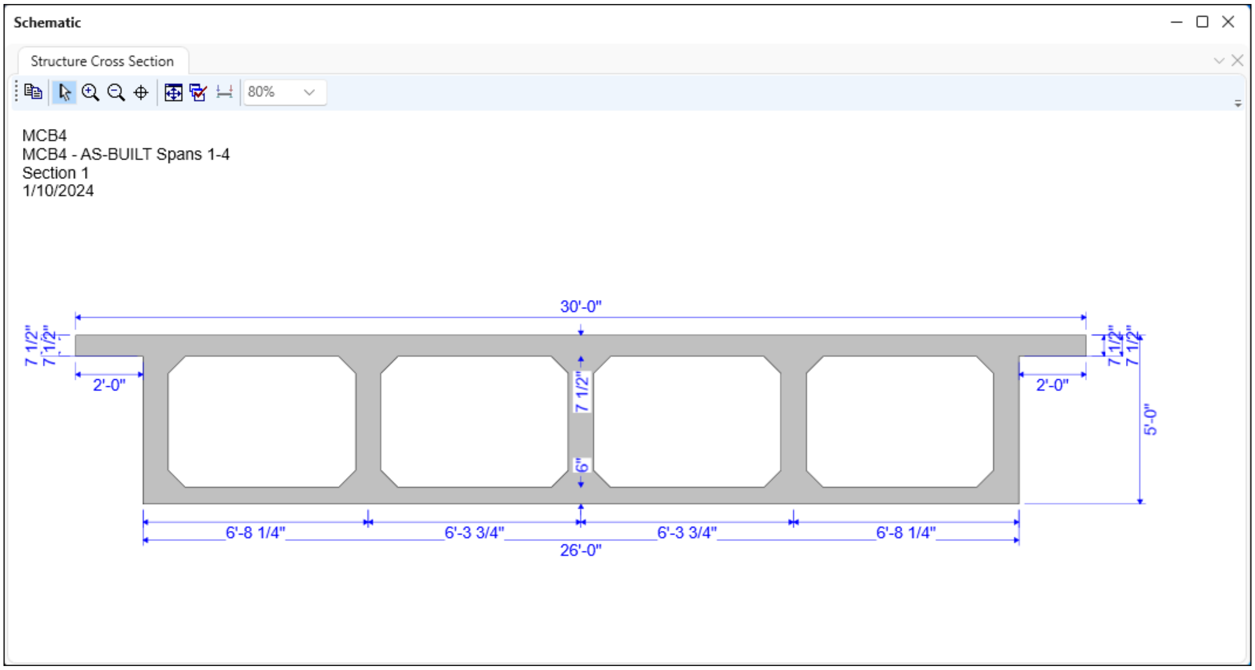
AASHTOWare BrDR 7.5.0

Multi-Cell Box Tutorial

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

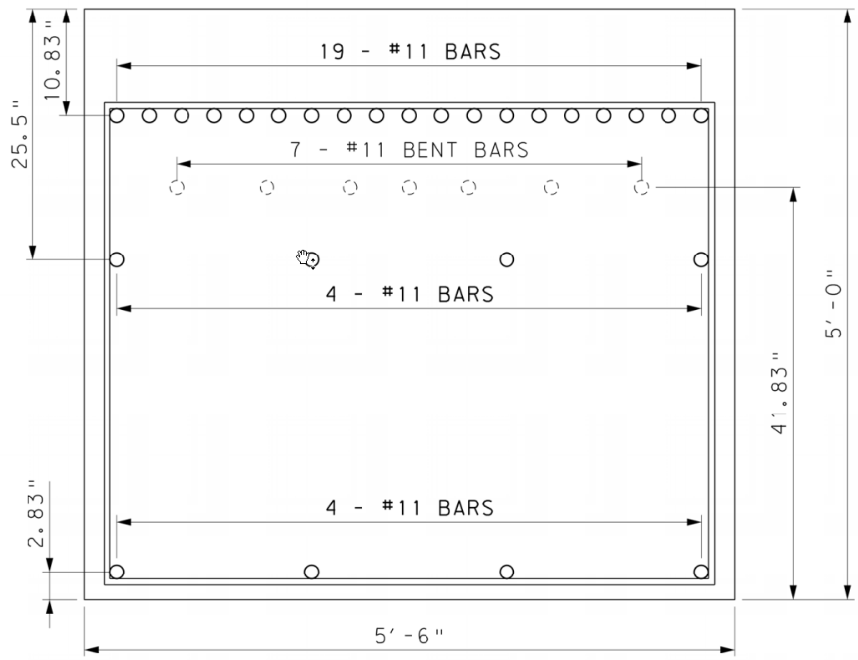
Analysis Methods

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

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

Comments and Assumptions

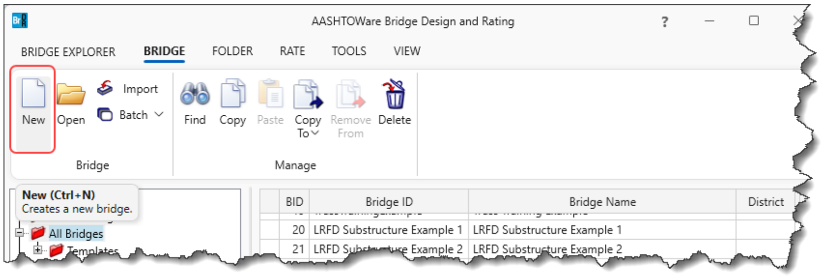
- Based on the year built, 1963, information contained in the design plans, and the AASHTO Manual for Bridge Evaluation:
  - Concrete compressive strength = 3 ksi (fc = 1.2 ksi)
  - Reinforcing steel yield strength = 40 ksi (fs = 20 ksi)
  - Structural Steel Yield Strength = 36 ksi
  - Pile size = 10BP42
- 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:



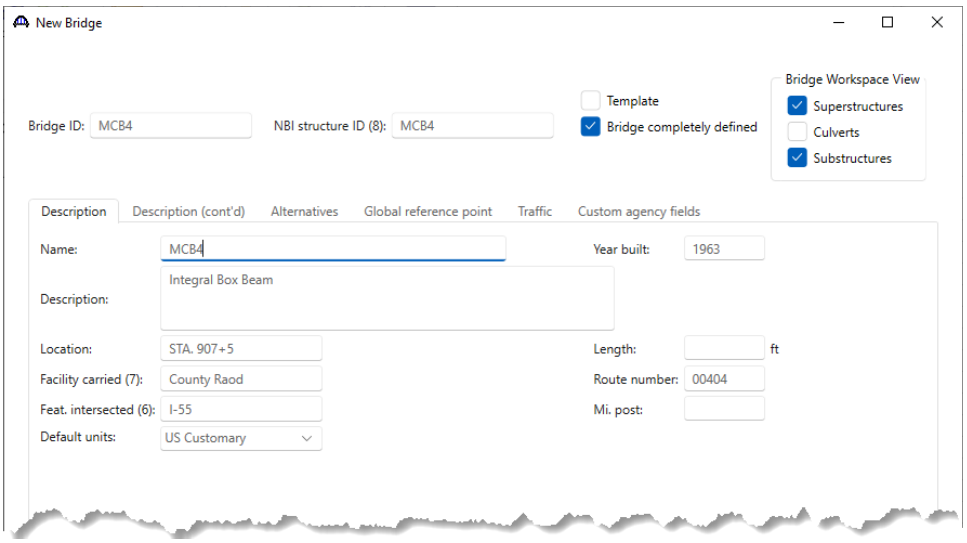
- Web shear reinforcement (S1 – S3 bars) are #5 bars.
- Top of footing elevation = 332.96 ft. for all piers.
- Finished ground line elevation = 335.00 ft. for all piers.
- Bottom of footing elevation = 328.71 ft. for all piers
- 30'-0" long piles with 1'-0" embedment
- Assume pile fixity elevation = 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

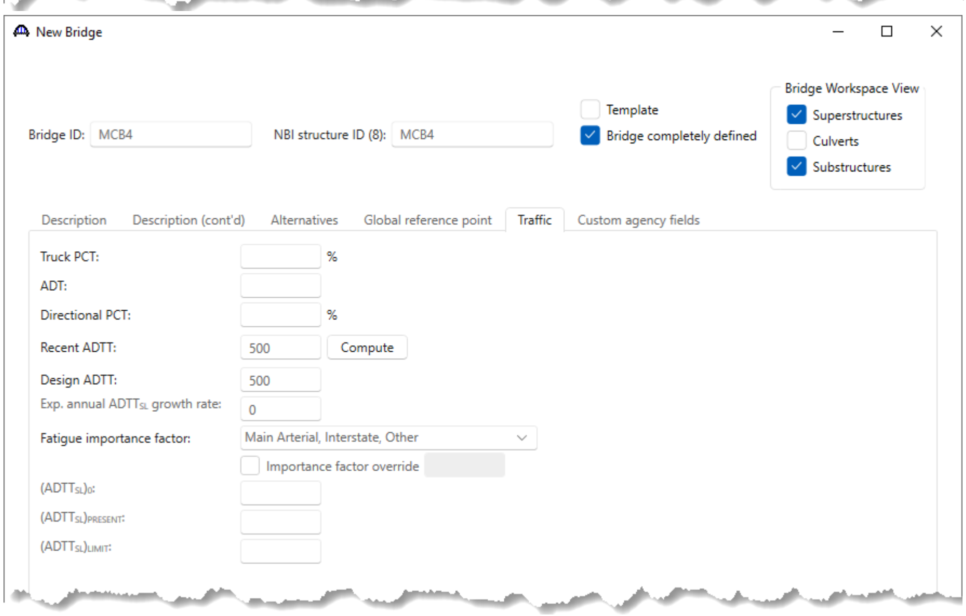
Data Entry

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



New Bridge



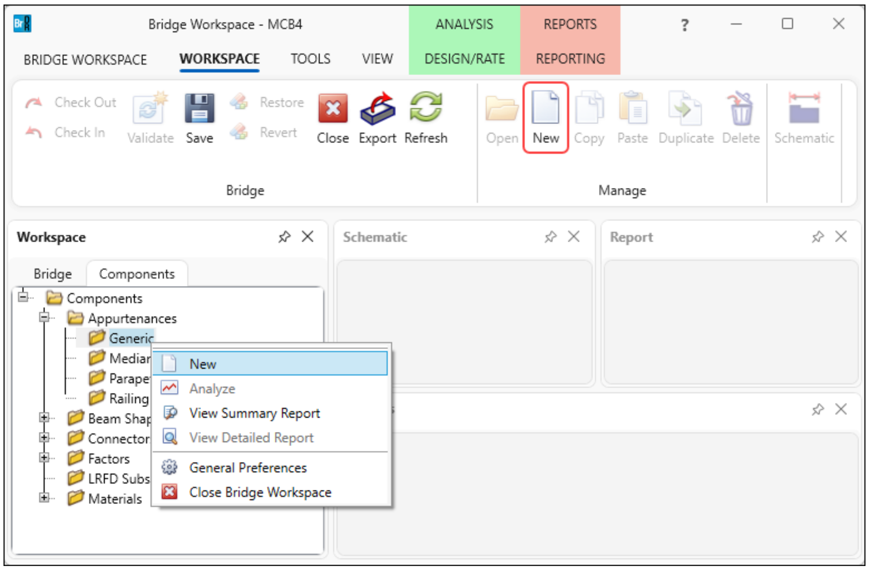


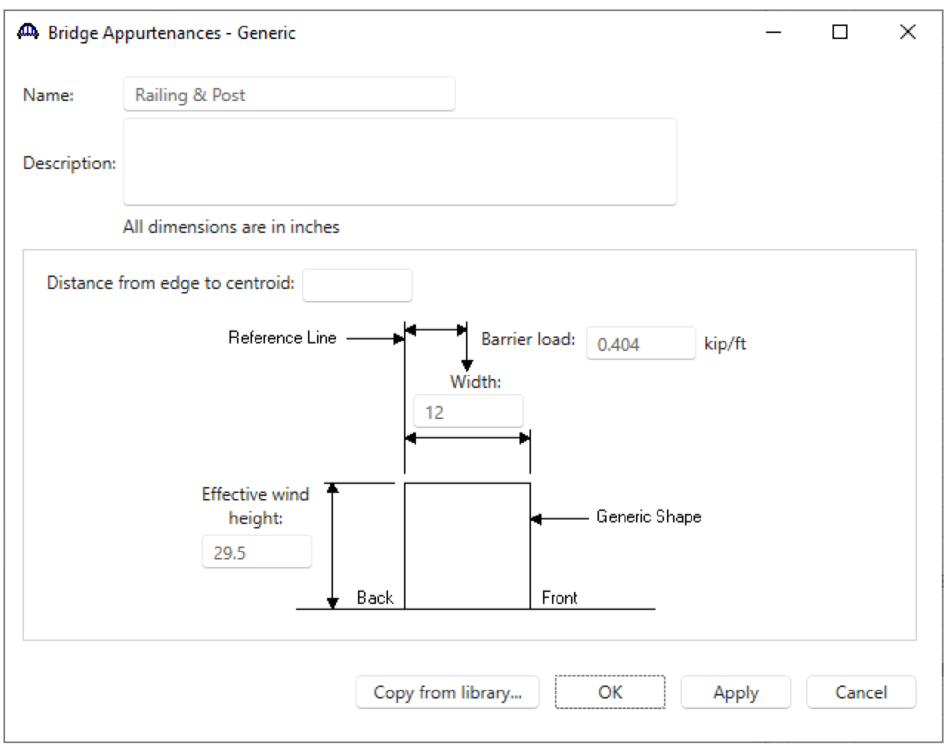
Click **OK** to apply the data and close the window.

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.

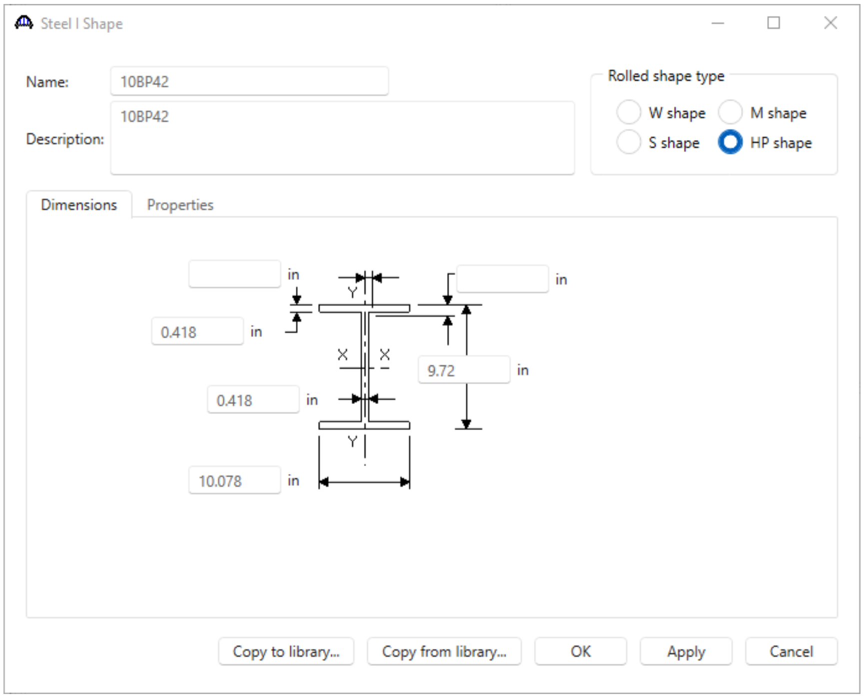




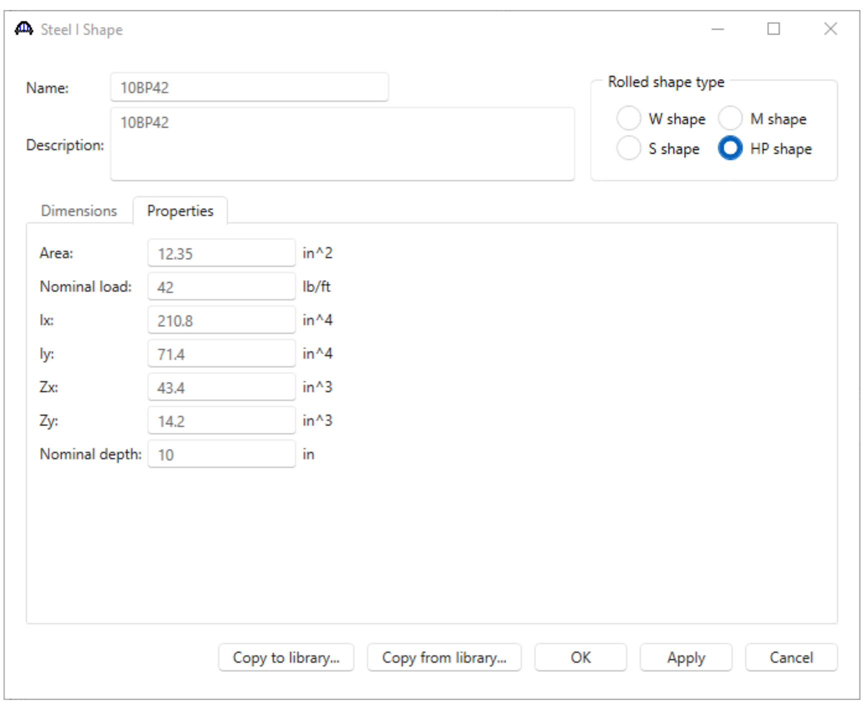
Click **OK** to apply the data and close the window.

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.

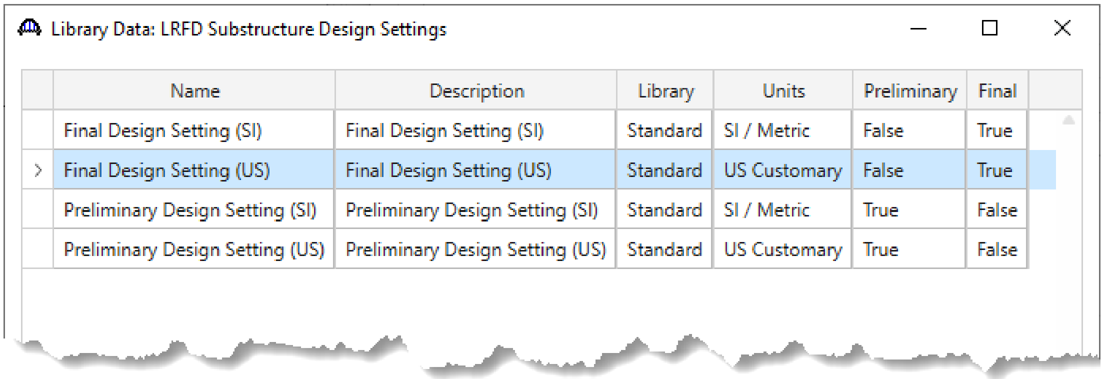


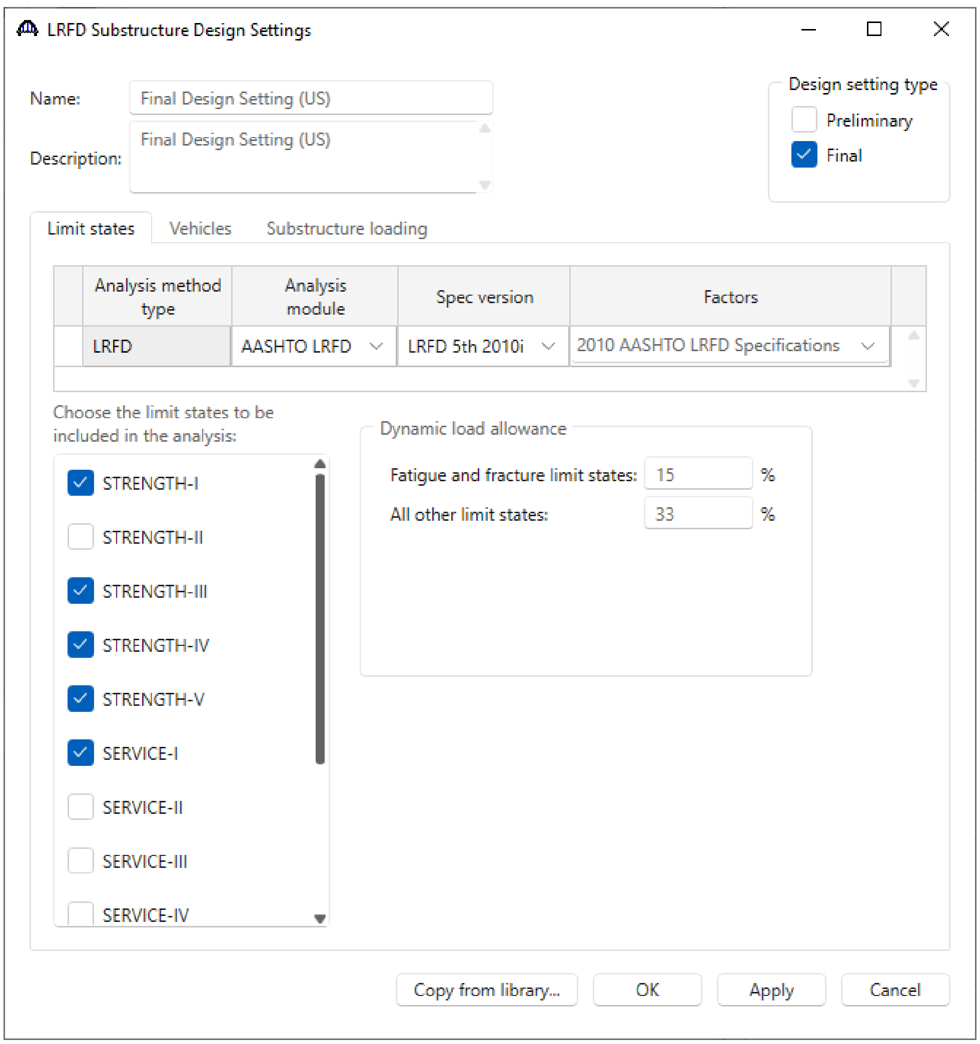
Click **OK** to apply the data and close the window.

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

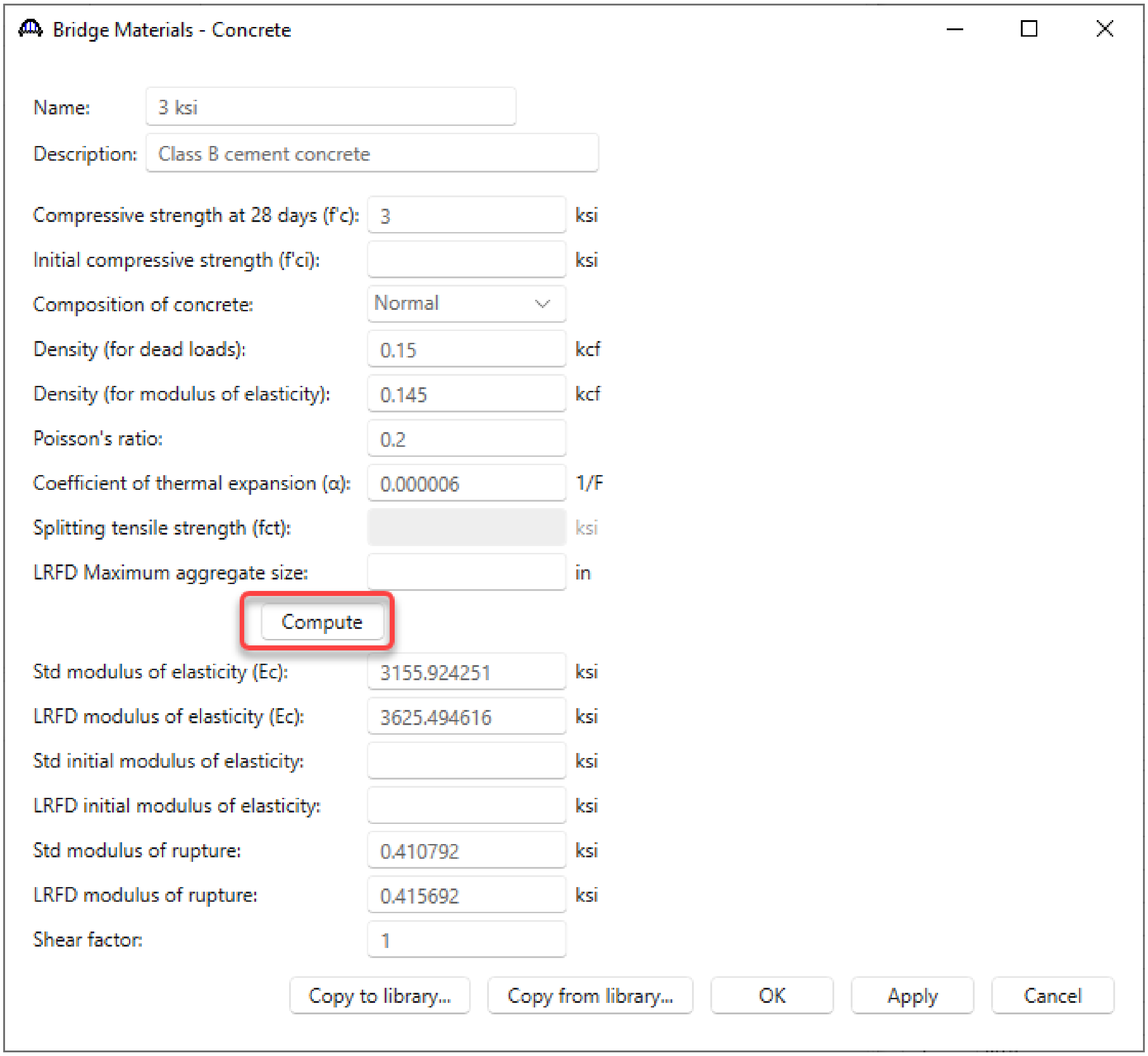




Click **OK** to apply the data and close the window.

Bridge Materials - Concrete

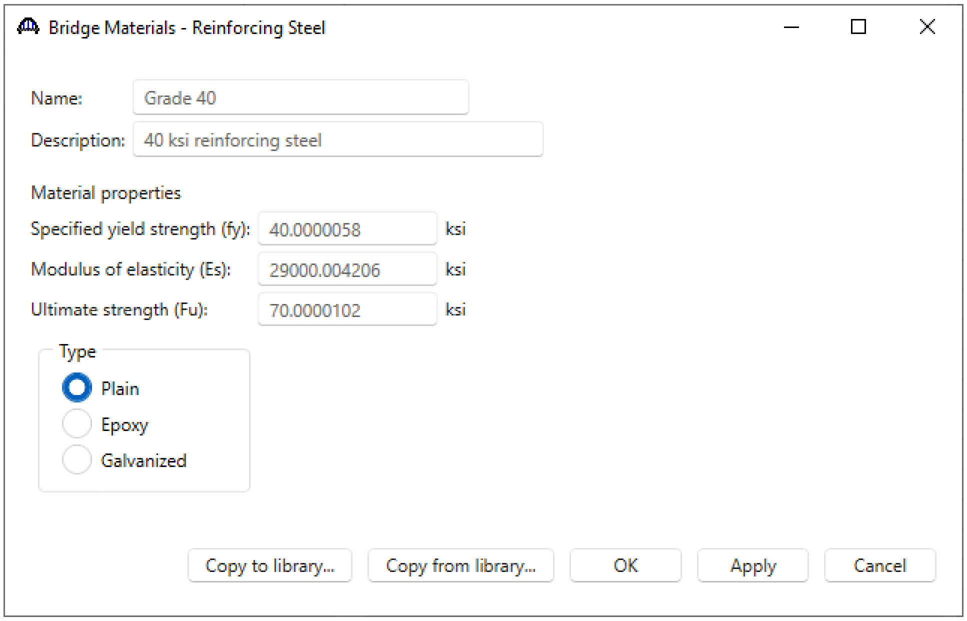
To add a new concrete material, expand the **Materials** folder and double click on **Concrete** in the tree. The window shown below will open. Enter the values shown below. Use the **Compute** button to fill in the lower portion of the window.



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

Bridge materials – Reinforcing Steel

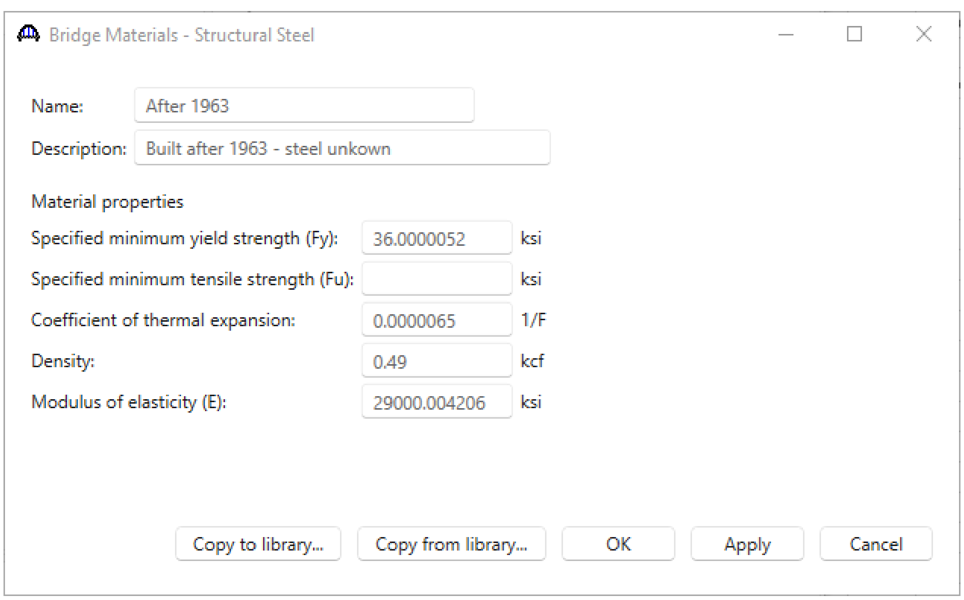
To add a new reinforcing steel material, double click on **Reinforcing Steel** in the tree and click on **Copy from library…** button. Select the **Grade 40** reinforcing steel and click **OK**. The selected material properties are copied to the **Bridge Materials – Reinforcing Steel** window as shown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



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

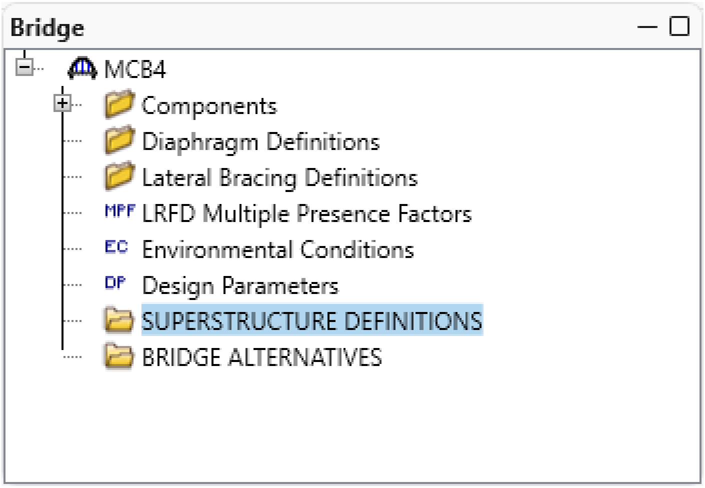
Bridge Materials – Structural Steel

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.



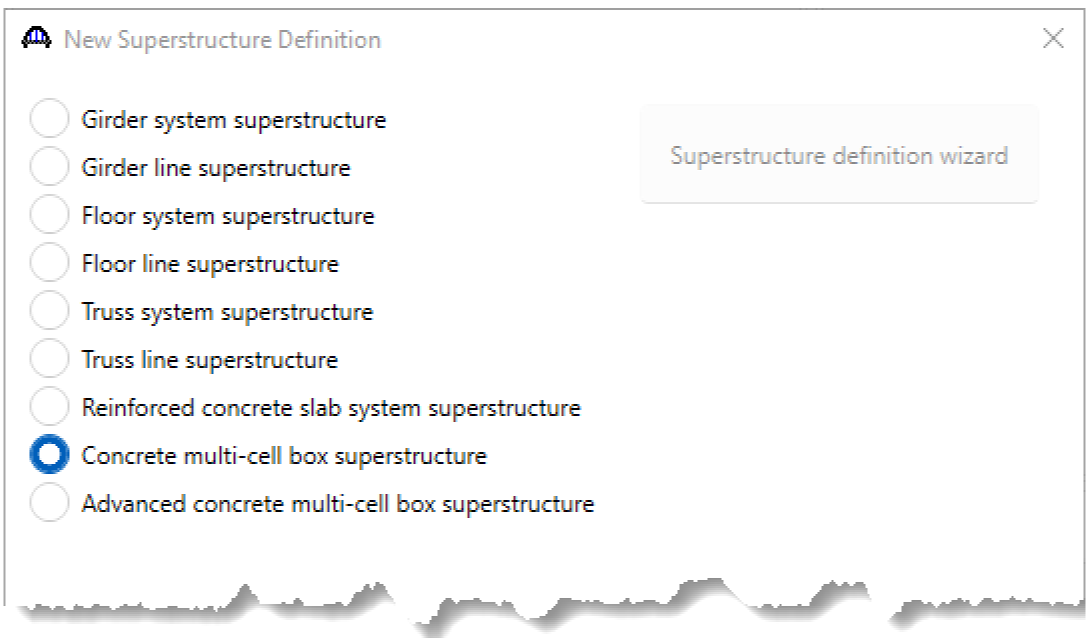
Click **OK** to apply the data and close the window.

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



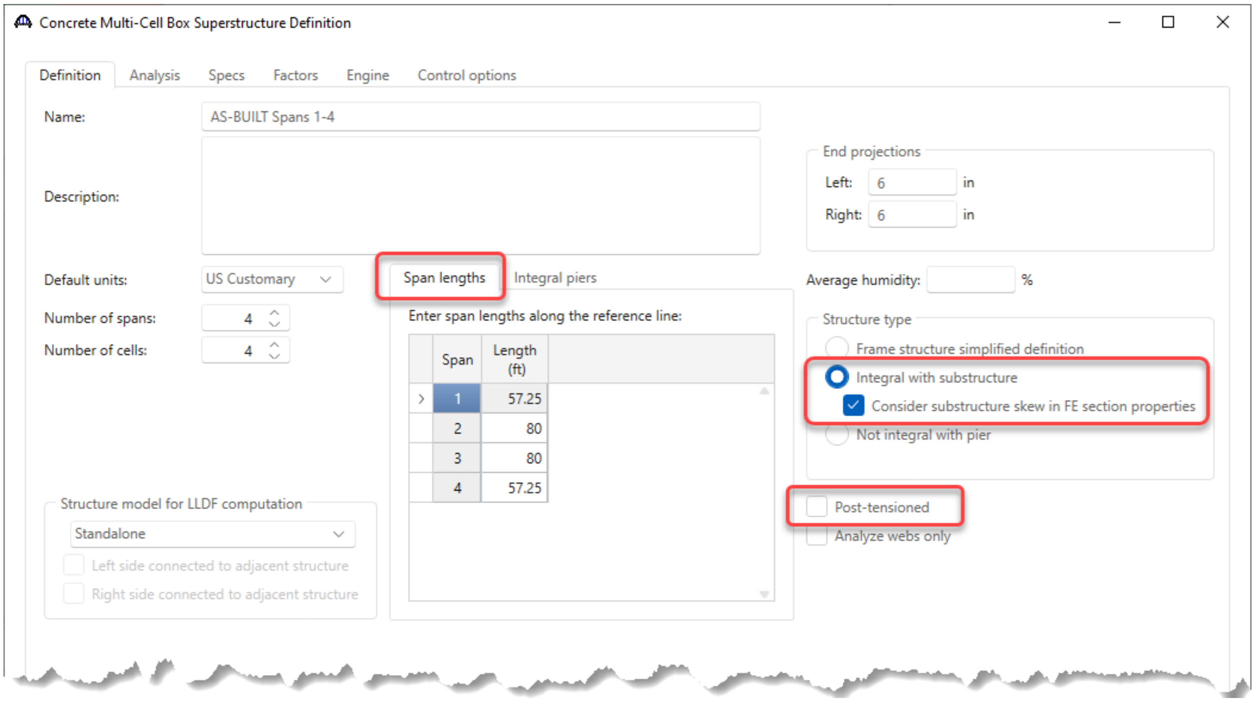
New Superstructure Definition

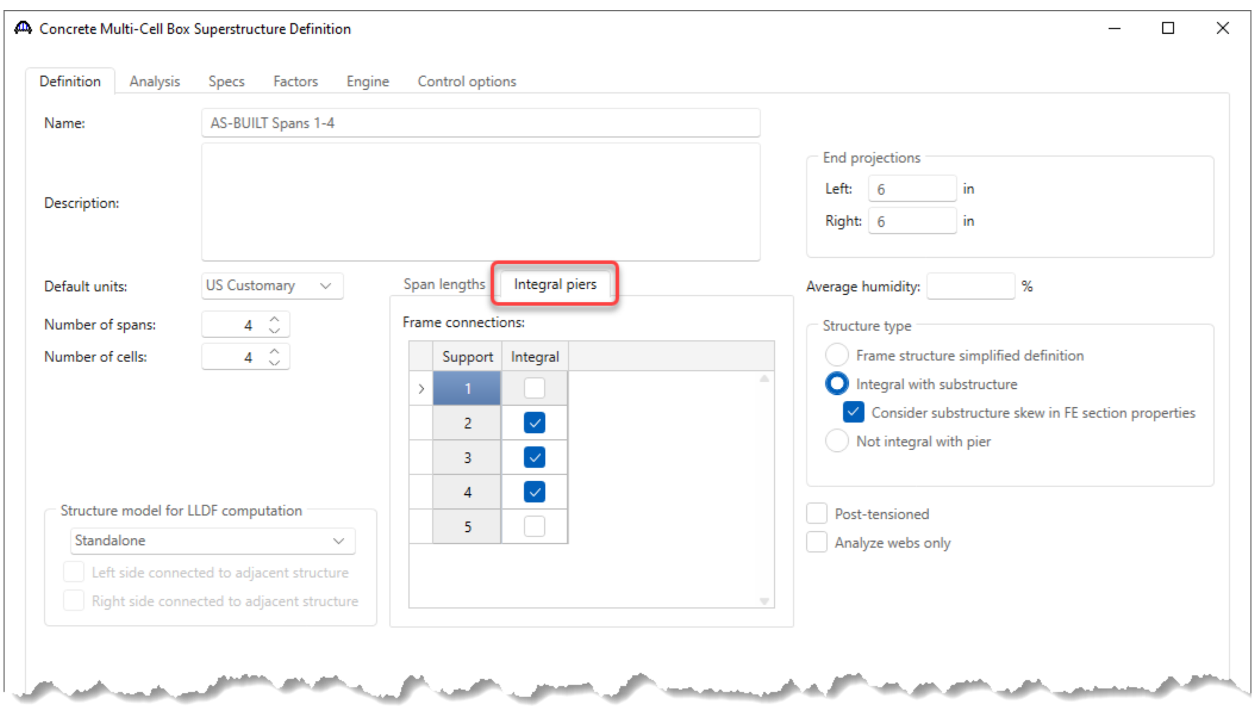
Create a new concrete multi-cell box superstructure definition by double clicking the **SUPERSTRUCTURE DEFINITIONS** folder. Select **Concrete multi-cell box superstructure** and click **OK**.



Concrete Multi-Cell Box Superstructure Definition

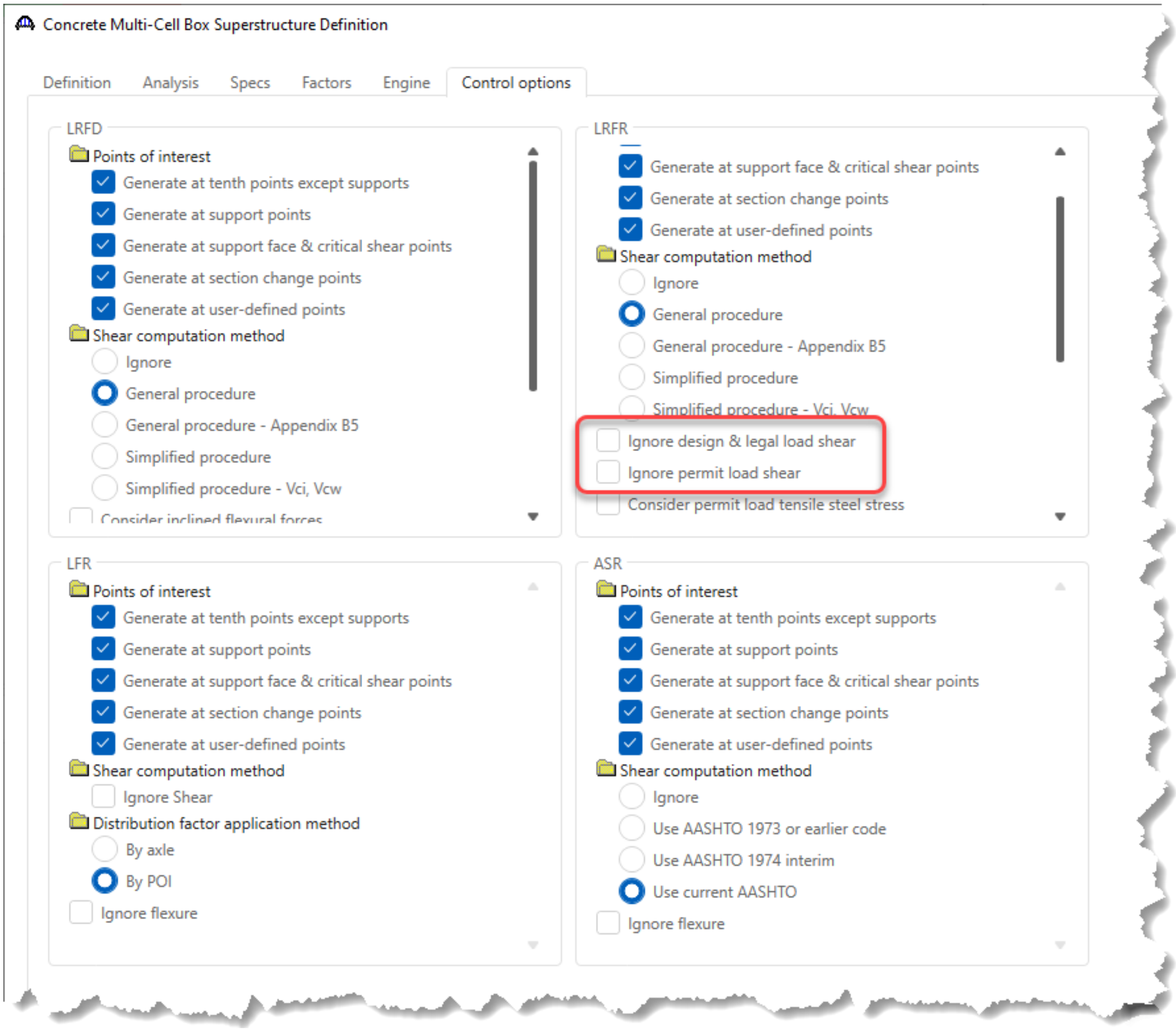
Enter data as shown below. Be sure to leave make the superstructure **Integral with substructure** and that the **Post-tensioned** box is unchecked.





Concrete Multi-Cell Box Superstructure Definition – Control options tab

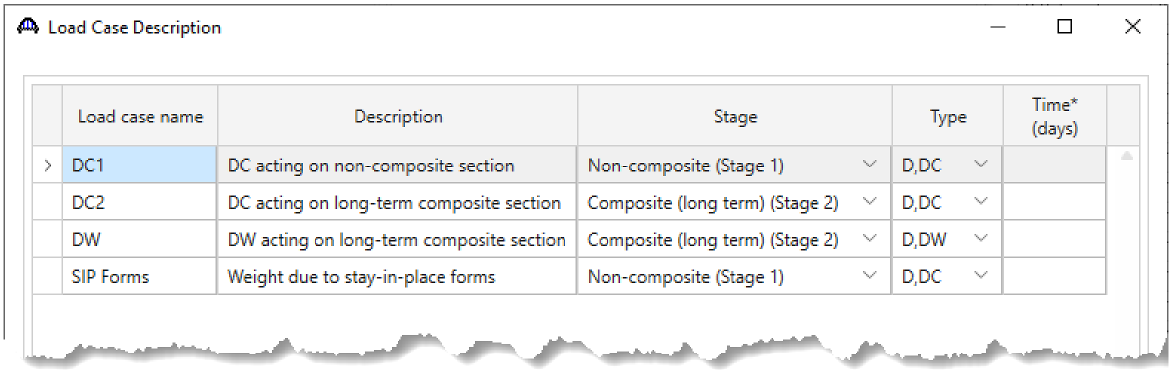
Navigate to the **Control options** tab. Uncheck the LRFR **Ignore shear** checkboxes.



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

Load case Description

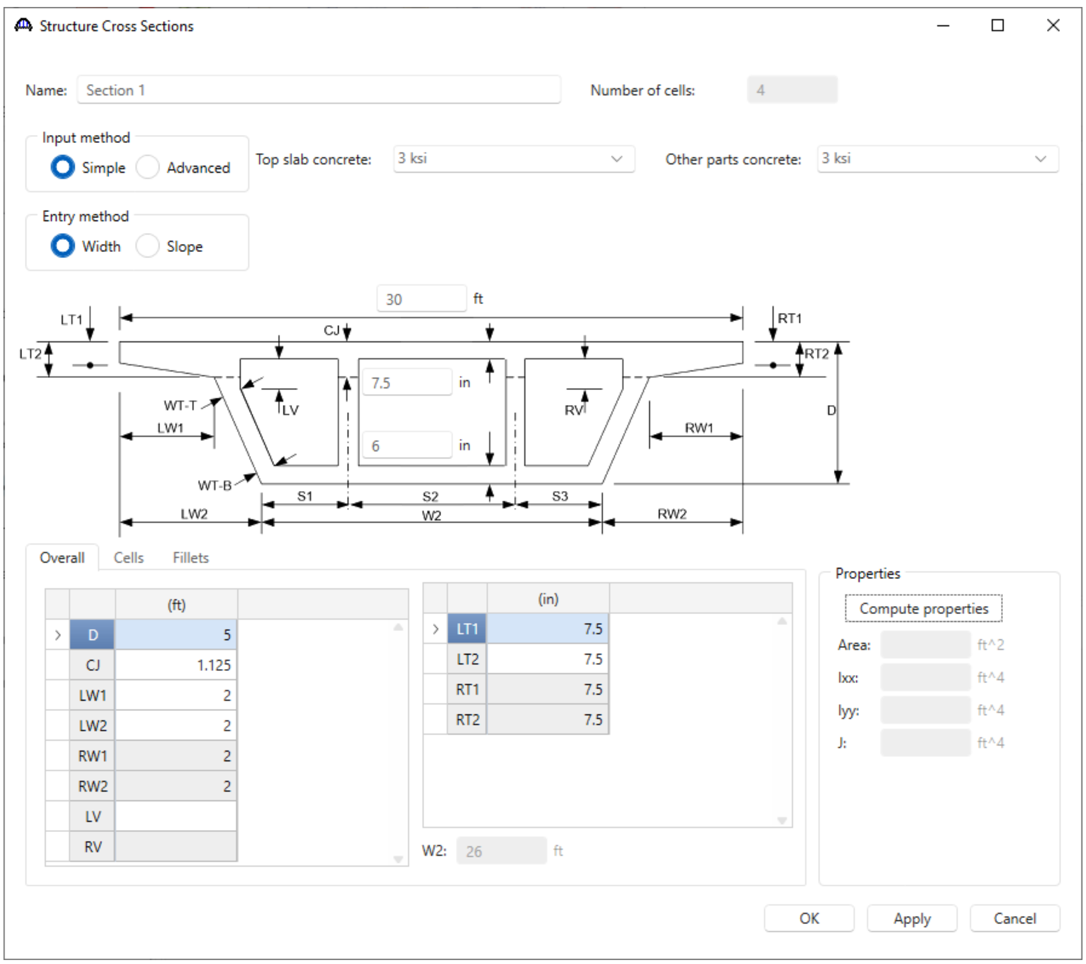
Expand the newly created superstructure definition and double click **Load Case Description** and create default load cases. Use the **Add default load case descriptions** button. Load cases are populated as shown below.

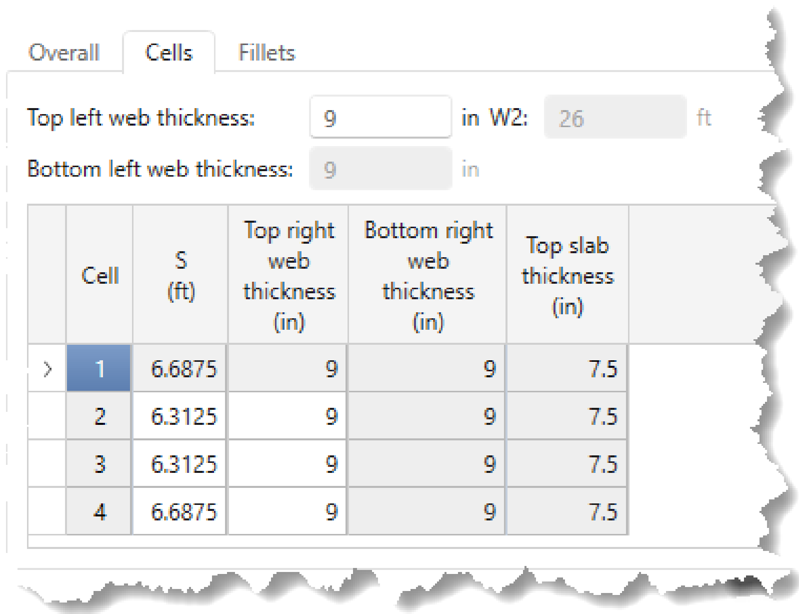


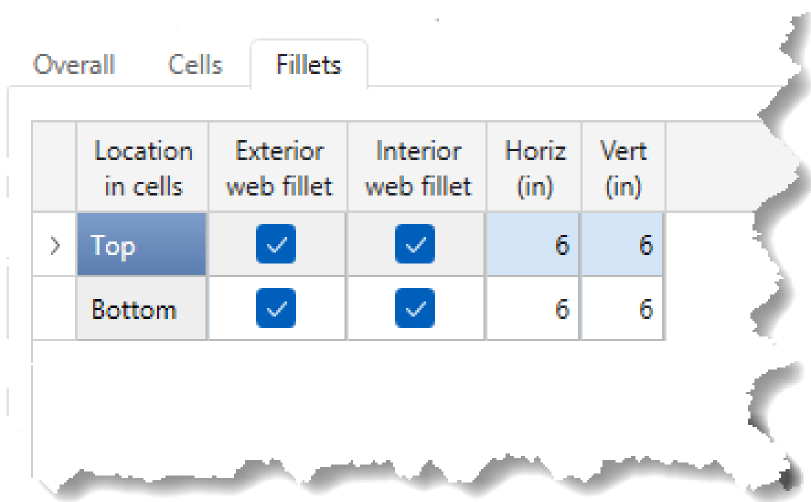
Click **OK** to apply the data and close the window.

Structure Cross Sections

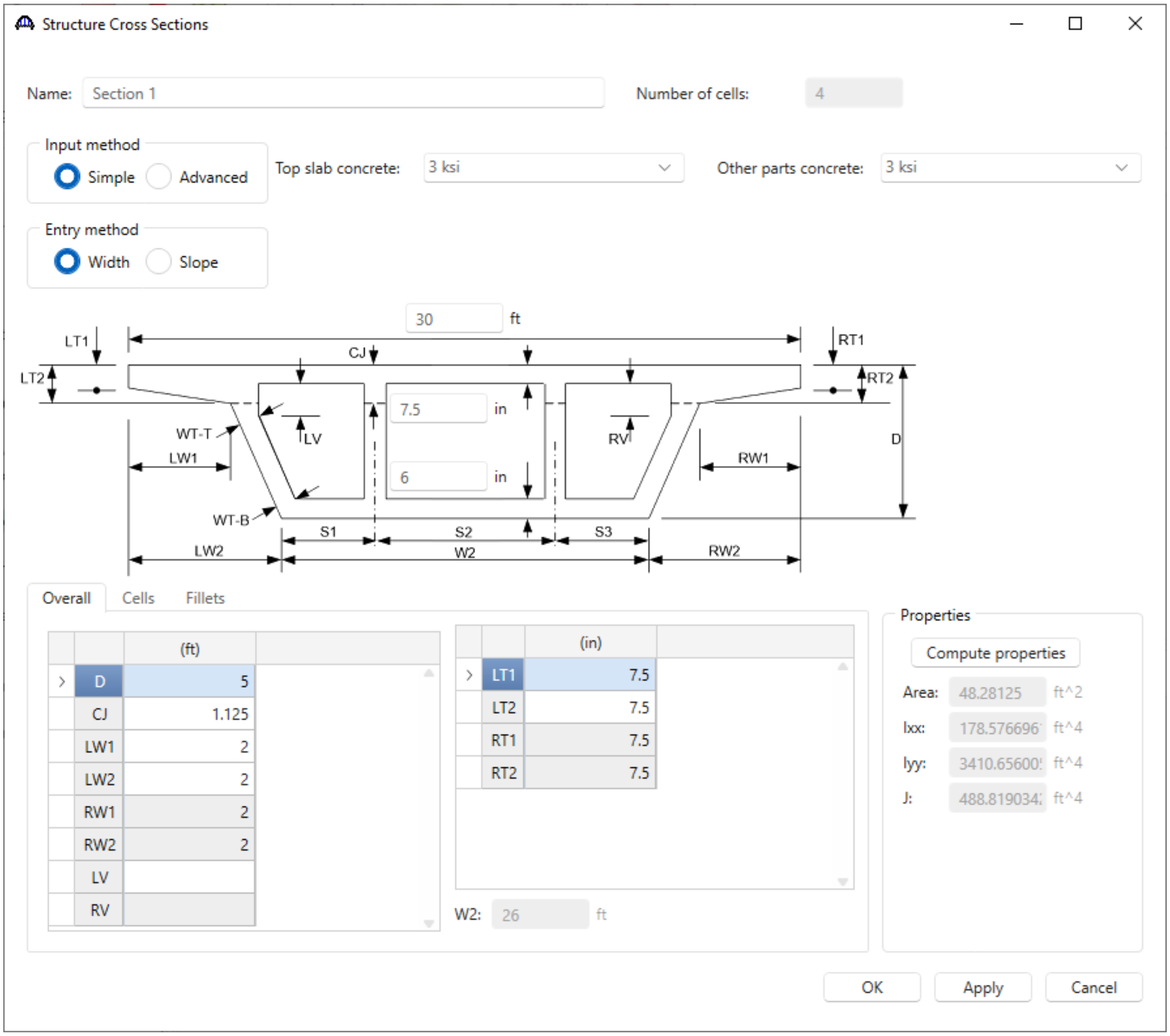
Double click the **Structure Cross Sections** folder and create the following cross section by entering the values shown.




Overall
Cells
Fillets
Top left web thickness: 9 in
W2: 26 ft
Bottom left web thickness: 9 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

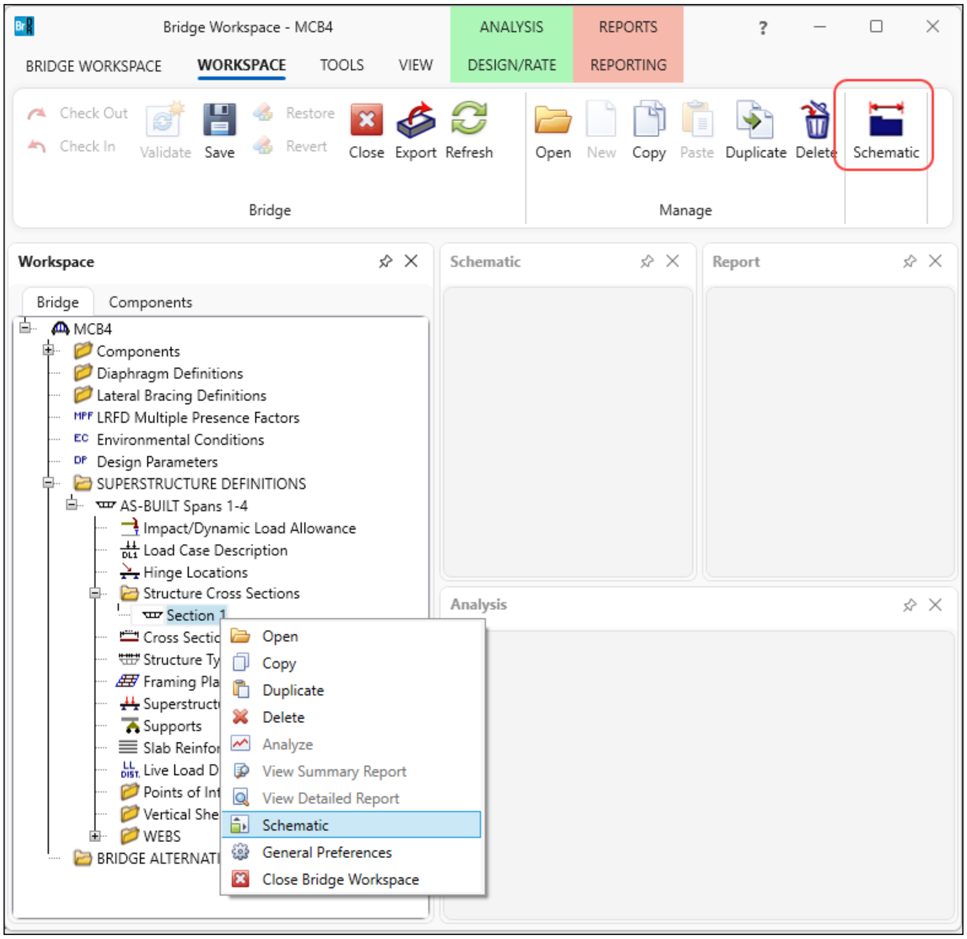

Overall
Cells
Fillets
Location in cells | Exterior web fillet | Interior web fillet | Horiz (in) | Vert (in)
Top | 6 | 6
Bottom | 6 | 6

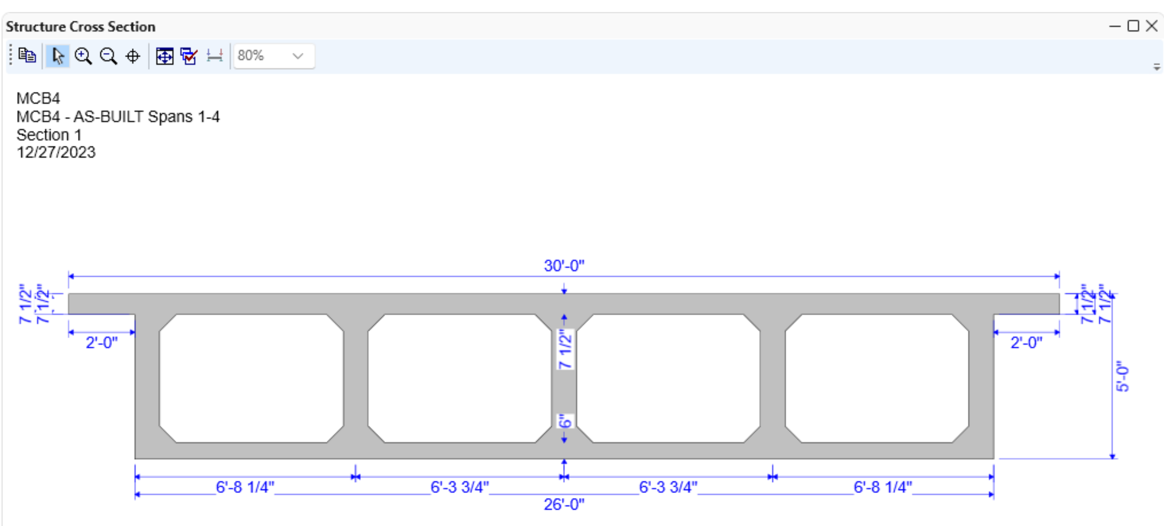
With all the data entered click the **Compute properties** button to see the window below then click **OK** to apply this data and close the window**.**



Schematic – Structure Cross Sections

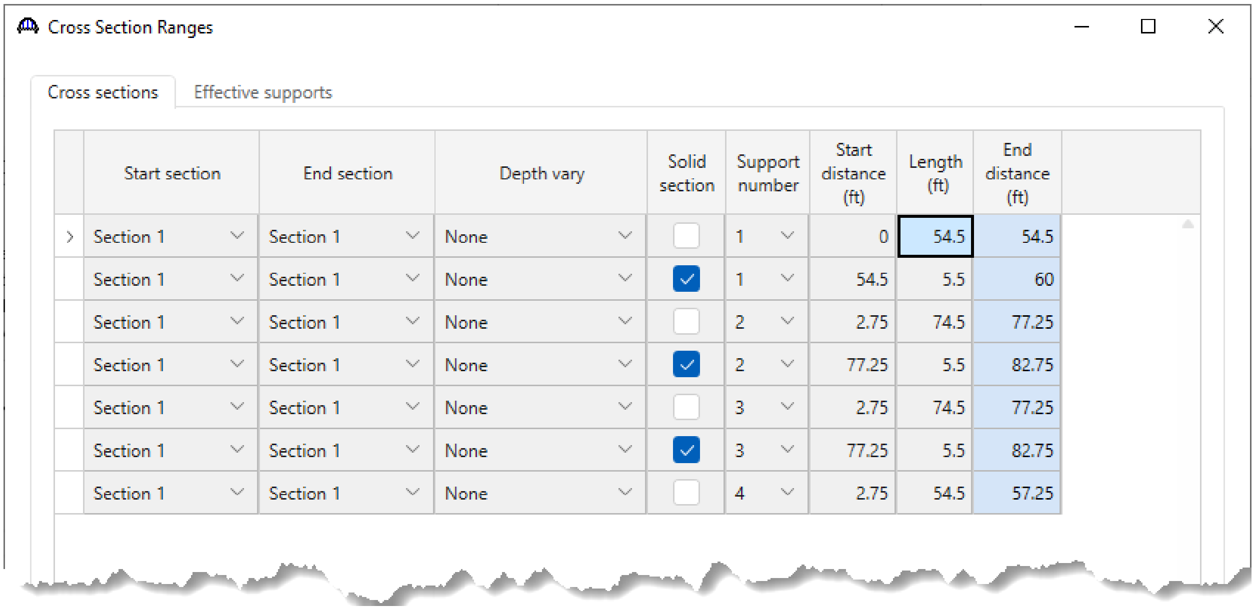
A schematic can be viewed by right clicking the section just created and selecting **Schematic** (or clicking the **Schematic** button from the **WORKSPACE** ribbon).





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.

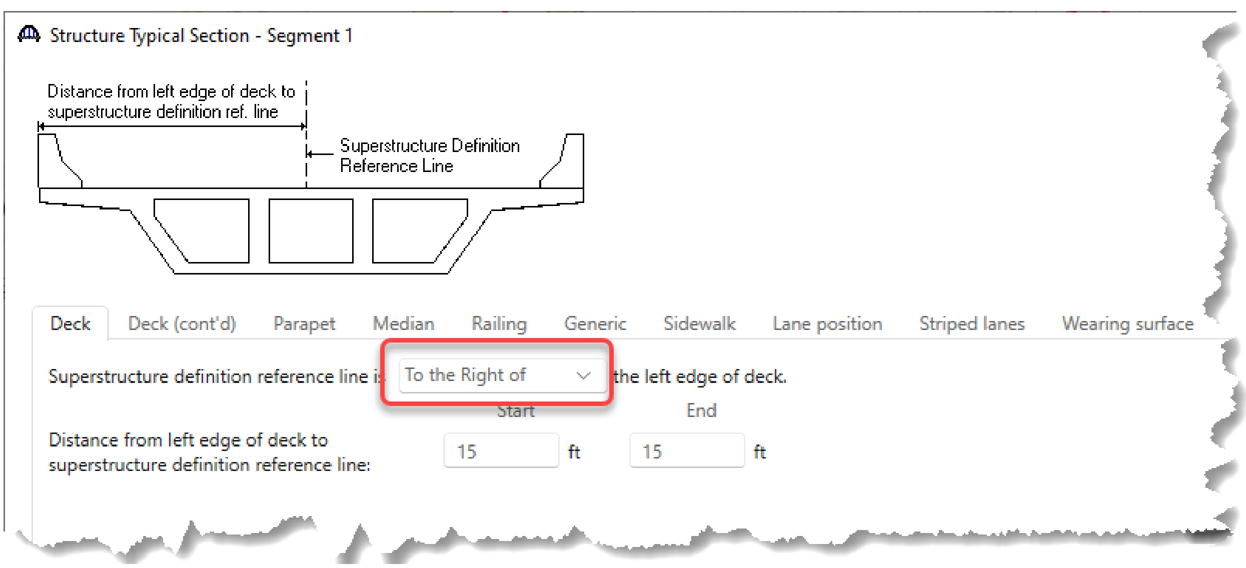


Start section	End section	Depth vary	Solid section	Support number	Start distance (ft)	Length (ft)	End distance (ft)
Section 1	Section 1	None	☐	1	0	54.5	54.5
Section 1	Section 1	None	☑	1	54.5	5.5	60
Section 1	Section 1	None	☐	2	2.75	74.5	77.25
Section 1	Section 1	None	☑	2	77.25	5.5	82.75
Section 1	Section 1	None	☐	3	2.75	74.5	77.25
Section 1	Section 1	None	☑	3	77.25	5.5	82.75
Section 1	Section 1	None	☐	4	2.75	54.5	57.25

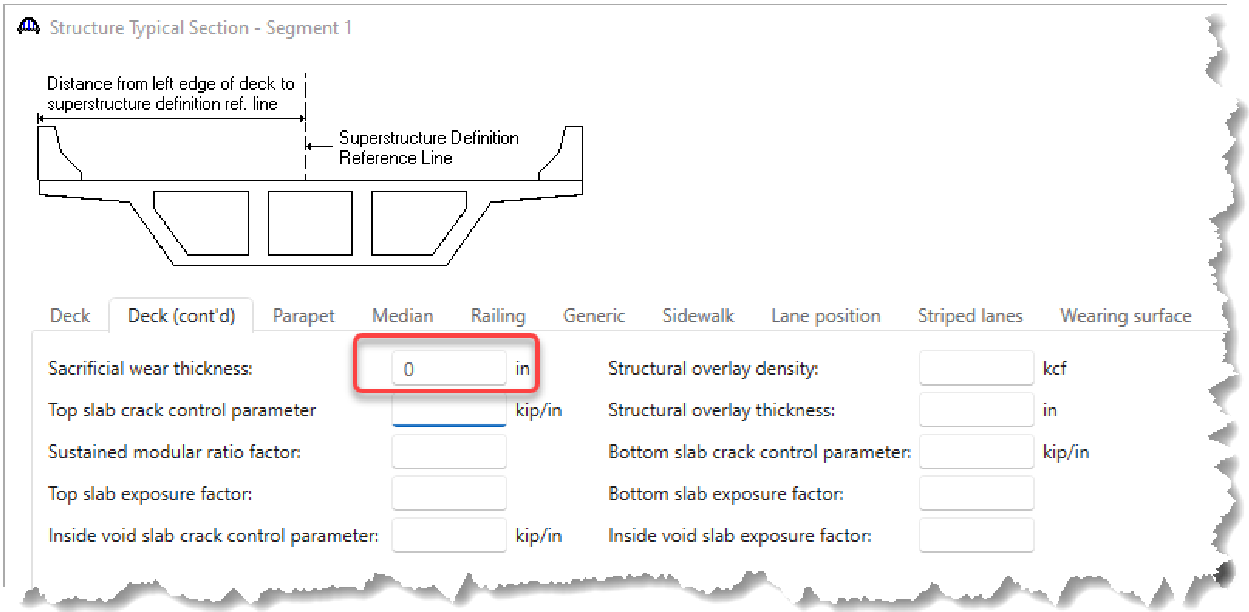
Click **OK** to apply the data and close the window.

Structure Typical Section

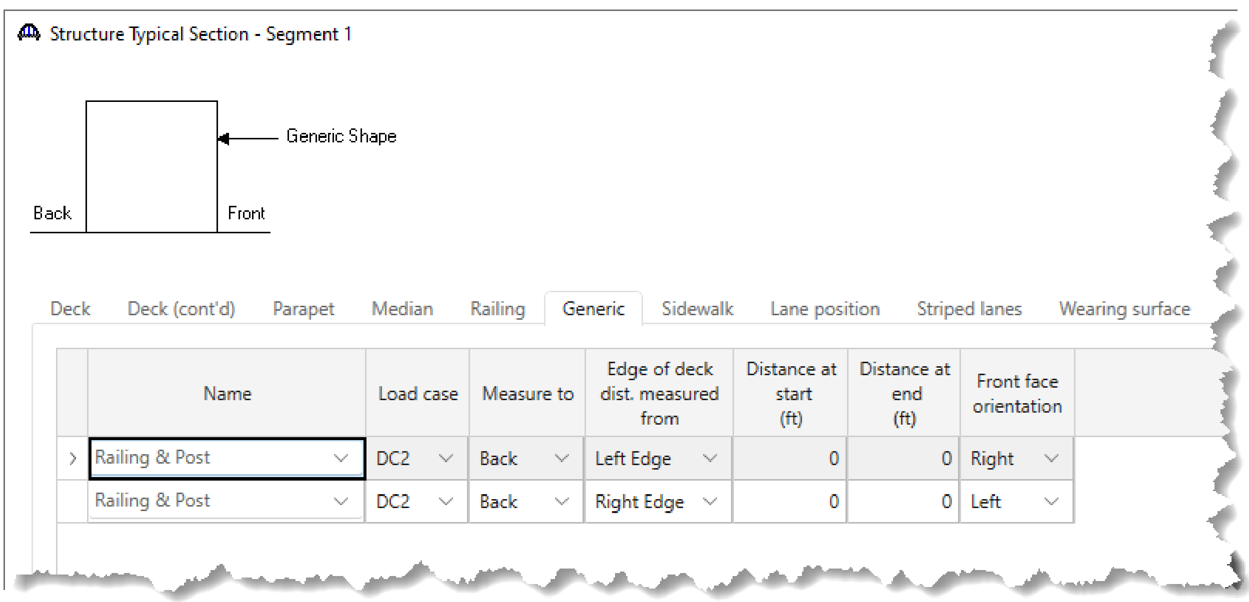
Open the **Structure Typical Section** from the tree and locate the superstructure definition reference line in the center of the structure as shown below.



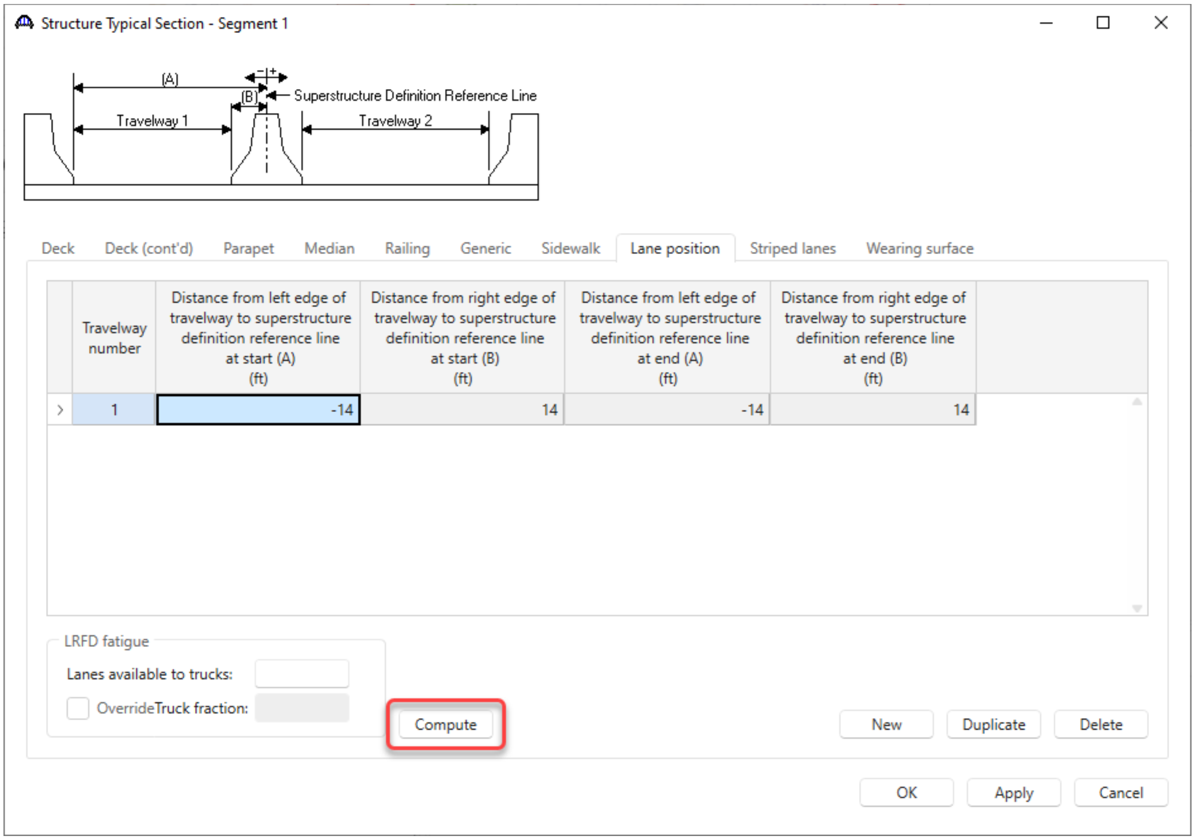
Navigate to the **Deck (cont'd)** tab and define the sacrificial wearing surface as shown below.



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



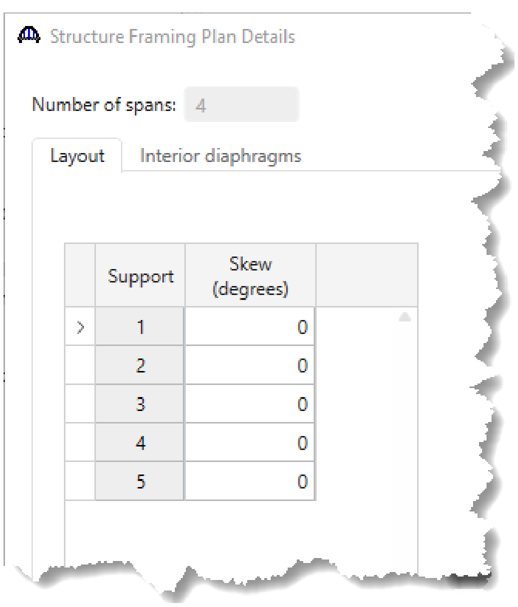
In the Lane position tab, use the **Compute** button to create the lane positions.



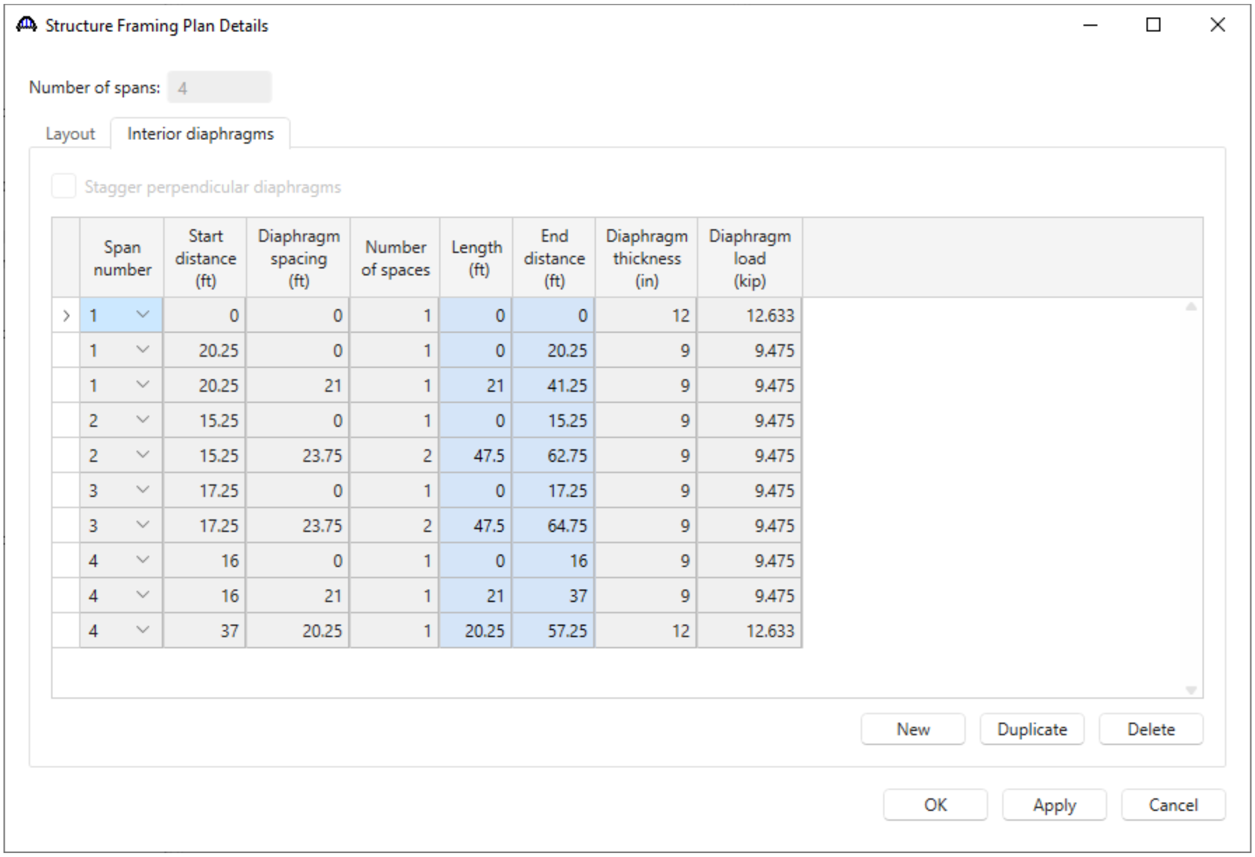
Click **OK** to apply the data and close the window.

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.



Navigate to the **Interior diaphragms** tab and enter the diaphragm locations as shown below.

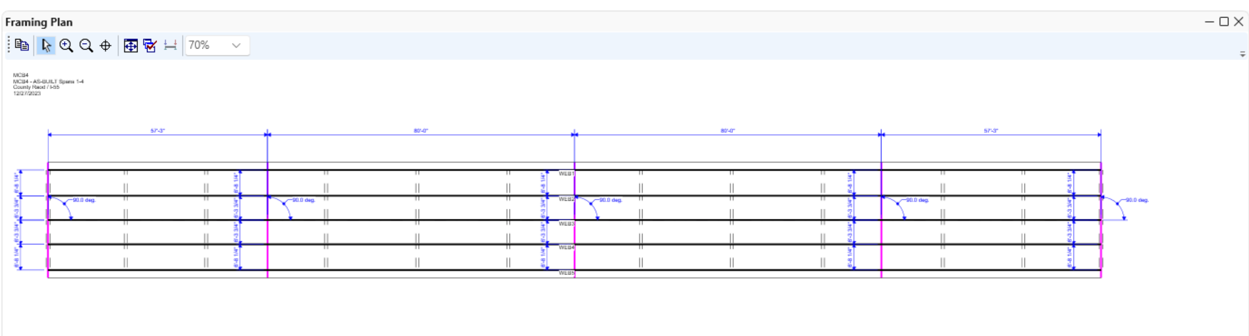


Span number	Start distance (ft)	Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)	Diaphragm thickness (in)	Diaphragm load (kip)
1	0	0	1	0	0	12	12.633
1	20.25	0	1	0	20.25	9	9.475
1	20.25	21	1	21	41.25	9	9.475
2	15.25	0	1	0	15.25	9	9.475
2	15.25	23.75	2	47.5	62.75	9	9.475
3	17.25	0	1	0	17.25	9	9.475
3	17.25	23.75	2	47.5	64.75	9	9.475
4	16	0	1	0	16	9	9.475
4	16	21	1	21	37	9	9.475
4	37	20.25	1	20.25	57.25	12	12.633

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

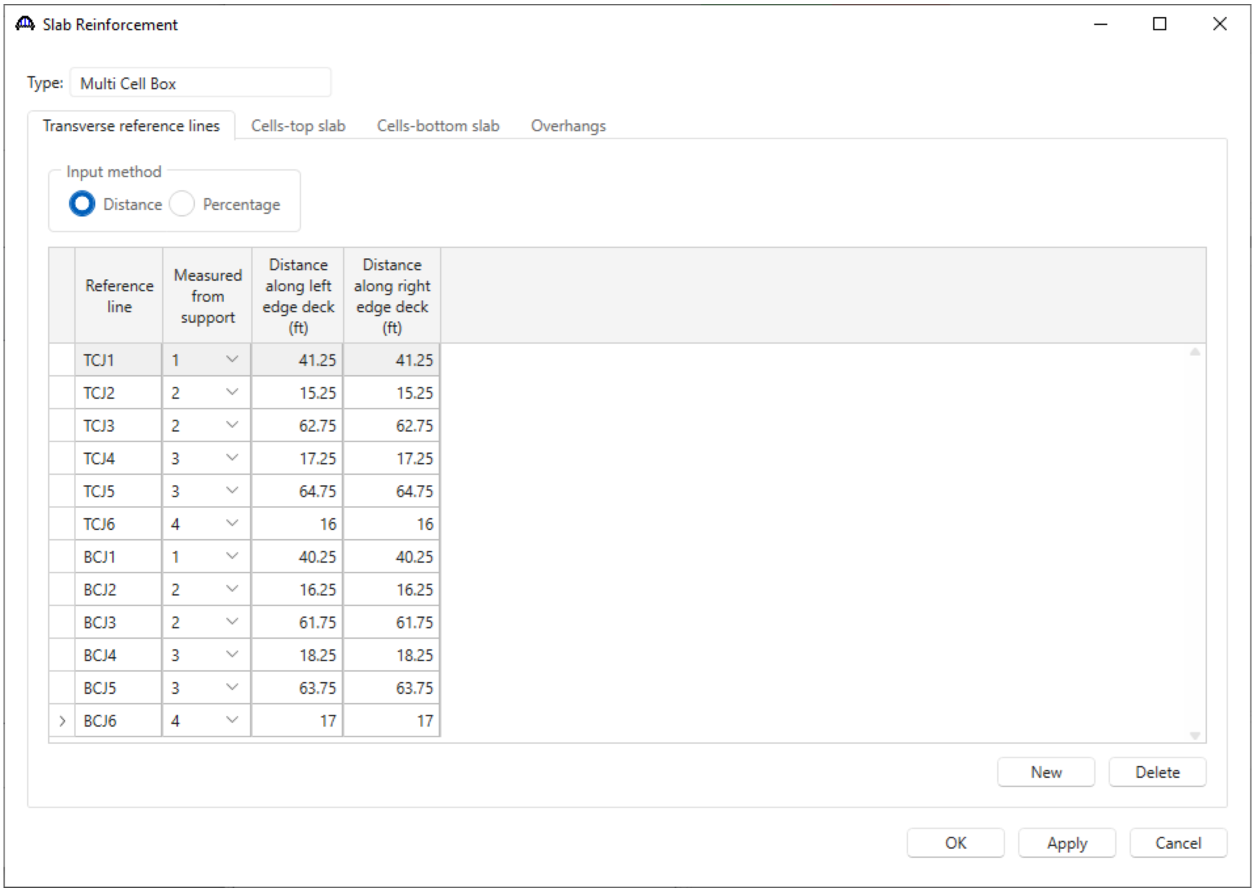
Schematic - Structure Framing Plan Details

A schematic of the framing plan can be viewed like the typical section.

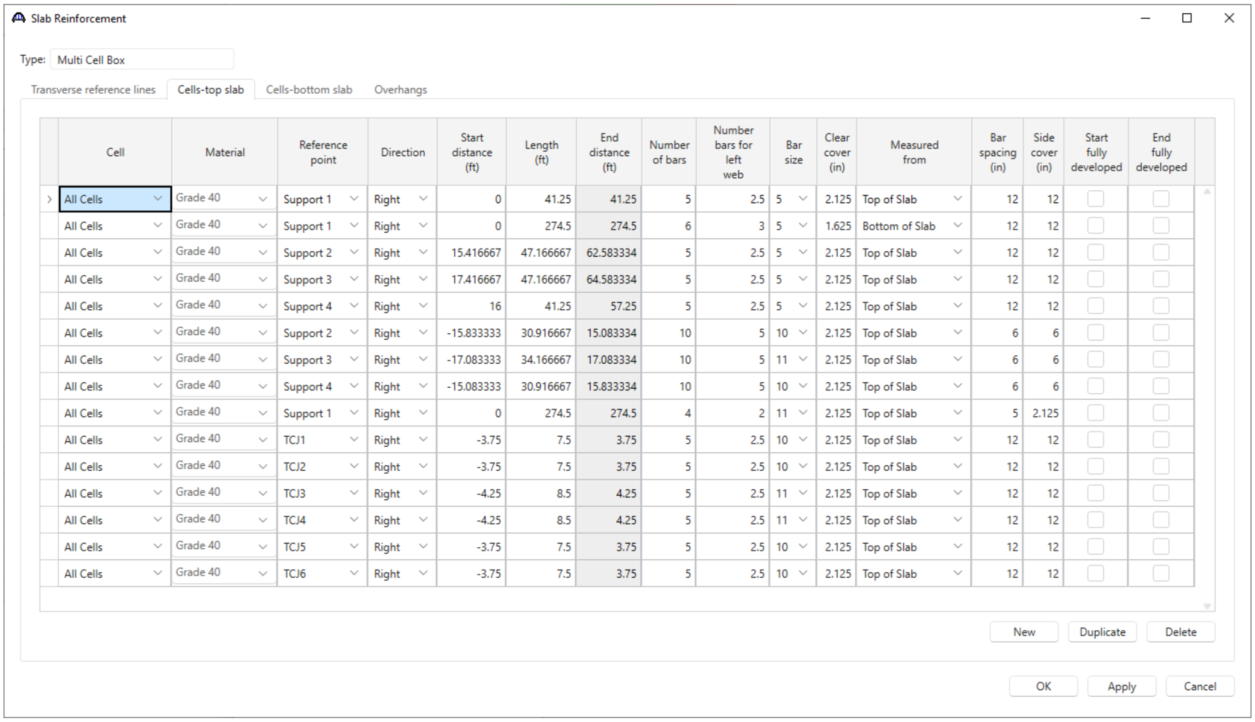


Slab reinforcement

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.

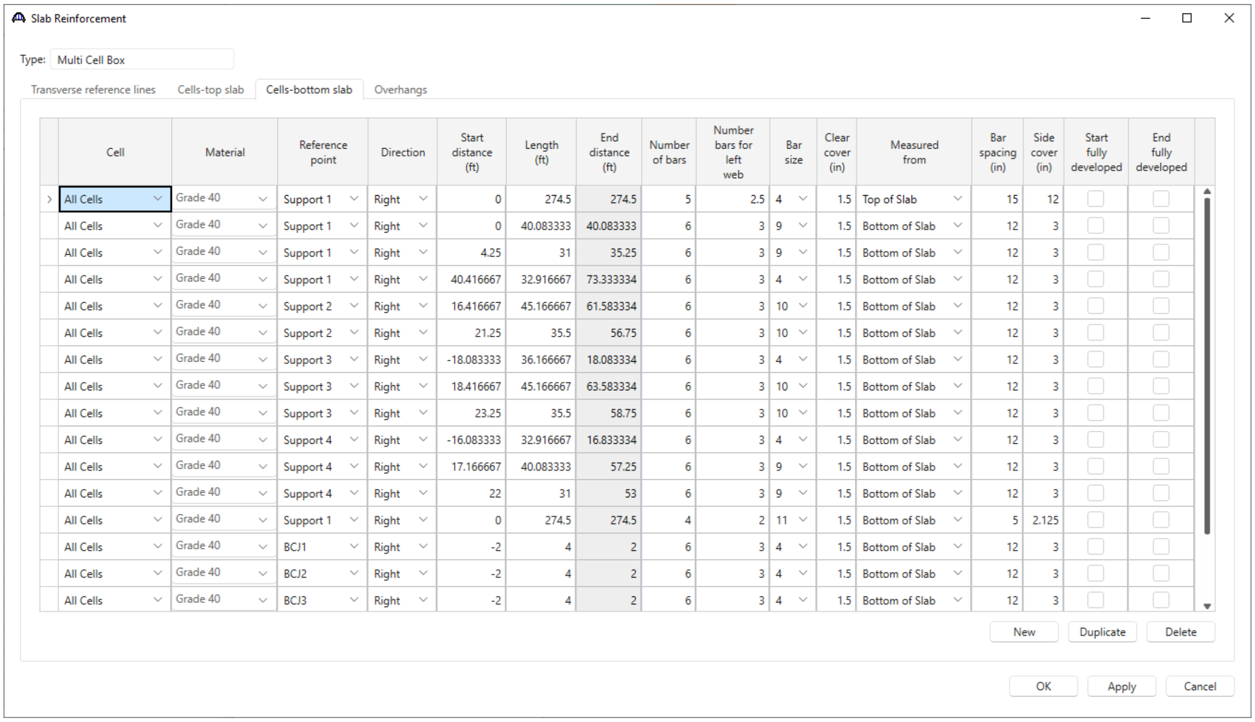


The data entry for the top slab is shown below.



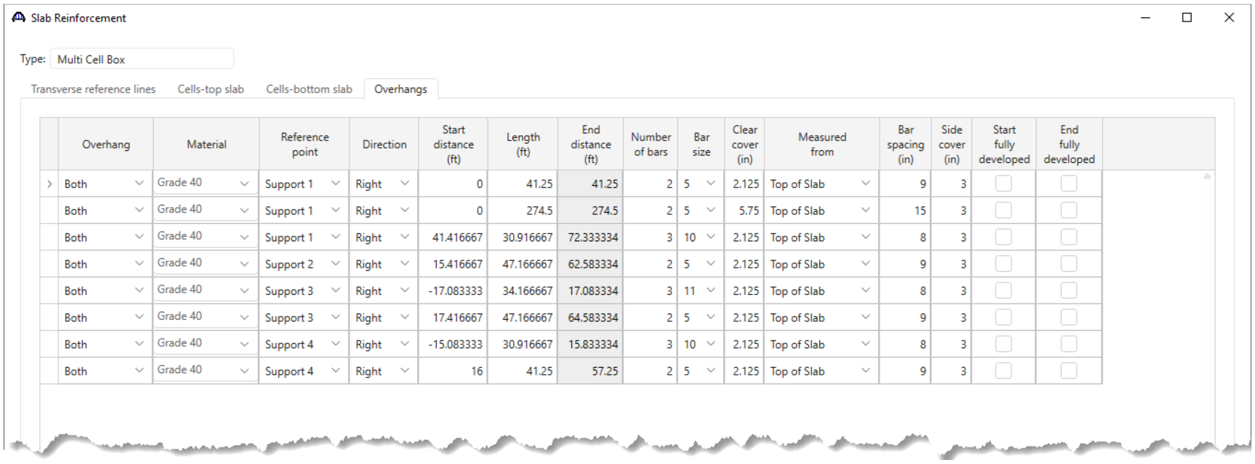
Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
All Cells	Grade 40	Support 1	Right	0	41.25	41.25	5	2.5	5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

The data entry for the bottom slab is shown below.



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		
All Cells	Grade 40	Support 1	Right	0	40.083333	40.083333	6	3	9	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 1	Right	4.25	31	35.25	6	3	9	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 1	Right	40.416667	32.916667	73.333334	6	3	4	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 2	Right	16.416667	45.166667	61.583334	6	3	10	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 2	Right	21.25	35.5	56.75	6	3	10	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 3	Right	-18.083333	36.166667	18.083334	6	3	4	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 3	Right	18.416667	45.166667	63.583334	6	3	10	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 3	Right	23.25	35.5	58.75	6	3	10	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 4	Right	-16.083333	32.916667	16.833334	6	3	4	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 4	Right	17.166667	40.083333	57.25	6	3	9	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 4	Right	22	31	53	6	3	9	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	Support 1	Right	0	274.5	274.5	4	2	11	1.5	Bottom of Slab	5	2.125		
All Cells	Grade 40	BCJ1	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	BCJ2	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3		
All Cells	Grade 40	BCJ3	Right	-2	4	2	6	3	4	1.5	Bottom of Slab	12	3		

The data entry for the overhangs is shown below.

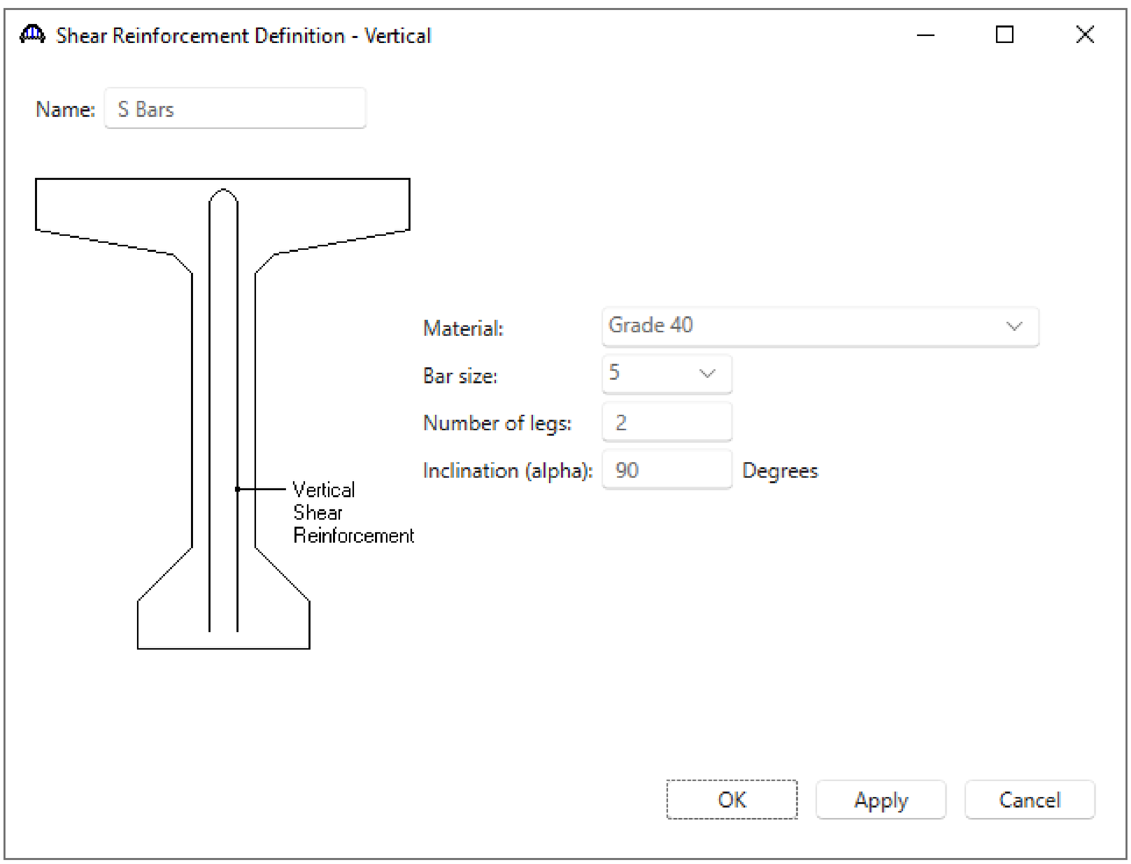


Overhang	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
Both	Grade 40	Support 1	Right	0	41.25	41.25	2	5	2.125	Top of Slab	9	3	☐	☐
Both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

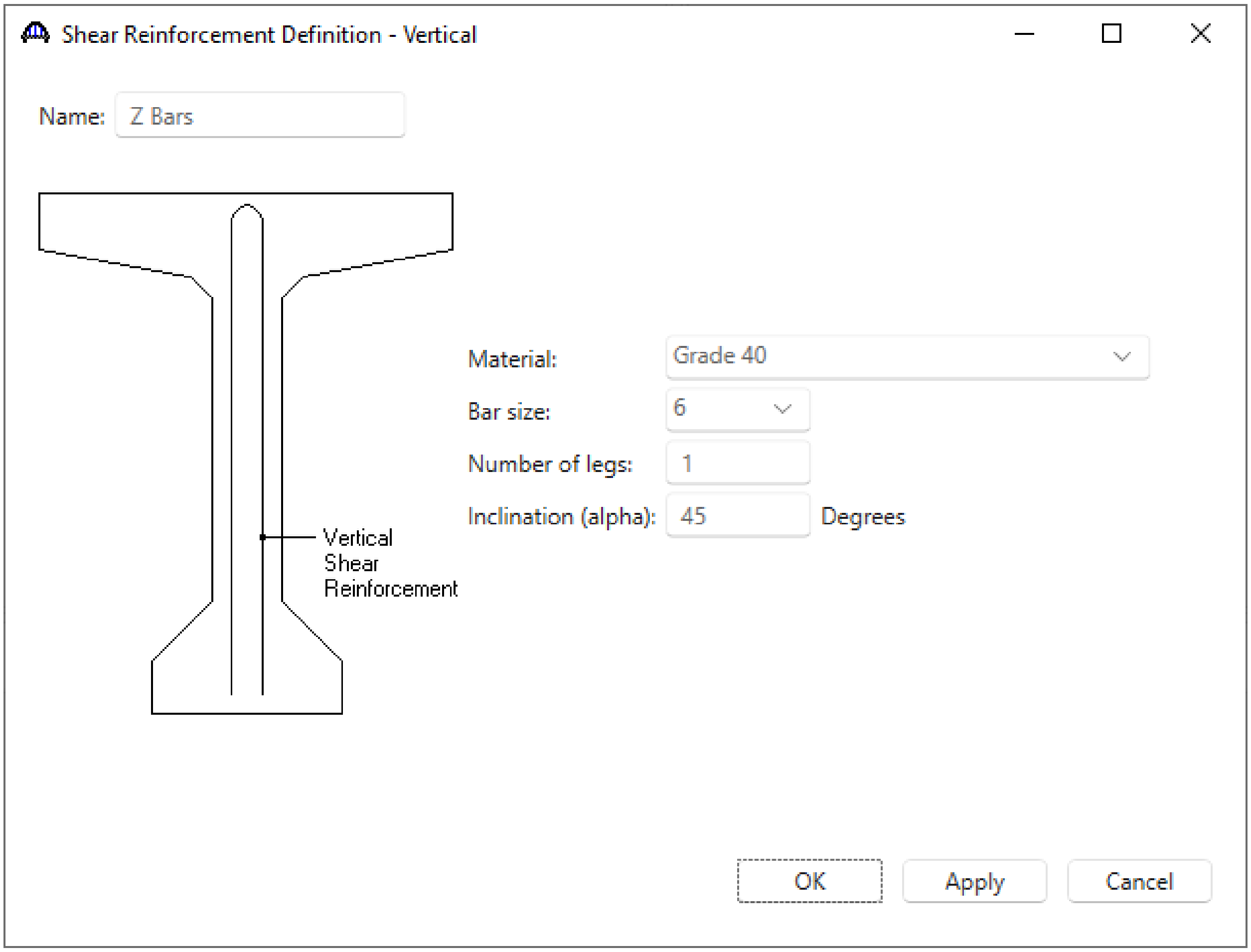
Click **OK** to apply the data and close the window.

Vertical Shear Reinforcement Definition

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



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

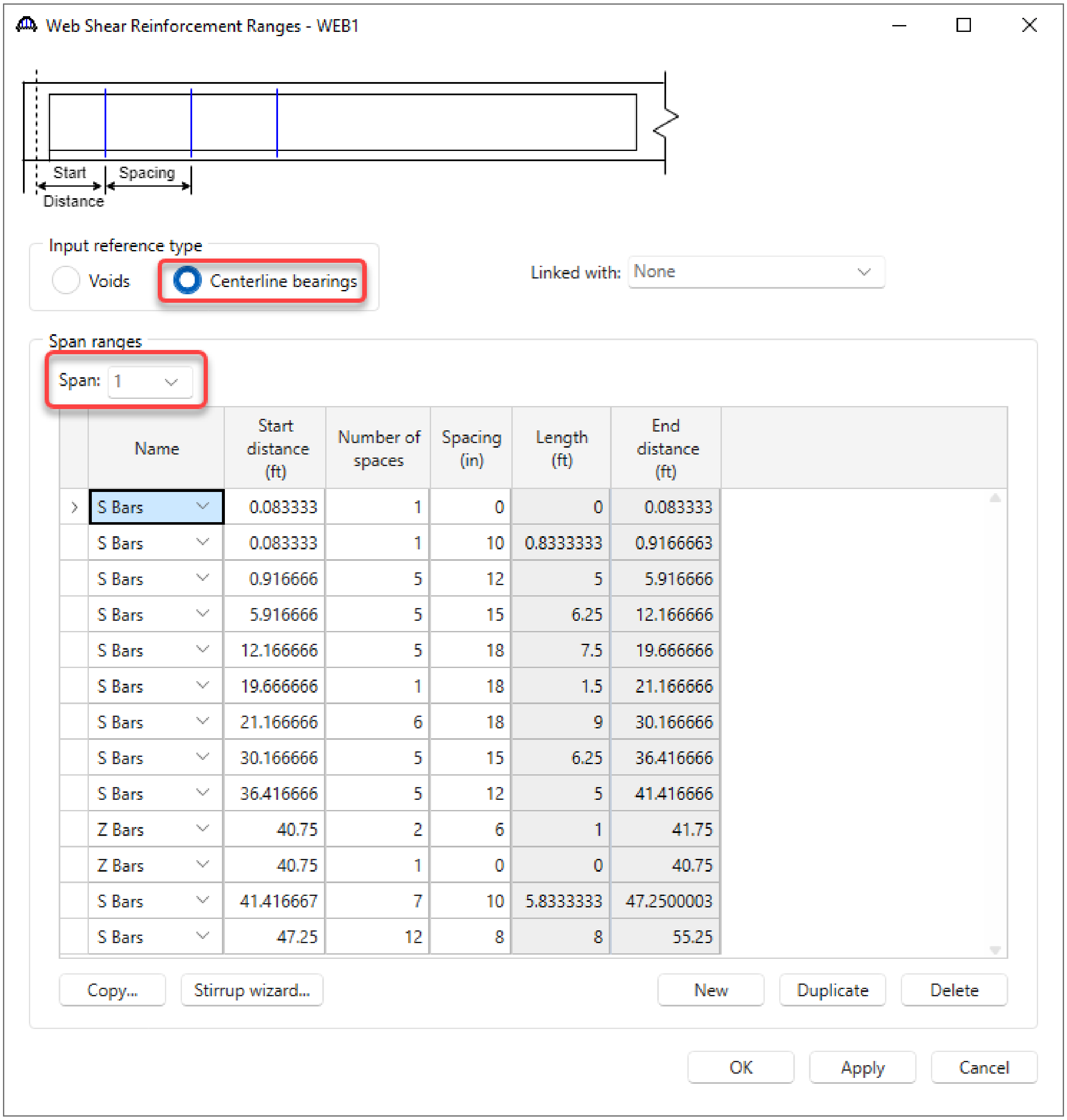


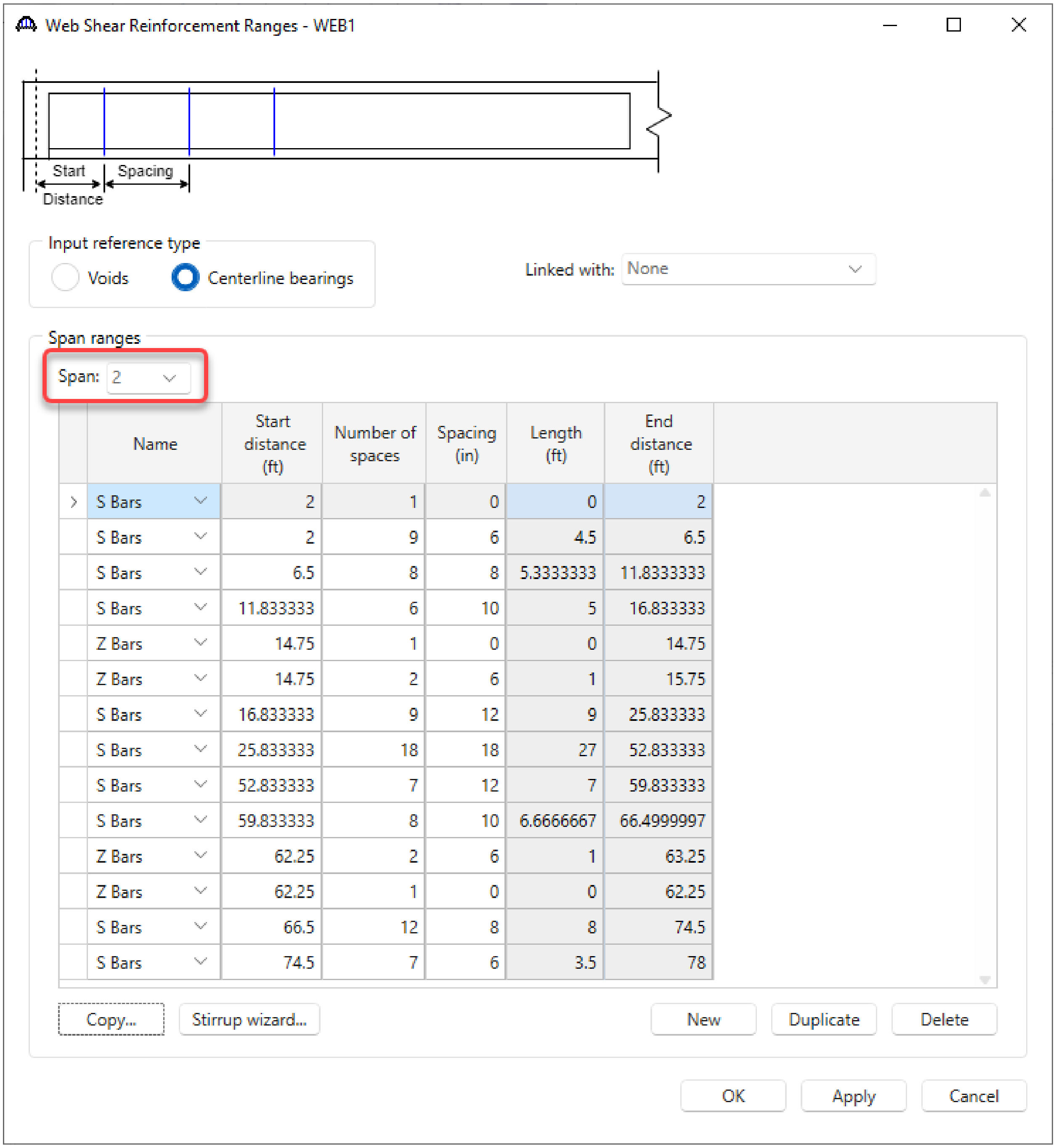
Click **OK** to apply the data and close the window.

Web Shear Reinforcement Ranges – WEB1

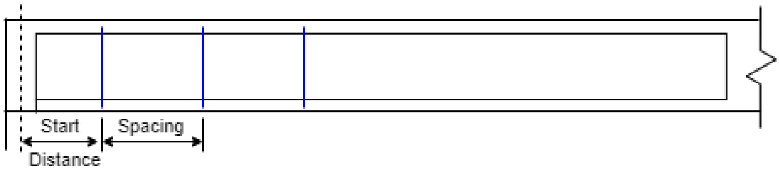
Open the **WEB1 Shear Reinforcement Ranges** window and select Input Reference Type to **Centerline bearings**. Enter the data for Span 1 and repeat for Spans 2-4.

The stirrup ranges are created as follows.




Web Shear Reinforcement Ranges - WEB1
Start
Spacing
Distance
Input reference type
Voids
Centerline bearings
Linked with:
None
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

Web Shear Reinforcement Ranges - WEB1



Input reference type

Voids   Centerline bearings

Linked with: None

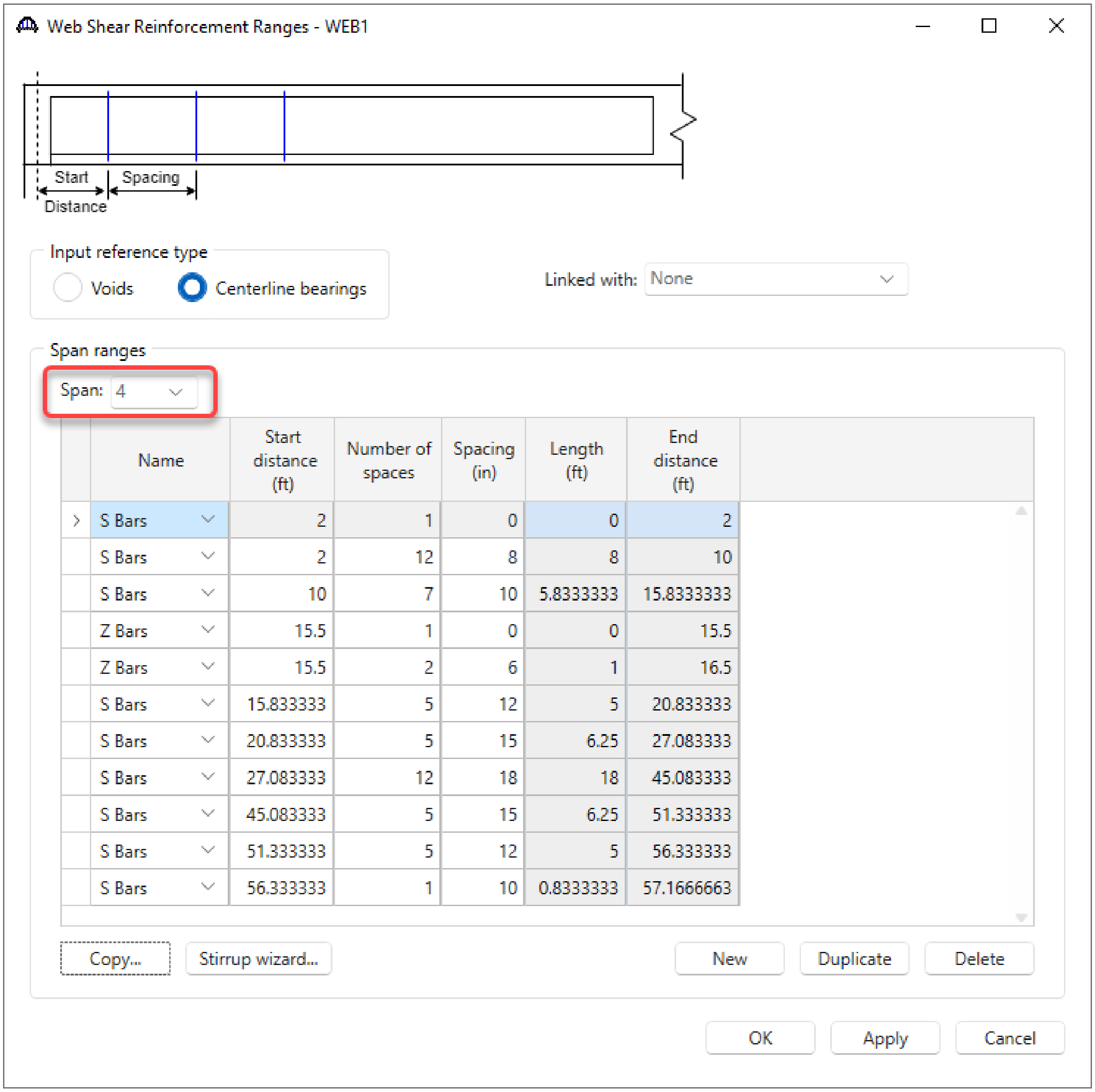
Span ranges

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	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

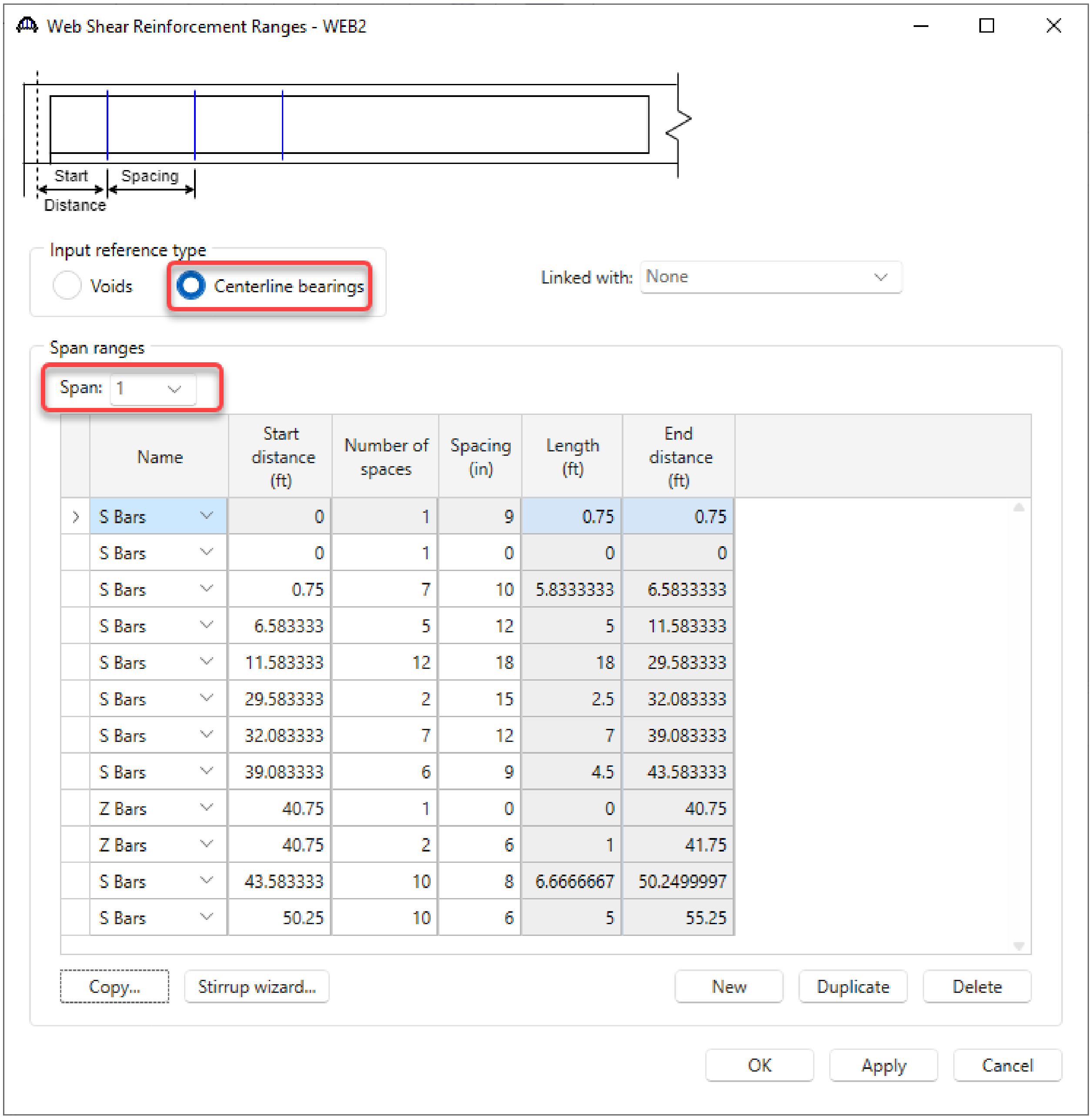


Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
S Bars	2	1	0	0	2
S Bars	2	12	8	8	10
S Bars	10	7	10	5.8333333	15.8333333
Z Bars	15.5	1	0	0	15.5
Z Bars	15.5	2	6	1	16.5
S Bars	15.833333	5	12	5	20.833333
S Bars	20.833333	5	15	6.25	27.083333
S Bars	27.083333	12	18	18	45.083333
S Bars	45.083333	5	15	6.25	51.333333
S Bars	51.333333	5	12	5	56.333333
S Bars	56.333333	1	10	0.8333333	57.1666663

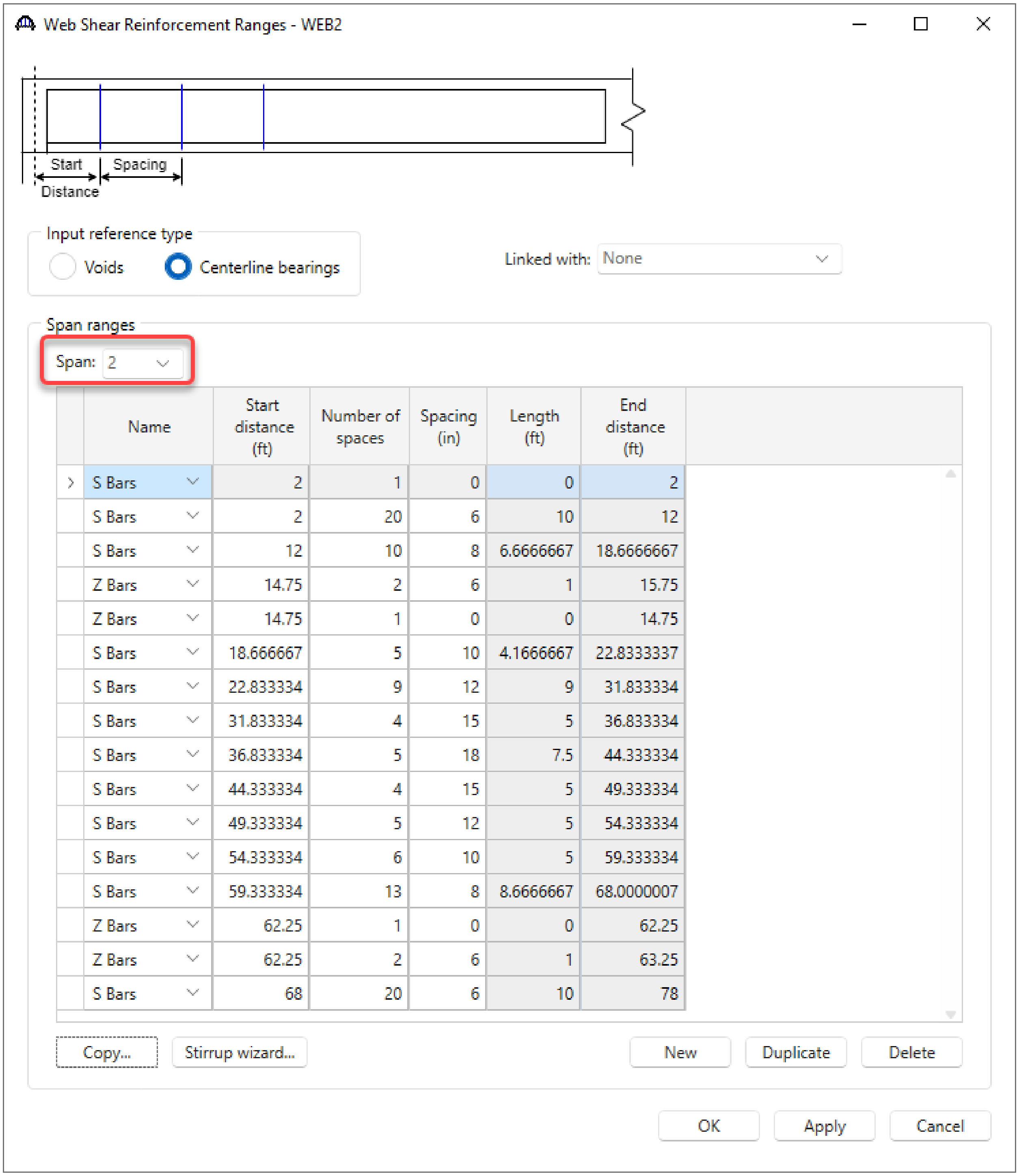
Click **OK** to apply the data and close the window.

Web Shear Reinforcement Ranges – WEB2

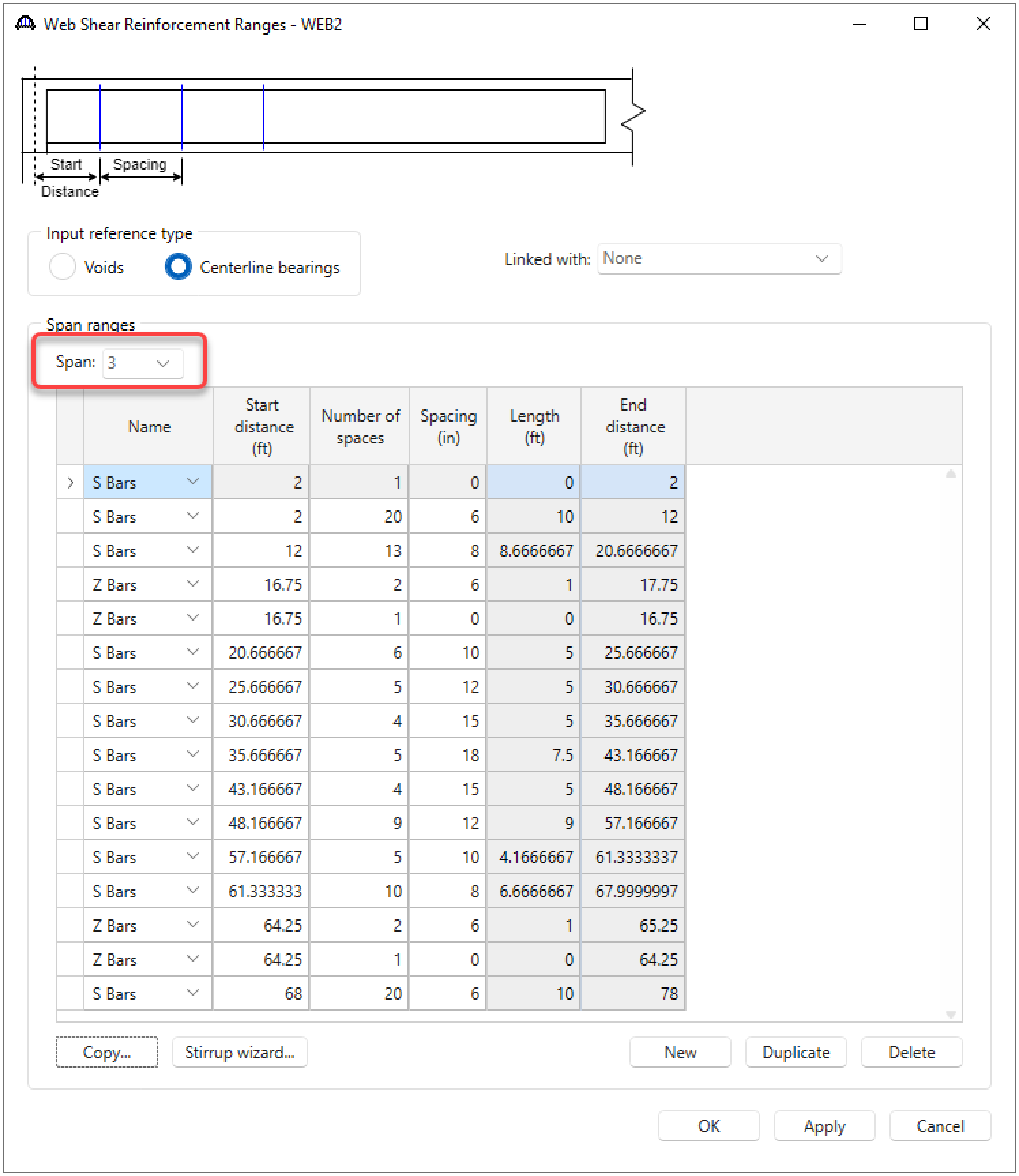
Double click on the **Shear Reinforcement Ranges** for **WEB2** and enter the following data for Spans 1-4.



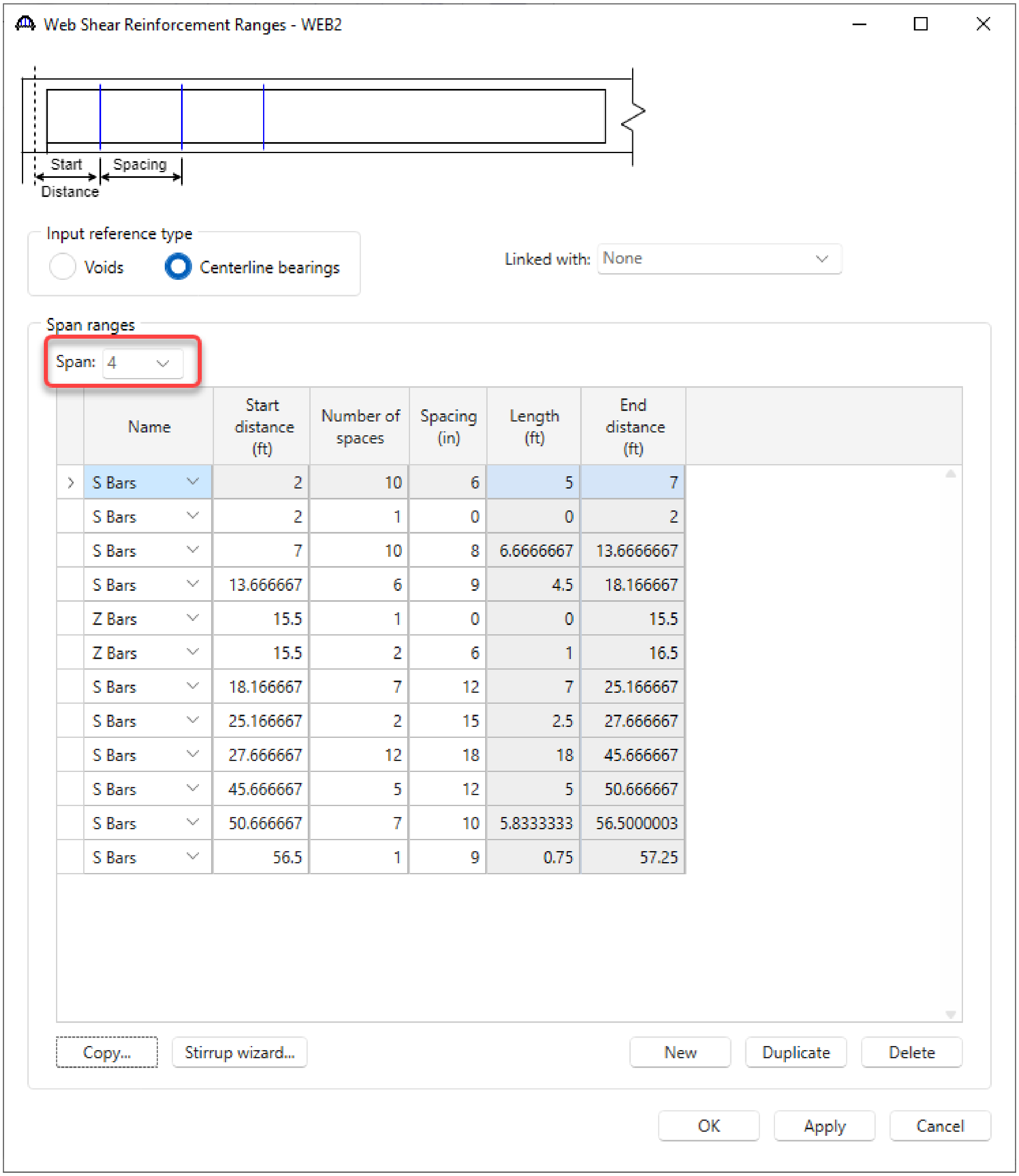
Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
S Bars	0	1	9	0.75	0.75
S Bars	0	1	0	0	0
S Bars	0.75	7	10	5.8333333	6.5833333
S Bars	6.583333	5	12	5	11.583333
S Bars	11.583333	12	18	18	29.583333
S Bars	29.583333	2	15	2.5	32.083333
S Bars	32.083333	7	12	7	39.083333
S Bars	39.083333	6	9	4.5	43.583333
Z Bars	40.75	1	0	0	40.75
Z Bars	40.75	2	6	1	41.75
S Bars	43.583333	10	8	6.6666667	50.2499997
S Bars	50.25	10	6	5	55.25



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



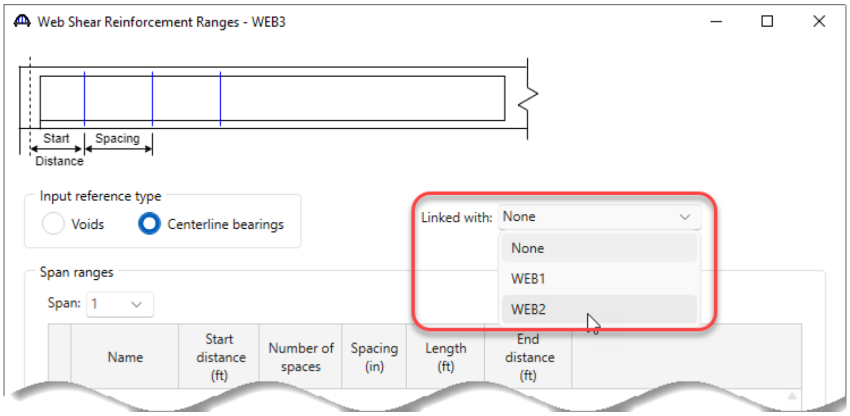
Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
S Bars	2	1	0	0	2
S Bars	2	20	6	10	12
S Bars	12	13	8	8.6666667	20.6666667
Z Bars	16.75	2	6	1	17.75
Z Bars	16.75	1	0	0	16.75
S Bars	20.666667	6	10	5	25.666667
S Bars	25.666667	5	12	5	30.666667
S Bars	30.666667	4	15	5	35.666667
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

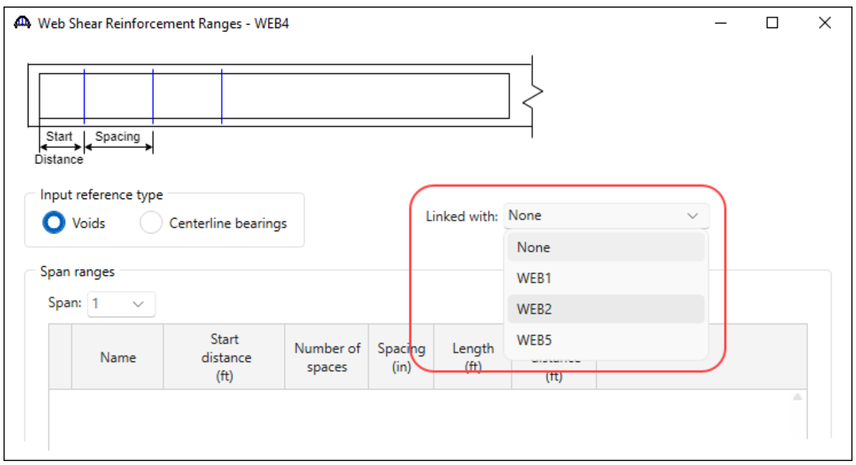


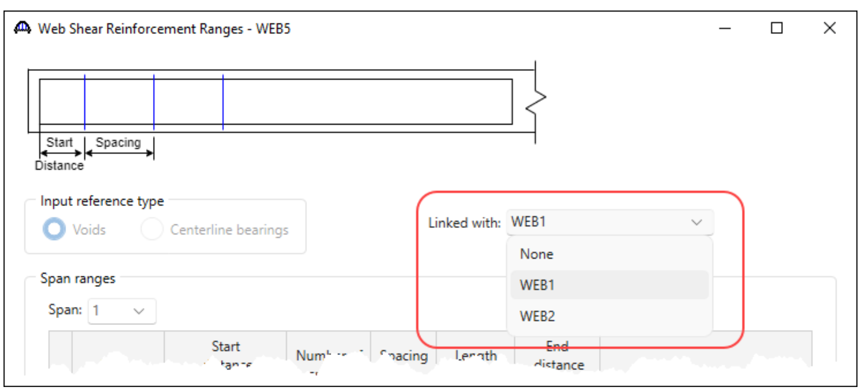
Name	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
S Bars	2	10	6	5	7
S Bars	2	1	0	0	2
S Bars	7	10	8	6.6666667	13.6666667
S Bars	13.666667	6	9	4.5	18.166667
Z Bars	15.5	1	0	0	15.5
Z Bars	15.5	2	6	1	16.5
S Bars	18.166667	7	12	7	25.166667
S Bars	25.166667	2	15	2.5	27.666667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

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**.

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.



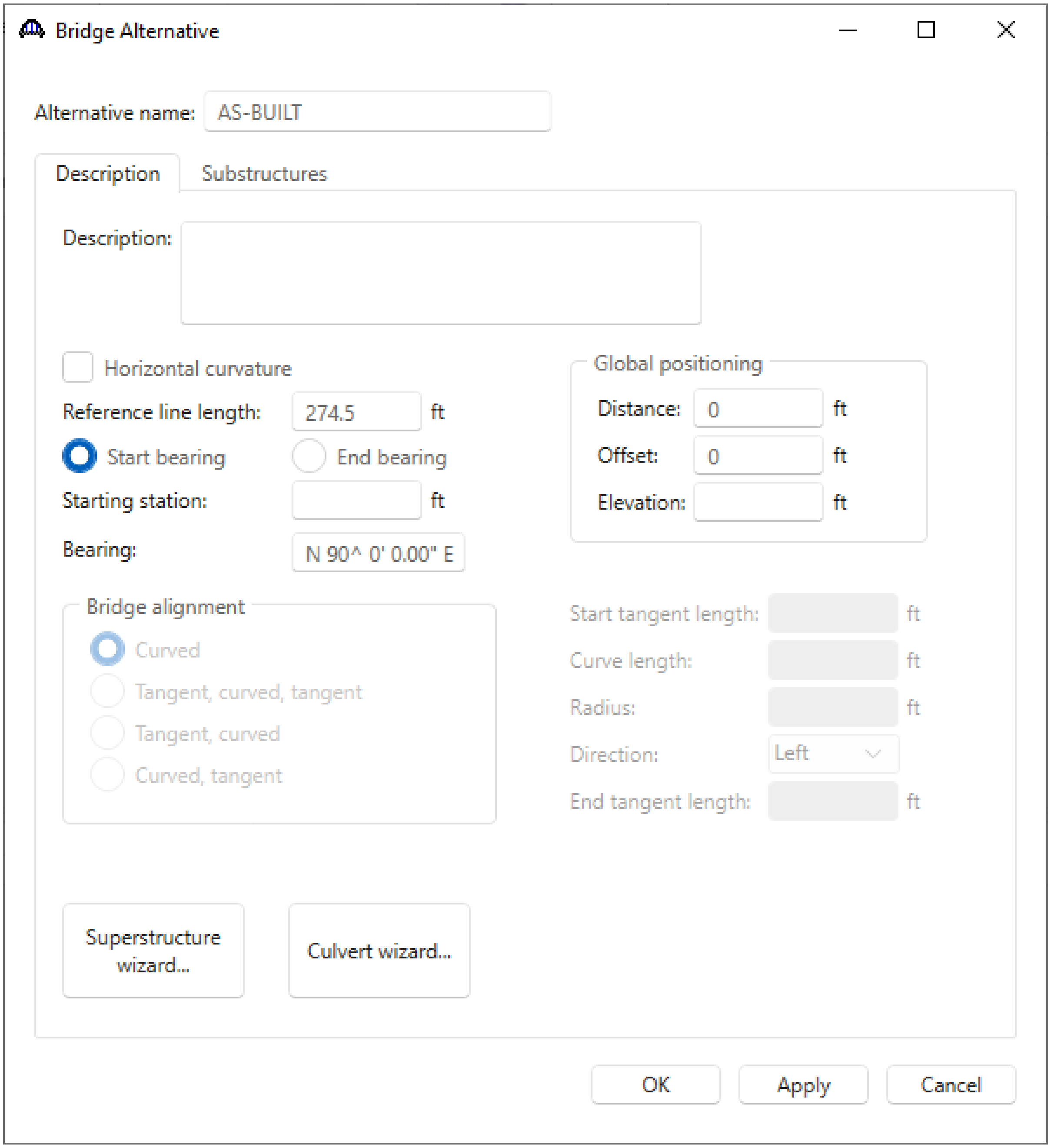




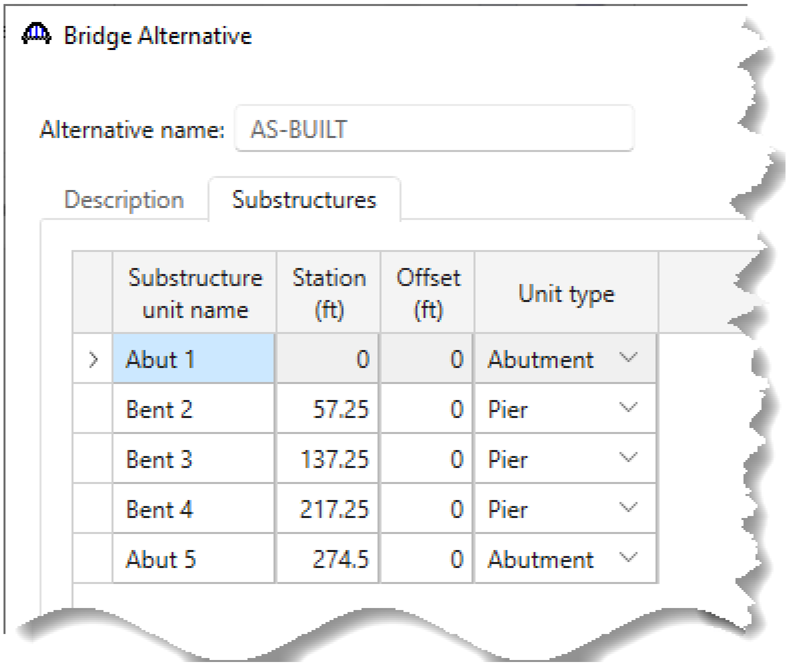
Bridge Alternatives

Bridge alternative

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



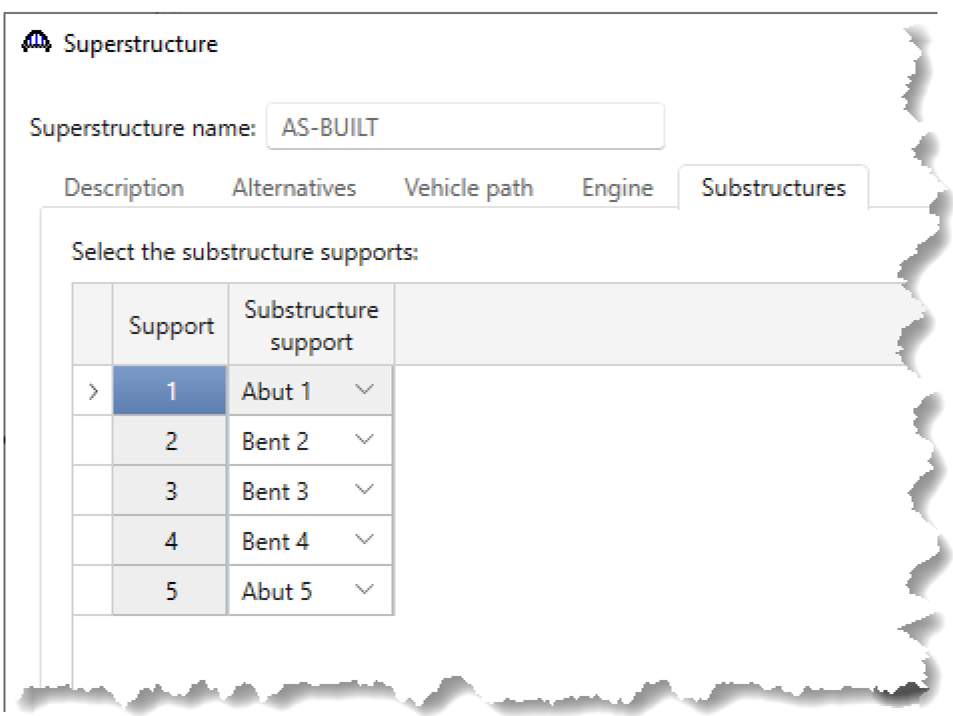
In the **Substructures** tab, define substructure locations as shown below.



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

Superstructures

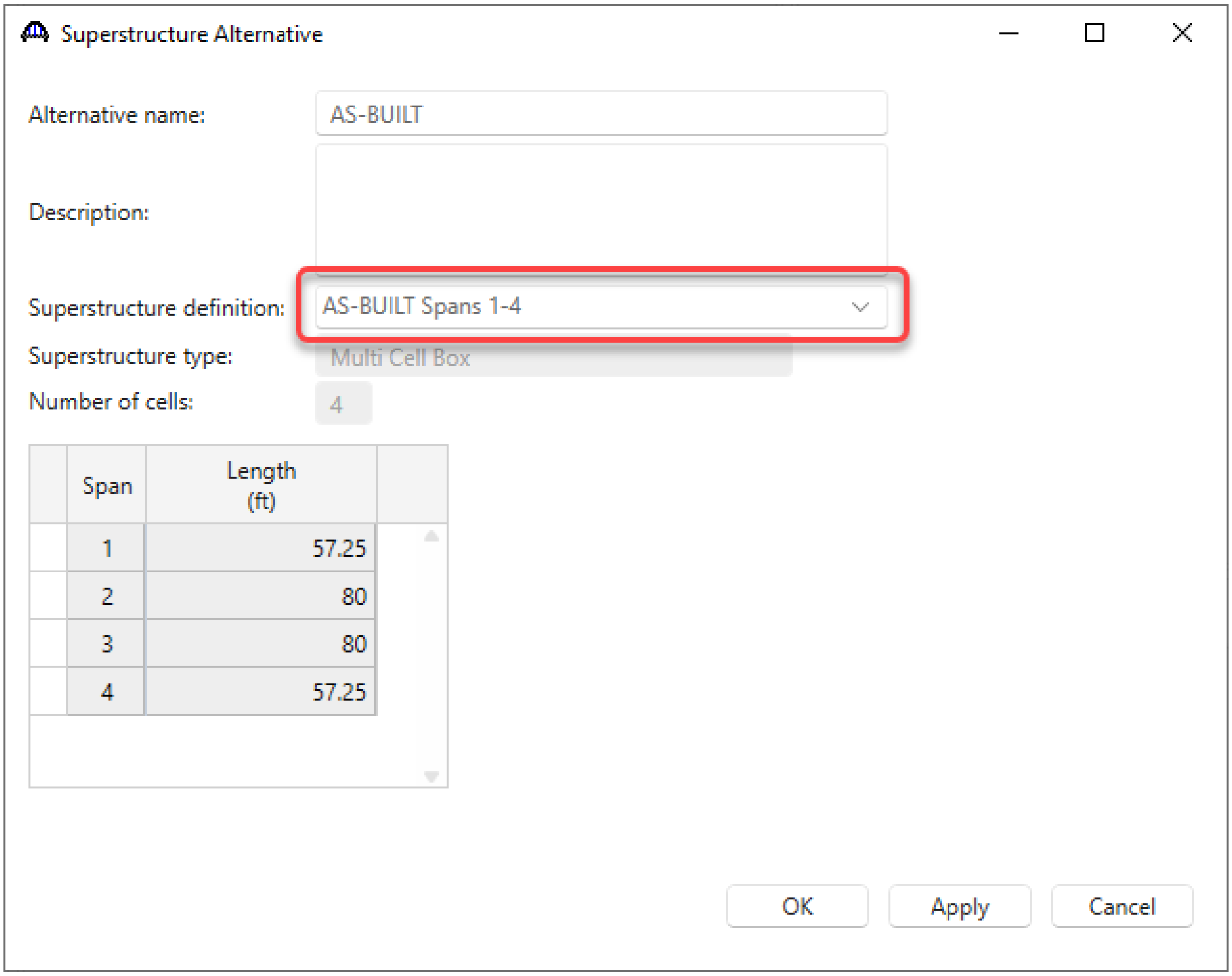
Double click on the **SUPERSTRUCTURES** folder and enter the name **AS-BUILT**. Move to the **Substructures** tab and assign substructures at each support.



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

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.

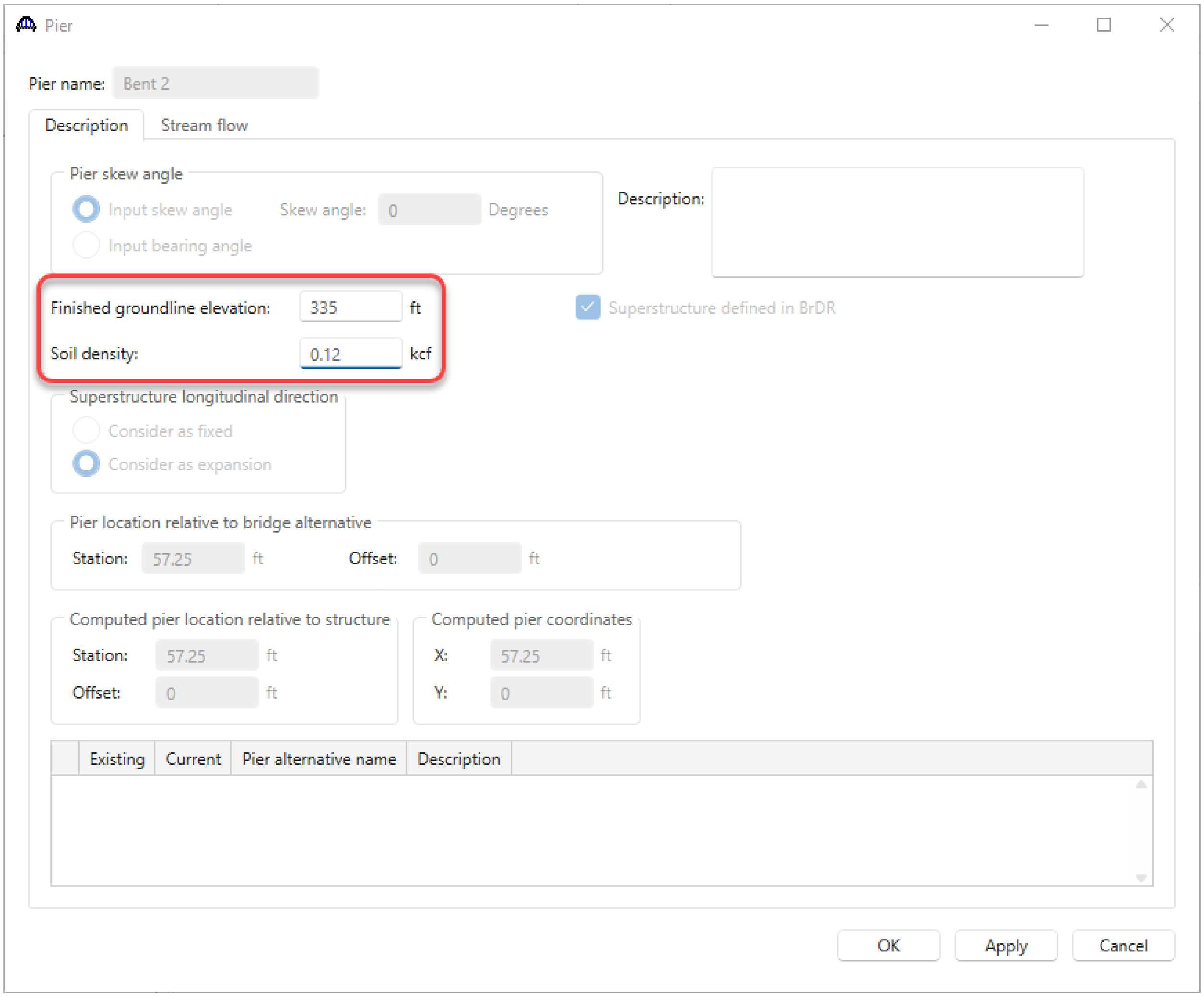


Click **OK** to apply the data and close the window.

Pier Data Entry

Pier

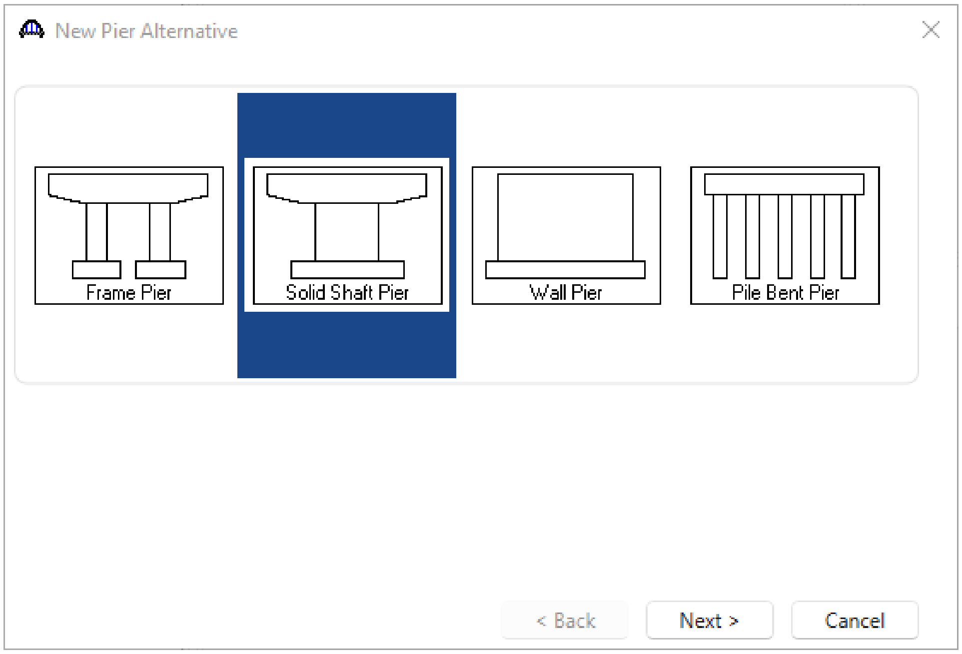
Now open the **Bent 2** Pier window, enter the data for the **finished groundline** and the **soil density**. This example assumes that the finished ground elevation is the same for each pier.



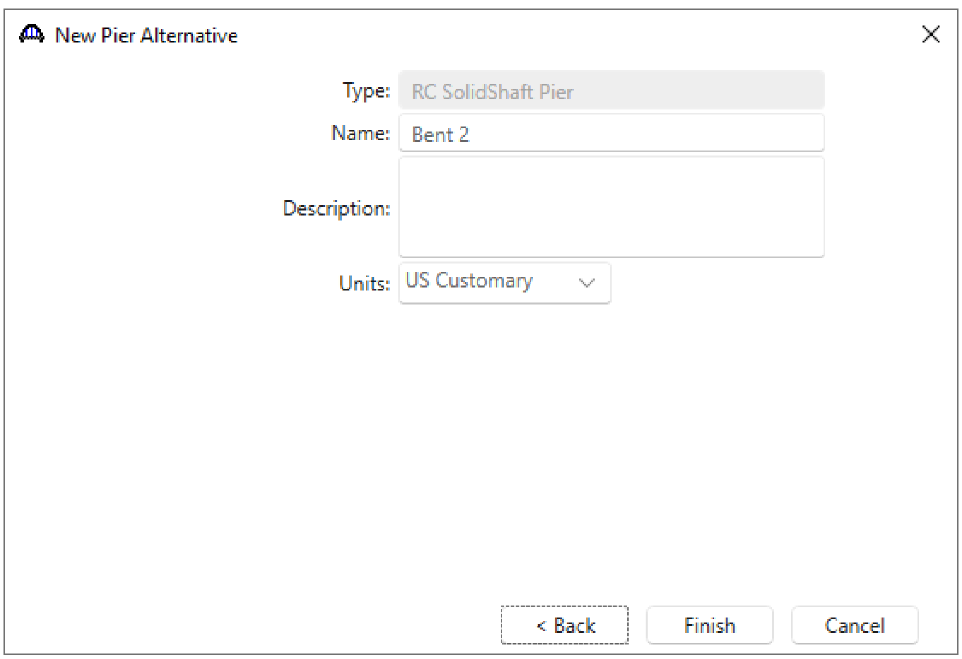
Click **OK** to apply the data and close the window.

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**.

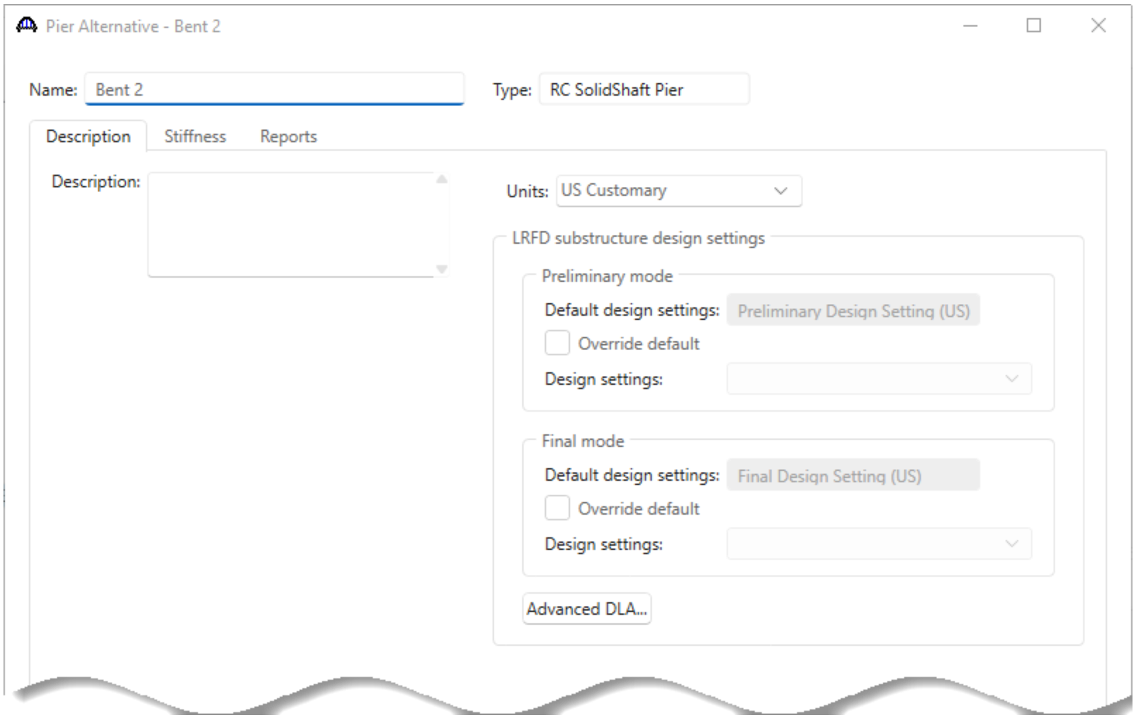


Enter the values shown and click **Finish**.



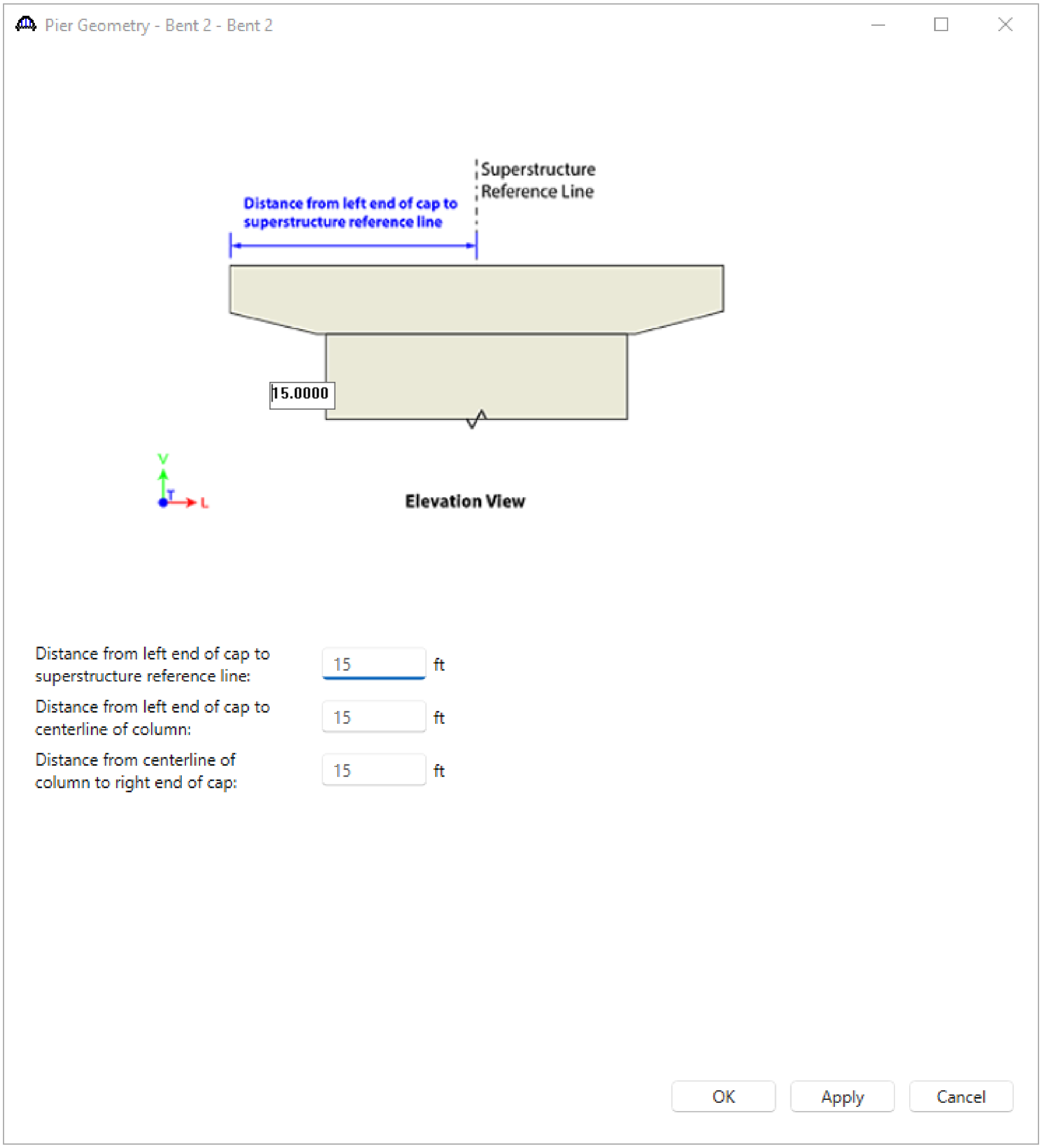
Pier Alternative – Bent 2

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



Pier Geometry – Bent 2 – Bent 2

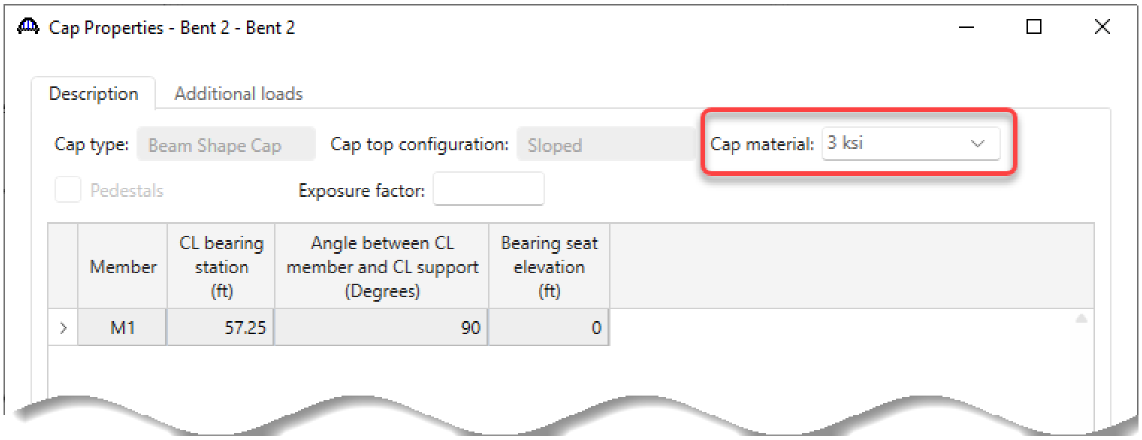
Double click on **Geometry** under **Bent 2** in the tree. Enter the data shown below.



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

Cap Properties – Bent 2 – Bent 2

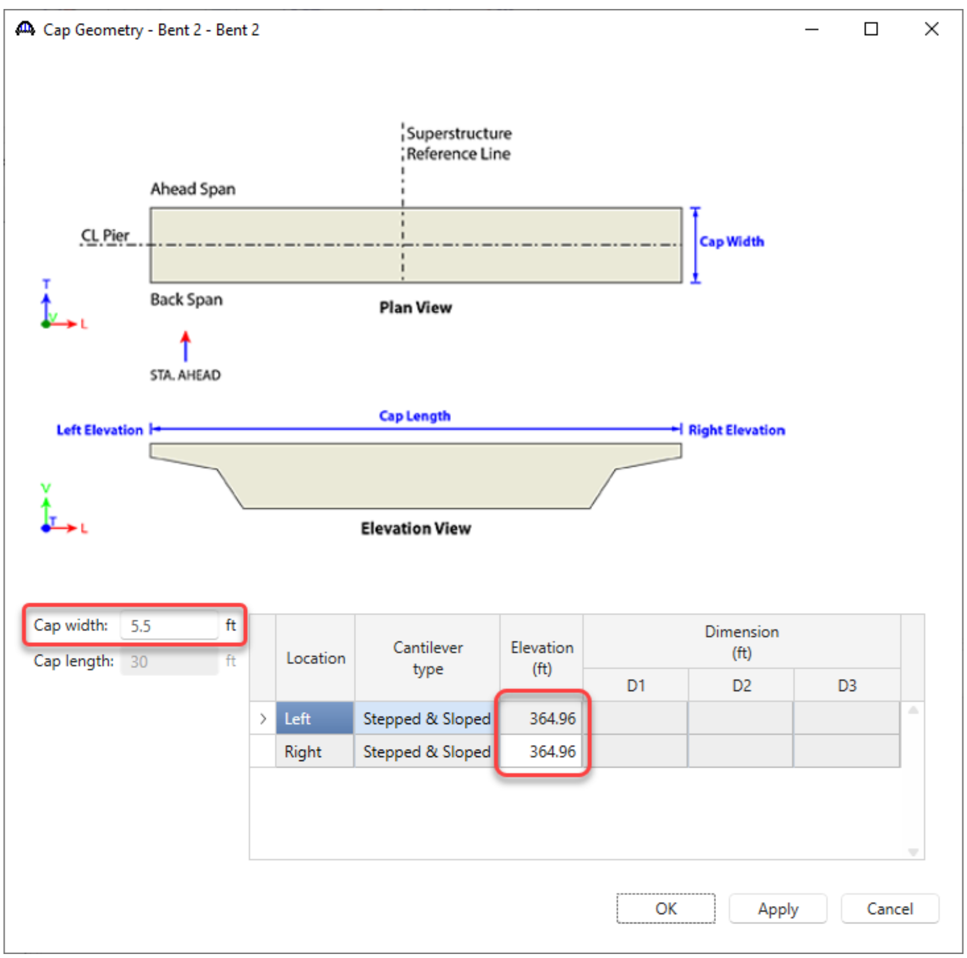
Open the **Cap** window and verify the correct cap concrete material is selected.



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

Cap Geometry – Bent 2 – Bent 2

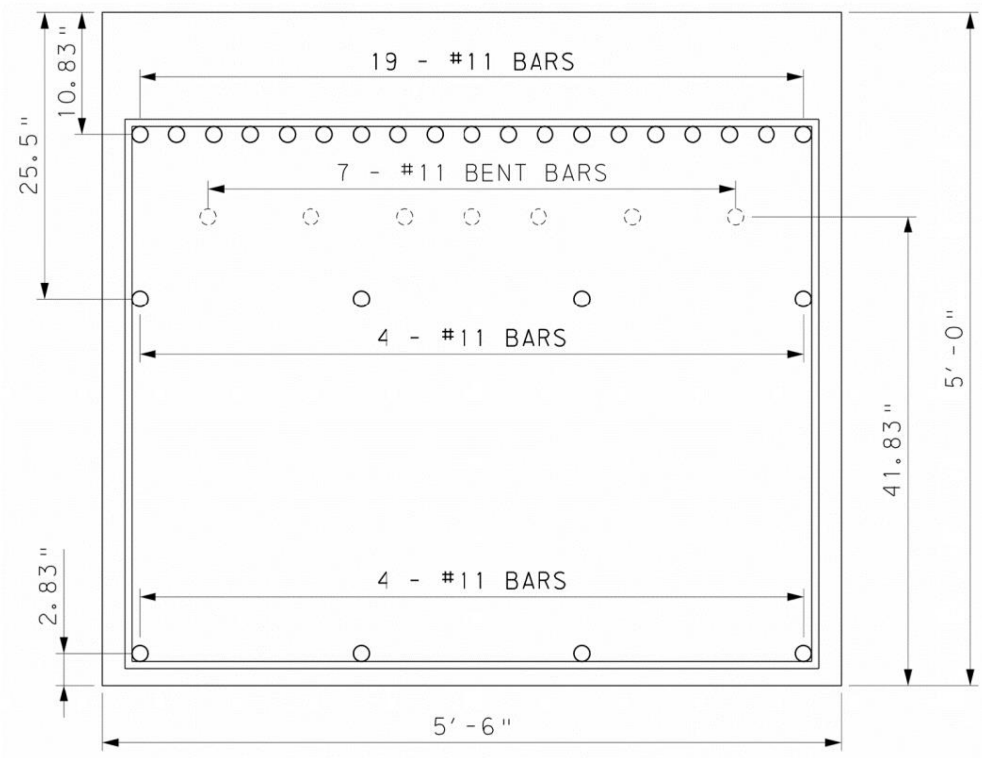
Open the Cap **Geometry** window and enter the following data for the pier cap geometry.



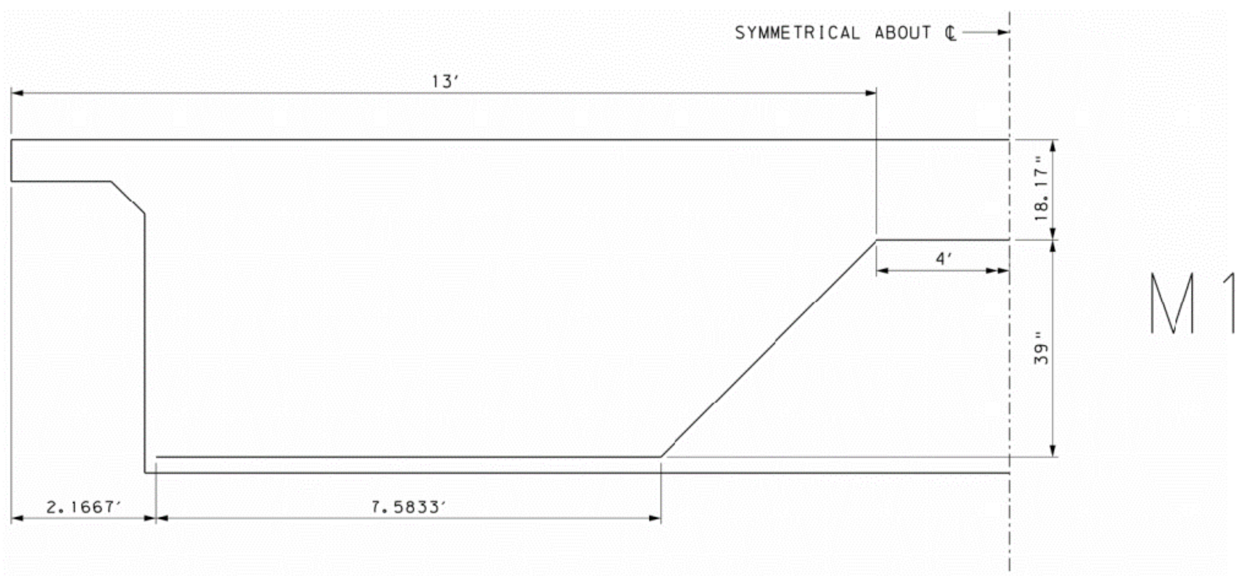
Click **OK** to apply the data and close the window.

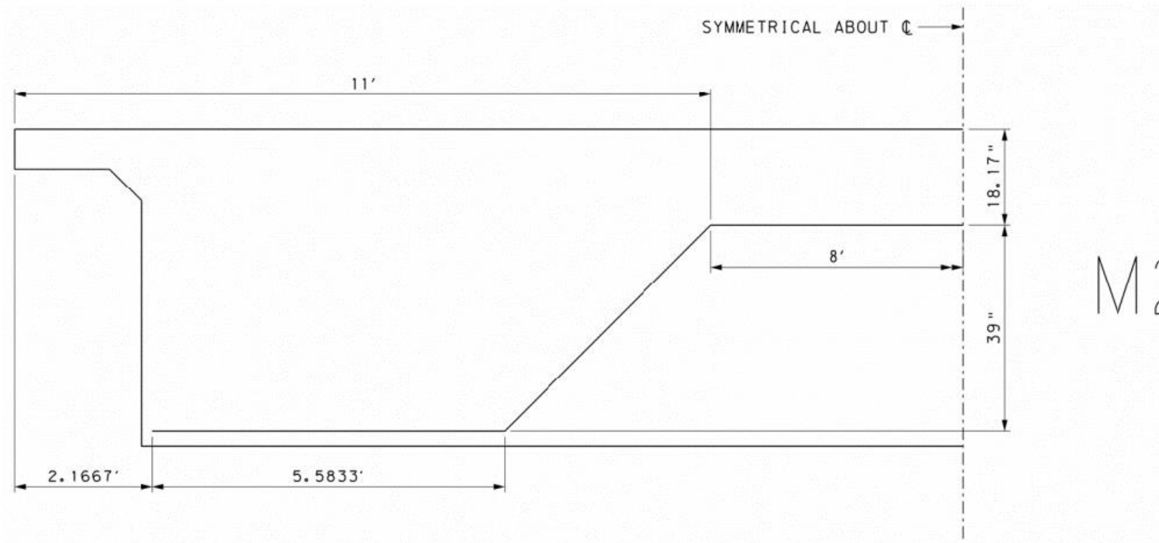
Cap Reinforcement – Bent 2 – Bent 2

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).

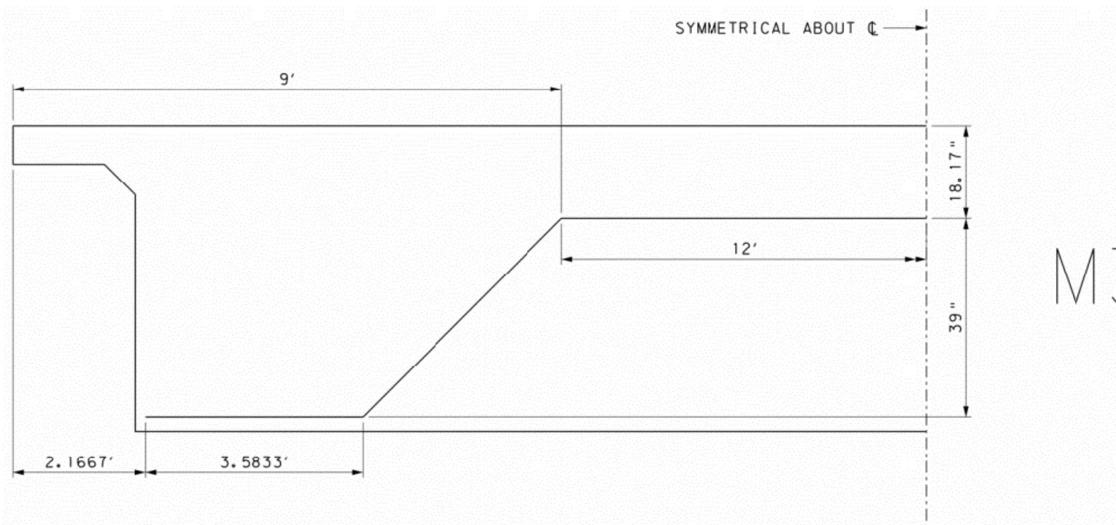


Pier cap elevations shown below with bent M Bar locations.

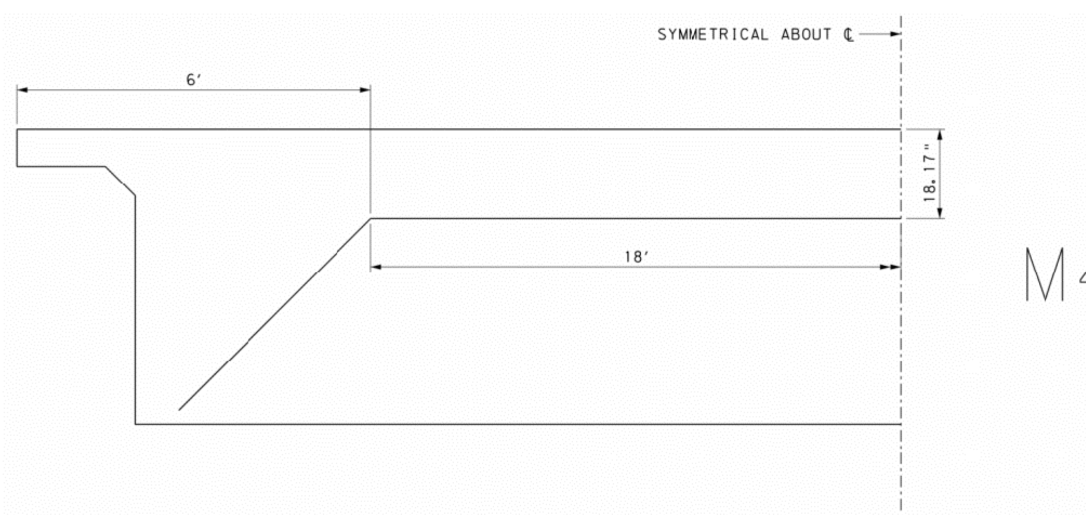



SYMMETRICAL ABOUT ℄
11′
18.17"
8′
39"
2.1667′
5.5833′

M2


SYMMETRICAL ABOUT ℄
9′
18.17"
12′
39"
2.1667′
3.5833′

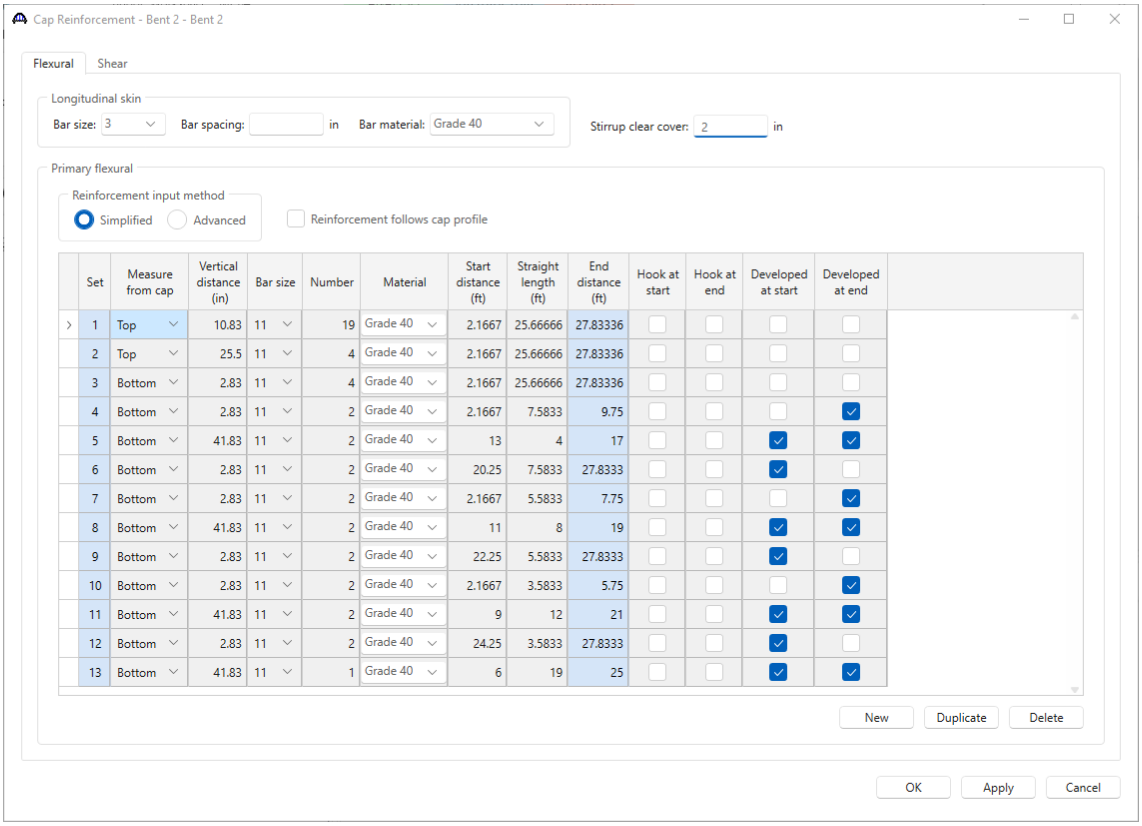
M3


SYMMETRICAL ABOUT ℄
6′
18.17"
18′

M4

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

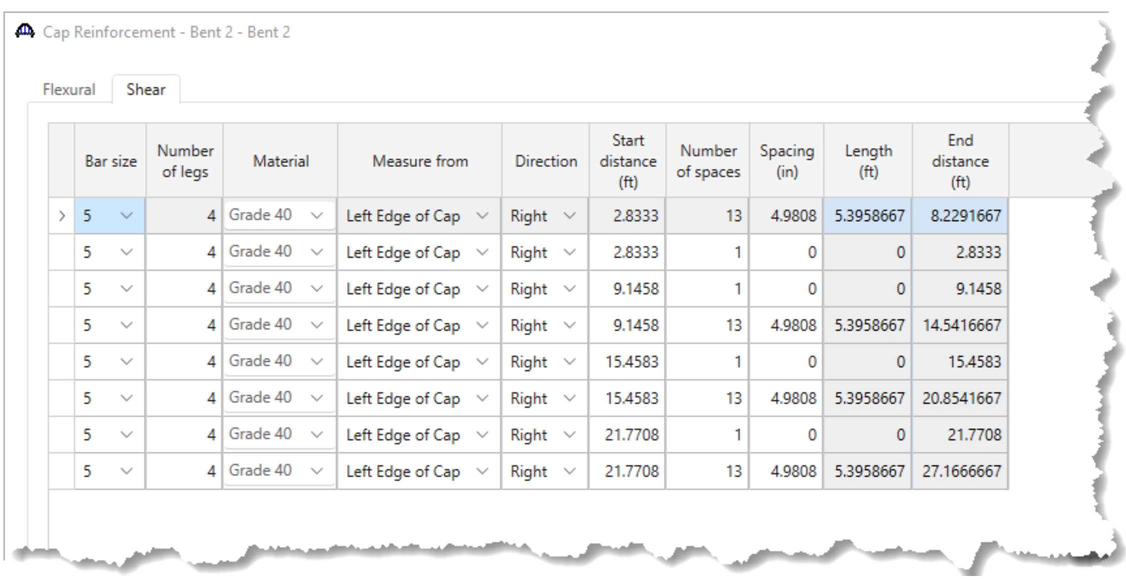
Primary flexural — Reinforcement input method: Simplified / Advanced — Reinforcement follows cap profile

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				
2	Top	25.5	11	4	Grade 40	2.1667	25.66666	27.83336				
3	Bottom	2.83	11	4	Grade 40	2.1667	25.66666	27.83336				
4	Bottom	2.83	11	2	Grade 40	2.1667	7.5833	9.75				✓
5	Bottom	41.83	11	2	Grade 40	13	4	17			✓	✓
6	Bottom	2.83	11	2	Grade 40	20.25	7.5833	27.8333			✓	
7	Bottom	2.83	11	2	Grade 40	2.1667	5.5833	7.75				✓
8	Bottom	41.83	11	2	Grade 40	11	8	19			✓	✓
9	Bottom	2.83	11	2	Grade 40	22.25	5.5833	27.8333			✓	
10	Bottom	2.83	11	2	Grade 40	2.1667	3.5833	5.75				✓
11	Bottom	41.83	11	2	Grade 40	9	12	21			✓	✓
12	Bottom	2.83	11	2	Grade 40	24.25	3.5833	27.8333			✓	
13	Bottom	41.83	11	1	Grade 40	6	19	25			✓	✓

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

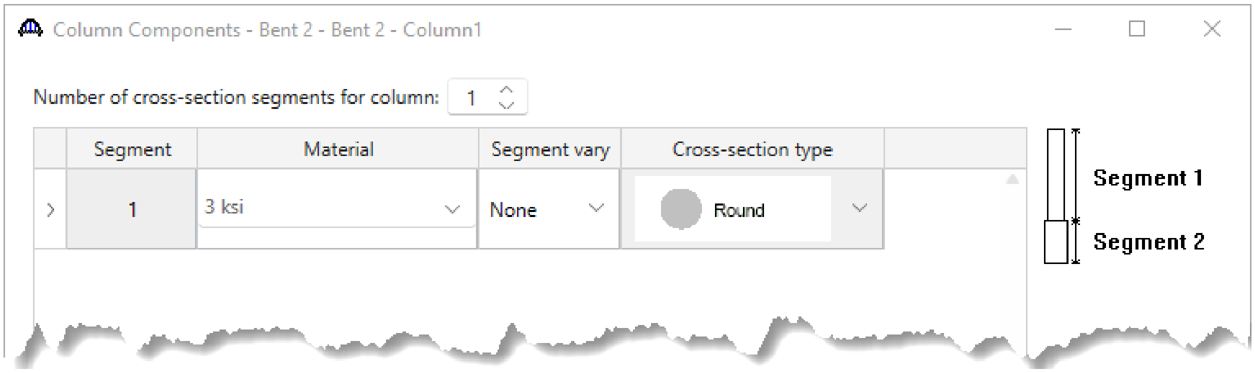
Flexural | Shear

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.

Column Components – Bent 2 – Bent 2 – Column1

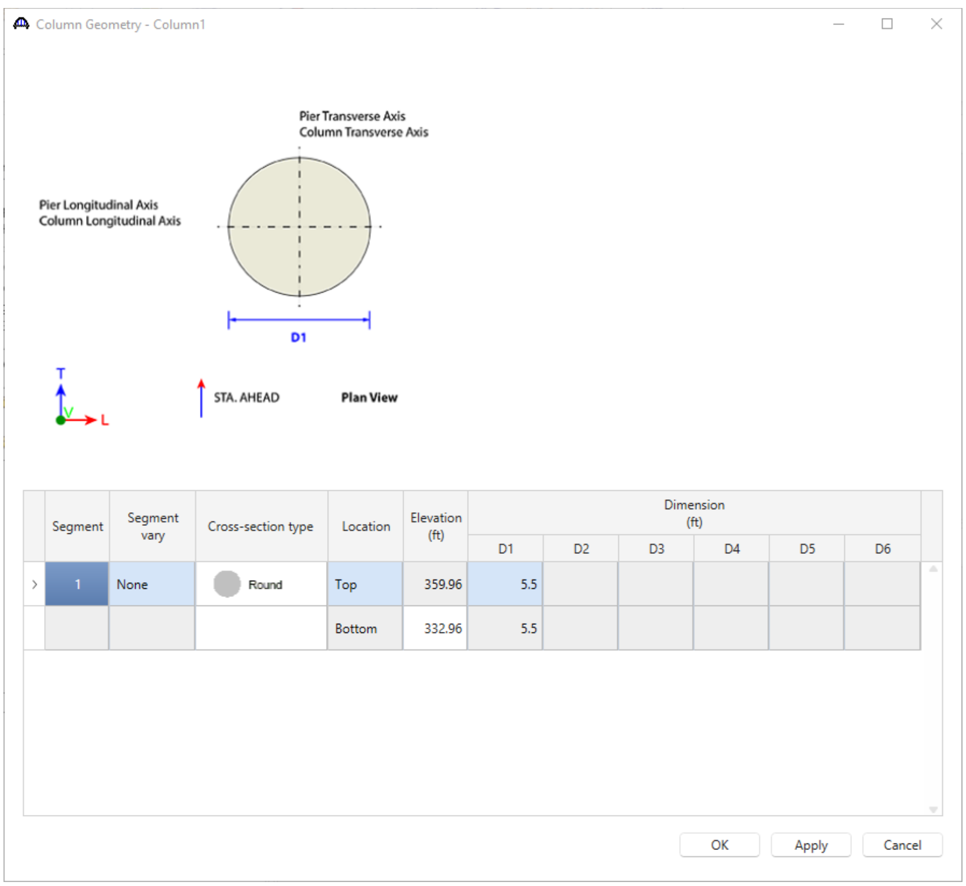
Open the Column1 **Components** window and select the following concrete material.



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.

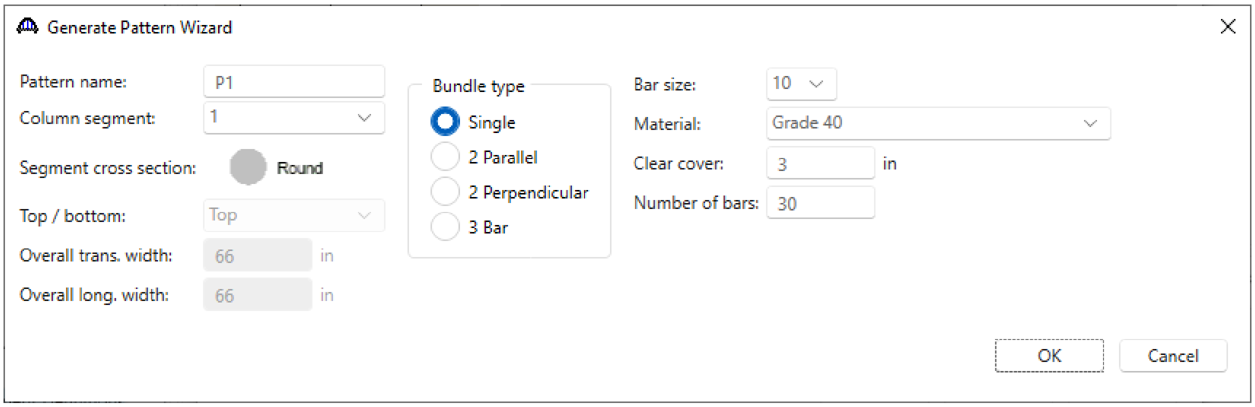


Click **OK** to apply the data and close the window.

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.

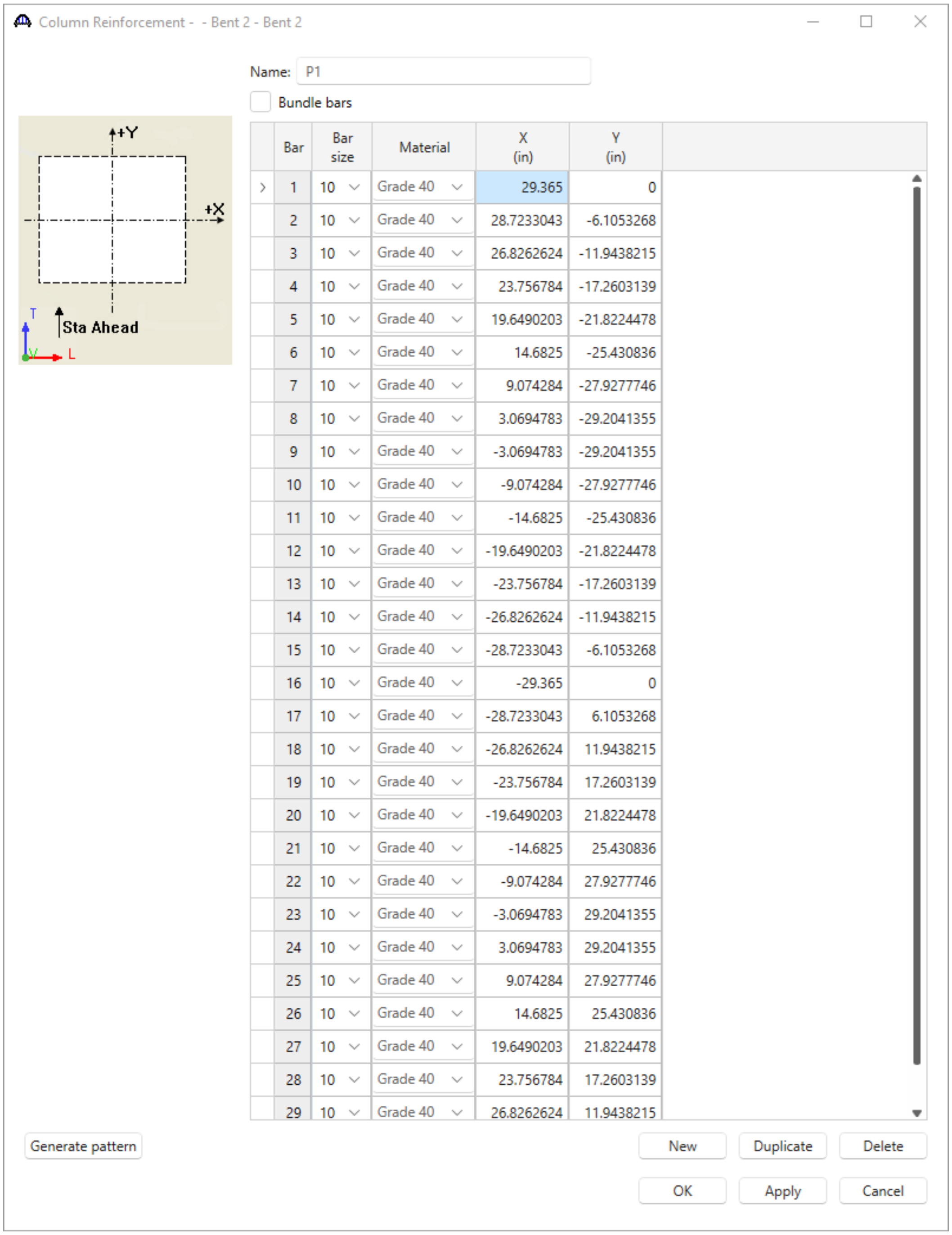
Generate Pattern Wizard

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



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

Column Reinforcement – Bent 2 – Bent 2

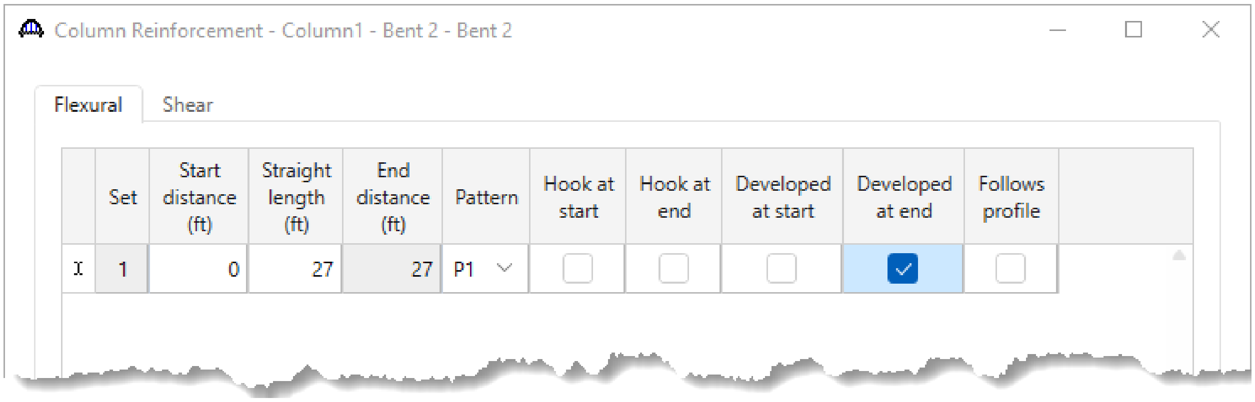


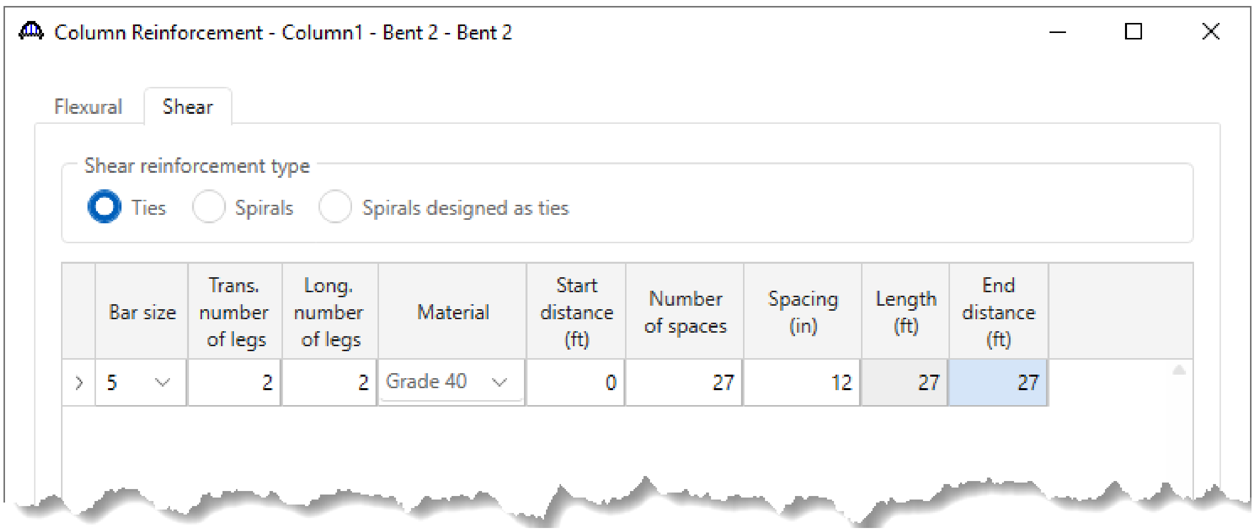
Bar	Bar size	Material	X (in)	Y (in)
1	10	Grade 40	29.365	0
2	10	Grade 40	28.7233043	-6.1053268
3	10	Grade 40	26.8262624	-11.9438215
4	10	Grade 40	23.756784	-17.2603139
5	10	Grade 40	19.6490203	-21.8224478
6	10	Grade 40	14.6825	-25.430836
7	10	Grade 40	9.074284	-27.9277746
8	10	Grade 40	3.0694783	-29.2041355
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.

Column Reinforcement – Column1 – Bent 2 – Bent 2

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



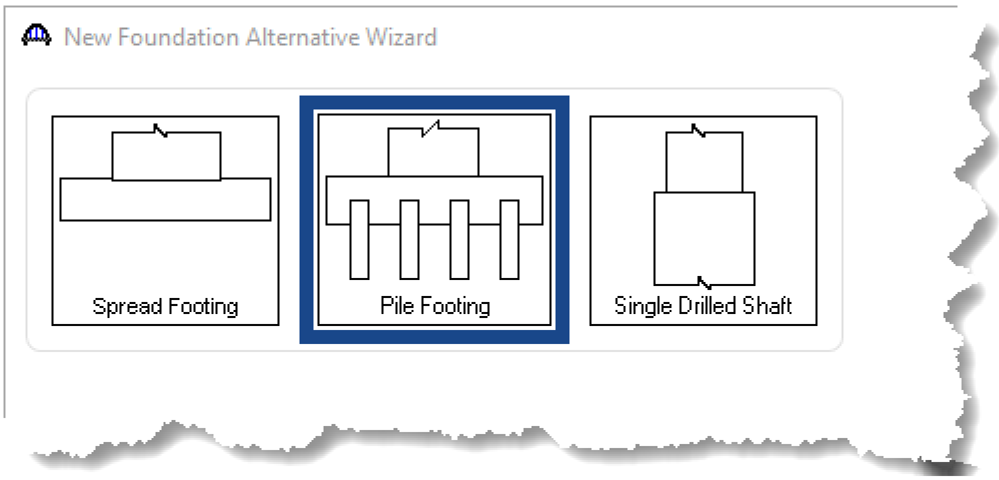


Click **OK** to apply the data and close the window.

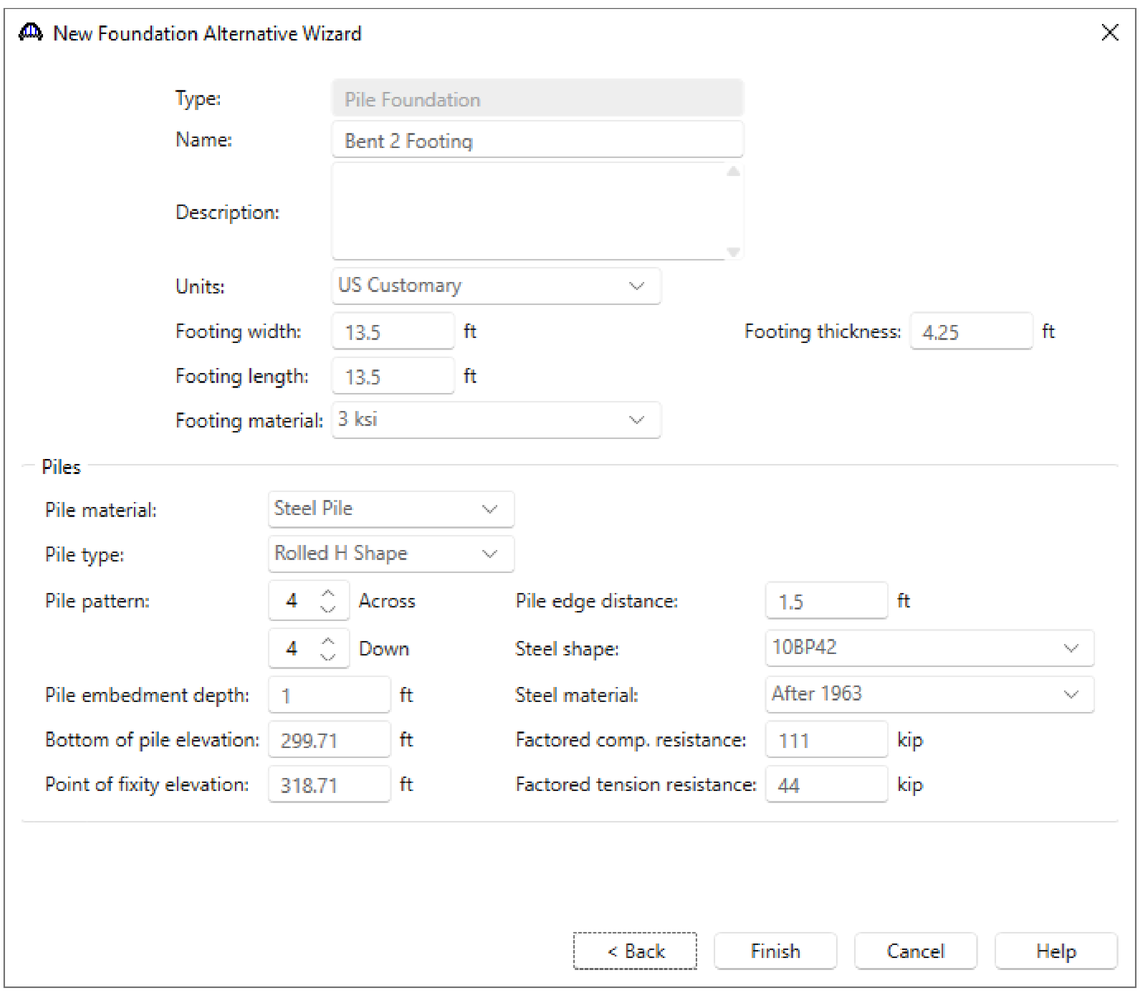
Foundation Alternatives

New Foundation Alternative Wizard

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

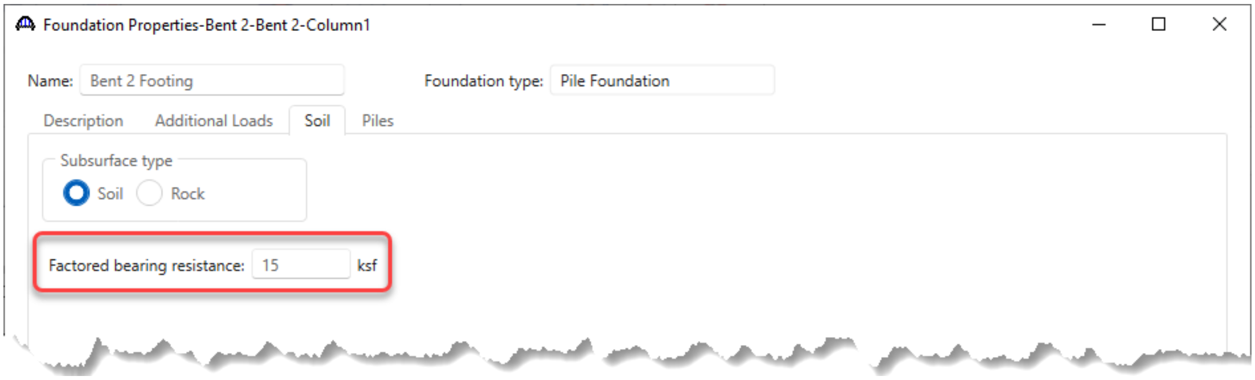


Enter the data shown below and click **Finish**.

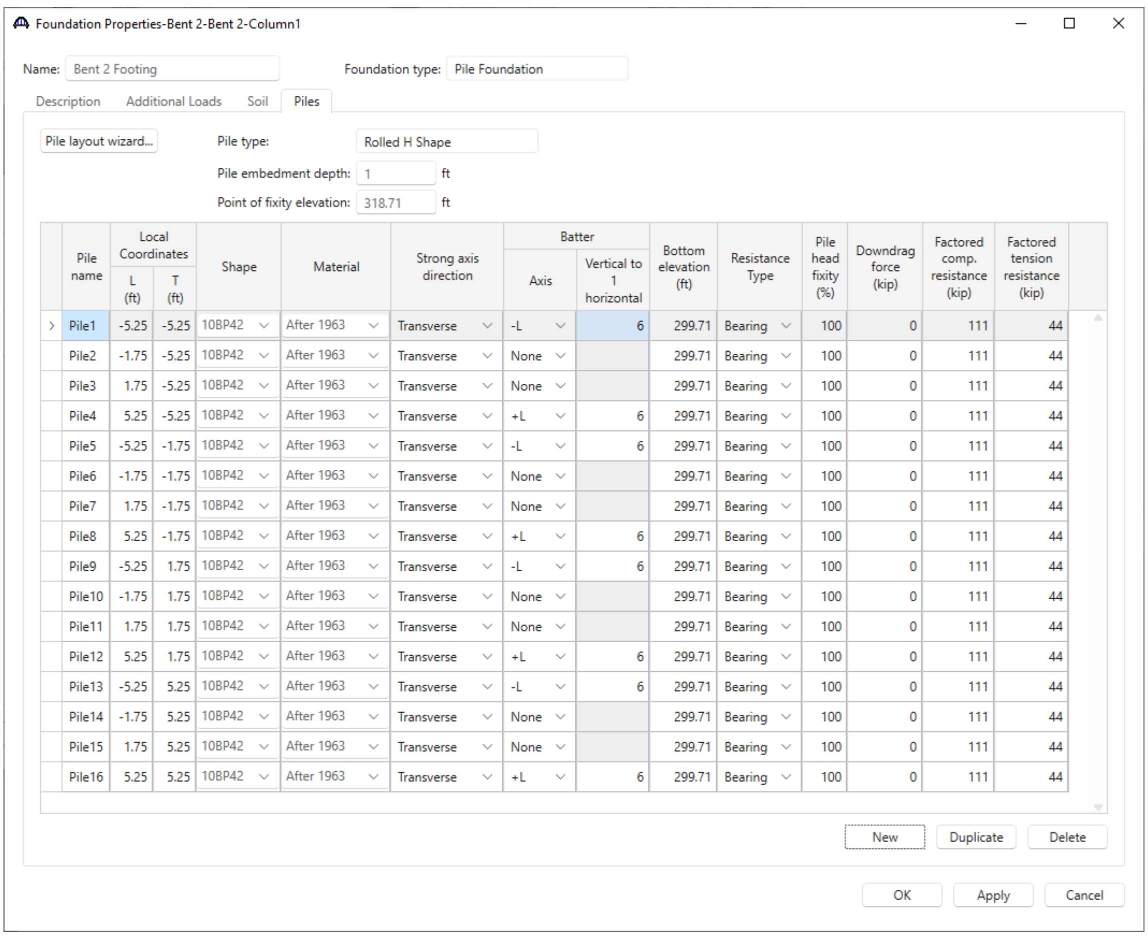


Foundation Properties – Bent 2 – Bent 2 – Column1

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



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

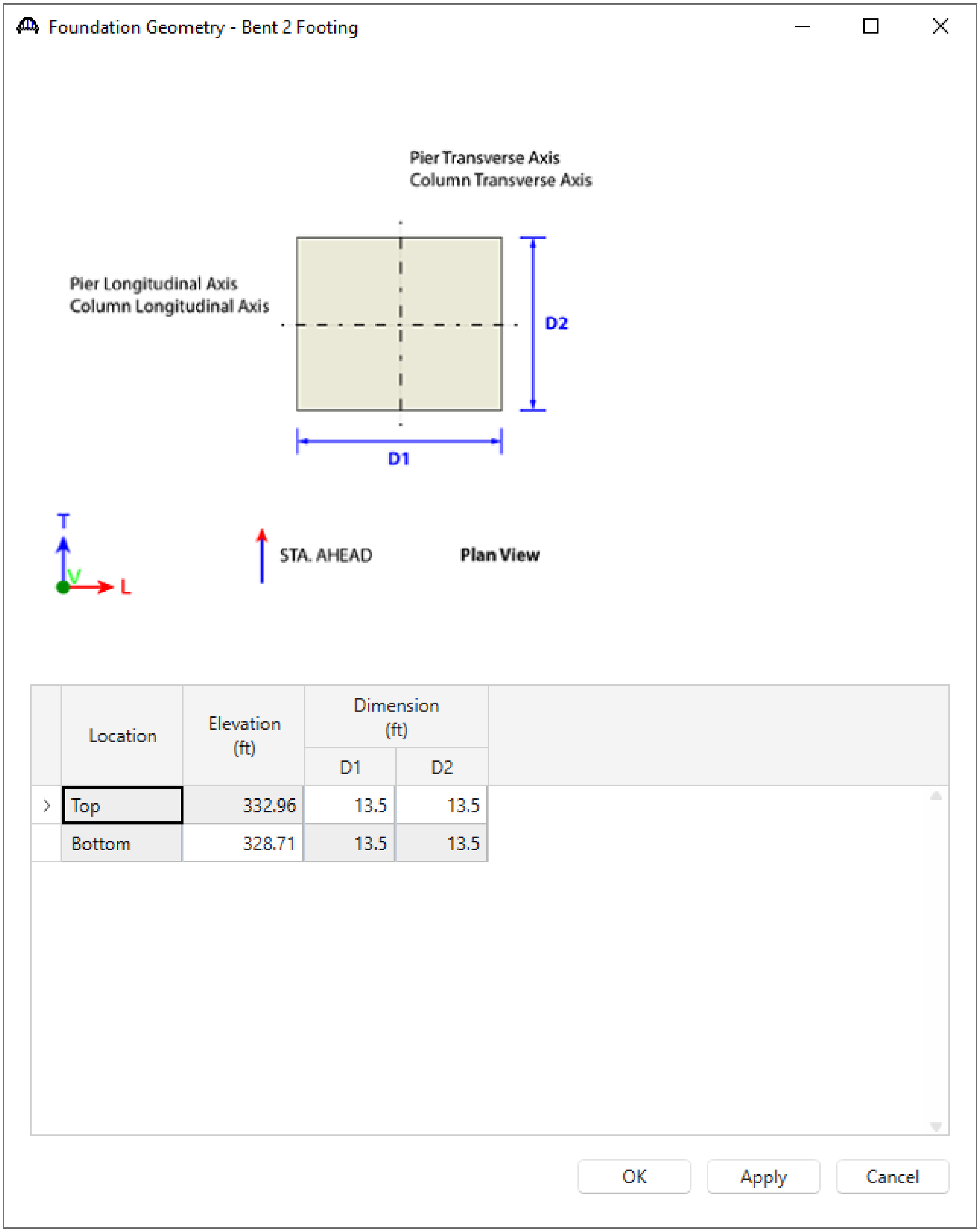


Pile name	Local Coordinates L (ft)	Local Coordinates T (ft)	Shape	Material	Strong axis direction	Batter Axis	Batter Vertical to 1 horizontal	Bottom elevation (ft)	Resistance Type	Pile head fixity (%)	Downdrag force (kip)	Factored comp. resistance (kip)	Factored tension resistance (kip)
Pile1	-5.25	-5.25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

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

Foundation geometry – Bent 2 Footing

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

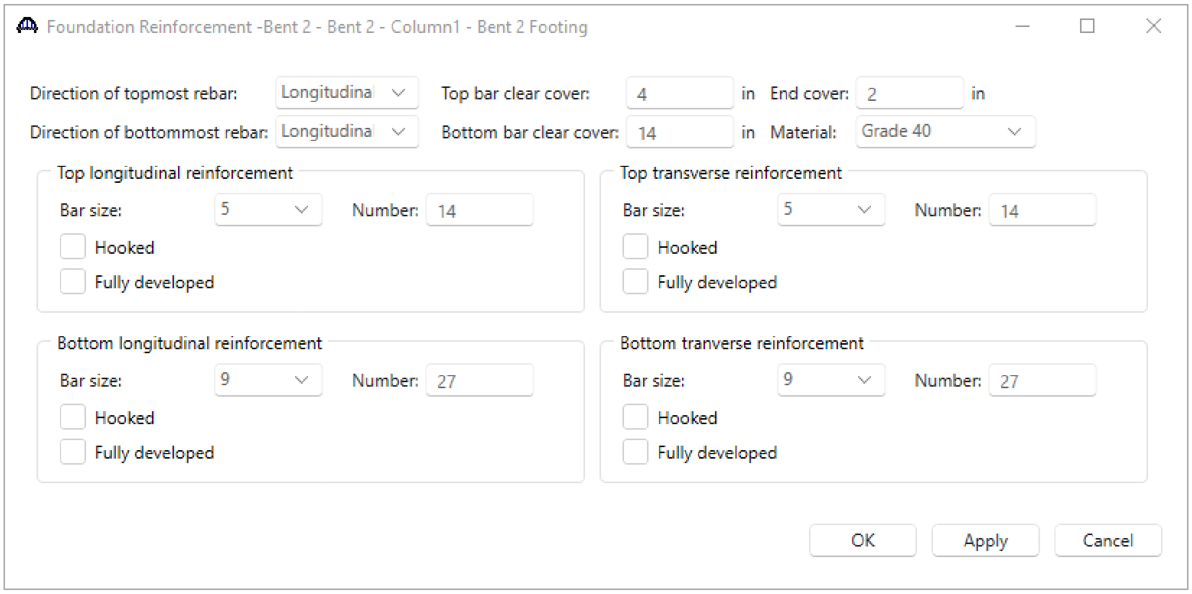


Location	Elevation (ft)	Dimension (ft)	
		D1	D2
Top	332.96	13.5	13.5
Bottom	328.71	13.5	13.5

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

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

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

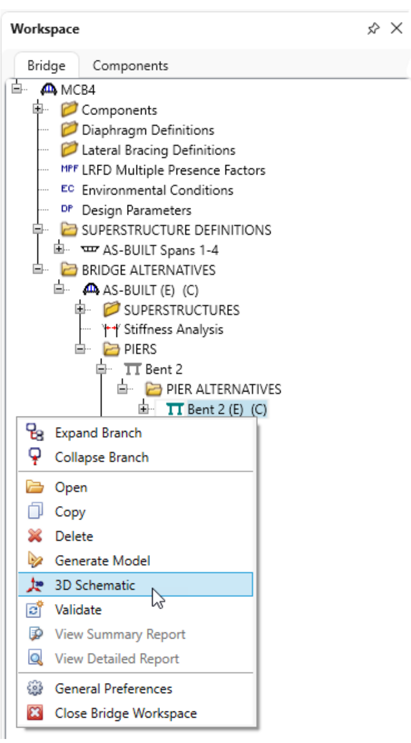


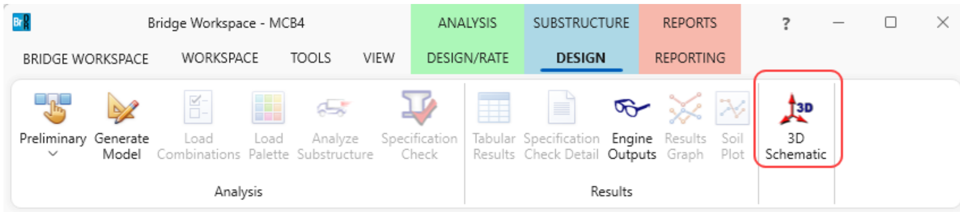
Click **OK** to apply the data and close the window.

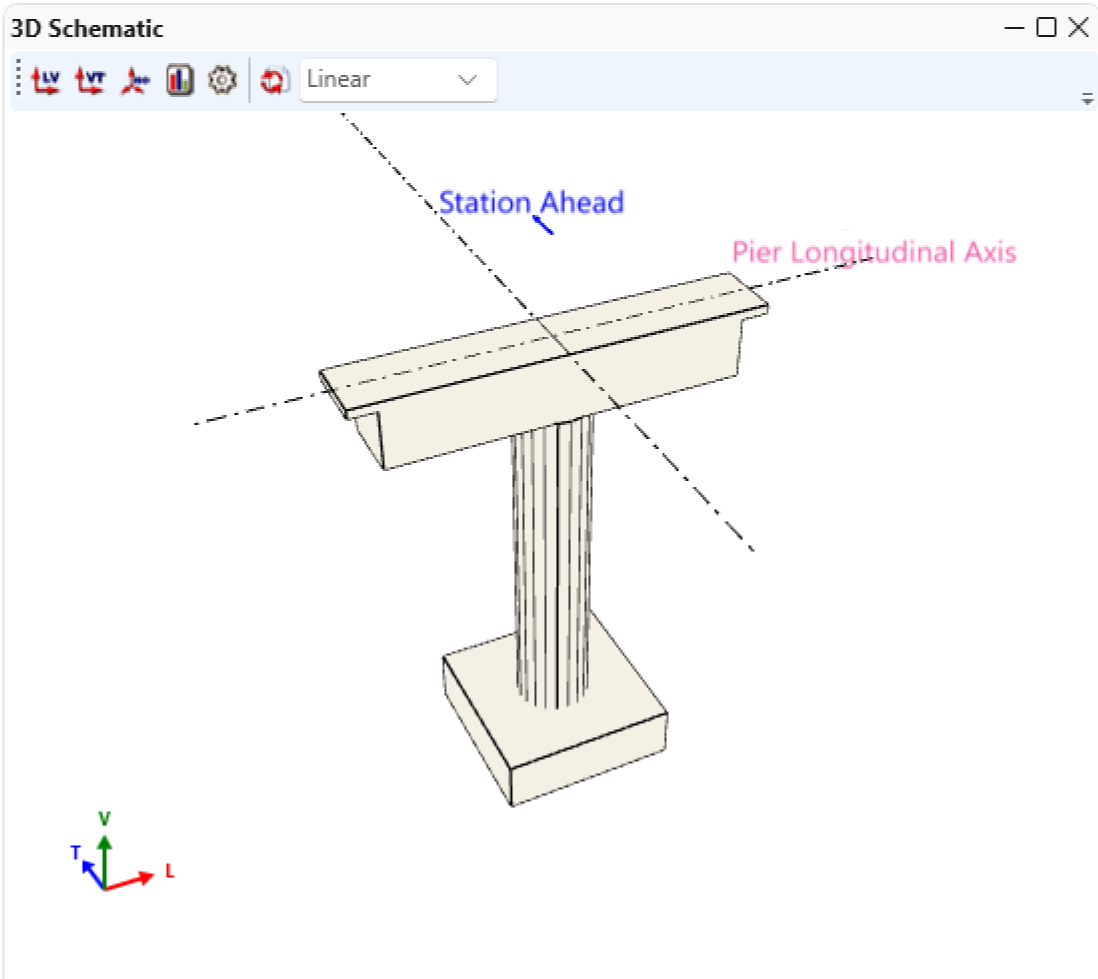
The input for Bent 2 is complete.

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**)

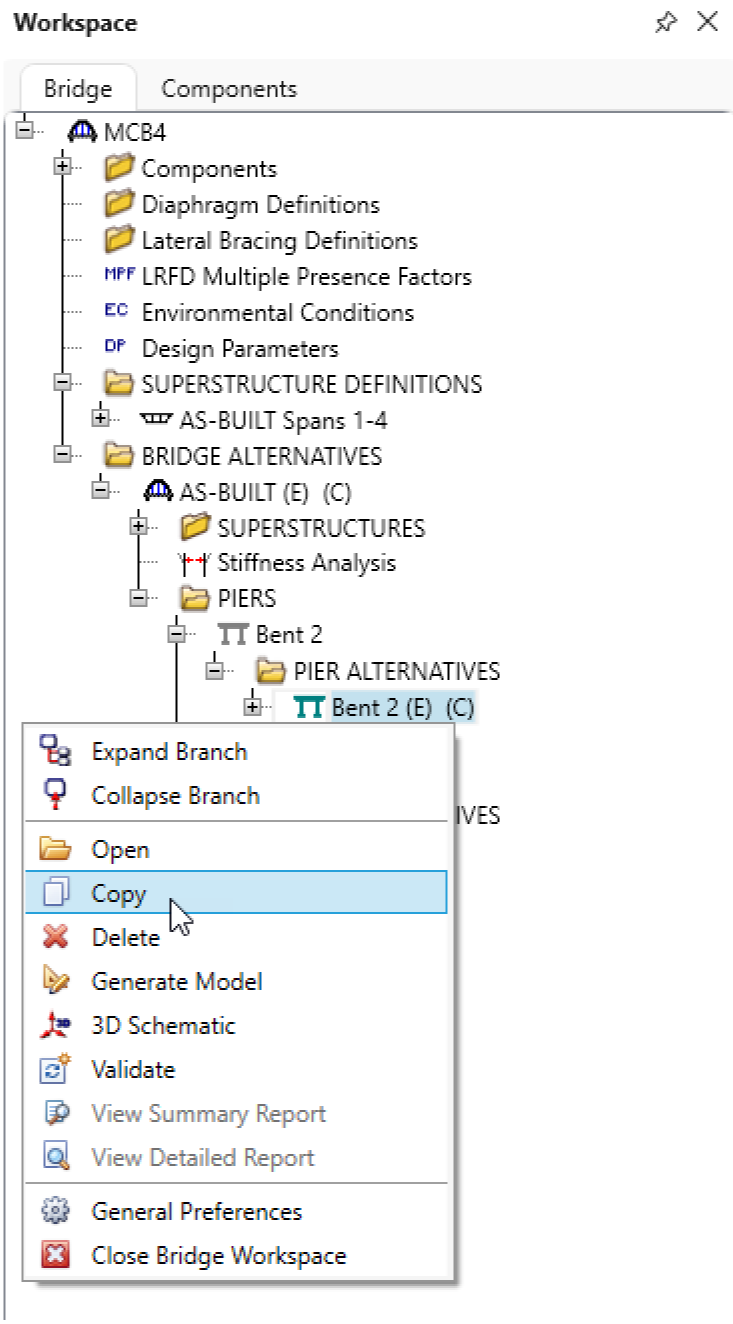



Bridge Workspace - MCB4
ANALYSIS
SUBSTRUCTURE
REPORTS
BRIDGE WORKSPACE
WORKSPACE
TOOLS
VIEW
DESIGN/RATE
DESIGN
REPORTING
Preliminary
Generate Model
Load Combinations
Load Palette
Analyze Substructure
Specification Check
Tabular Results
Specification Check Detail
Engine Outputs
Results Graph
Soil Plot
3D Schematic
Analysis
Results

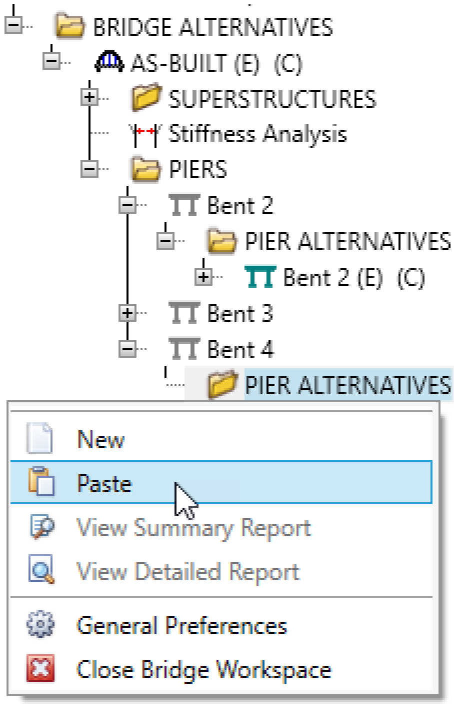

3D Schematic
Linear
Station Ahead
Pier Longitudinal Axis
V
T
L

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**.



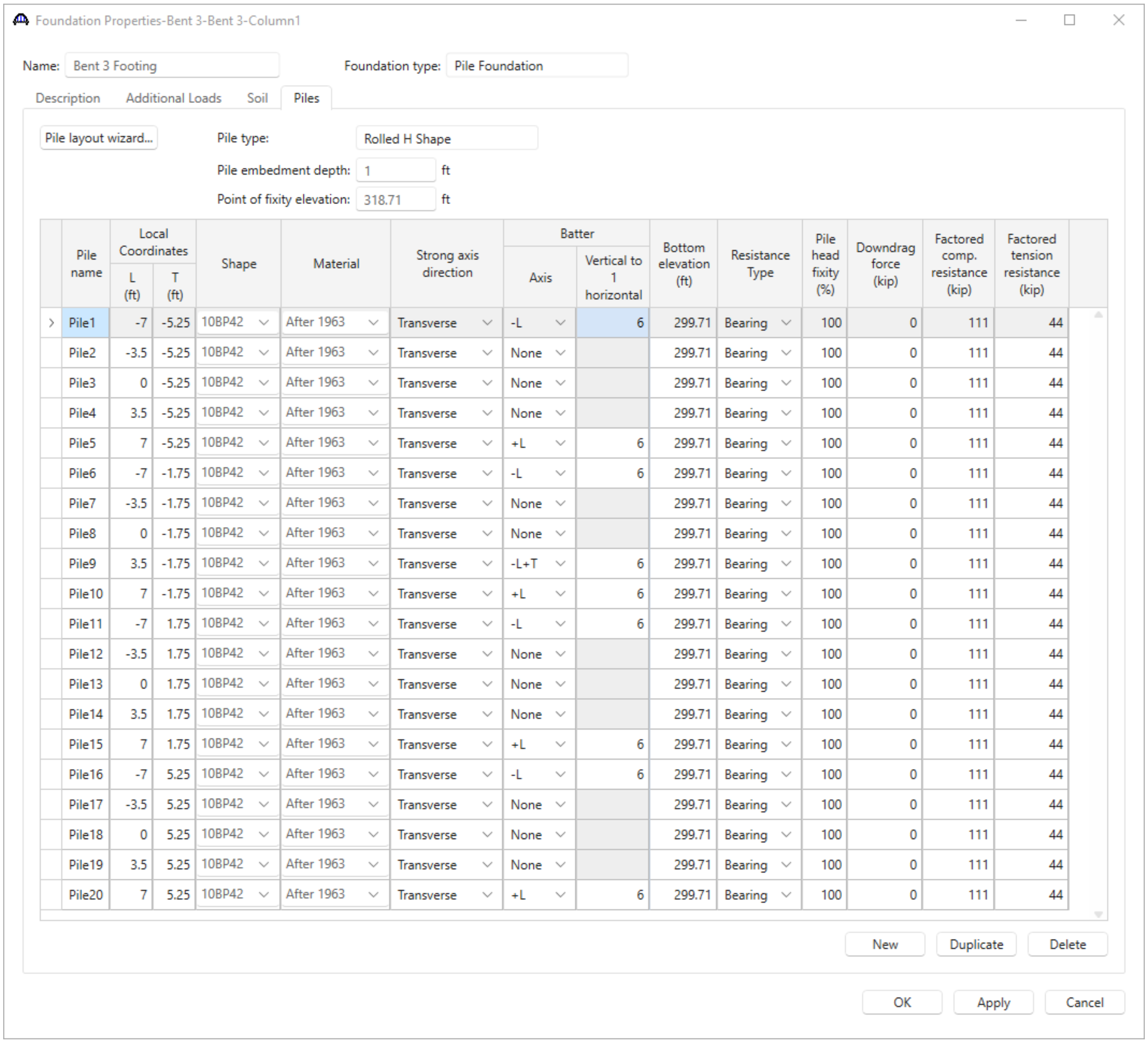
Expand **Bent 4,** right click on the **Pier Alternative** and select **Paste**. Change the name from **Bent 2** to **Bent 4**. The input for **Bent 4** is now complete.



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

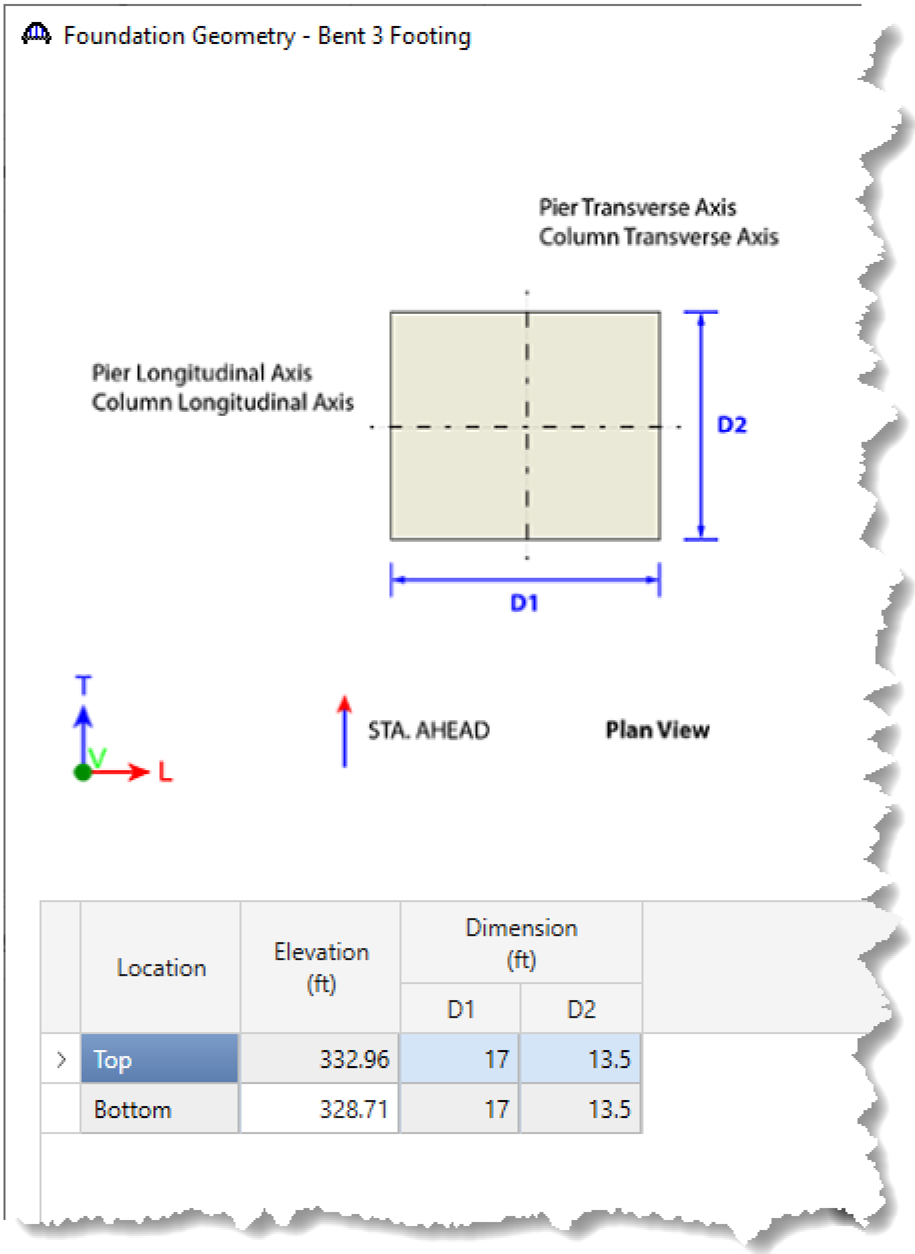


Pile name	Local Coordinates L (ft)	Local Coordinates T (ft)	Shape	Material	Strong axis direction	Batter Axis	Batter Vertical to 1 horizontal	Bottom elevation (ft)	Resistance Type	Pile head fixity (%)	Downdrag force (kip)	Factored comp. resistance (kip)	Factored tension resistance (kip)
Pile1	-7	-5.25	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

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

Foundation Geometry – Bent 3 Footing

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

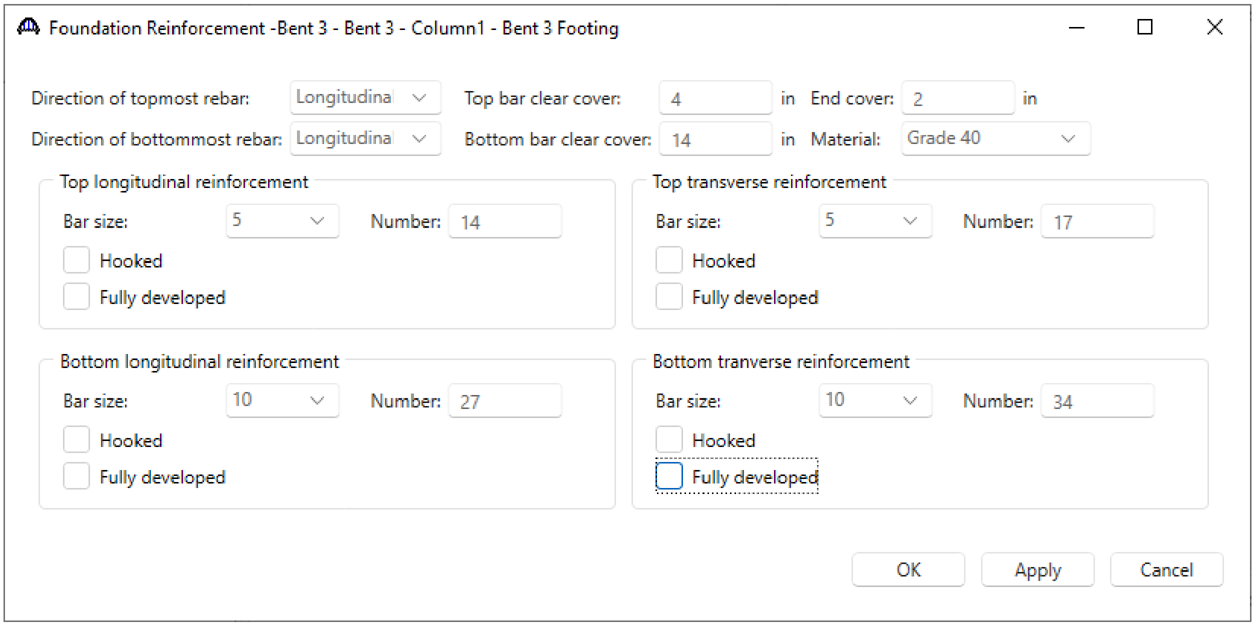


Location	Elevation (ft)	Dimension (ft)	
		D1	D2
Top	332.96	17	13.5
Bottom	328.71	17	13.5

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

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

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



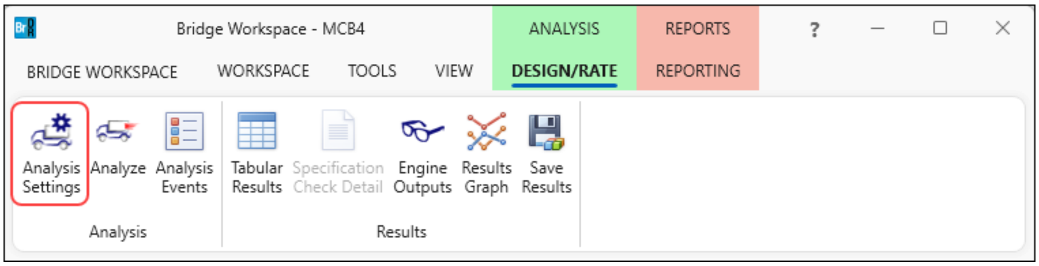
Click **OK** to apply the data and close the window.

Analysis and Results

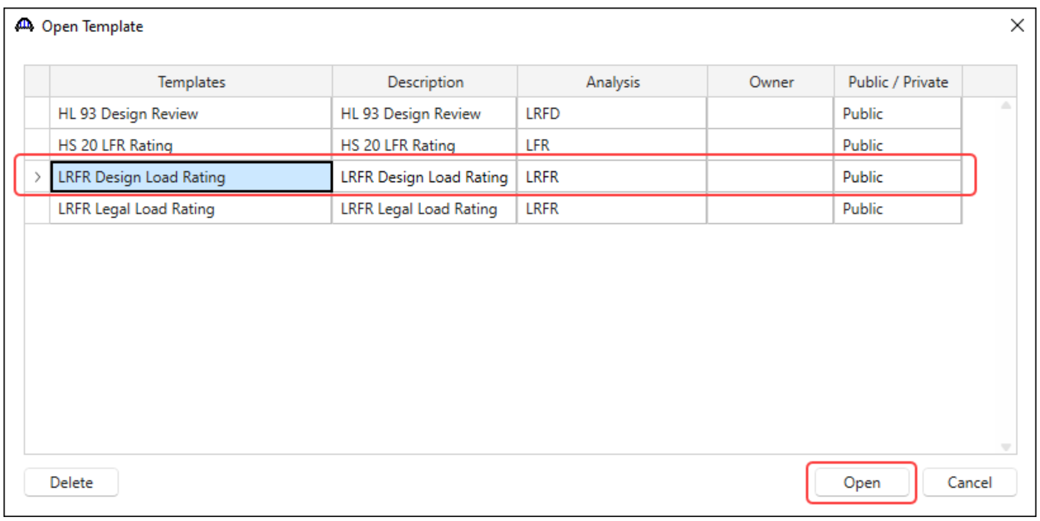
The structure is ready for analysis. Note that a design review of substructures for integral box girders cannot be performed at this time.

LRFR Analysis

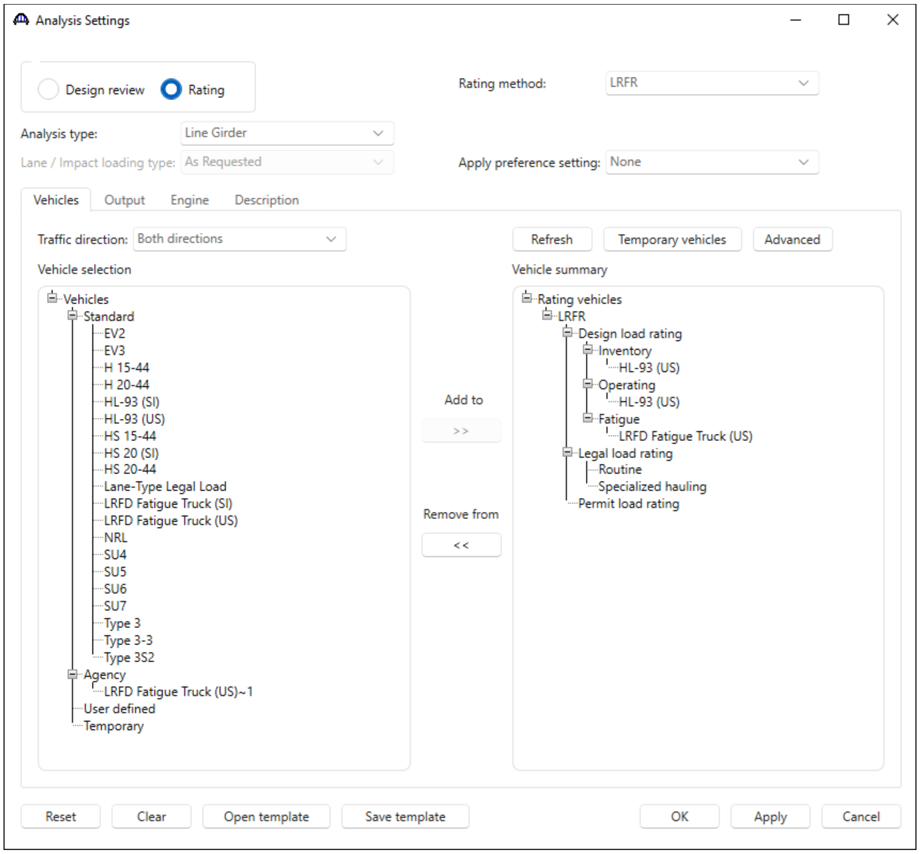
To perform an LRFR analysis of the superstructure – **AS-BUILT Spans 1-4**, click on the **Analysis Settings** button from the **Analysis** group of the **DESIGN/RATE** ribbon.



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

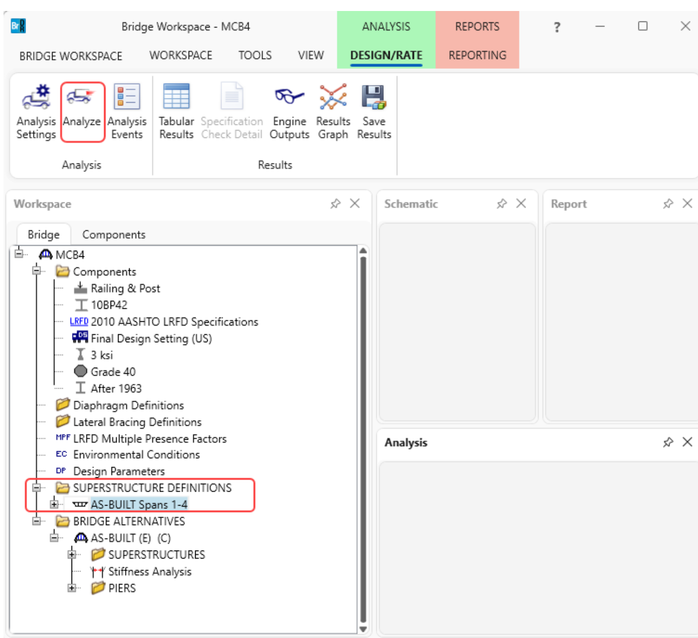


The **Analysis Settings** window is updated as shown below.



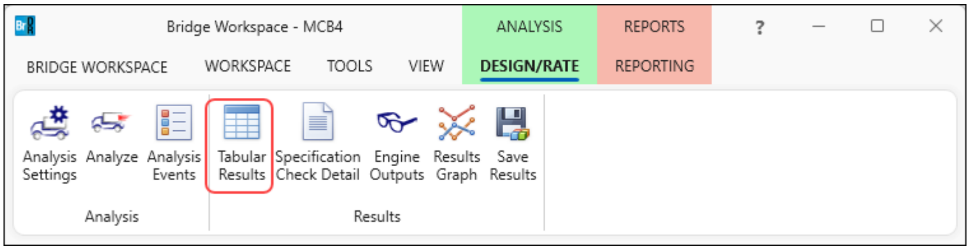
Click **OK** to apply the settings and close the window.

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.

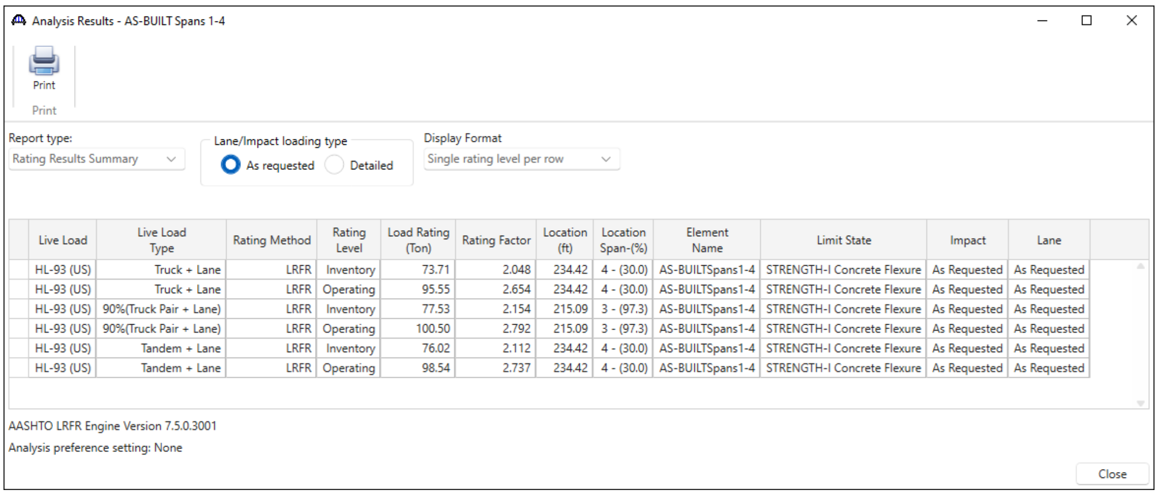


Tabular Results

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.



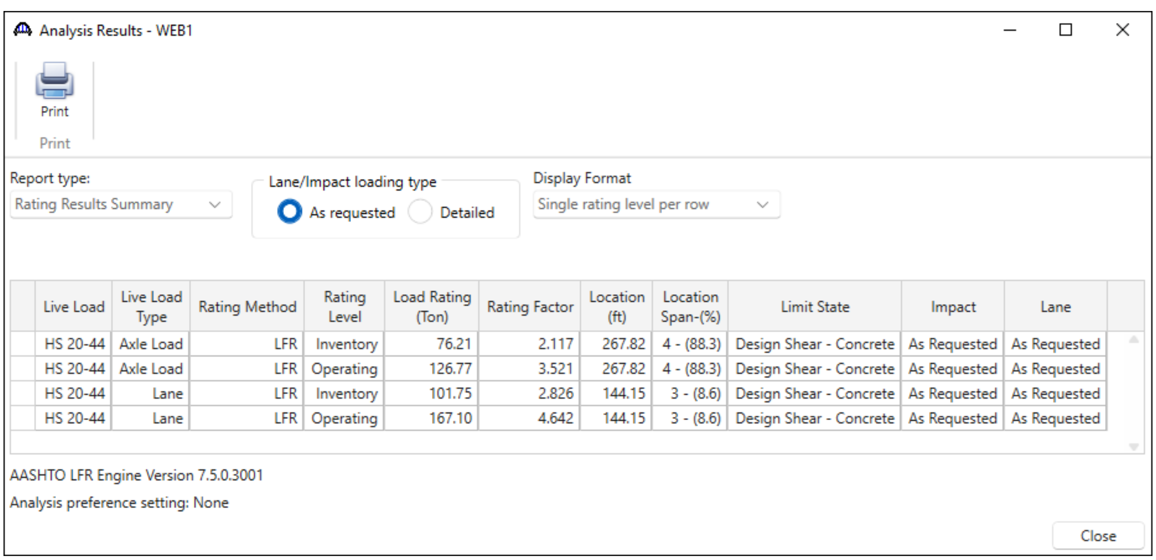
Superstructure LRFR ratings for full box unit are shown below.



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

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.



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