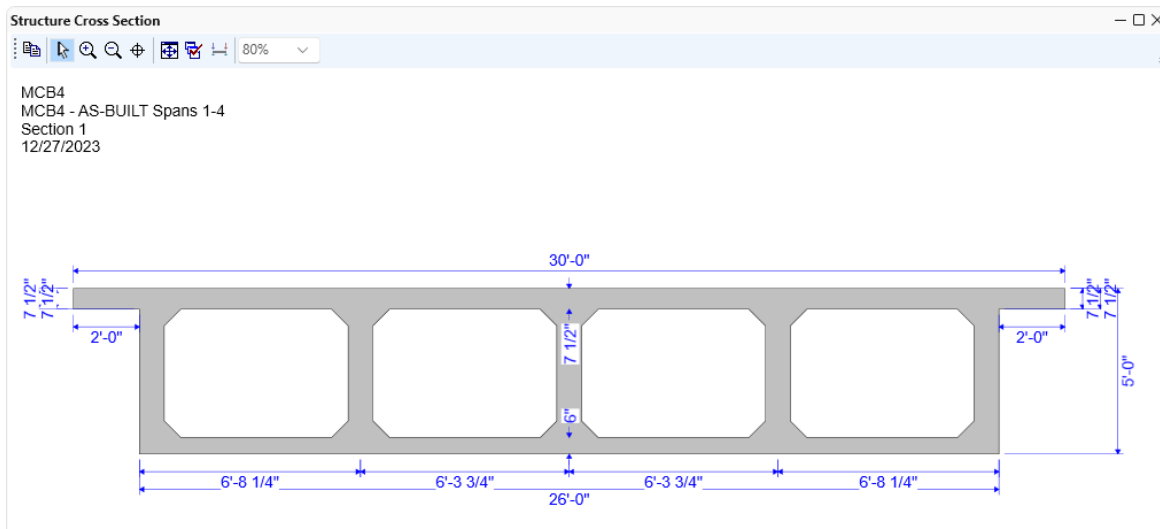
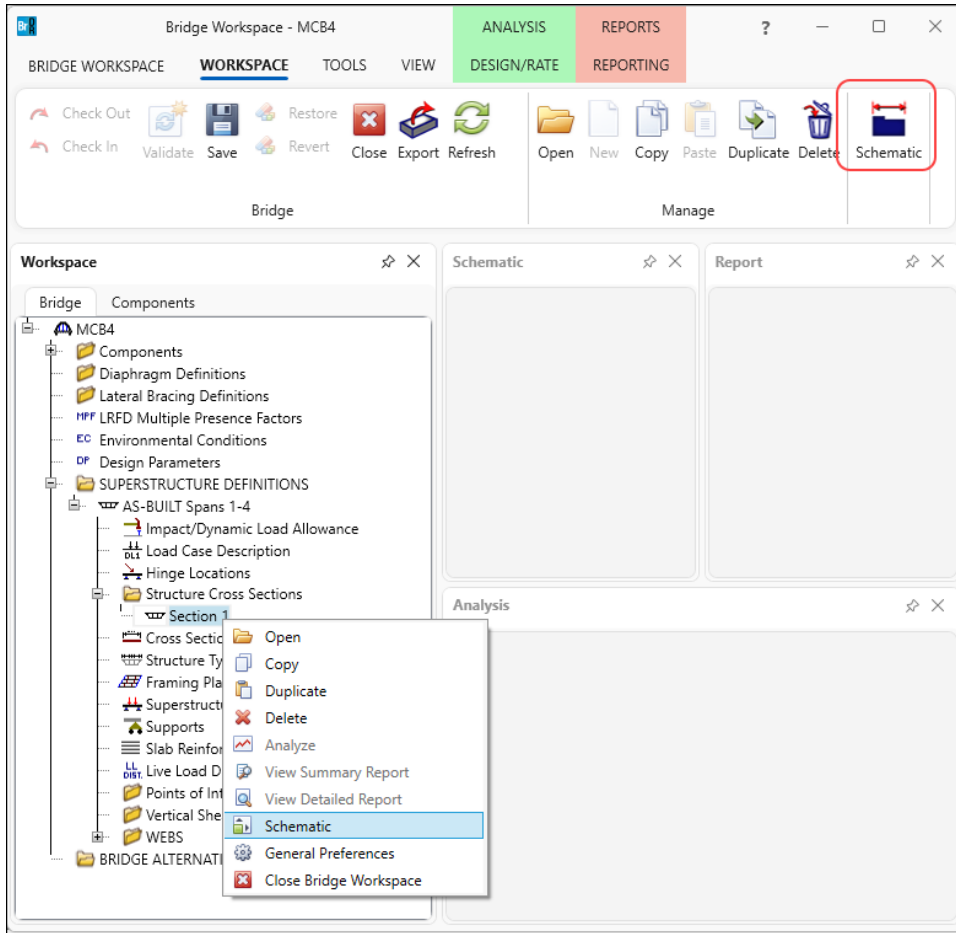
Iyy: ft⁴

J: ft⁴

MCB4 – RC MCB Integral with Pier Example

Schematic – Structure Cross Sections

A schematic can be viewed by right clicking the section just created and selecting **Schematic** (or clicking the **Schematic** button from the **WORKSPACE** ribbon).



MCB4 – RC MCB Integral with Pier Example

Cross Section Ranges

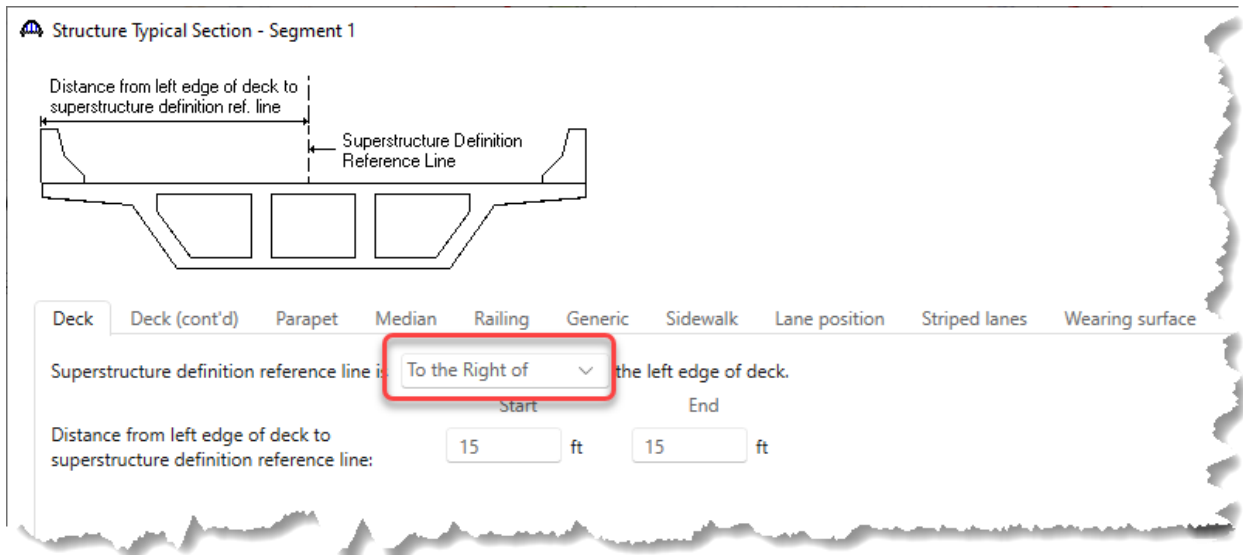
Assign the cross section to the length of the superstructure by double clicking the **Cross Section Range Properties** in the tree and enter the values shown.

	Start section	End section	Depth vary	Solid section	Support number	Start distance (ft)	Length (ft)	End distance (ft)
>	Section 1	Section 1	None	<input type="checkbox"/>	1	0	54.5	54.5
	Section 1	Section 1	None	<input checked="" type="checkbox"/>	1	54.5	5.5	60
	Section 1	Section 1	None	<input type="checkbox"/>	2	2.75	74.5	77.25
	Section 1	Section 1	None	<input checked="" type="checkbox"/>	2	77.25	5.5	82.75
	Section 1	Section 1	None	<input type="checkbox"/>	3	2.75	74.5	77.25
	Section 1	Section 1	None	<input checked="" type="checkbox"/>	3	77.25	5.5	82.75
	Section 1	Section 1	None	<input type="checkbox"/>	4	2.75	54.5	57.25

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

Structure Typical Section

Open the **Structure Typical Section** from the tree and locate the superstructure definition reference line in the center of the structure as shown below.



MCB4 – RC MCB Integral with Pier Example

Navigate to the **Deck (cont'd)** tab and define the sacrificial wearing surface as shown below.

Structure Typical Section - Segment 1

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

Top slab crack control parameter: kip/in

Structural overlay thickness: in

Sustained modular ratio factor:

Bottom slab crack control parameter: kip/in

Top slab exposure factor:

Bottom slab exposure factor:

Inside void slab crack control parameter: kip/in

Inside void slab exposure factor:

Navigate to the **Generic** tab and locate the barriers as shown below.

Structure Typical Section - Segment 1

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
> Railing & Post	DC2	Back	Left Edge	0	0	Right
Railing & Post	DC2	Back	Right Edge	0	0	Left

MCB4 – RC MCB Integral with Pier Example

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

Structure Typical Section - Segment 1

Deck Deck (cont'd) Parapet Median Railing Generic Sidewalk Lane position Striped lanes Wearing surface

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	14	-14	14

LRFD fatigue
 Lanes available to trucks:
 Override Truck fraction:

Compute New Duplicate Delete

OK Apply Cancel

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

Framing Plan Detail

Double click on **Framing Plan Detail** in the tree and enter the skew at each support in the **Layout** tab. In the case all skews are zero.

Structure Framing Plan Details

Number of spans: 4

Layout Interior diaphragms

Support	Skew (degrees)
> 1	0
2	0
3	0
4	0
5	0

MCB4 – RC MCB Integral with Pier Example

Slab reinforcement

Double click on the **Slab Reinforcement** node in the **BWS** tree. **Slab Reinforcement** can be located within the structure in several ways for multi-cell boxes. For this example, the reinforcement is defined from the supports and Transverse Reference Lines. The user also has the option to locate rebar about the midspan. Enter **Transverse Reference Lines** as shown below. Each reference line corresponds to a construction joint.

Type: Multi Cell Box

Transverse reference lines | Cells-top slab | Cells-bottom slab | Overhangs

Input method
 Distance Percentage

Reference line	Measured from support	Distance along left edge deck (ft)	Distance along right edge deck (ft)
TCJ1	1	41.25	41.25
TCJ2	2	15.25	15.25
TCJ3	2	62.75	62.75
TCJ4	3	17.25	17.25
TCJ5	3	64.75	64.75
TCJ6	4	16	16
BCJ1	1	40.25	40.25
BCJ2	2	16.25	16.25
BCJ3	2	61.75	61.75
BCJ4	3	18.25	18.25
BCJ5	3	63.75	63.75
> BCJ6	4	17	17

New Delete

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

The data entry for the top slab is shown below.

Slab Reinforcement

Type: Multi Cell Box

Transverse reference lines: Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
All Cells	Grade 40	Support 1	Right	0	41.25	41.25	5	2.5	5	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	0	274.5	274.5	6	3	5	1.625	Bottom of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 2	Right	15.416667	47.166667	62.583334	5	2.5	5	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 3	Right	17.416667	47.166667	64.583334	5	2.5	5	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 4	Right	16	41.25	57.25	5	2.5	5	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 2	Right	-15.833333	30.916667	15.083334	10	5	10	2.125	Top of Slab	6	6	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 3	Right	-17.083333	34.166667	17.083334	10	5	11	2.125	Top of Slab	6	6	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 4	Right	-15.083333	30.916667	15.833334	10	5	10	2.125	Top of Slab	6	6	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	0	274.5	274.5	4	2	11	2.125	Top of Slab	5	2.125	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ1	Right	-3.75	7.5	3.75	5	2.5	10	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ2	Right	-3.75	7.5	3.75	5	2.5	10	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ3	Right	-4.25	8.5	4.25	5	2.5	11	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ4	Right	-4.25	8.5	4.25	5	2.5	11	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ5	Right	-3.75	7.5	3.75	5	2.5	10	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	TCJ6	Right	-3.75	7.5	3.75	5	2.5	10	2.125	Top of Slab	12	12	<input type="checkbox"/>	<input type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

The data entry for the bottom slab is shown below.

Slab Reinforcement

Type: Multi Cell Box

Transverse reference lines: Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
All Cells	Grade 40	Support 1	Right	0	274.5	274.5	5	2.5	4	1.5	Top of Slab	15	12	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	0	40.083333	40.083333	6	3	9	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	4.25	31	35.25	6	3	9	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	40.416667	32.916667	73.333334	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 2	Right	16.416667	45.166667	61.583334	6	3	10	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 2	Right	21.25	35.5	56.75	6	3	10	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 3	Right	-18.083333	36.166667	18.083334	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 3	Right	18.416667	45.166667	63.583334	6	3	10	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 3	Right	23.25	35.5	58.75	6	3	10	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 4	Right	-16.083333	32.916667	16.833334	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 4	Right	17.166667	40.083333	57.25	6	3	9	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 4	Right	22	31	53	6	3	9	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	Support 1	Right	0	274.5	274.5	4	2	11	1.5	Bottom of Slab	5	2.125	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	BCJ1	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	BCJ2	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>
All Cells	Grade 40	BCJ3	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3	<input type="checkbox"/>	<input type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

The data entry for the overhangs is shown below.

Slab Reinforcement

Type: Multi Cell Box

Transverse reference lines Cells-top slab Cells-bottom slab **Overhangs**

Overhang	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
> Both	Grade 40	Support 1	Right	0	41.25	41.25	2	5	2.125	Top of Slab	9	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 1	Right	0	274.5	274.5	2	5	5.75	Top of Slab	15	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 1	Right	41.416667	30.916667	72.333334	3	10	2.125	Top of Slab	8	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 2	Right	15.416667	47.166667	62.583334	2	5	2.125	Top of Slab	9	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 3	Right	-17.083333	34.166667	17.083334	3	11	2.125	Top of Slab	8	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 3	Right	17.416667	47.166667	64.583334	2	5	2.125	Top of Slab	9	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 4	Right	-15.083333	30.916667	15.833334	3	10	2.125	Top of Slab	8	3	<input type="checkbox"/>	<input type="checkbox"/>
Both	Grade 40	Support 4	Right	16	41.25	57.25	2	5	2.125	Top of Slab	9	3	<input type="checkbox"/>	<input type="checkbox"/>

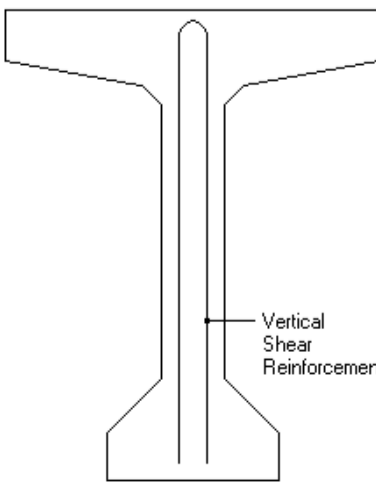
Click **OK** to apply the data and close the window.

Vertical Shear Reinforcement Definition

Create the following shear stirrups by double clicking the **Vertical Shear Reinforcement Definitions** and entering the data shown.

Shear Reinforcement Definition - Vertical

Name: S Bars



Material: Grade 40

Bar size: 5

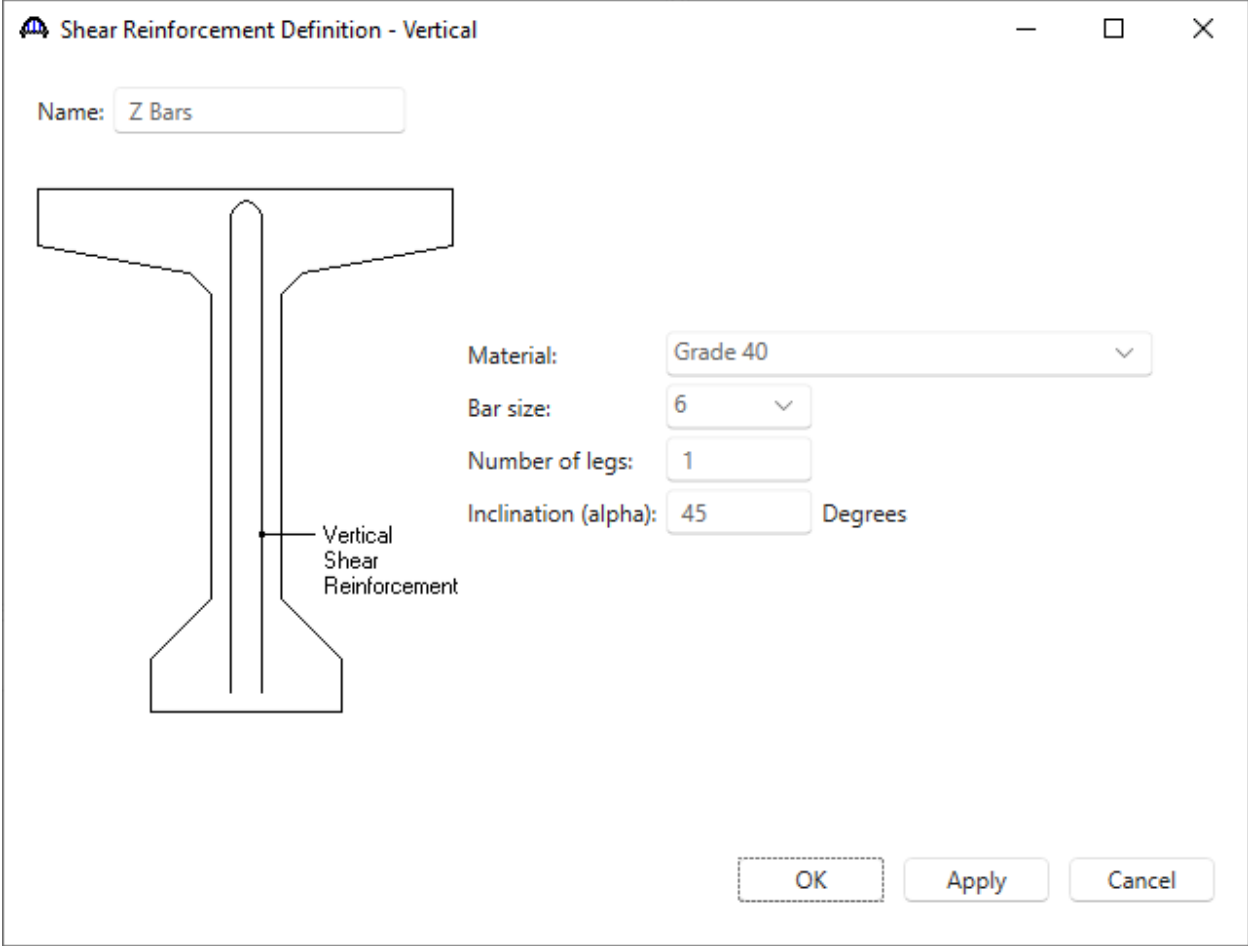
Number of legs: 2

Inclination (alpha): 90 Degrees

OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example



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

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges – WEB1

Open the **WEB1 Shear Reinforcement Ranges** window and select Input Reference Type to **Centerline bearings**.

Enter the data for Span 1 and repeat for Spans 2-4.

The stirrup ranges are created as follows.

Web Shear Reinforcement Ranges - WEB1

Input reference type: Voids Centerline bearings

Linked with: None

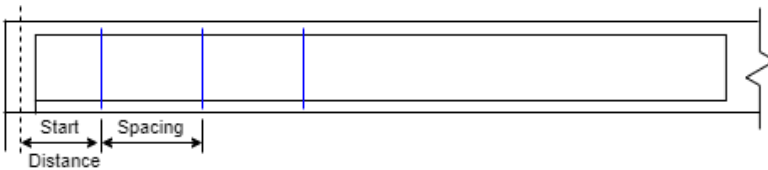
Span ranges: Span: 1

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
S Bars	0.083333	1	0	0	0.083333
S Bars	0.083333	1	10	0.833333	0.916663
S Bars	0.916666	5	12	5	5.916666
S Bars	5.916666	5	15	6.25	12.166666
S Bars	12.166666	5	18	7.5	19.666666
S Bars	19.666666	1	18	1.5	21.166666
S Bars	21.166666	6	18	9	30.166666
S Bars	30.166666	5	15	6.25	36.416666
S Bars	36.416666	5	12	5	41.416666
Z Bars	40.75	2	6	1	41.75
Z Bars	40.75	1	0	0	40.75
S Bars	41.416667	7	10	5.833333	47.250003
S Bars	47.25	12	8	8	55.25

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

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB1



Input reference type: Voids Centerline bearings

Linked with:

Span ranges: Span: 2

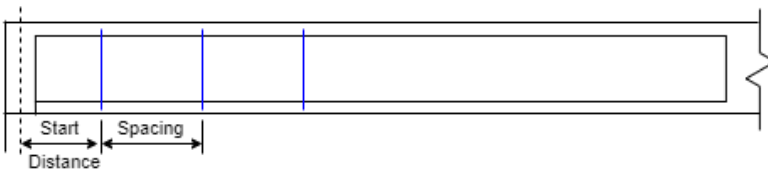
Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	2	1	0	0	2
S Bars	2	9	6	4.5	6.5
S Bars	6.5	8	8	5.3333333	11.8333333
S Bars	11.833333	6	10	5	16.833333
Z Bars	14.75	1	0	0	14.75
Z Bars	14.75	2	6	1	15.75
S Bars	16.833333	9	12	9	25.833333
S Bars	25.833333	18	18	27	52.833333
S Bars	52.833333	7	12	7	59.833333
S Bars	59.833333	8	10	6.6666667	66.4999997
Z Bars	62.25	2	6	1	63.25
Z Bars	62.25	1	0	0	62.25
S Bars	66.5	12	8	8	74.5
S Bars	74.5	7	6	3.5	78

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

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB1



Input reference type: Voids Centerline bearings

Linked with:

Span ranges: Span: 3

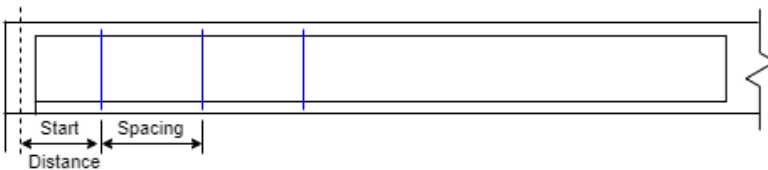
Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	2	1	0	0	2
S Bars	2	7	6	3.5	5.5
S Bars	5.5	12	8	8	13.5
S Bars	13.5	8	10	6.6666667	20.1666667
Z Bars	16.75	2	6	1	17.75
Z Bars	16.75	1	0	0	16.75
S Bars	20.166667	7	12	7	27.166667
S Bars	27.166667	8	18	12	39.166667
S Bars	39.166667	1	18	1.5	40.666667
S Bars	40.666667	9	18	13.5	54.166667
S Bars	54.166667	9	12	9	63.166667
S Bars	63.166667	6	10	5	68.166667
Z Bars	64.25	2	6	1	65.25
Z Bars	64.25	1	0	0	64.25
S Bars	68.166667	8	8	5.3333333	73.5000003
S Bars	73.5	9	6	4.5	78

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

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB1



Input reference type: Voids Centerline bearings

Linked with:

Span ranges: Span: 4

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	2	1	0	0	2
S Bars	2	12	8	8	10
S Bars	10	7	10	5.8333333	15.8333333
Z Bars	15.5	1	0	0	15.5
Z Bars	15.5	2	6	1	16.5
S Bars	15.8333333	5	12	5	20.8333333
S Bars	20.8333333	5	15	6.25	27.0833333
S Bars	27.0833333	12	18	18	45.0833333
S Bars	45.0833333	5	15	6.25	51.3333333
S Bars	51.3333333	5	12	5	56.3333333
S Bars	56.3333333	1	10	0.8333333	57.1666663

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

OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges – WEB2

Double click on the **Shear Reinforcement Ranges** for **WEB2** and enter the following data for Spans 1-4.

Web Shear Reinforcement Ranges - WEB2

Input reference type: Voids Centerline bearings

Linked with: None

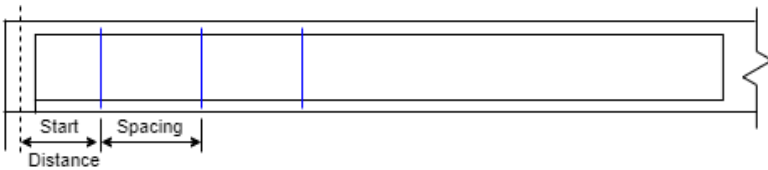
Span ranges: Span: 1

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	0	1	9	0.75	0.75
S Bars	0	1	0	0	0
S Bars	0.75	7	10	5.8333333	6.5833333
S Bars	6.5833333	5	12	5	11.5833333
S Bars	11.5833333	12	18	18	29.5833333
S Bars	29.5833333	2	15	2.5	32.0833333
S Bars	32.0833333	7	12	7	39.0833333
S Bars	39.0833333	6	9	4.5	43.5833333
Z Bars	40.75	1	0	0	40.75
Z Bars	40.75	2	6	1	41.75
S Bars	43.5833333	10	8	6.6666667	50.2499997
S Bars	50.25	10	6	5	55.25

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

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB2



Input reference type: Voids Centerline bearings

Linked with:

Span ranges: Span: 2

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	2	1	0	0	2
S Bars	2	20	6	10	12
S Bars	12	10	8	6.6666667	18.6666667
Z Bars	14.75	2	6	1	15.75
Z Bars	14.75	1	0	0	14.75
S Bars	18.666667	5	10	4.1666667	22.8333337
S Bars	22.833334	9	12	9	31.833334
S Bars	31.833334	4	15	5	36.833334
S Bars	36.833334	5	18	7.5	44.333334
S Bars	44.333334	4	15	5	49.333334
S Bars	49.333334	5	12	5	54.333334
S Bars	54.333334	6	10	5	59.333334
S Bars	59.333334	13	8	8.6666667	68.0000007
Z Bars	62.25	1	0	0	62.25
Z Bars	62.25	2	6	1	63.25
S Bars	68	20	6	10	78

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

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB2
— □ ×

Input reference type

Voids
 Centerline bearings

Linked with: None ▾

Span ranges

Span: 3 ▾

	Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
>	S Bars ▾	2	1	0	0	2
	S Bars ▾	2	20	6	10	12
	S Bars ▾	12	13	8	8.6666667	20.6666667
	Z Bars ▾	16.75	2	6	1	17.75
	Z Bars ▾	16.75	1	0	0	16.75
	S Bars ▾	20.666667	6	10	5	25.666667
	S Bars ▾	25.666667	5	12	5	30.666667
	S Bars ▾	30.666667	4	15	5	35.666667
	S Bars ▾	35.666667	5	18	7.5	43.166667
	S Bars ▾	43.166667	4	15	5	48.166667
	S Bars ▾	48.166667	9	12	9	57.166667
	S Bars ▾	57.166667	5	10	4.1666667	61.3333337
	S Bars ▾	61.333333	10	8	6.6666667	67.9999997
	Z Bars ▾	64.25	2	6	1	65.25
	Z Bars ▾	64.25	1	0	0	64.25
	S Bars ▾	68	20	6	10	78

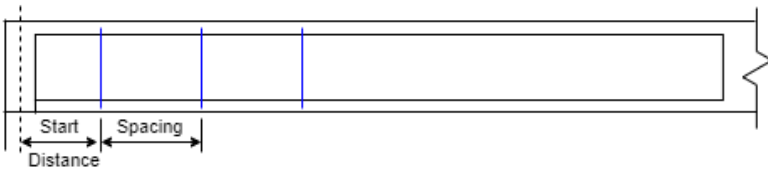
Copy...
Stirrup wizard...

New
Duplicate
Delete

OK
Apply
Cancel

MCB4 – RC MCB Integral with Pier Example

Web Shear Reinforcement Ranges - WEB2



Input reference type: Voids Centerline bearings

Linked with: None

Span ranges: Span: 4

Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> S Bars	2	10	6	5	7
S Bars	2	1	0	0	2
S Bars	7	10	8	6.6666667	13.6666667
S Bars	13.666667	6	9	4.5	18.166667
Z Bars	15.5	1	0	0	15.5
Z Bars	15.5	2	6	1	16.5
S Bars	18.166667	7	12	7	25.166667
S Bars	25.166667	2	15	2.5	27.666667
S Bars	27.666667	12	18	18	45.666667
S Bars	45.666667	5	12	5	50.666667
S Bars	50.666667	7	10	5.8333333	56.5000003
S Bars	56.5	1	9	0.75	57.25

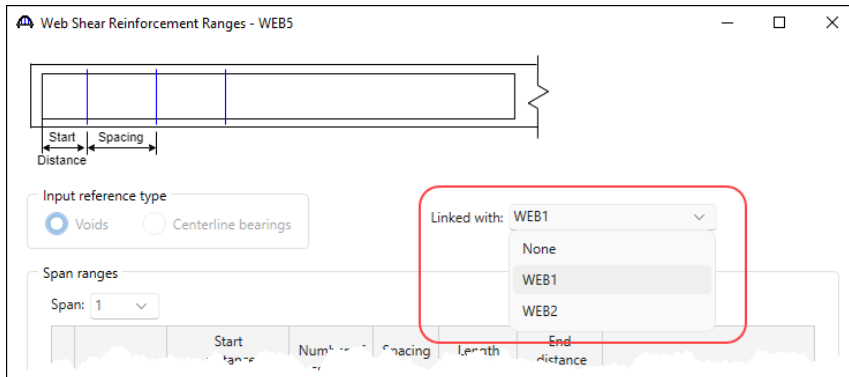
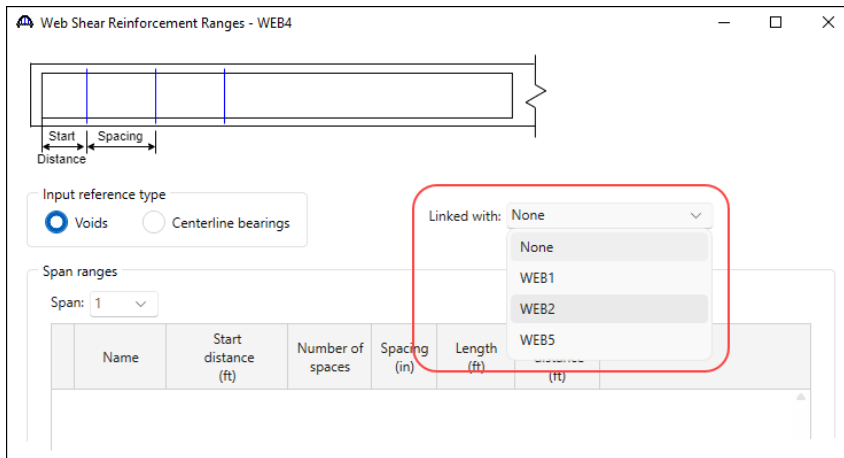
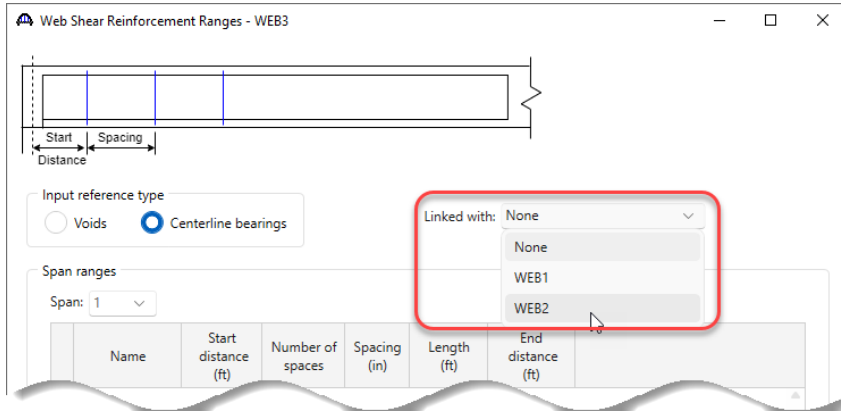
Copy... Stirrup wizard... New Duplicate Delete

OK Apply Cancel

Once the shear reinforcement for **WEB1** and **WEB2** are entered, **WEB3** though **WEB5** can be linked to them since **WEB5** is identical to **WEB1** and **WEB3** and **WEB4** are identical to **WEB2**.

MCB4 – RC MCB Integral with Pier Example

To link **WEB3** with **WEB2**, open the **Web Shear Reinforcement Ranges** window and select **WEB2** from the dropdown menu. The ranges will then populate the window. Click **OK** to accept and close. Repeat this process for the remaining webs.



MCB4 – RC MCB Integral with Pier Example

Bridge Alternatives

Bridge alternative

Double click the **BRIDGE ALTERNATIVES** folder and enter in the information shown below.

Bridge Alternative

Alternative name: AS-BUILT

Description Substructures

Description:

Horizontal curvature

Reference line length: 274.5 ft

Start bearing End bearing

Starting station: ft

Bearing: N 90^ 0' 0.00" E

Global positioning

Distance: 0 ft

Offset: 0 ft

Elevation: ft

Bridge alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Start tangent length: ft

Curve length: ft

Radius: ft

Direction: Left

End tangent length: ft

Superstructure wizard...

Culvert wizard...

OK Apply Cancel

MCB4 – RC MCB Integral with Pier Example

In the **Substructures** tab, define substructure locations as shown below.

The screenshot shows the 'Bridge Alternative' dialog box with the 'Substructures' tab selected. The 'Alternative name' is 'AS-BUILT'. The table below lists the substructure units.

	Substructure unit name	Station (ft)	Offset (ft)	Unit type
>	Abut 1	0	0	Abutment
	Bent 2	57.25	0	Pier
	Bent 3	137.25	0	Pier
	Bent 4	217.25	0	Pier
	Abut 5	274.5	0	Abutment

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

Superstructures

Double click on the **SUPERSTRUCTURES** folder and enter the name **AS-BUILT**. Move to the **Substructures** tab and assign substructures at each support.

The screenshot shows the 'Superstructure' dialog box with the 'Substructures' tab selected. The 'Superstructure name' is 'AS-BUILT'. The 'Select the substructure supports:' section contains the following table:

	Support	Substructure support
>	1	Abut 1
	2	Bent 2
	3	Bent 3
	4	Bent 4
	5	Abut 5

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

MCB4 – RC MCB Integral with Pier Example

Superstructure Alternative

Double click on the **SUPERSTRUCTURE ALTERNATIVES** folder. Enter the name **AS-BUILT** and select **AS-BUILT Spans 1-4** from the dropdown box.

Superstructure Alternative

Alternative name: AS-BUILT

Description:

Superstructure definition: AS-BUILT Spans 1-4

Superstructure type: Multi Cell Box

Number of cells: 4

Span	Length (ft)
1	57.25
2	80
3	80
4	57.25

OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example

Pier Data Entry

Pier

Now open the **Bent 2** Pier window, enter the data for the **finished groundline** and the **soil density**. This example assumes that the finished ground elevation is the same for each pier.

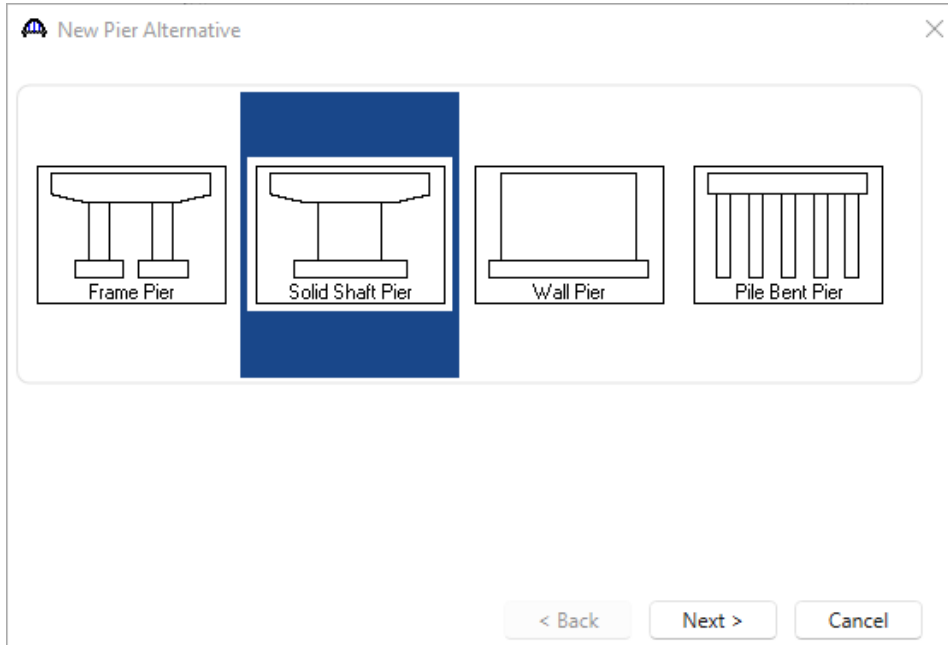
The screenshot shows the 'Pier' window for 'Bent 2'. The 'Description' tab is selected, showing 'Stream flow'. The 'Pier skew angle' section has 'Input skew angle' selected with a skew angle of 0 Degrees. The 'Finished groundline elevation' is 335 ft and 'Soil density' is 0.12 kcf, both highlighted with a red box. The 'Superstructure longitudinal direction' is set to 'Consider as expansion'. The 'Pier location relative to bridge alternative' shows Station: 57.25 ft and Offset: 0 ft. The 'Computed pier location relative to structure' and 'Computed pier coordinates' both show Station: 57.25 ft and Offset: 0 ft. At the bottom, there are 'OK', 'Apply', and 'Cancel' buttons.

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

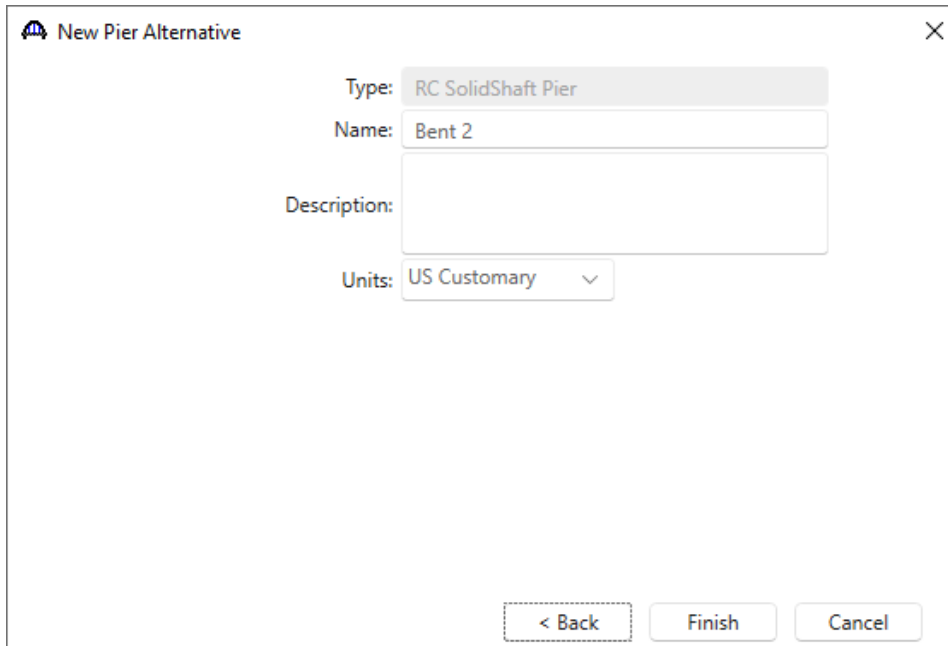
MCB4 – RC MCB Integral with Pier Example

New Pier Alternative

Now create a solid shaft pier alternative. Double click on the **Bent 2 PIER ALTERNATIVE** and select **Solid Shaft Pier** and click **Next**.



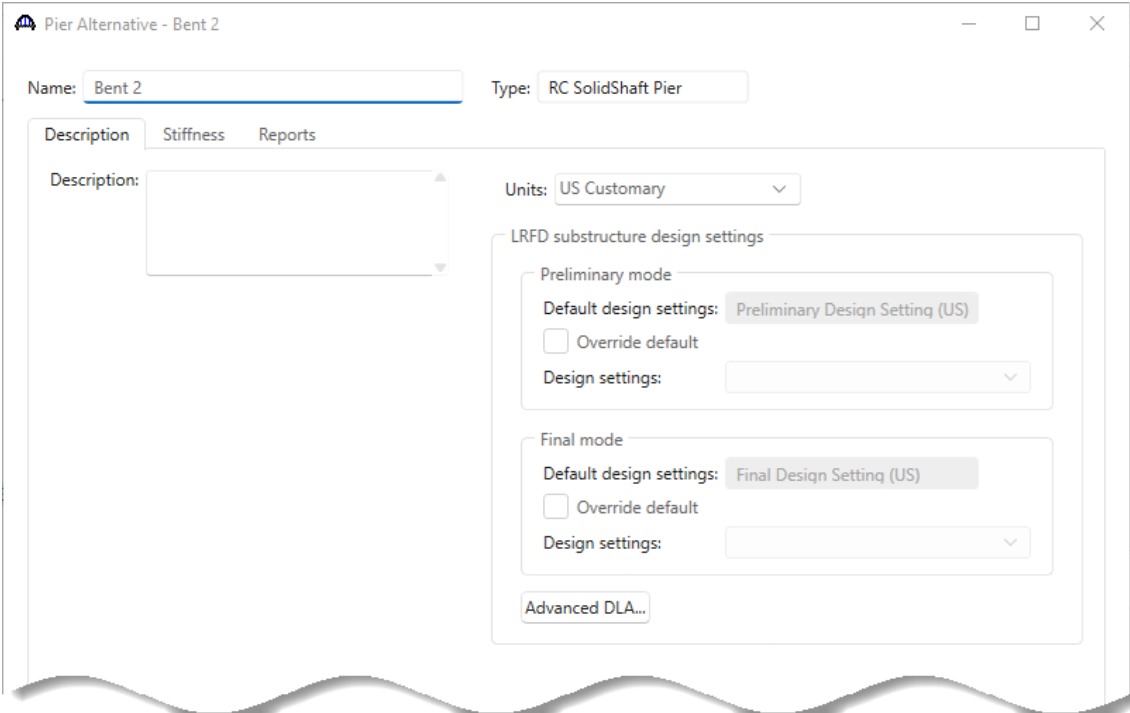
Enter the values shown and click **Finish**.



MCB4 – RC MCB Integral with Pier Example

Pier Alternative – Bent 2

No data needs to be changed on the resulting **Pier Alternative** window so click **OK** to close it.



MCB4 – RC MCB Integral with Pier Example

Pier Geometry – Bent 2 – Bent 2

Double click on **Geometry** under **Bent 2** in the tree. Enter the data shown below.

Pier Geometry - Bent 2 - Bent 2

Distance from left end of cap to superstructure reference line

Superstructure Reference Line

15.0000

Elevation View

V
T
L

Distance from left end of cap to superstructure reference line: ft

Distance from left end of cap to centerline of column: ft

Distance from centerline of column to right end of cap: ft

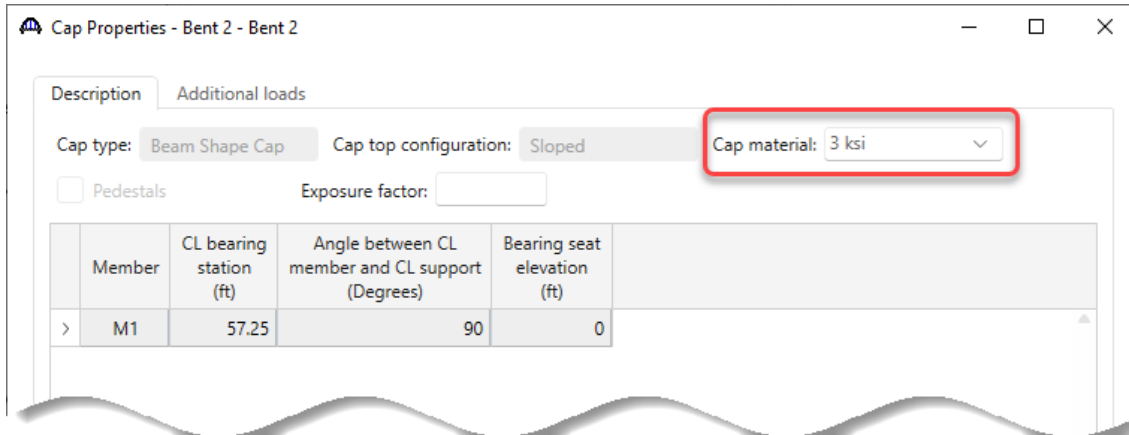
OK Apply Cancel

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

MCB4 – RC MCB Integral with Pier Example

Cap Properties – Bent 2 – Bent 2

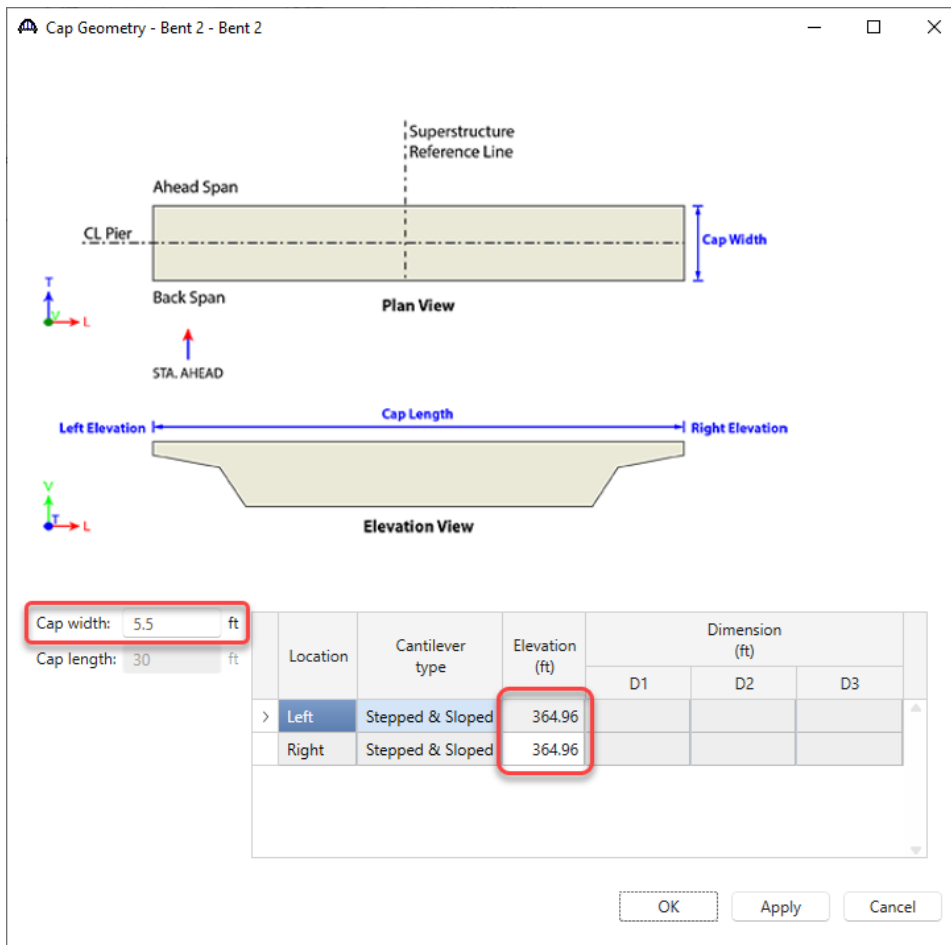
Open the **Cap** window and verify the correct cap concrete material is selected.



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

Cap Geometry – Bent 2 – Bent 2

Open the Cap **Geometry** window and enter the following data for the pier cap geometry.

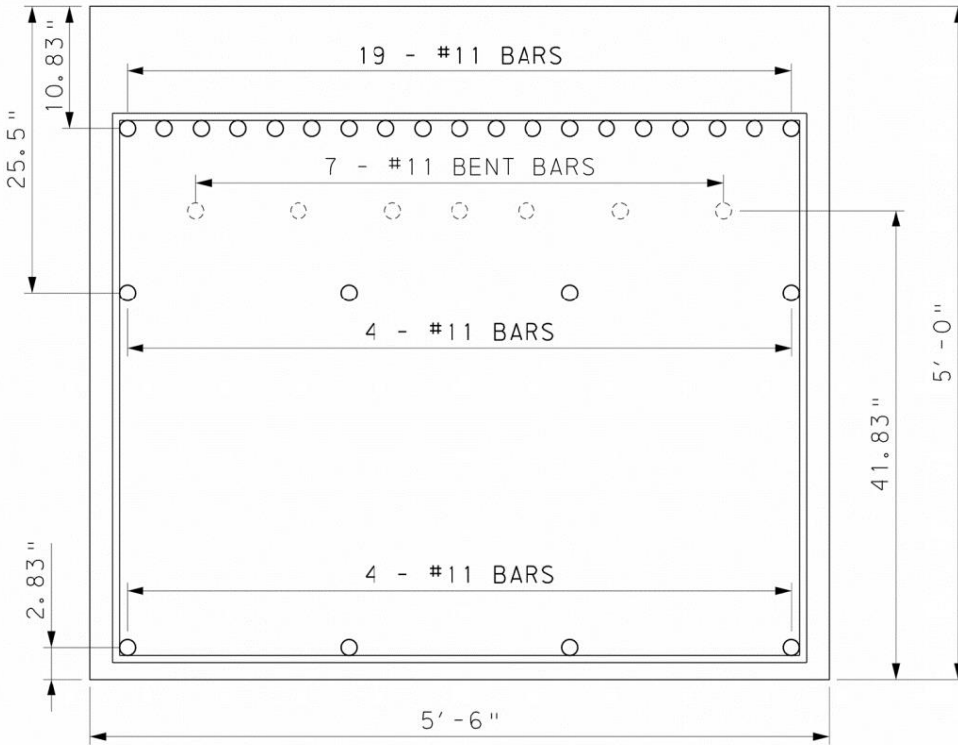


Click **OK** to apply the data and close the window.

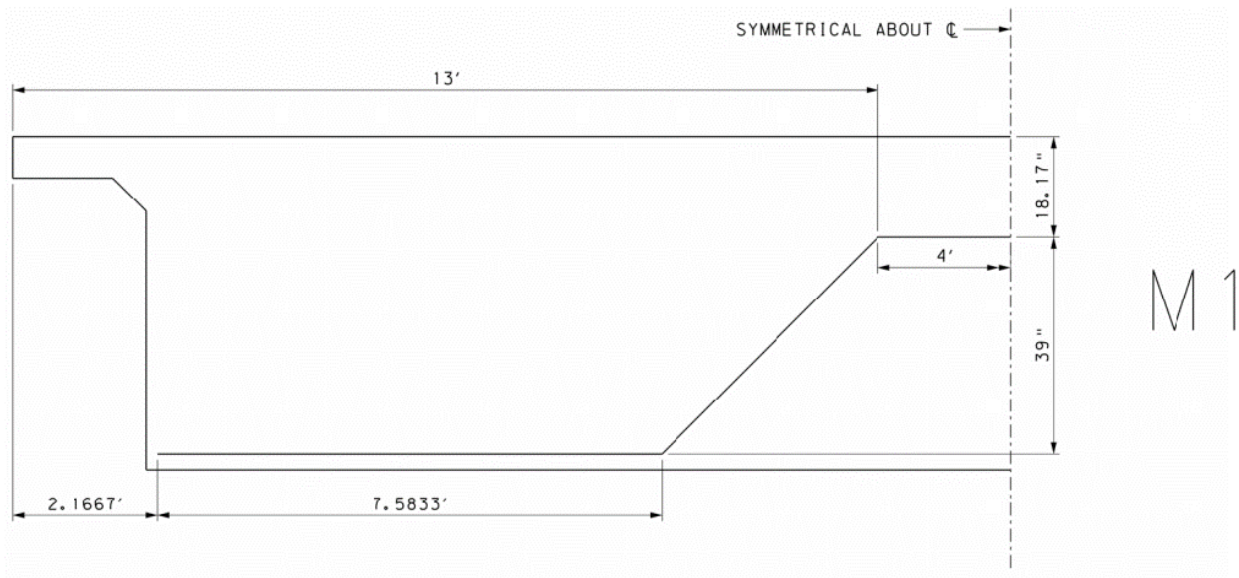
MCB4 – RC MCB Integral with Pier Example

Cap Reinforcement – Bent 2 – Bent 2

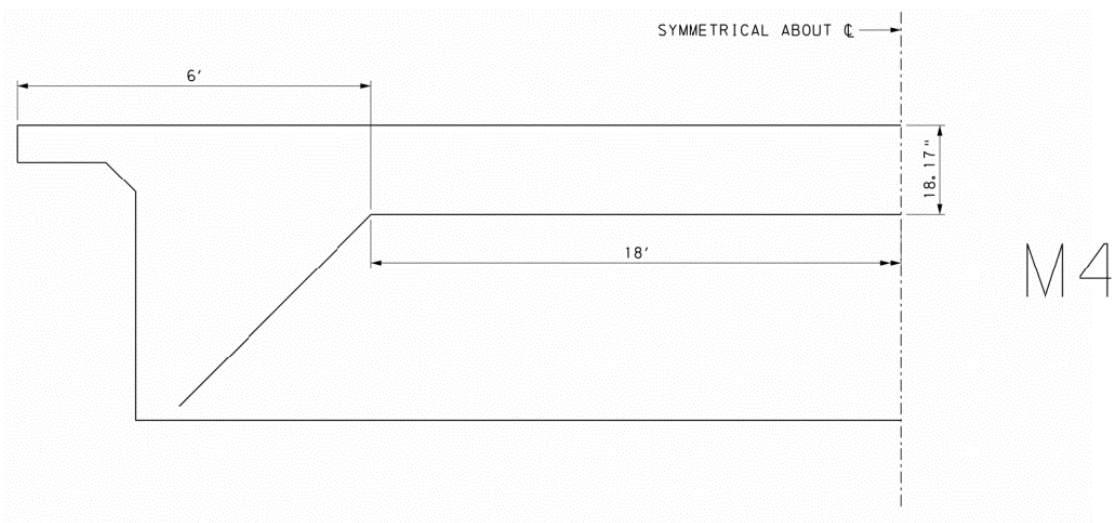
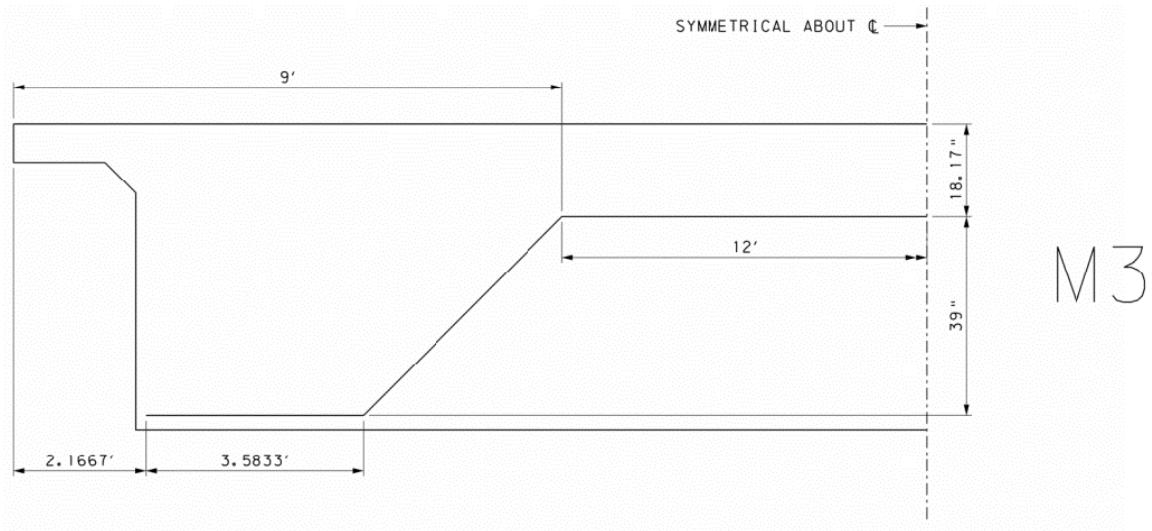
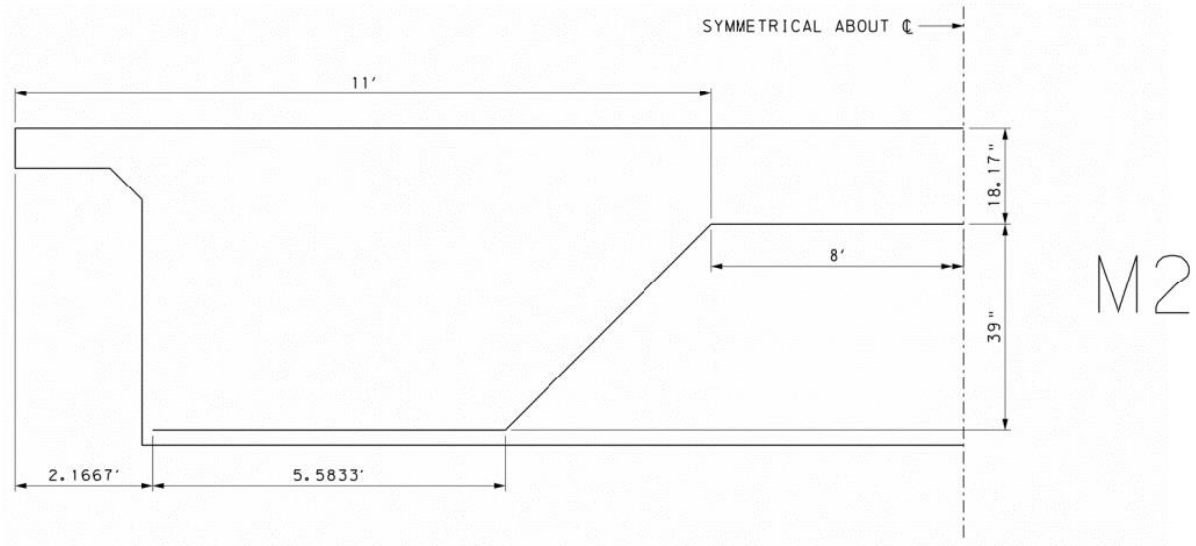
Open the **Cap Reinforcement** window to enter the flexural and shear reinforcement. A section taken at mid-cap is shown below (Note that the section and elevation view are CADD drawings and were not generated by BrDR).



Pier cap elevations shown below with bent M Bar locations.



MCB4 – RC MCB Integral with Pier Example



MCB4 – RC MCB Integral with Pier Example

Cap Reinforcement – Bent 2 – Bent 2

Based on the section and elevations above, enter the data shown below.

Cap Reinforcement - Bent 2 - Bent 2

Flexural Shear

Longitudinal skin
 Bar size: 3 Bar spacing: in Bar material: Grade 40 Stirrup clear cover: 2 in

Primary flexural
 Reinforcement input method
 Simplified Advanced Reinforcement follows cap profile

Set	Measure from cap	Vertical distance (in)	Bar size	Number	Material	Start distance (ft)	Straight length (ft)	End distance (ft)	Hook at start	Hook at end	Developed at start	Developed at end
> 1	Top	10.83	11	19	Grade 40	2.1667	25.66666	27.83336	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Top	25.5	11	4	Grade 40	2.1667	25.66666	27.83336	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Bottom	2.83	11	4	Grade 40	2.1667	25.66666	27.83336	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Bottom	2.83	11	2	Grade 40	2.1667	7.5833	9.75	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
5	Bottom	41.83	11	2	Grade 40	13	4	17	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6	Bottom	2.83	11	2	Grade 40	20.25	7.5833	27.8333	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
7	Bottom	2.83	11	2	Grade 40	2.1667	5.5833	7.75	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
8	Bottom	41.83	11	2	Grade 40	11	8	19	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	Bottom	2.83	11	2	Grade 40	22.25	5.5833	27.8333	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
10	Bottom	2.83	11	2	Grade 40	2.1667	3.5833	5.75	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
11	Bottom	41.83	11	2	Grade 40	9	12	21	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
12	Bottom	2.83	11	2	Grade 40	24.25	3.5833	27.8333	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
13	Bottom	41.83	11	1	Grade 40	6	19	25	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

Navigate to the **Shear** tab. The assumed shear reinforcement spacing is shown below. Enter the data as shown below.

Cap Reinforcement - Bent 2 - Bent 2

Flexural Shear

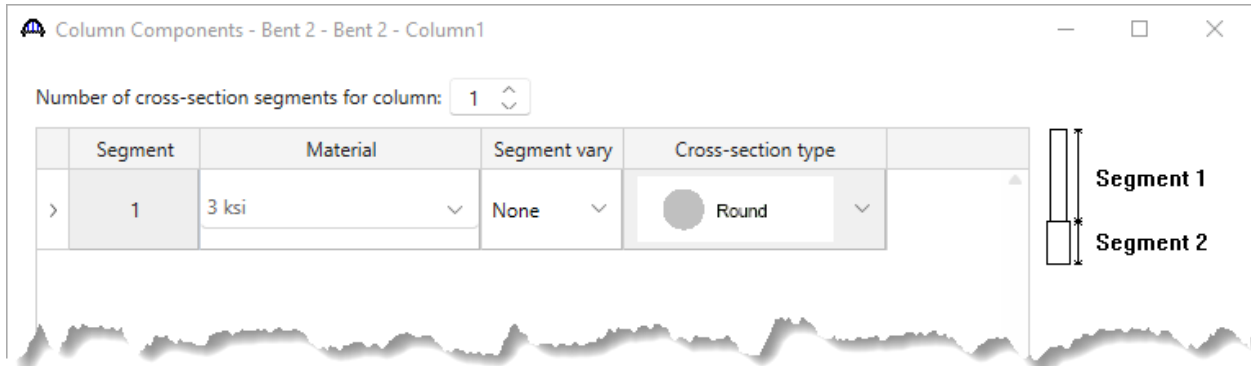
Bar size	Number of legs	Material	Measure from	Direction	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> 5	4	Grade 40	Left Edge of Cap	Right	2.8333	13	4.9808	5.3958667	8.2291667
5	4	Grade 40	Left Edge of Cap	Right	2.8333	1	0	0	2.8333
5	4	Grade 40	Left Edge of Cap	Right	9.1458	1	0	0	9.1458
5	4	Grade 40	Left Edge of Cap	Right	9.1458	13	4.9808	5.3958667	14.5416667
5	4	Grade 40	Left Edge of Cap	Right	15.4583	1	0	0	15.4583
5	4	Grade 40	Left Edge of Cap	Right	15.4583	13	4.9808	5.3958667	20.8541667
5	4	Grade 40	Left Edge of Cap	Right	21.7708	1	0	0	21.7708
5	4	Grade 40	Left Edge of Cap	Right	21.7708	13	4.9808	5.3958667	27.1666667

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

MCB4 – RC MCB Integral with Pier Example

Column Components – Bent 2 – Bent 2 – Column1

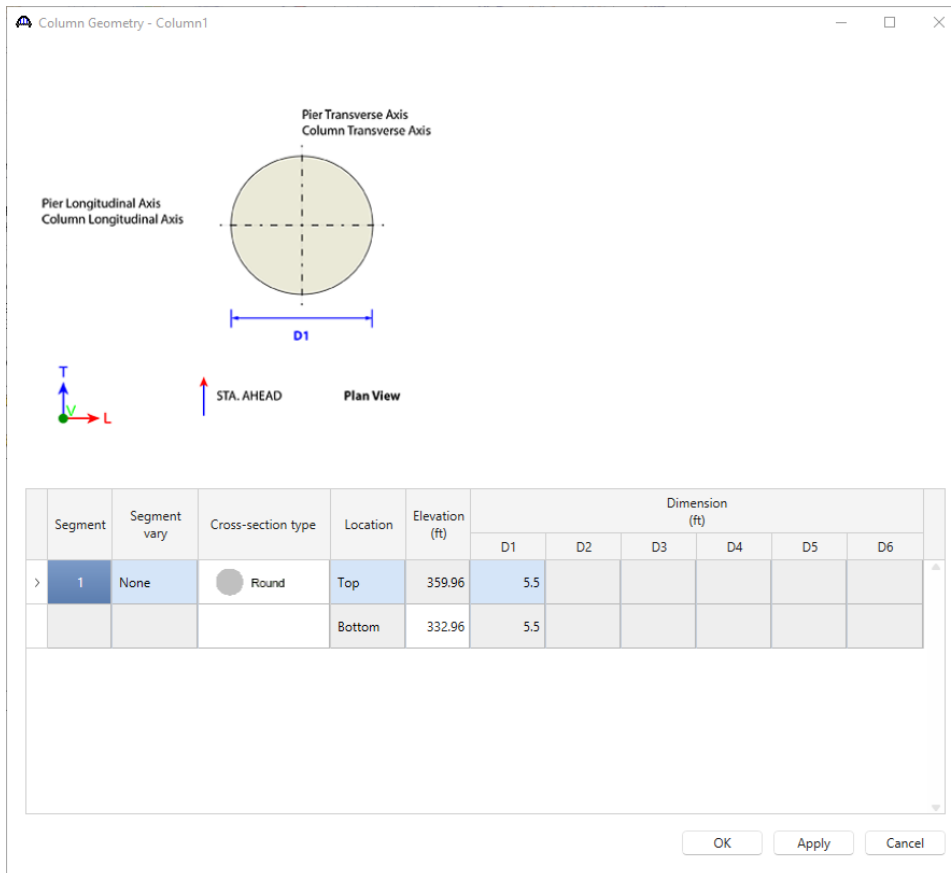
Open the Column1 **Components** window and select the following concrete material.



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

Column Geometry – Column1

Open the Column1 **Geometry** window and enter the following data. The maximum shaft height of 27'-0" is used for all piers.



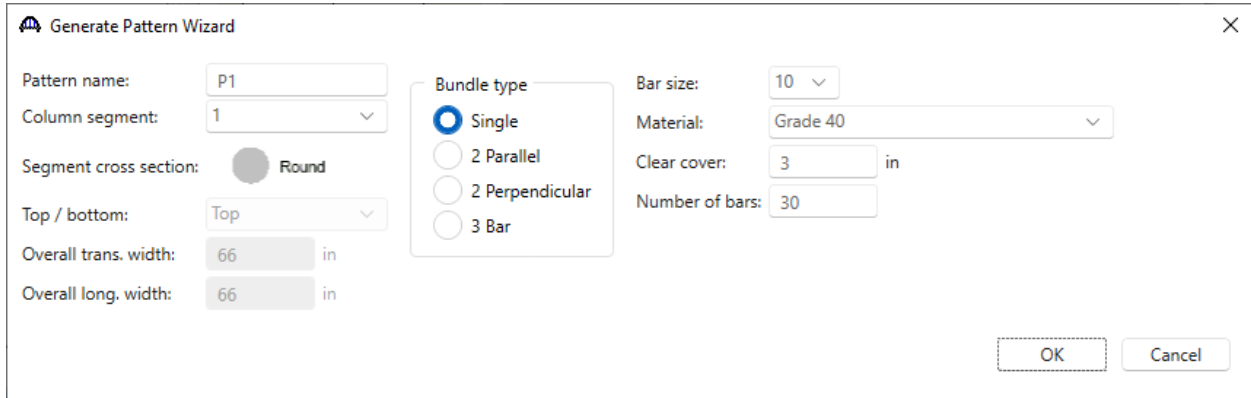
Click **OK** to apply the data and close the window.

MCB4 – RC MCB Integral with Pier Example

The pier is now sufficiently defined to be considered in the superstructure analysis. The column will be considered fixed at the base of the column. This percent fixity can be adjusted on the **Pier Model Settings** window if desired. The FE model created during the superstructure analysis will include an element modeling the column length and stiffness. For this example, the reinforcement and foundations will be entered.

Generate Pattern Wizard

Open the **Reinforcement Definitions** window to enter the flexural reinforcement pattern. Click the **Generate pattern** button and enter the following input.



The screenshot shows the 'Generate Pattern Wizard' dialog box with the following settings:

- Pattern name: P1
- Column segment: 1
- Segment cross section: Round
- Top / bottom: Top
- Overall trans. width: 66 in
- Overall long. width: 66 in
- Bundle type: Single (selected), 2 Parallel, 2 Perpendicular, 3 Bar
- Bar size: 10
- Material: Grade 40
- Clear cover: 3 in
- Number of bars: 30

Buttons: OK, Cancel

Click **OK** and all rebar locations will be generated.

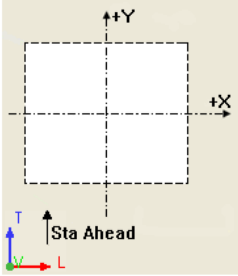
MCB4 – RC MCB Integral with Pier Example

Column Reinforcement – Bent 2 – Bent 2

Column Reinforcement - - Bent 2 - Bent 2

Name:

Bundle bars



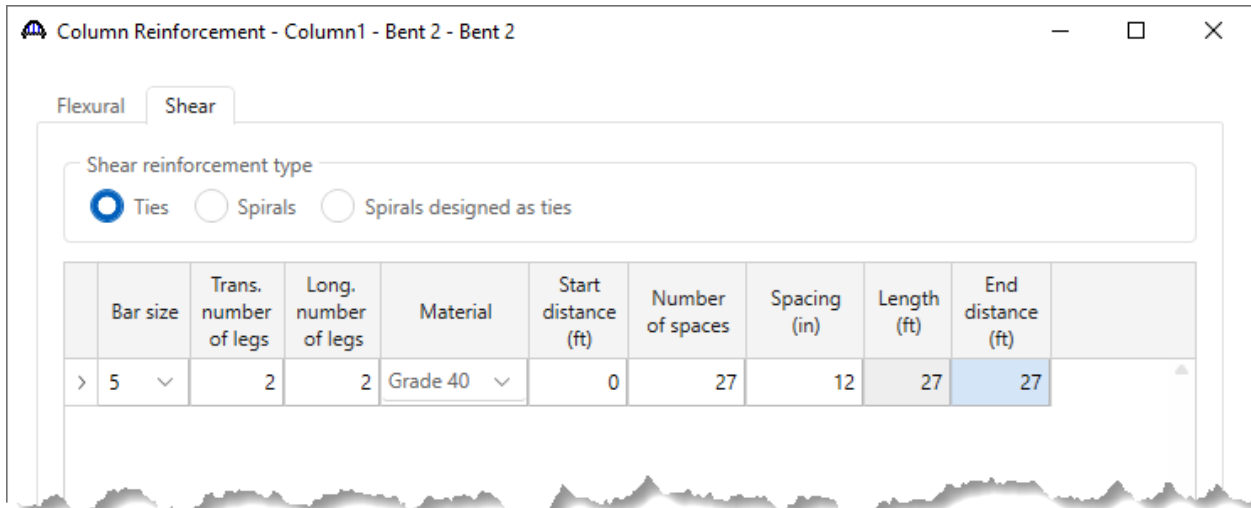
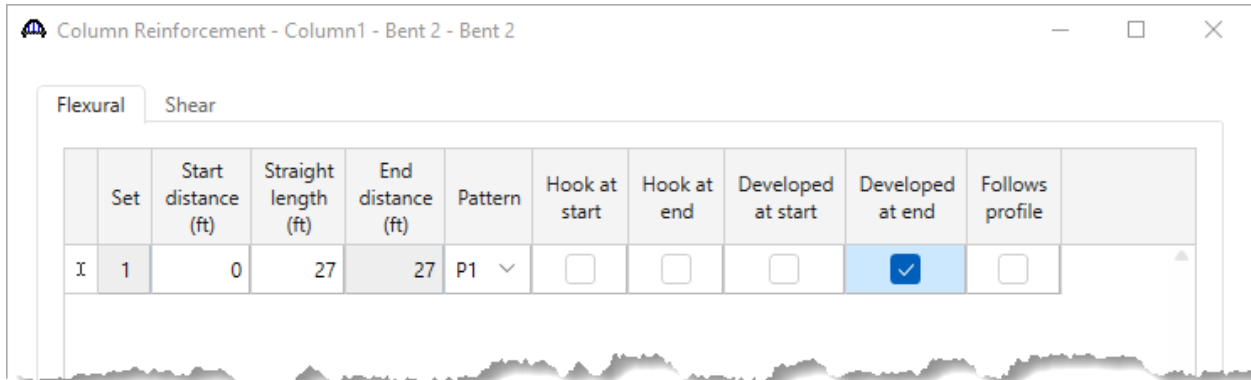
Bar	Bar size	Material	X (in)	Y (in)
> 1	10	Grade 40	29.365	0
2	10	Grade 40	28.7233043	-6.1053268
3	10	Grade 40	26.8262624	-11.9438215
4	10	Grade 40	23.756784	-17.2603139
5	10	Grade 40	19.6490203	-21.8224478
6	10	Grade 40	14.6825	-25.430836
7	10	Grade 40	9.074284	-27.9277746
8	10	Grade 40	3.0694783	-29.2041355
9	10	Grade 40	-3.0694783	-29.2041355
10	10	Grade 40	-9.074284	-27.9277746
11	10	Grade 40	-14.6825	-25.430836
12	10	Grade 40	-19.6490203	-21.8224478
13	10	Grade 40	-23.756784	-17.2603139
14	10	Grade 40	-26.8262624	-11.9438215
15	10	Grade 40	-28.7233043	-6.1053268
16	10	Grade 40	-29.365	0
17	10	Grade 40	-28.7233043	6.1053268
18	10	Grade 40	-26.8262624	11.9438215
19	10	Grade 40	-23.756784	17.2603139
20	10	Grade 40	-19.6490203	21.8224478
21	10	Grade 40	-14.6825	25.430836
22	10	Grade 40	-9.074284	27.9277746
23	10	Grade 40	-3.0694783	29.2041355
24	10	Grade 40	3.0694783	29.2041355
25	10	Grade 40	9.074284	27.9277746
26	10	Grade 40	14.6825	25.430836
27	10	Grade 40	19.6490203	21.8224478
28	10	Grade 40	23.756784	17.2603139
29	10	Grade 40	26.8262624	11.9438215

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

MCB4 – RC MCB Integral with Pier Example

Column Reinforcement – Column1 – Bent 2 – Bent 2

Open the Column1 **Reinforcement** window and enter the flexural and shear reinforcement as shown.



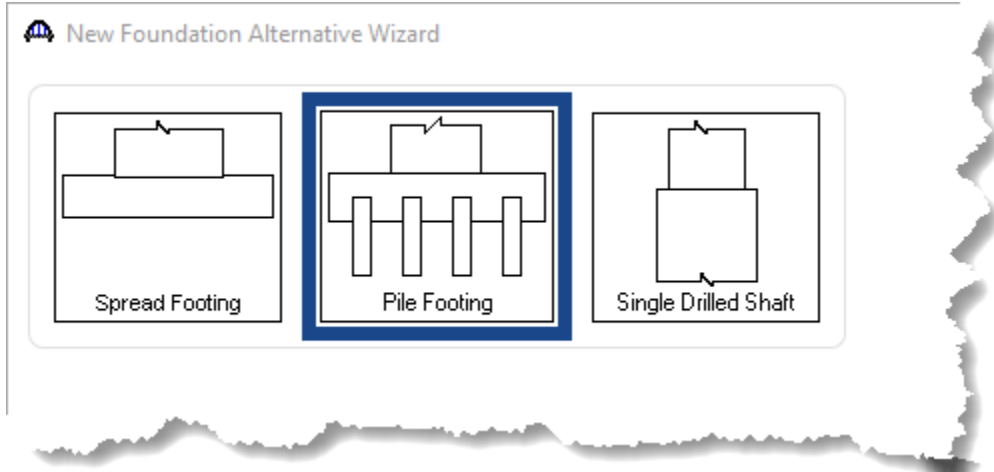
Click **OK** to apply the data and close the window.

MCB4 – RC MCB Integral with Pier Example

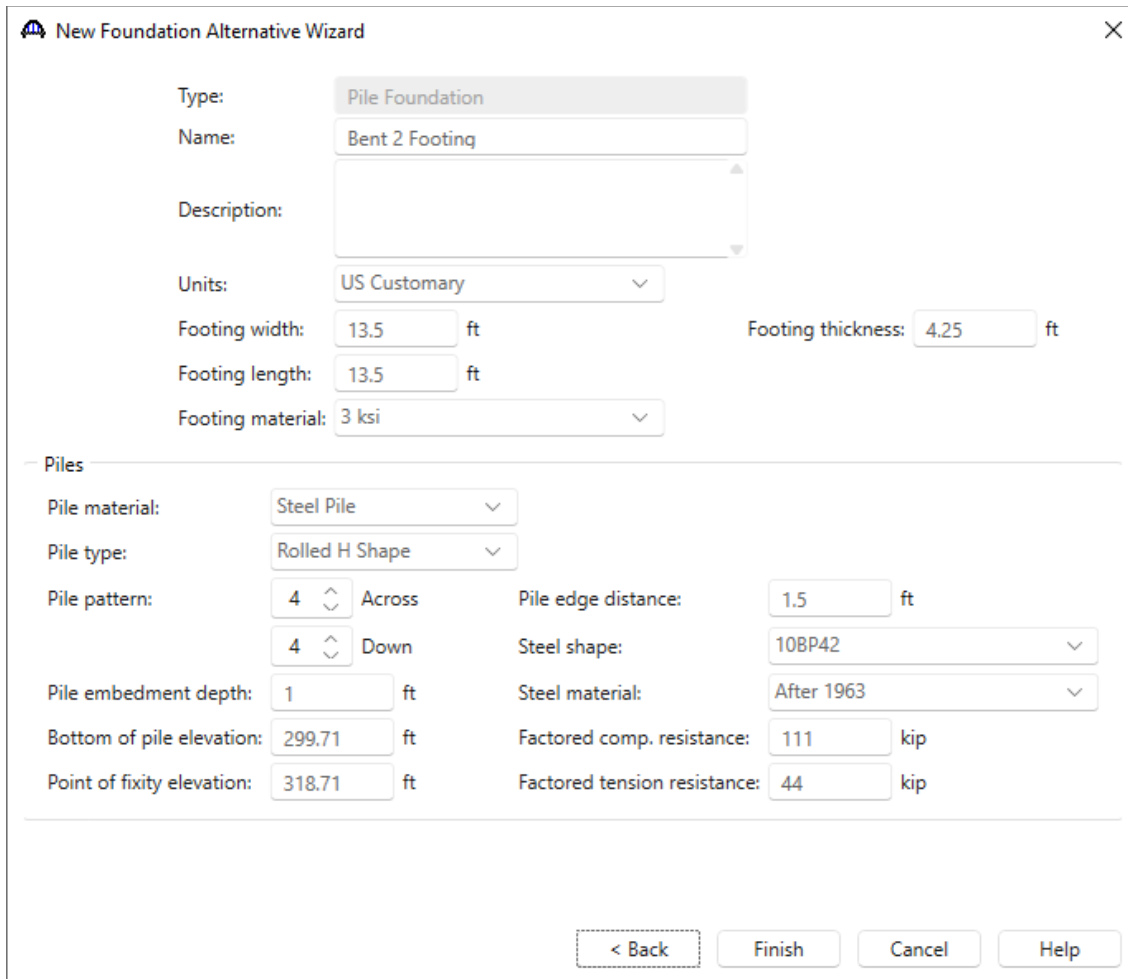
Foundation Alternatives

New Foundation Alternative Wizard

Open the **Foundation Alternatives** window, highlight the **Pile Footing** option, and click **Next**.



Enter the data shown below and click **Finish**.

The image shows the "New Foundation Alternative Wizard" dialog box with the following fields filled out:

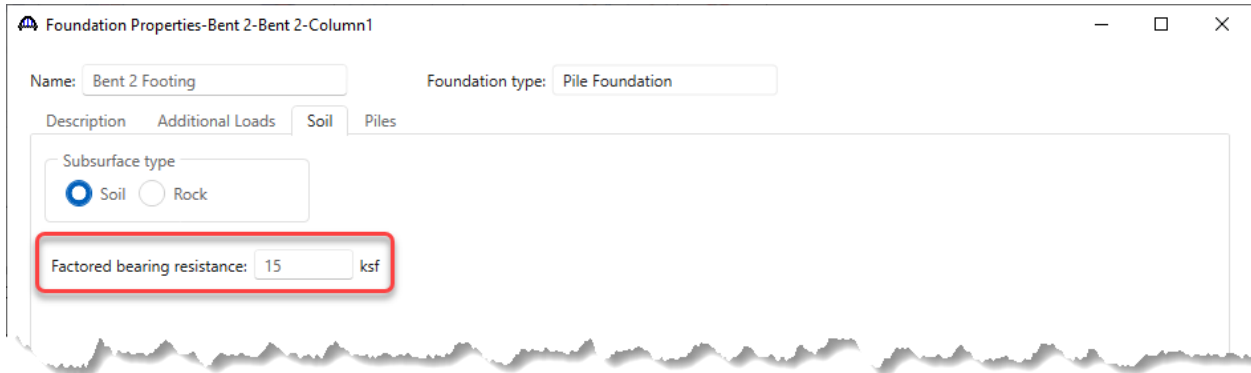
- Type: Pile Foundation
- Name: Bent 2 Footing
- Description: (empty)
- Units: US Customary
- Footing width: 13.5 ft
- Footing thickness: 4.25 ft
- Footing length: 13.5 ft
- Footing material: 3 ksi
- Piles section:
 - Pile material: Steel Pile
 - Pile type: Rolled H Shape
 - Pile pattern: 4 Across, 4 Down
 - Pile edge distance: 1.5 ft
 - Steel shape: 10BP42
 - Steel material: After 1963
 - Pile embedment depth: 1 ft
 - Bottom of pile elevation: 299.71 ft
 - Point of fixity elevation: 318.71 ft
 - Factored comp. resistance: 111 kip
 - Factored tension resistance: 44 kip

At the bottom of the dialog box, there are four buttons: "< Back", "Finish", "Cancel", and "Help".

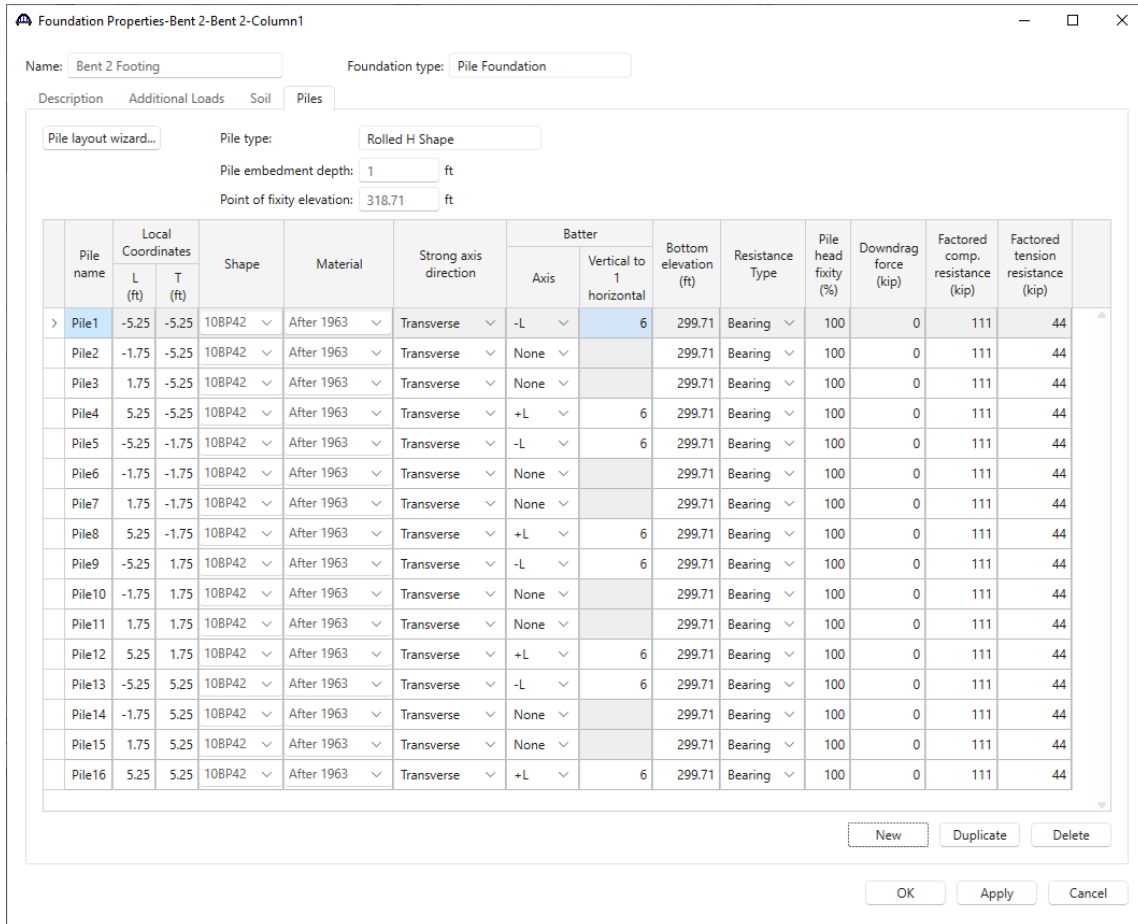
MCB4 – RC MCB Integral with Pier Example

Foundation Properties – Bent 2 – Bent 2 – Column1

Click the **Soil** tab and enter the Factored bearing resistance.



Navigate to the **Piles** tab and enter the following data.



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

MCB4 – RC MCB Integral with Pier Example

Foundation geometry – Bent 2 Footing

Open the Foundations Alternatives **Geometry**. Verify the dimensions.

The diagram shows a square footing in plan view. The horizontal dimension is labeled D1 and the vertical dimension is labeled D2. The axes are labeled: Pier Transverse Axis (top), Column Transverse Axis (top), Pier Longitudinal Axis (left), and Column Longitudinal Axis (left). A coordinate system shows T (vertical), L (horizontal), and V (diagonal). A red arrow points up labeled STA. AHEAD. The text 'Plan View' is centered below the diagram.

	Location	Elevation (ft)	Dimension (ft)	
			D1	D2
>	Top	332.96	13.5	13.5
	Bottom	328.71	13.5	13.5

Buttons: OK, Apply, Cancel

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

MCB4 – RC MCB Integral with Pier Example

Foundation Reinforcement – Bent 2 – Bent 2 – Column1 – Bent 2 Footing

Open the Foundation Alternatives **Reinforcement** window and enter the data as shown below.

Foundation Reinforcement - Bent 2 - Bent 2 - Column1 - Bent 2 Footing

Direction of topmost rebar: Longitudina Top bar clear cover: 4 in End cover: 2 in

Direction of bottommost rebar: Longitudina Bottom bar clear cover: 14 in Material: Grade 40

Top longitudinal reinforcement

Bar size: 5 Number: 14

Hooked

Fully developed

Top transverse reinforcement

Bar size: 5 Number: 14

Hooked

Fully developed

Bottom longitudinal reinforcement

Bar size: 9 Number: 27

Hooked

Fully developed

Bottom tranverse reinforcement

Bar size: 9 Number: 27

Hooked

Fully developed

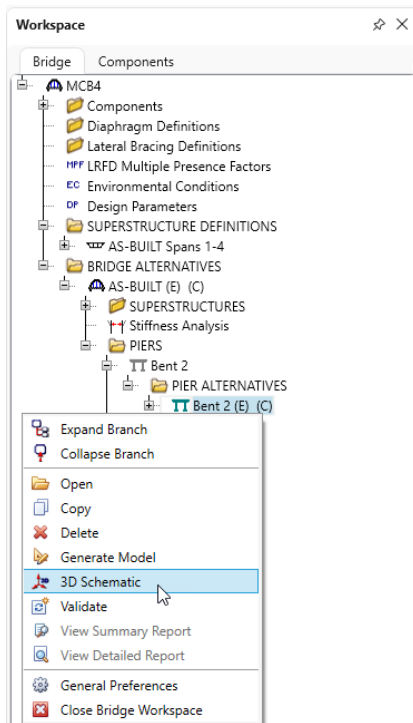
OK Apply Cancel

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

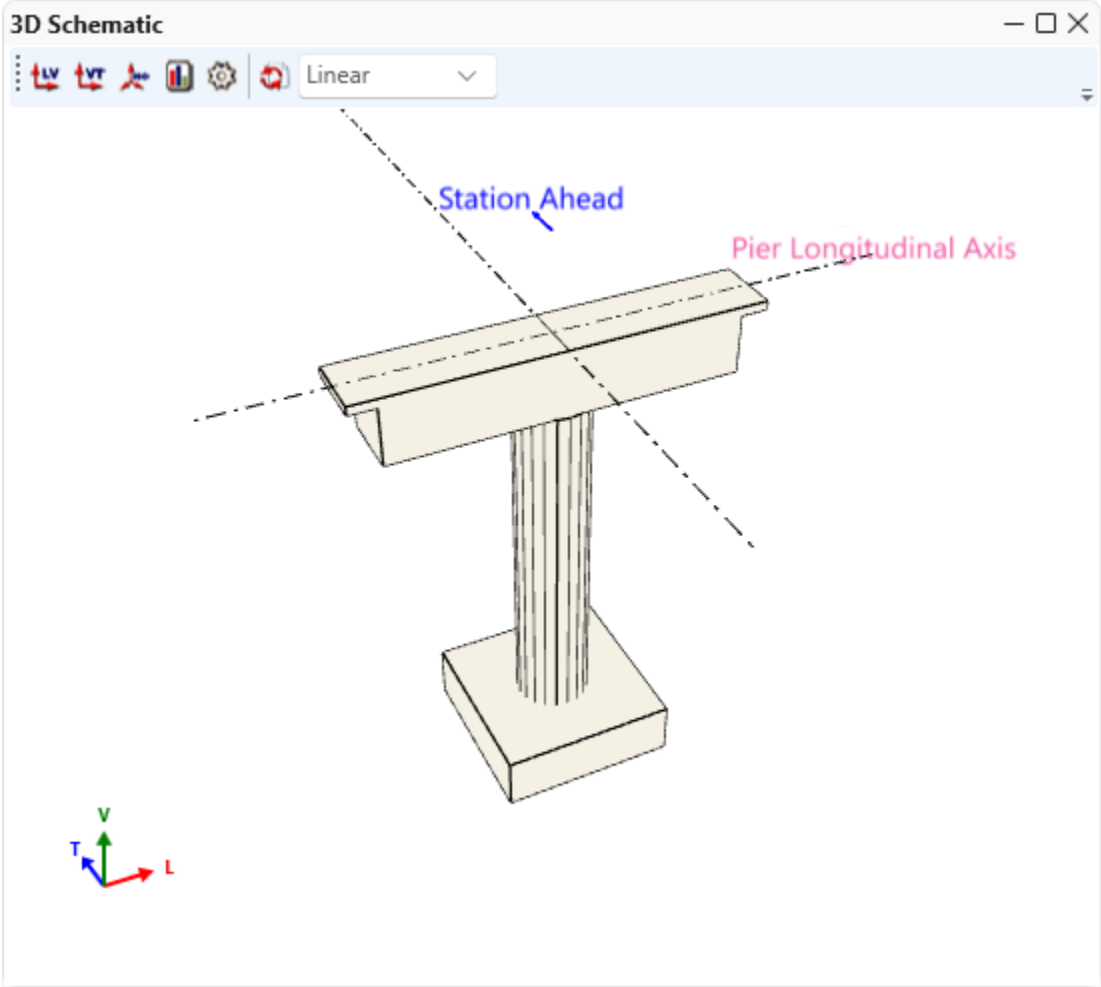
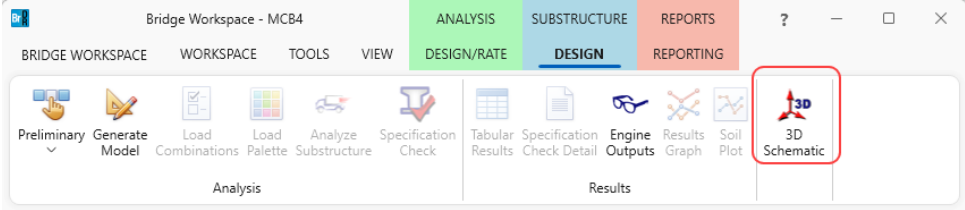
The input for Bent 2 is complete.

3D Schematic – Pier Alternative

With pier alternative – **Bent 2** selected, click on the **3D Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon (or right click and select **3D Schematic**)



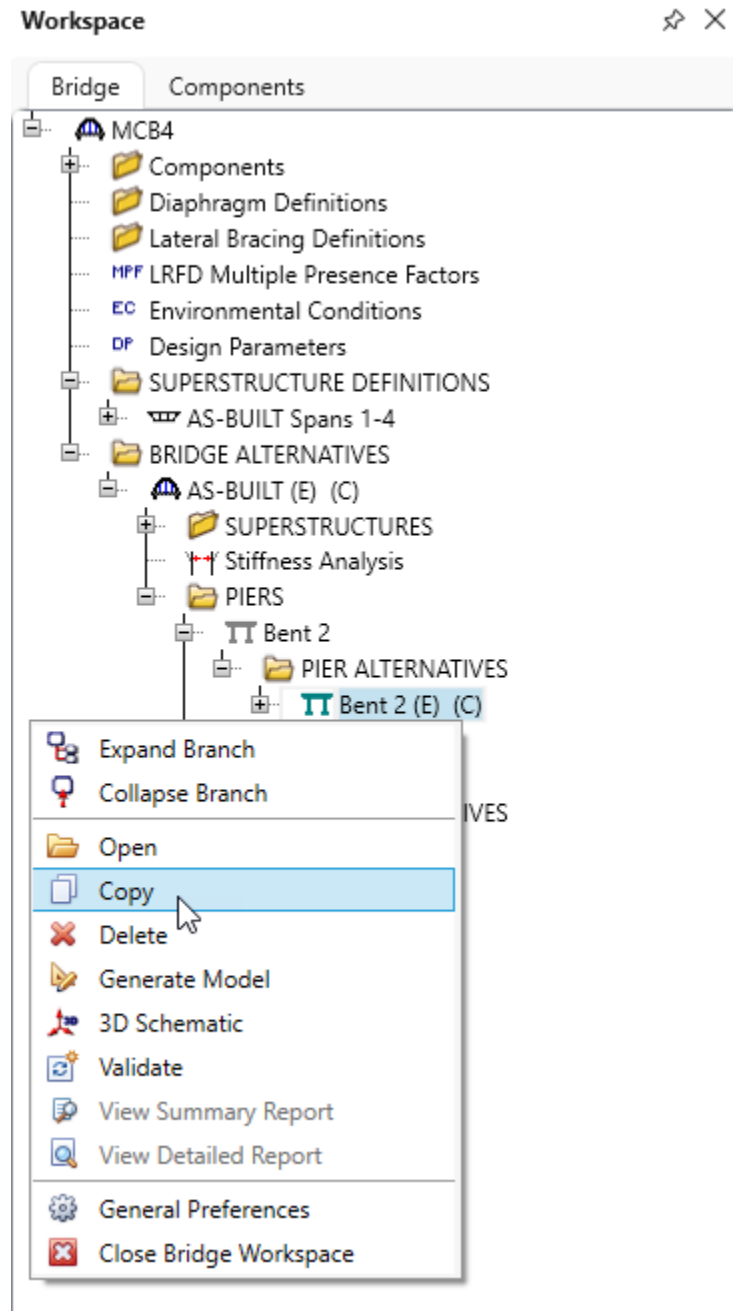
MCB4 – RC MCB Integral with Pier Example



MCB4 – RC MCB Integral with Pier Example

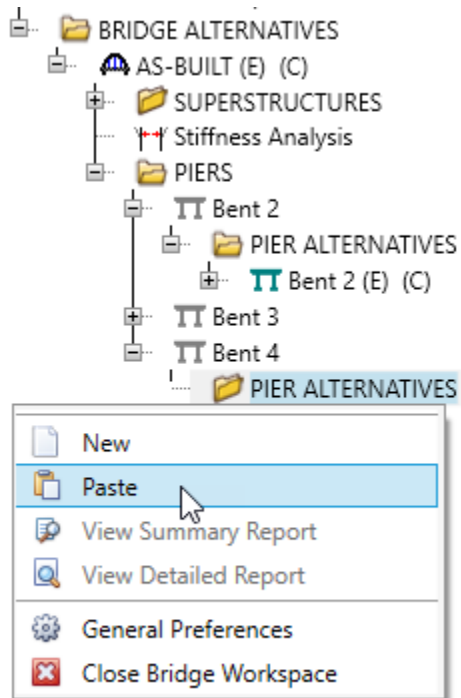
[Copy pier alternative](#)

Bent 4 is identical to **Bent 2**. Therefore, a copy of **Bent 2** can be created for **Bent 4**. Right click on the **Bent 2** Pier Alternative and select **Copy**.



MCB4 – RC MCB Integral with Pier Example

Expand **Bent 4**, right click on the **Pier Alternative** and select **Paste**. Change the name from **Bent 2** to **Bent 4**. The input for **Bent 4** is now complete.



MCB4 – RC MCB Integral with Pier Example

Follow the same procedure for **Bent 3**. However, additional input will need to be modified as shown below.

Pile Layout

Foundation Properties – Bent 3 - Bent 3 – Column1

Foundation Properties-Bent 3-Bent 3-Column1

Name: Foundation type:

Description Additional Loads Soil **Piles**

Pile layout wizard... Pile type:

Pile embedment depth: ft

Point of fixity elevation: ft

Pile name	Local Coordinates		Shape	Material	Strong axis direction	Batter		Bottom elevation (ft)	Resistance Type	Pile head fixity (%)	Downdrag force (kip)	Factored comp. resistance (kip)	Factored tension resistance (kip)
	L (ft)	T (ft)				Axis	Vertical to 1 horizontal						
> Pile1	-7	-5.25	10BP42	After 1963	Transverse	-L	6	299.71	Bearing	100	0	111	44
Pile2	-3.5	-5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile3	0	-5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile4	3.5	-5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile5	7	-5.25	10BP42	After 1963	Transverse	+L	6	299.71	Bearing	100	0	111	44
Pile6	-7	-1.75	10BP42	After 1963	Transverse	-L	6	299.71	Bearing	100	0	111	44
Pile7	-3.5	-1.75	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile8	0	-1.75	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile9	3.5	-1.75	10BP42	After 1963	Transverse	-L+T	6	299.71	Bearing	100	0	111	44
Pile10	7	-1.75	10BP42	After 1963	Transverse	+L	6	299.71	Bearing	100	0	111	44
Pile11	-7	1.75	10BP42	After 1963	Transverse	-L	6	299.71	Bearing	100	0	111	44
Pile12	-3.5	1.75	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile13	0	1.75	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile14	3.5	1.75	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile15	7	1.75	10BP42	After 1963	Transverse	+L	6	299.71	Bearing	100	0	111	44
Pile16	-7	5.25	10BP42	After 1963	Transverse	-L	6	299.71	Bearing	100	0	111	44
Pile17	-3.5	5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile18	0	5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile19	3.5	5.25	10BP42	After 1963	Transverse	None		299.71	Bearing	100	0	111	44
Pile20	7	5.25	10BP42	After 1963	Transverse	+L	6	299.71	Bearing	100	0	111	44

New Duplicate Delete


OK Apply Cancel

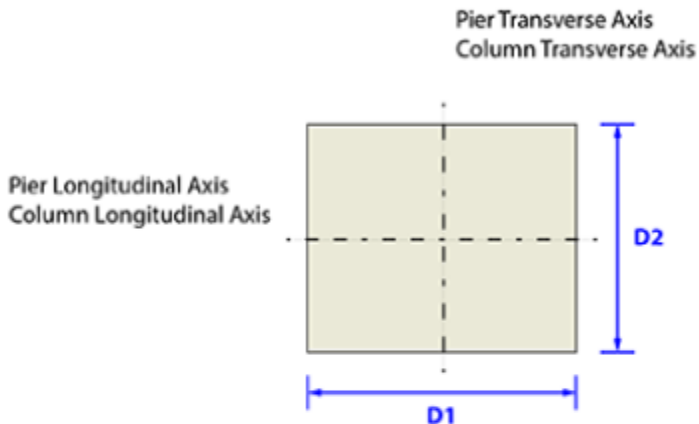
Click **OK** to apply the data and close the window.


MCB4 – RC MCB Integral with Pier Example


Foundation Geometry – Bent 3 Footing

Open the **Foundation Geometry** window and enter the data as shown below.

 Foundation Geometry - Bent 3 Footing







STA. AHEAD

Plan View

	Location	Elevation (ft)	Dimension (ft)	
			D1	D2
>	Top	332.96	17	13.5
	Bottom	328.71	17	13.5

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

MCB4 – RC MCB Integral with Pier Example

Foundation Reinforcement – Bent 3 – Bent 3 – Column1 – Bent 3 Footing

Open the **Foundation Reinforcement** window and enter data as shown below.

Foundation Reinforcement - Bent 3 - Bent 3 - Column1 - Bent 3 Footing

Direction of topmost rebar: Longitudinal ▾ Top bar clear cover: 4 in End cover: 2 in

Direction of bottommost rebar: Longitudinal ▾ Bottom bar clear cover: 14 in Material: Grade 40 ▾

Top longitudinal reinforcement

Bar size: 5 ▾ Number: 14

Hooked
 Fully developed

Top transverse reinforcement

Bar size: 5 ▾ Number: 17

Hooked
 Fully developed

Bottom longitudinal reinforcement

Bar size: 10 ▾ Number: 27

Hooked
 Fully developed

Bottom transverse reinforcement

Bar size: 10 ▾ Number: 34

Hooked
 Fully developed

OK Apply Cancel

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

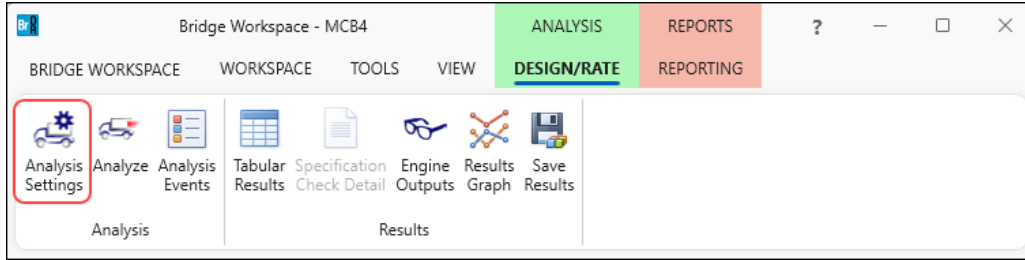
MCB4 – RC MCB Integral with Pier Example

Analysis and Results

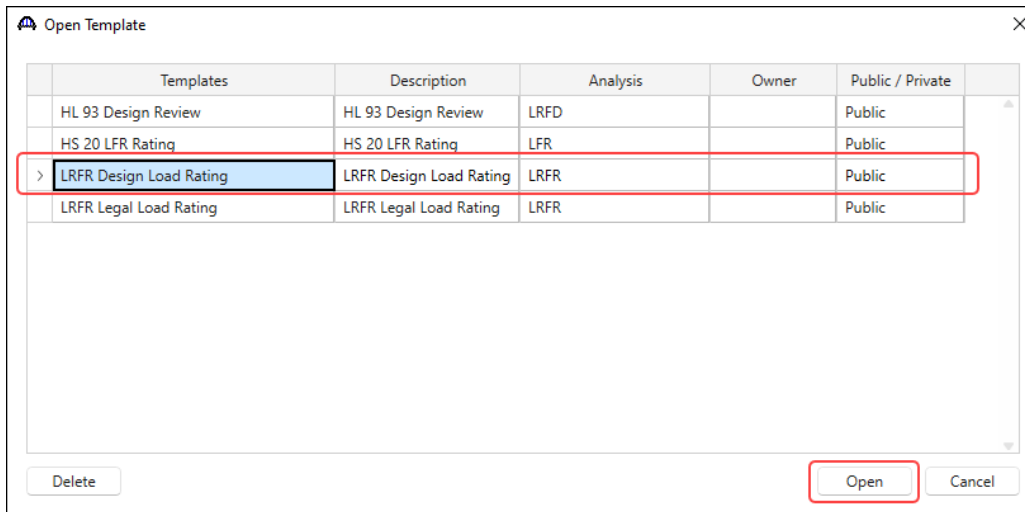
The structure is ready for analysis. Note that a design review of substructures for integral box girders cannot be performed at this time.

LRFR Analysis

To perform an LRFR analysis of the superstructure – **AS-BUILT Spans 1-4**, click on the **Analysis Settings** button from the **Analysis** group of the **DESIGN/RATE** ribbon.

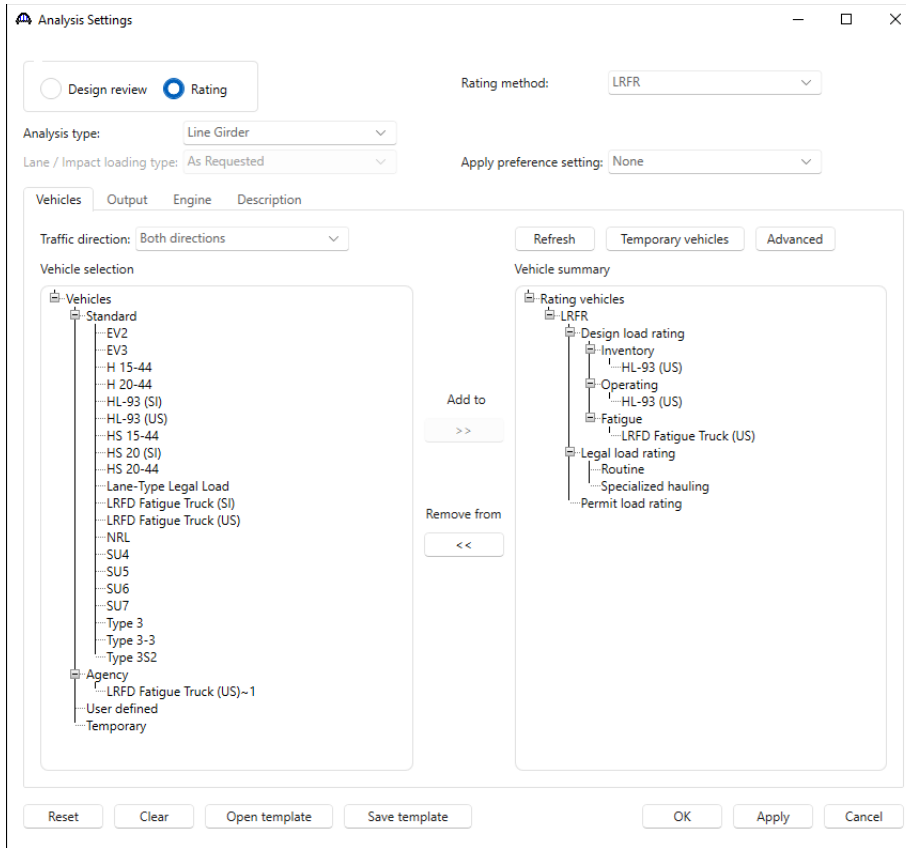


Click on the **Open template** button in the **Analysis Settings** window and select the **LRFR Design Load Rating** and click **Open**.



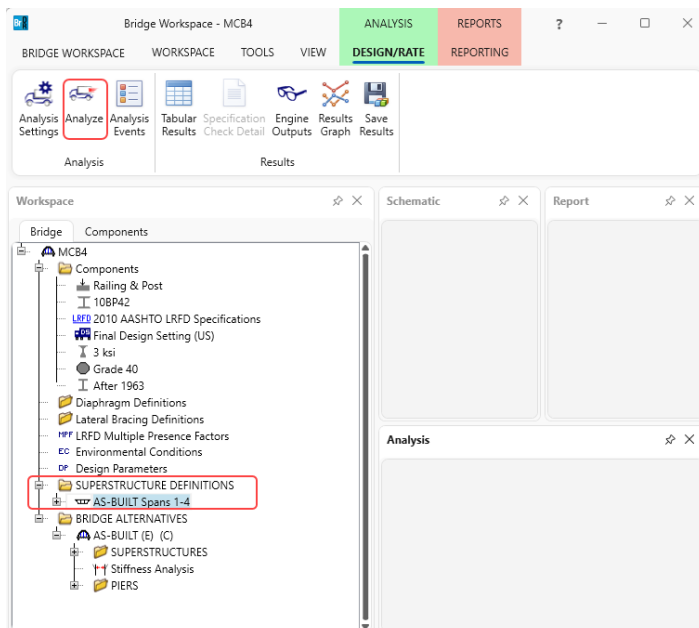
MCB4 – RC MCB Integral with Pier Example

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



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

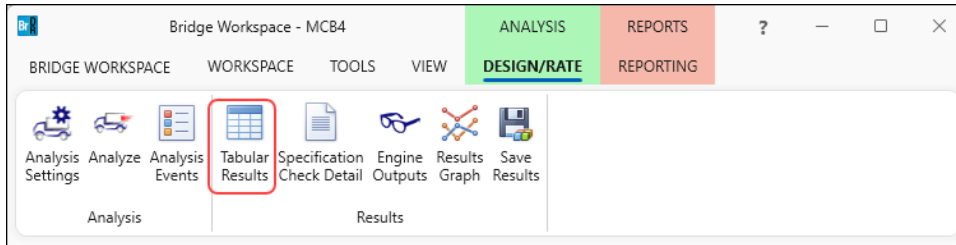
To run the analysis, with the superstructure – **AS-BUILT Spans 1-4** selected, click on the Analyze button from the **Analysis** group of the **DESIGN/RATE** ribbon.



MCB4 – RC MCB Integral with Pier Example

Tabular Results

Once the analysis is complete, results can be viewed by clicking on the **Tabular Results** button from the **Results** group of the **DESIGN/RATE** ribbon.



Superstructure LRFR ratings for full box unit are shown below.

Analysis Results - AS-BUILT Spans 1-4

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
HL-93 (US)	Truck + Lane	LRFR	Inventory	73.71	2.048	234.42	4 - (30.0)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	95.55	2.654	234.42	4 - (30.0)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	77.53	2.154	215.09	3 - (97.3)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	100.50	2.792	215.09	3 - (97.3)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	76.02	2.112	234.42	4 - (30.0)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	98.54	2.737	234.42	4 - (30.0)	AS-BUILTSpans1-4	STRENGTH-I Concrete Flexure	As Requested	As Requested

AASHTO LRFR Engine Version 7.5.0.3001
Analysis preference setting: None

LFR Analysis Results

The user also has the option to analyze individual web lines. LFR ratings for **Web 1** using the **HS 20 LFR Rating** template are shown below.

Analysis Results - WEB1

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
HS 20-44	Axle Load	LFR	Inventory	76.21	2.117	267.82	4 - (88.3)	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Axle Load	LFR	Operating	126.77	3.521	267.82	4 - (88.3)	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Inventory	101.75	2.826	144.15	3 - (8.6)	Design Shear - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Operating	167.10	4.642	144.15	3 - (8.6)	Design Shear - Concrete	As Requested	As Requested

AASHTO LFR Engine Version 7.5.0.3001
Analysis preference setting: None