
AASHTOWare BrDR 7.5.1
Substructure Tutorial
RC Pier Supporting Slab System

RC Pier Supporting Slab System Example

Topics Covered

- Reinforced concrete slab input as slab system.
- Schedule-based input
- RC slab system superstructure not integral with pier
- Superstructure loads, superstructure environmental loads and substructure loads for pier
- Analysis and specification checking of pier

This example describes defining a RC slab system superstructure not integral with pier using AASHTOWare BrDR.

Open the bridge **BID 11 RCTrainingBridge1** in the sample database. Open the window for **RCTrainingBridge1** and check the box for **Substructures** to make substructure a part of the tree.

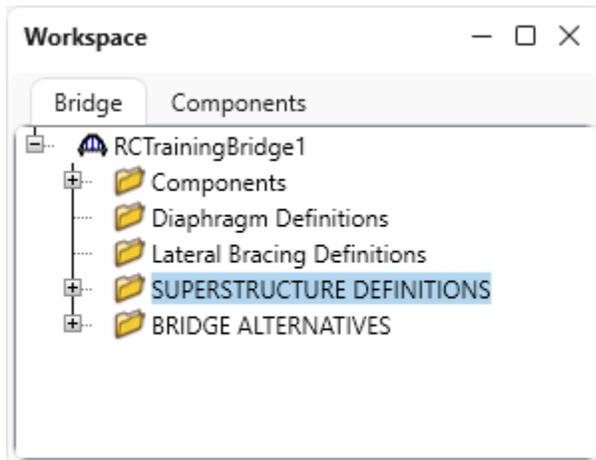
The screenshot shows the 'RCTrainingBridge1' dialog box. At the top, there are input fields for 'Bridge ID: RCTrainingBridge1' and 'NBI structure ID (8): RCTrainBridge1'. To the right, there are checkboxes for 'Template' (unchecked), 'Bridge completely defined' (checked), and a 'Bridge Workspace View' section with 'Superstructures' (checked), 'Culverts' (unchecked), and 'Substructures' (checked and highlighted with a red box). Below this is a tabbed interface with 'Description' selected. The 'Description' tab contains fields for 'Name: RC Training Bridge1(LFR)', 'Year built:', 'Description: Reinforced concrete tee-beam bridge, LFD design', 'Location:', 'Length: ft', 'Facility carried (7):', 'Route number: -1', 'Feat. intersected (6):', and 'Mi. post:'. At the bottom left, there is a 'Bridge association...' section with checkboxes for 'BrR' (checked), 'BrD' (checked), and 'BrM' (unchecked). At the bottom right, there are 'OK', 'Apply', and 'Cancel' buttons.

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

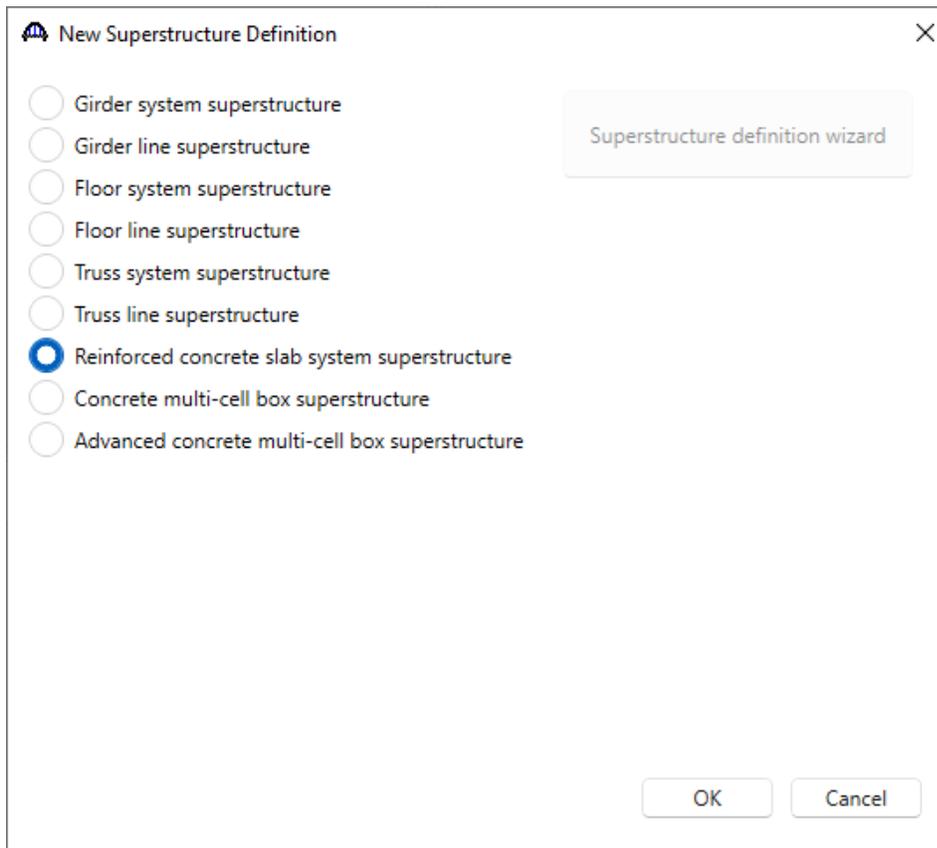
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Superstructure

Double click on **SUPERSTRUCTURE DEFINITIONS** (or click on **SUPERSTRUCTURE DEFINITIONS** and select the **New** button from the **Manage** group of the **WORKSPACE** ribbon or right click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the popup menu) to create a new structure definition.



Select **Reinforced concrete slab system superstructure**.

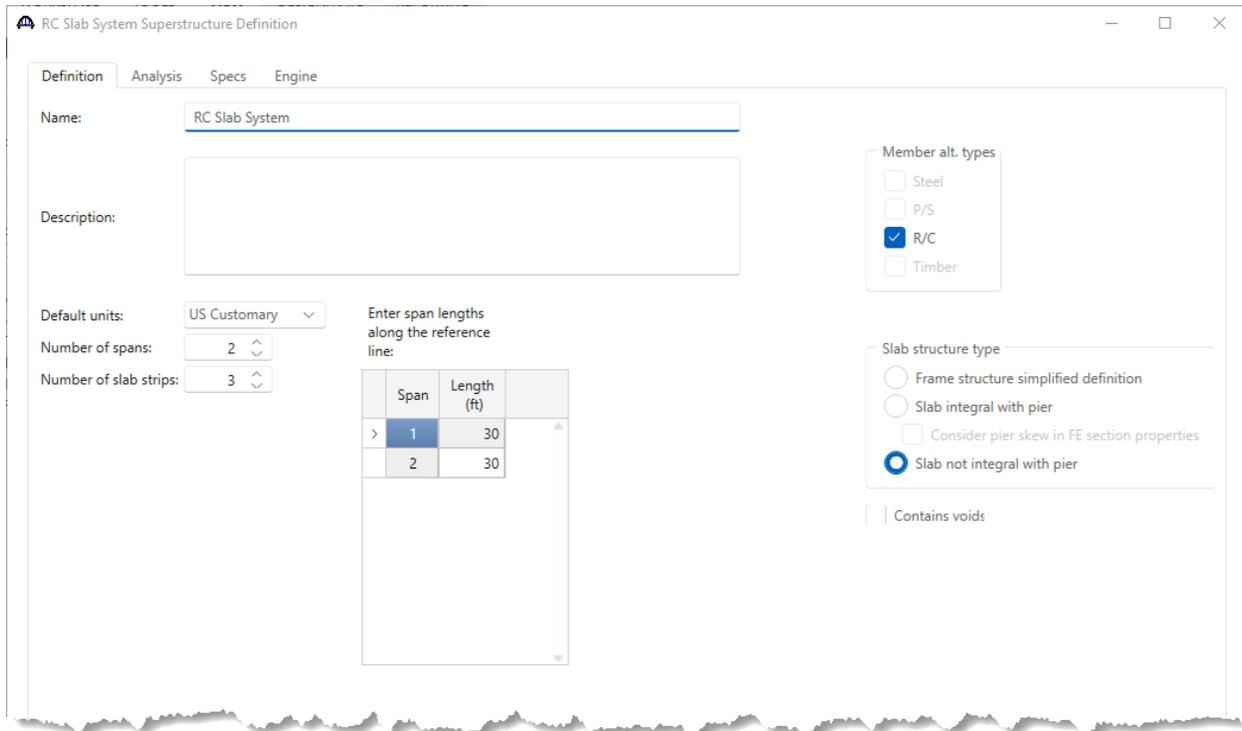


Click on **OK** to close the window and open the **RC Slab System Superstructure Definition** window.

RC Pier Supporting Slab System Example

RC Slab System Superstructure Definition

Enter the following description data in the **Superstructure Definition** window.



The screenshot shows the 'RC Slab System Superstructure Definition' dialog box with the following settings:

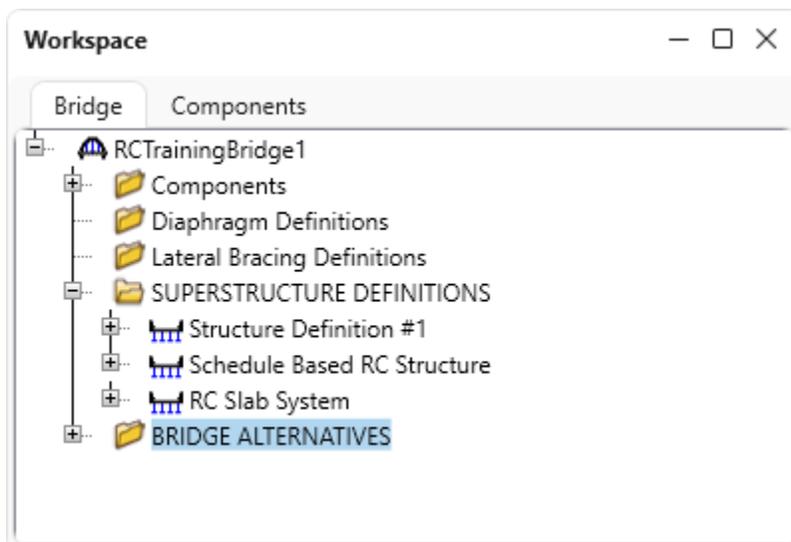
- Name: RC Slab System
- Description: (Empty text box)
- Default units: US Customary
- Number of spans: 2
- Number of slab strips: 3
- Member alt. types: Steel, P/S, R/C, Timber
- Slab structure type: Frame structure simplified definition, Slab integral with pier, Consider pier skew in FE section properties, Slab not integral with pier
- Contains voids: (Empty checkbox)
- Enter span lengths along the reference line:

	Span	Length (ft)
>	1	30
	2	30

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

Bridge Alternatives

Navigate to the **BRIDGE ALTERNATIVES** and create a new bridge alternative.



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Enter the following description data in the **Bridge Alternative** window.

The screenshot shows a software window titled "Bridge Alternative" with standard window controls (minimize, maximize, close). The "Alternative name" field contains "RC Slab System Alt". There are two tabs: "Description" (selected) and "Substructures".

Under the "Description" tab, there is a large empty text box for "Description:". Below it, there are several input fields and options:

- Horizontal curvature
- Reference line length: 60 ft
- Start bearing (selected) and End bearing
- Starting station: 0 ft
- Bearing: N 90° 0' 0.00" E

There is a "Global positioning" section with a rounded border containing:

- Distance: 0 ft
- Offset: 0 ft
- Elevation: [empty] ft

Below these are "Bridge alignment" options:

- Curved (selected)
- Tangent, curved, tangent
- Tangent, curved
- Curved, tangent

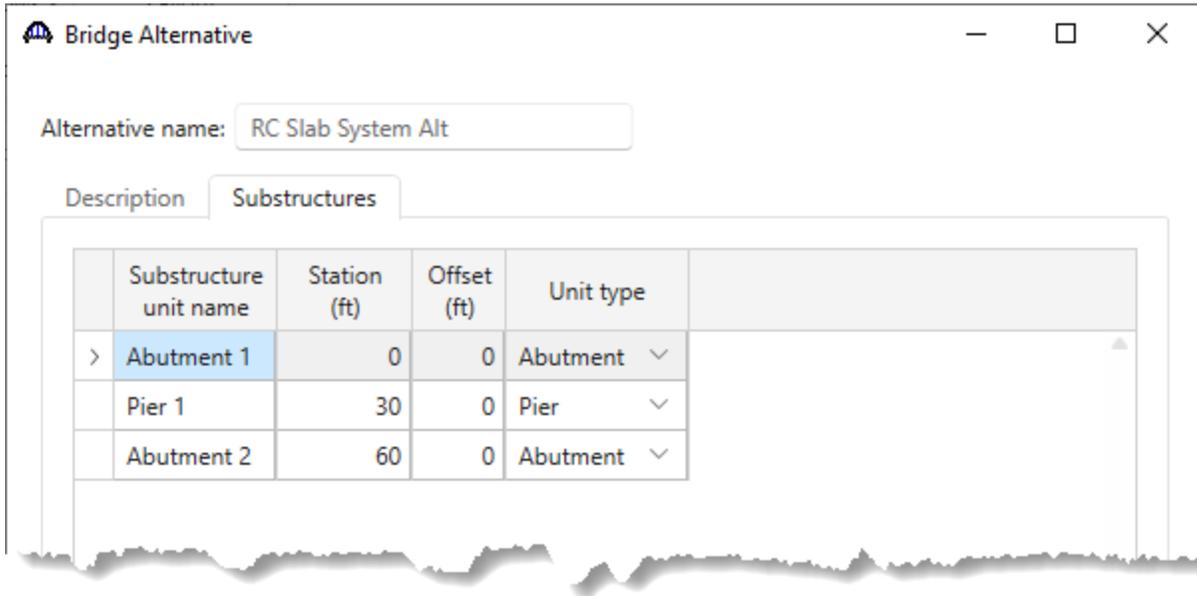
To the right of the alignment options are more input fields:

- Start tangent length: [empty] ft
- Curve length: [empty] ft
- Radius: [empty] ft
- Direction: Left (dropdown menu)
- End tangent length: [empty] ft

At the bottom left, there are two buttons: "Superstructure wizard..." and "Culvert wizard...". At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

RC Pier Supporting Slab System Example

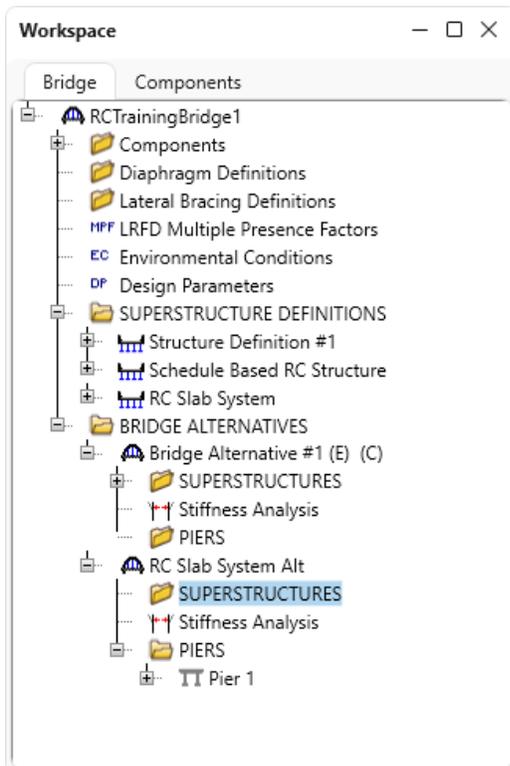
Navigate to the **Substructures** tab and define the substructure information as follows.



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

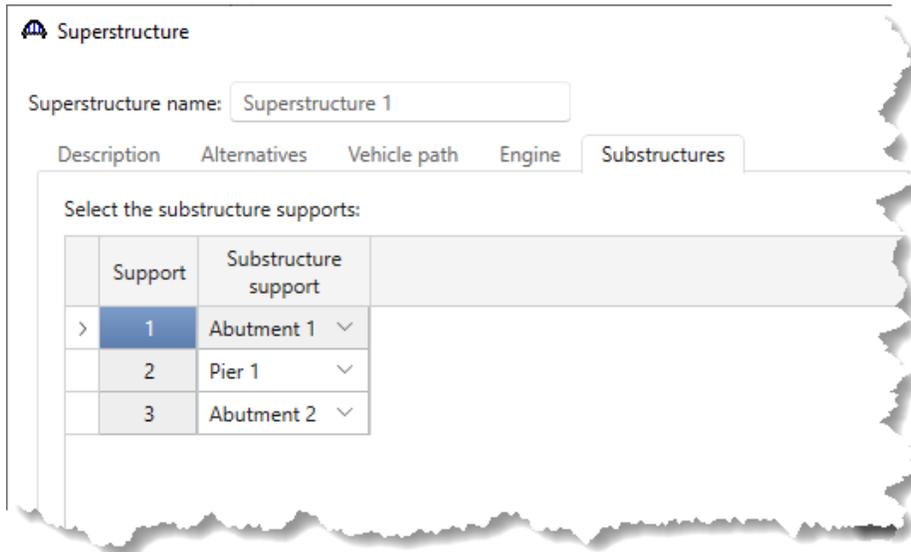
Superstructures

Double click on **SUPERSTRUCTURES** to create a new superstructure.



RC Pier Supporting Slab System Example

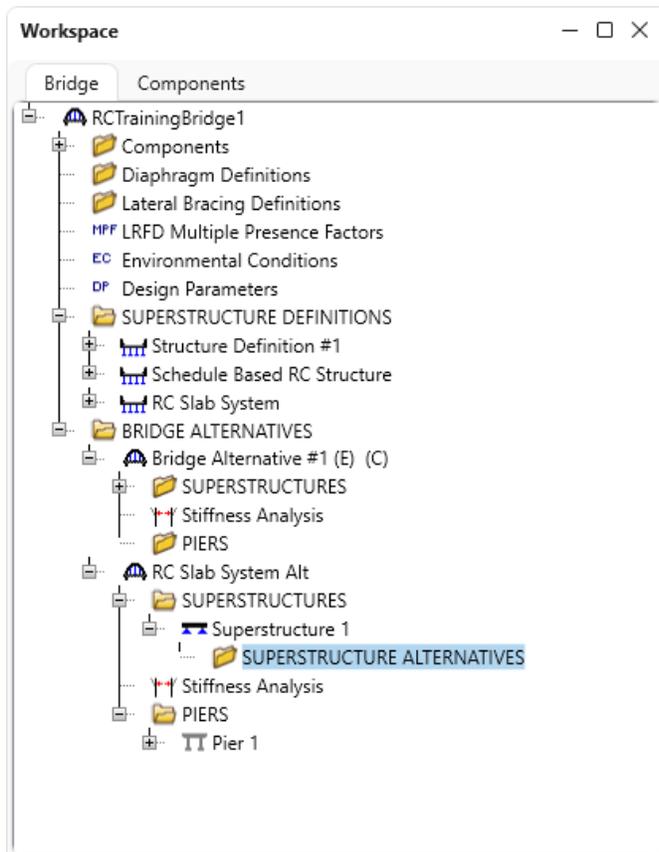
Enter the following description data in the **Superstructure** window.



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

Superstructure Alternative

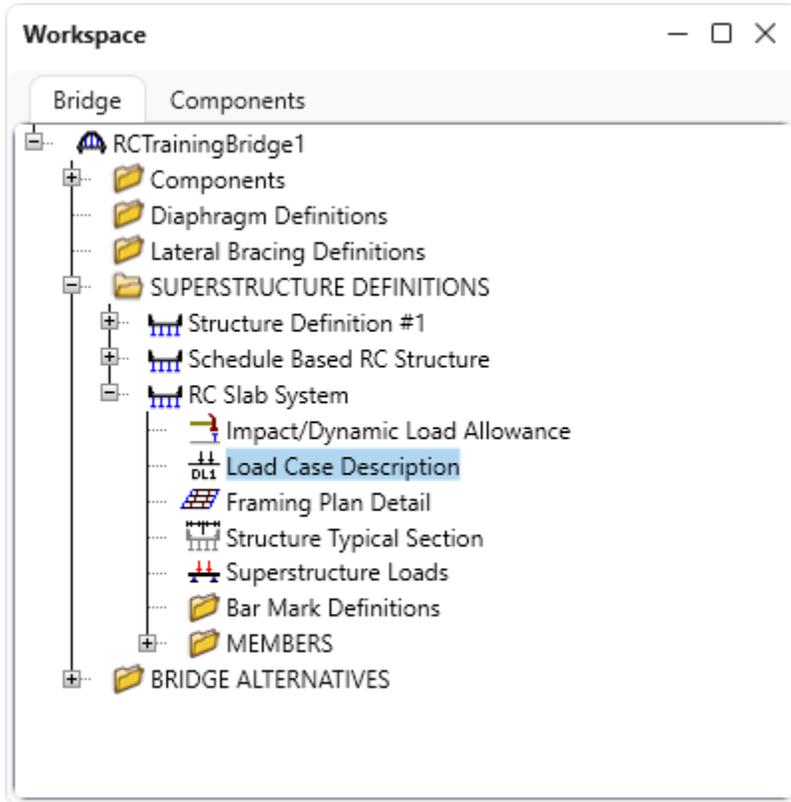
Double click on **SUPERSTRUCTURE ALTERNATIVES** to create a new superstructure alternative.



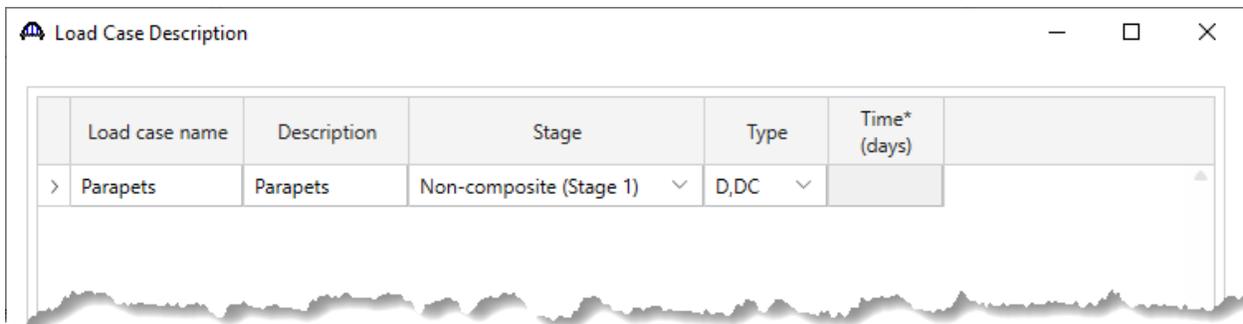
RC Pier Supporting Slab System Example

Load Case Description

Go back to **Superstructure Definition** and open the **Load Case Description** window in the Bridge Workspace tree to define the load cases.



The completed Load Case Description window is shown below.

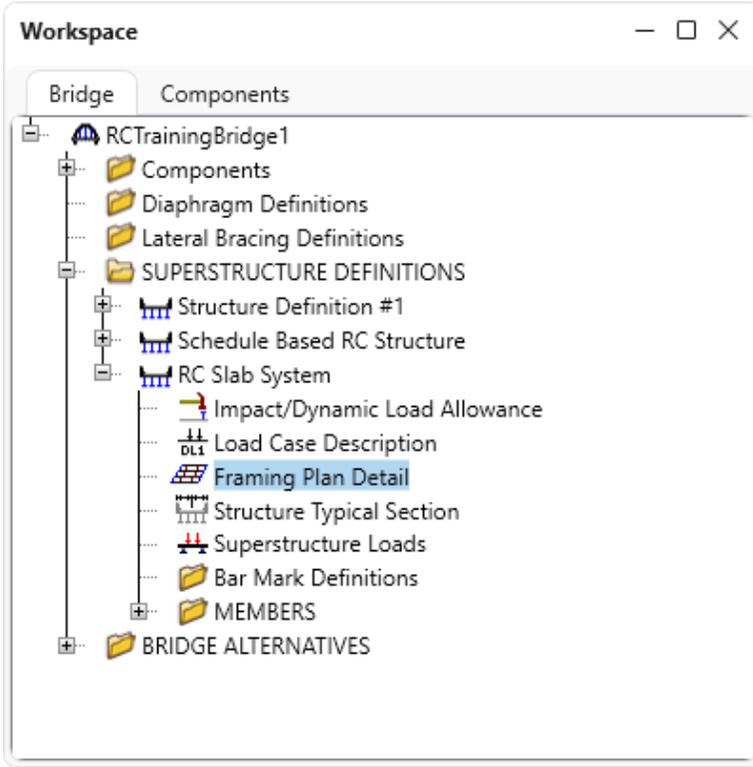


Click on **OK** to apply the data and close the window.

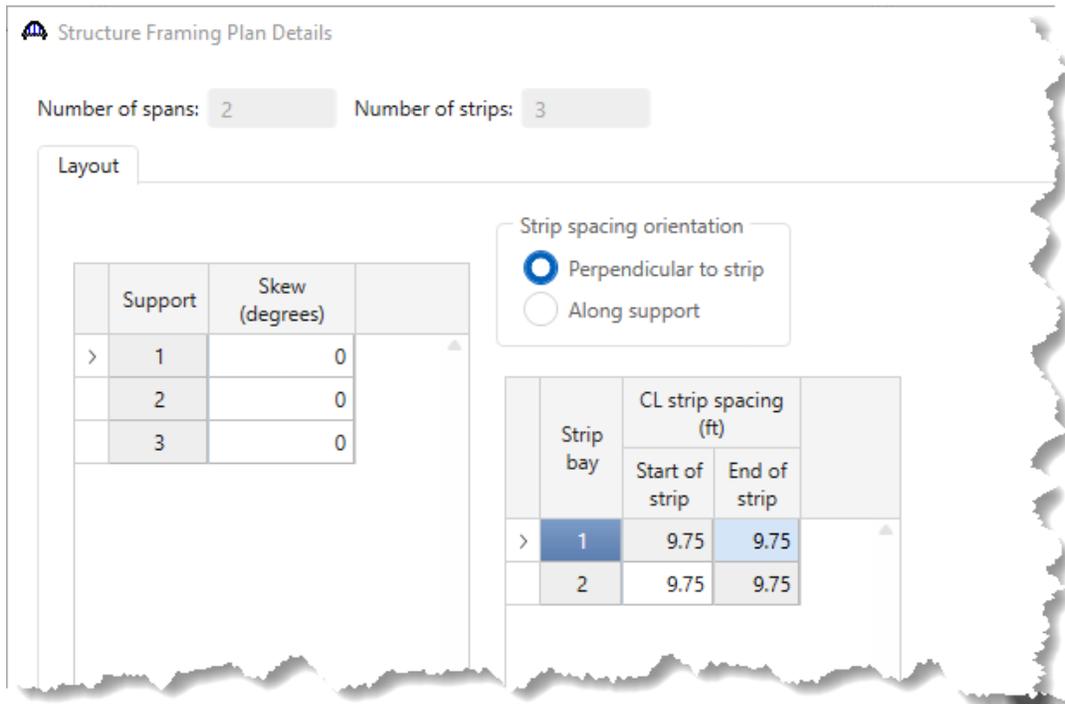
RC Pier Supporting Slab System Example

Framing Plan Detail

Open the **Framing Plan Detail** window in the Bridge Workspace tree to define the skew angles and strip spacing.



The completed **Framing Plan Details** window is shown below.

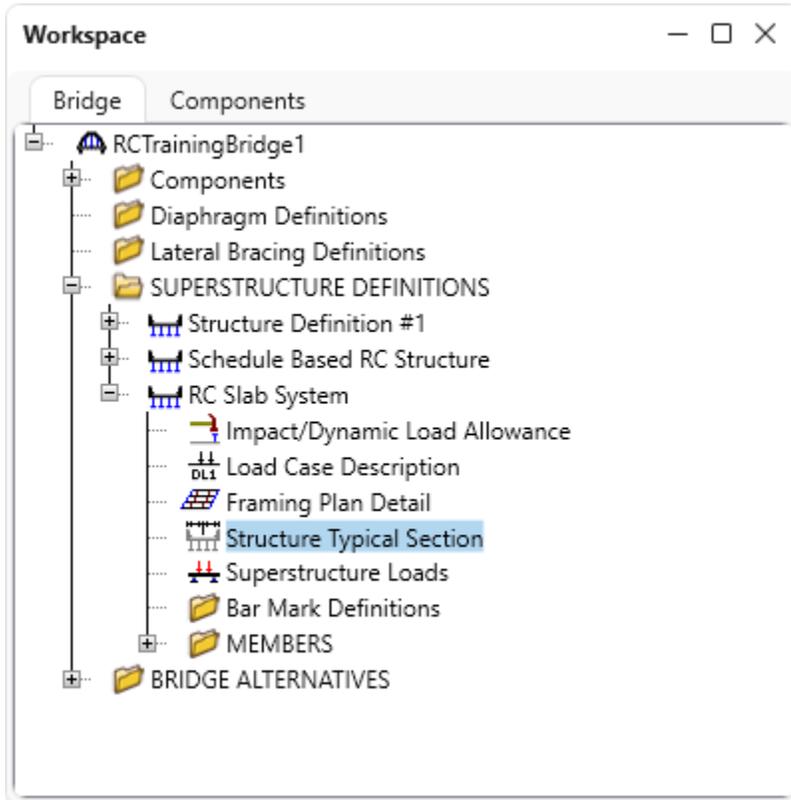


Click on **OK** to apply the data and close the window.

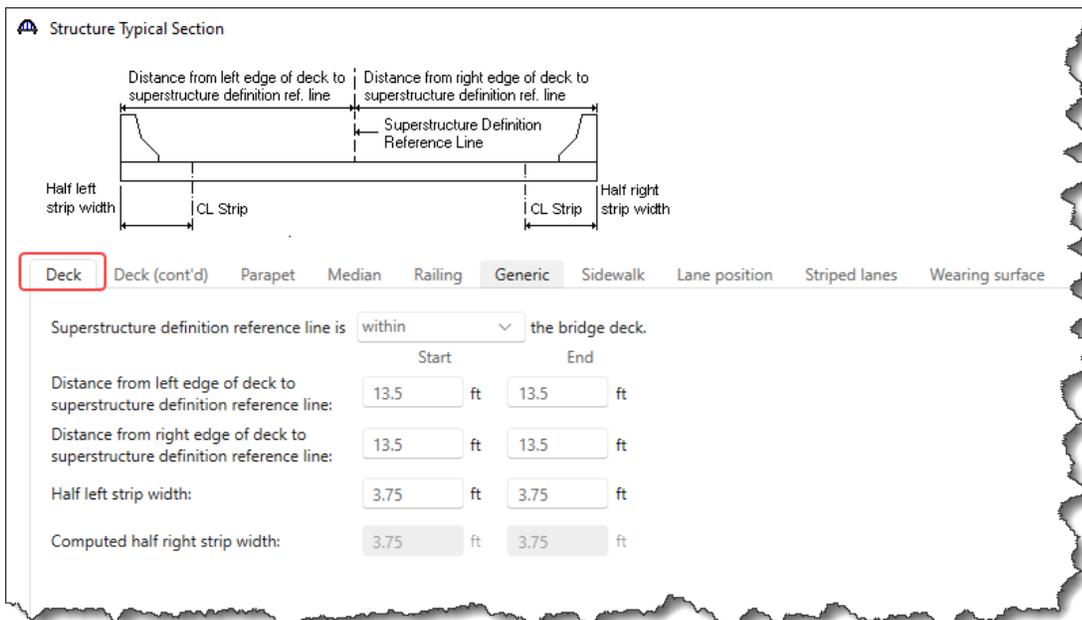
RC Pier Supporting Slab System Example

Structure Typical Section

Define the structure typical section by double-clicking on **Structure Typical Section** in the Bridge Workspace tree.

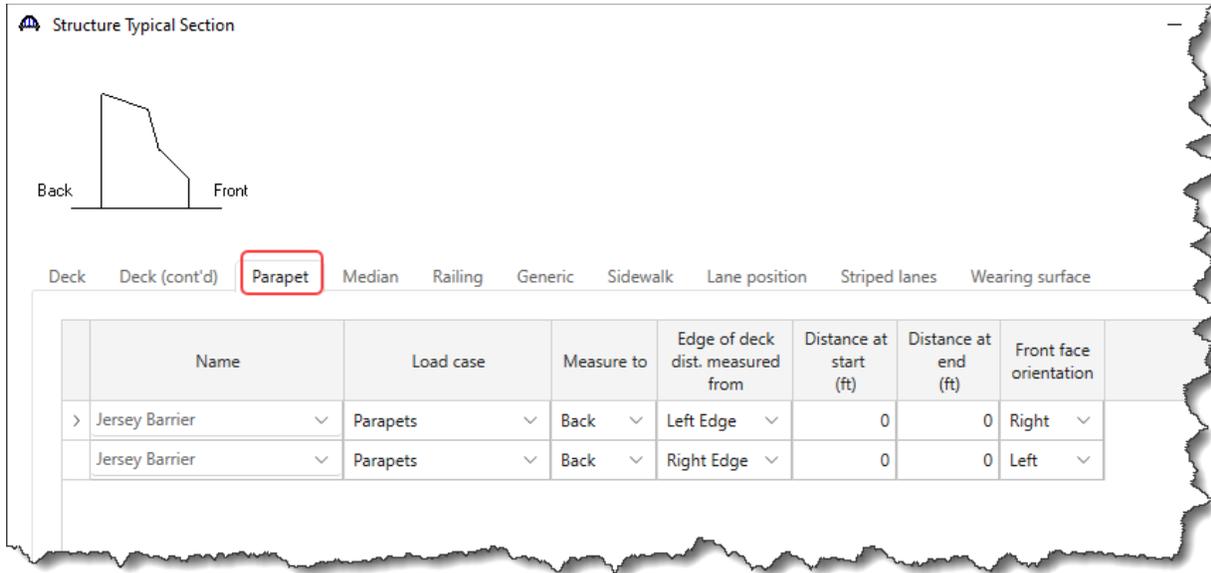


Input the data in the **Structure Typical Section** window describing the typical section as shown below.

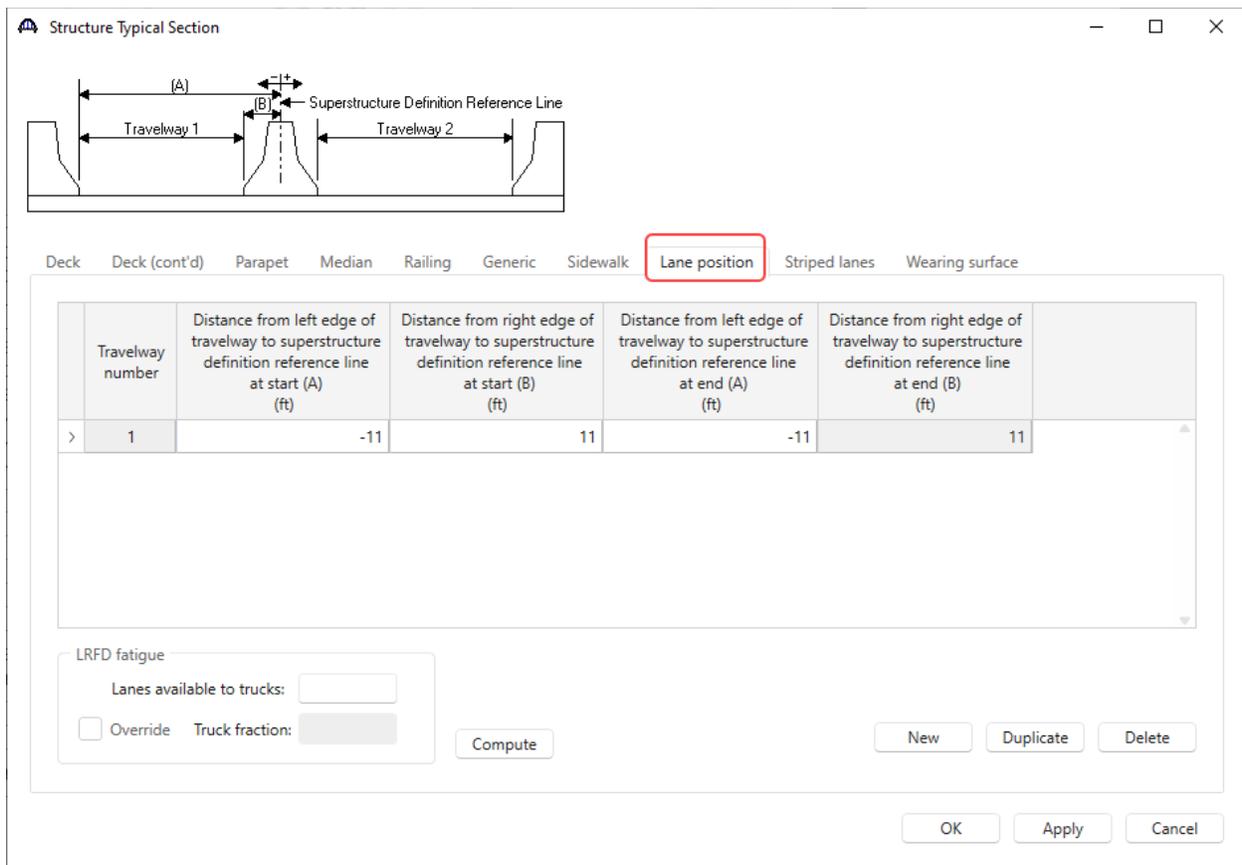


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Input the data describing the right and left parapets in the **Parapet** tab of this window as shown below.



Input the data describing the **Lane Position** as shown below.

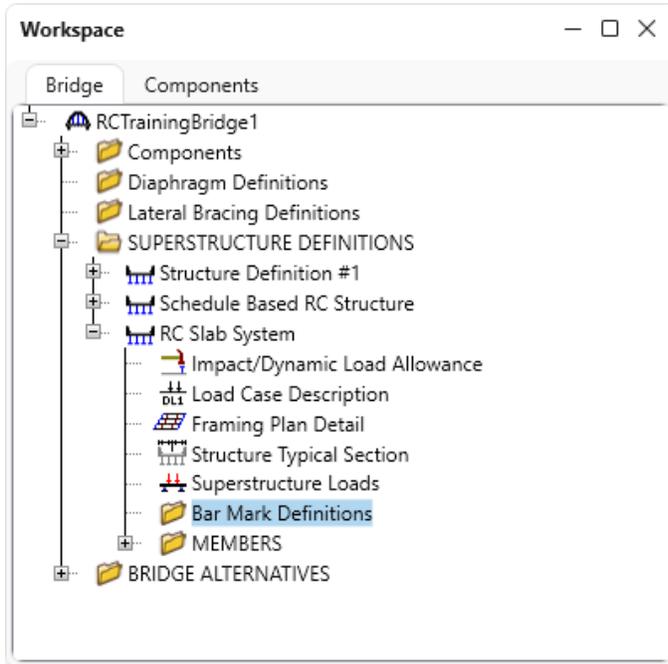


Click on **OK** to apply the data and close the window.

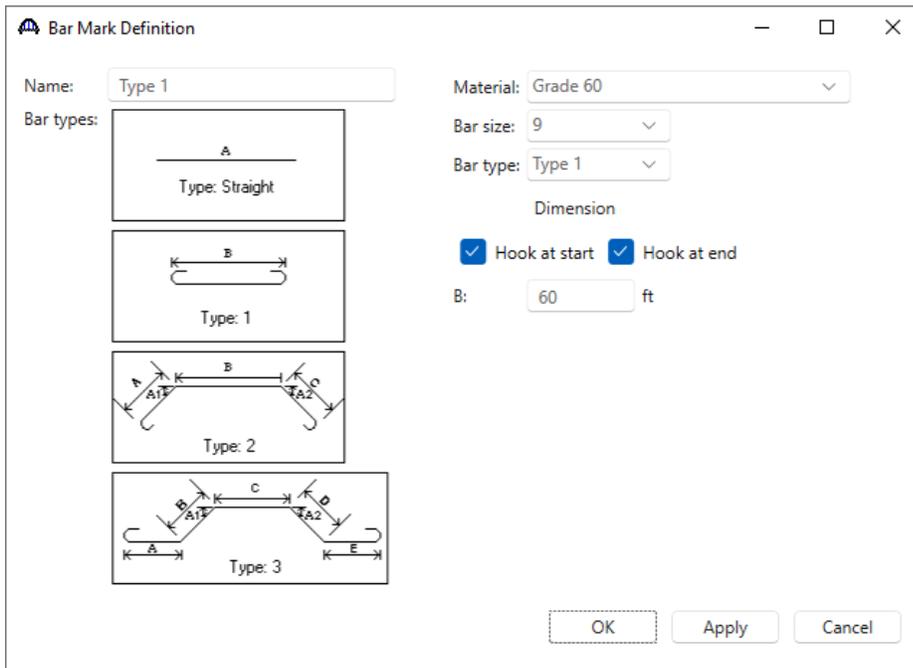
RC Pier Supporting Slab System Example

Bar Mark Definitions

Open the **Bar Mark Definitions** window in the Bridge Workspace tree to define a bar mark definition for the reinforced concrete slab.



The bar mark definitions are used to describe a schedule of flexural reinforcement in the **Strip Profile - Reinforcement** tab. Input the data as shown below.

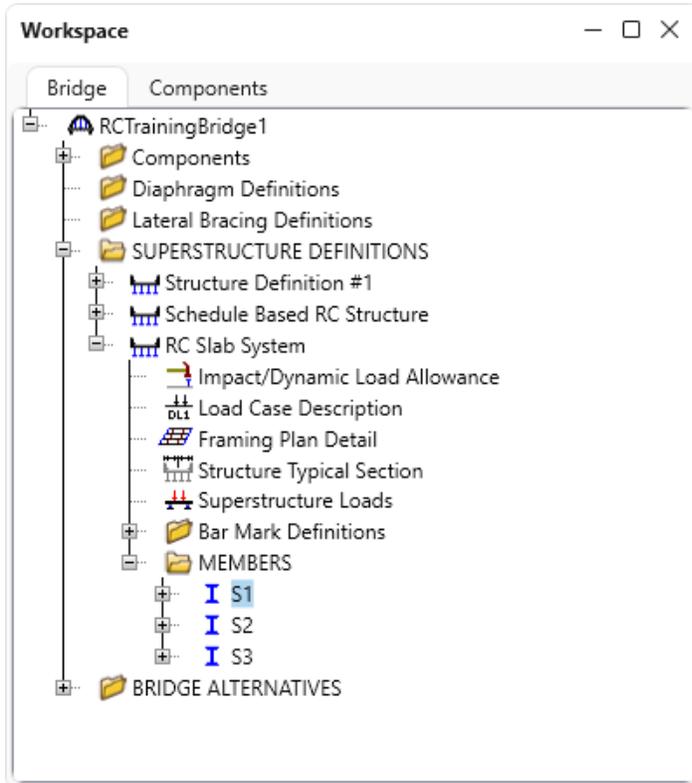


Click on **OK** to apply the data and close the window.

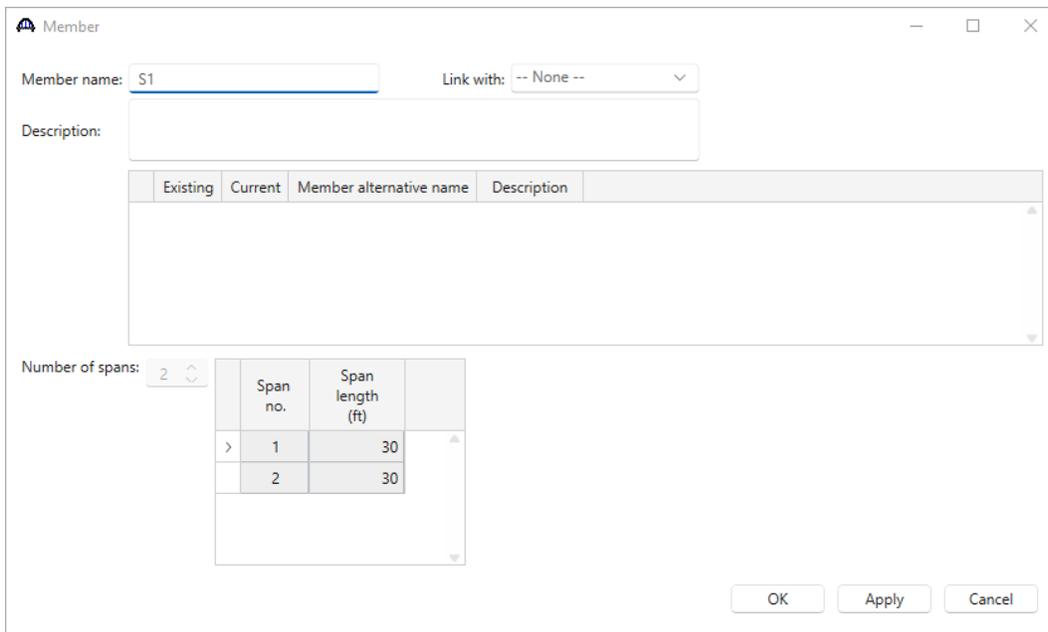
RC Pier Supporting Slab System Example

Describing a member

Double click on **S1** under **MEMBERS**. The member window will pop up and show the data that was generated when the structure definition was created.



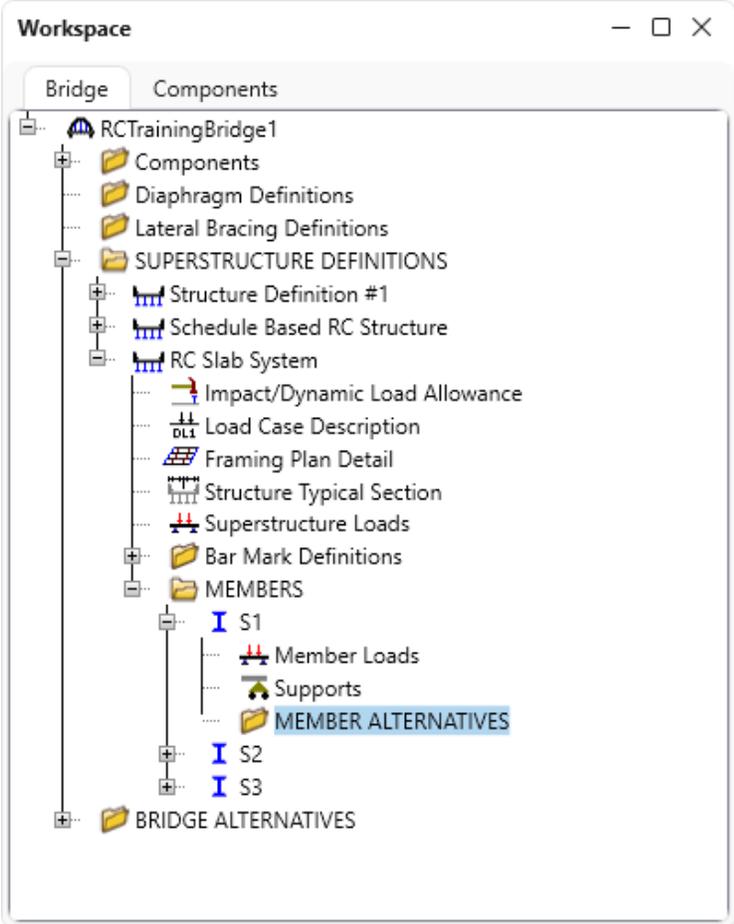
No changes are required in this window. The first **Member Alternative** created will automatically be assigned as the **Existing** and **Current** member alternative for this **Member**.



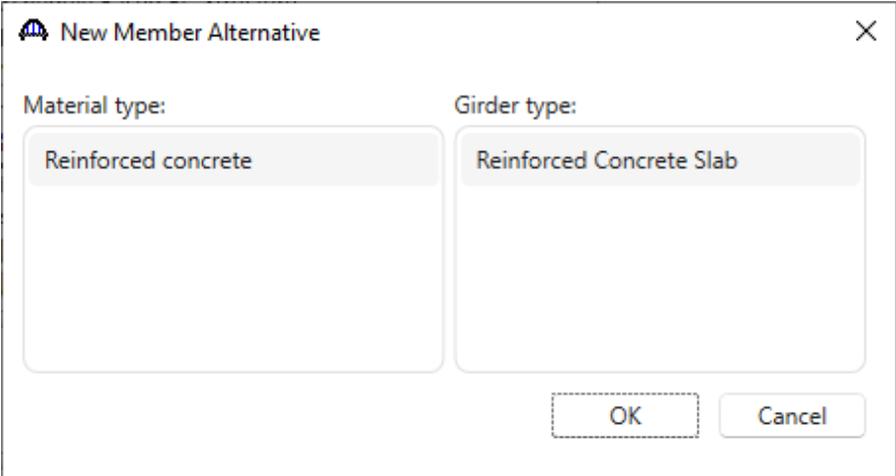
RC Pier Supporting Slab System Example

Defining a Member Alternative:

Double click on the **MEMBER ALTERNATIVES** in the tree to create a new member alternative.



The **New Member Alternative** window shown below will open. Select **Reinforced Concrete** for the **Material type** and **Reinforced Concrete Slab** for the **Girder type**.



Click **OK** to close the window and create a new member alternative.

RC Pier Supporting Slab System Example

The **Member Alternative Description** window will open. Enter the data as shown below.

Member alternative: S1

Description Specs Factors Engine Import Control options

Description:

Material type: Reinforced Concrete

Girder type: Reinforced Concrete Slab

Default units: US Customary

Girder property input method

Schedule based

Cross-section based

End bearing locations

Left: 6 in

Right: 6 in

Edge beam

Self load

Additional self load: kip/ft

Additional self load: %

Default rating method: LFR

Analysis strip

Full slab section width

User defined in

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

Strip Profile

Double click on the **Strip Profile** node in the Bridge Workspace tree and enter the data shown below describing the slab strip.

Strip Profile

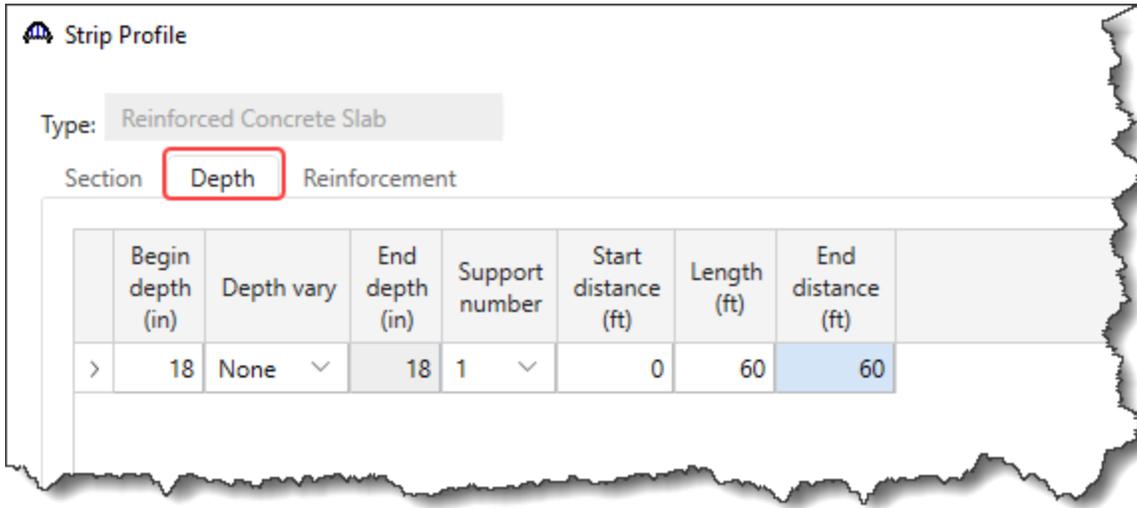
Type: Reinforced Concrete Slab

Section Depth Reinforcement

	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Start width (in)	End width (in)	Concrete material	Modular ratio
>	1	0	60	60	90	90	Class A (US)	

RC Pier Supporting Slab System Example

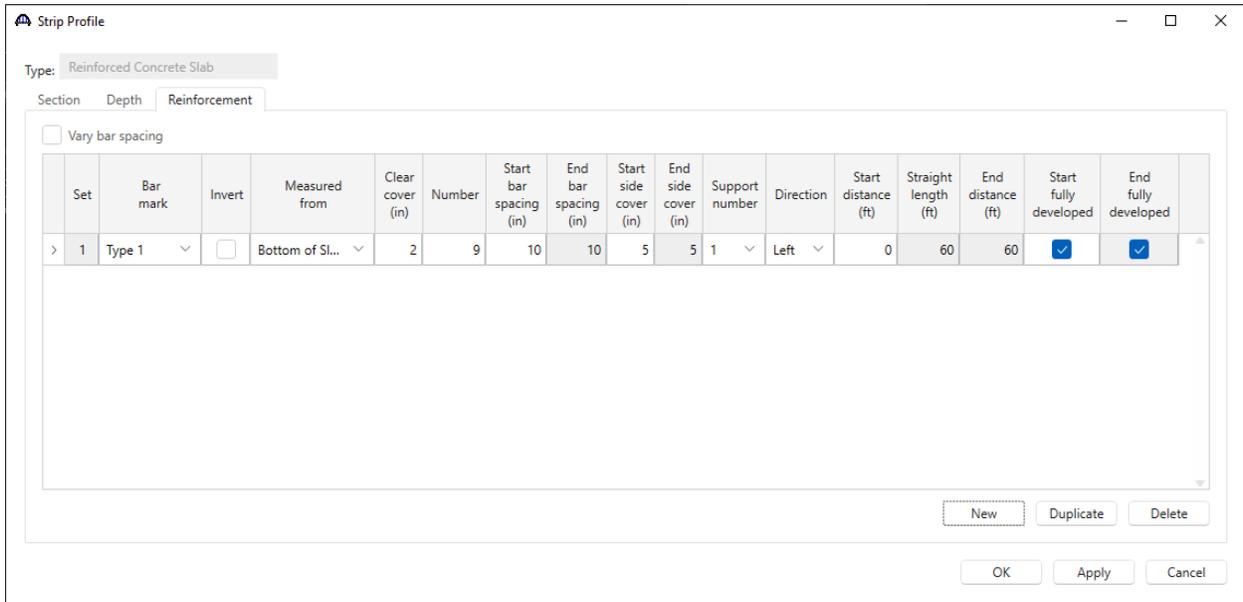
Navigate to the **Depth** tab and enter the data below to define the depth of the slab strip.



The screenshot shows the 'Strip Profile' dialog box with the 'Depth' tab selected. The 'Type' is 'Reinforced Concrete Slab'. The 'Section' tab is also visible. The 'Depth' tab contains a table with the following data:

	Begin depth (in)	Depth vary	End depth (in)	Support number	Start distance (ft)	Length (ft)	End distance (ft)
>	18	None	18	1	0	60	60

Switch to the **Reinforcement** tab and enter the data below to define the reinforcement in the slab strip.



The screenshot shows the 'Strip Profile' dialog box with the 'Reinforcement' tab selected. The 'Type' is 'Reinforced Concrete Slab'. The 'Reinforcement' tab contains a table with the following data:

	Set	Bar mark	Invert	Measured from	Clear cover (in)	Number	Start bar spacing (in)	End bar spacing (in)	Start side cover (in)	End side cover (in)	Support number	Direction	Start distance (ft)	Straight length (ft)	End distance (ft)	Start fully developed	End fully developed
>	1	Type 1	<input type="checkbox"/>	Bottom of Sl...	2	9	10	10	5	5	1	Left	0	60	60	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Buttons: New, Duplicate, Delete, OK, Apply, Cancel

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

The description of member alternative S1 is complete.

RC Pier Supporting Slab System Example

Member Alternative Description - S2

Definition of the member alternative for **S2** is the same as the definition of the member alternative for **S1** except for the strip profile. The window is shown below with the data describing the **Slab Strip S2**.

Member Alternative Description

Member alternative: S2

Description Specs Factors Engine Import Control options

Description:

Material type: Reinforced Concrete

Girder type: Reinforced Concrete Slab

Default units: US Customary

Girder property input method: Schedule based Cross-section based

End bearing locations: Edge beam

Left: 6 in

Right: 6 in

Self load: Additional self load: kip/ft

Additional self load: %

Default rating method: LFR

Analysis strip: Full slab section width User defined in

Strip Profile – S2

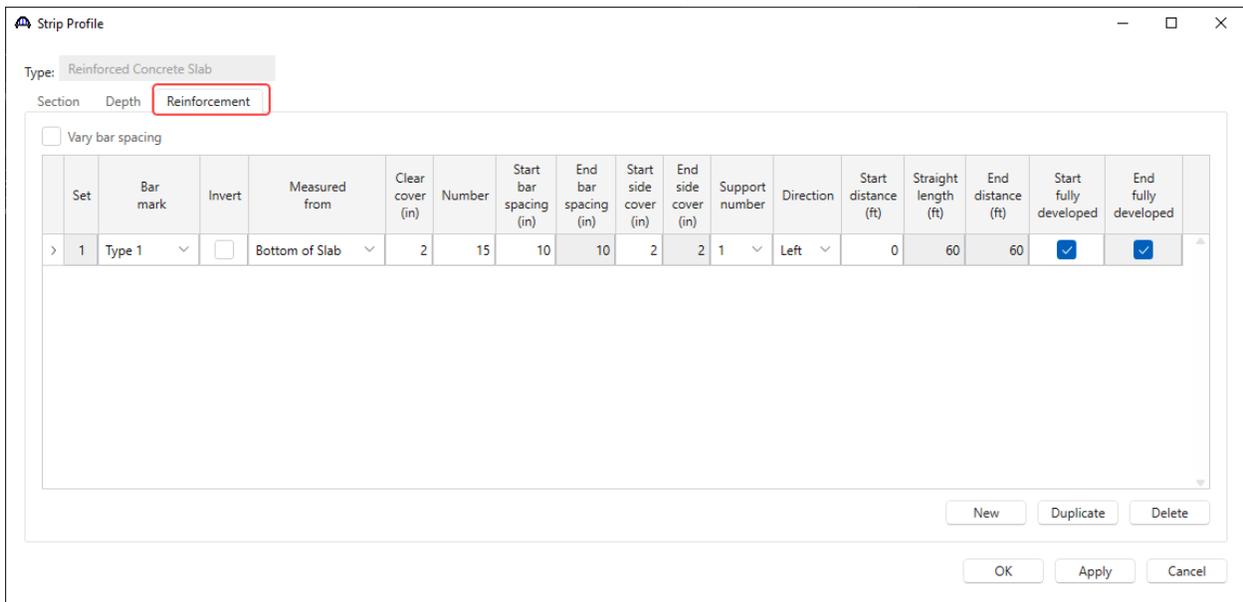
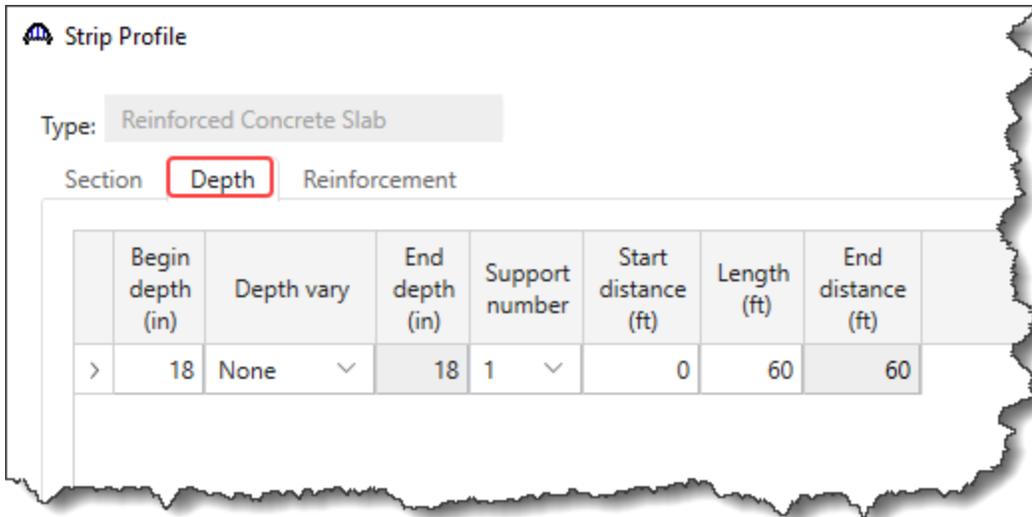
Strip Profile

Type: Reinforced Concrete Slab

Section Depth Reinforcement

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Start width (in)	End width (in)	Concrete material	Modular ratio
> 1	0	60	60	144	144	Class A (US)	

RC Pier Supporting Slab System Example



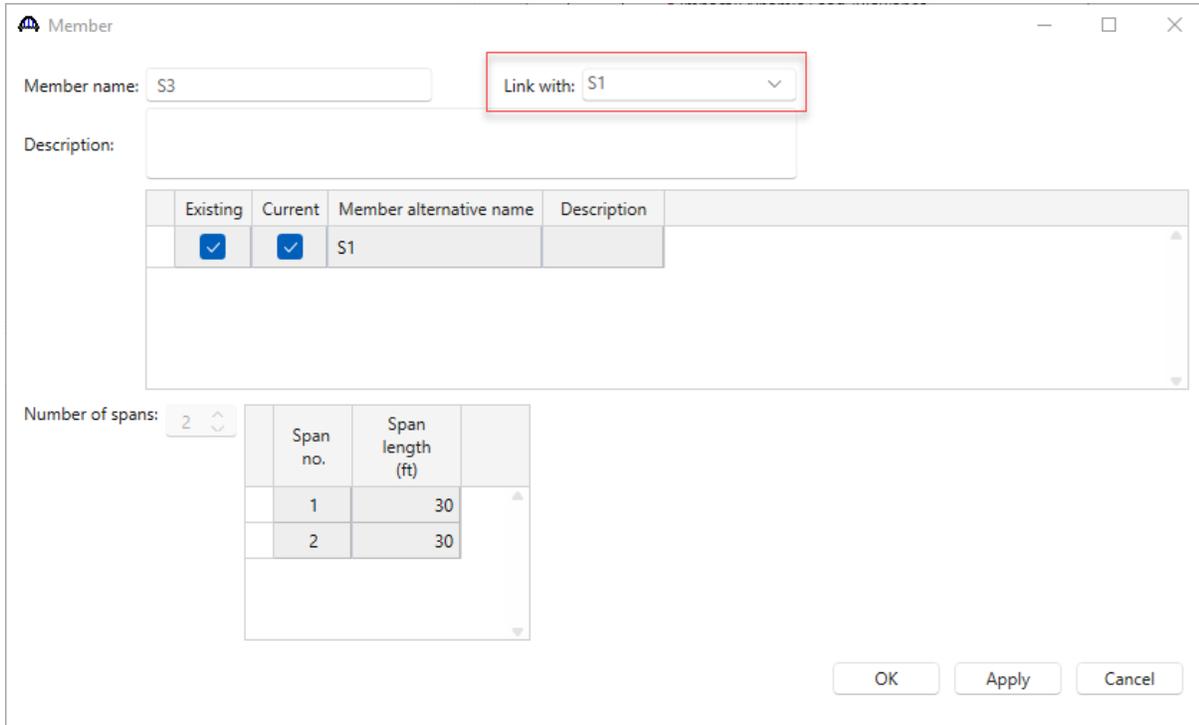
Click on **OK** to apply the data and close the window.

The description of member alternative S2 is complete.

RC Pier Supporting Slab System Example

Linking Members

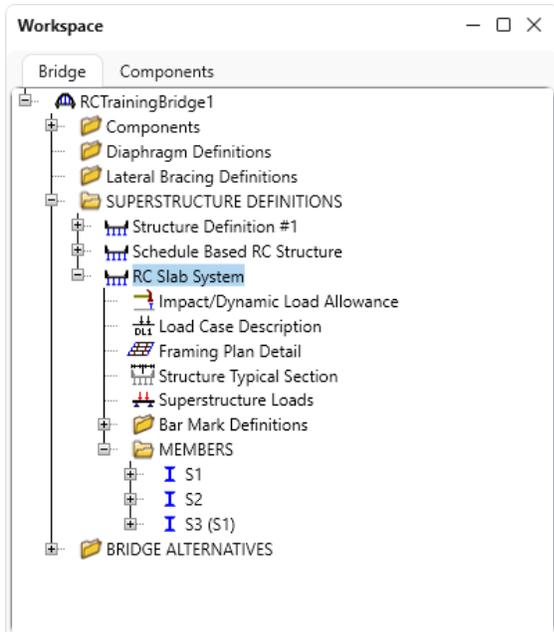
Link member **S3** with member **S1** so that they share the same definition. Open **Member S3** and select **Link with S1**.



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

The description of this structure is complete.

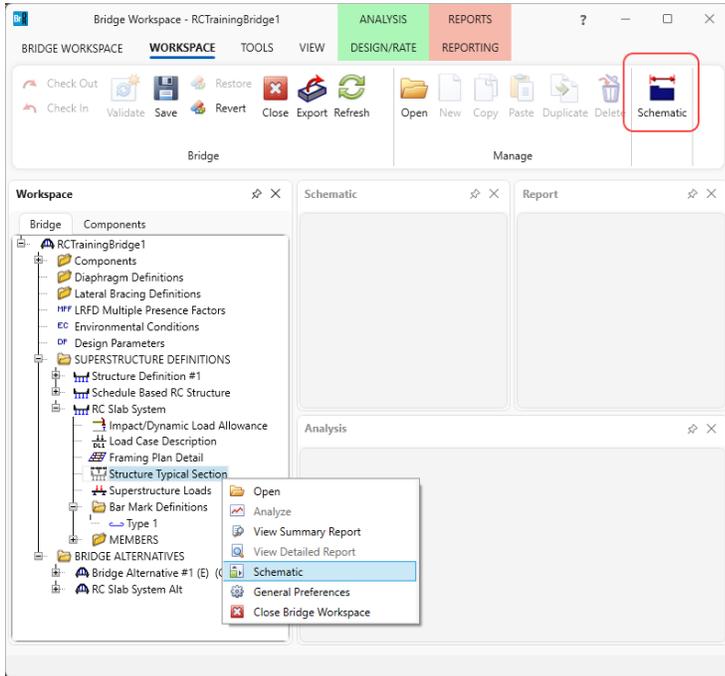
The partially expanded Bridge Workspace tree is shown below.



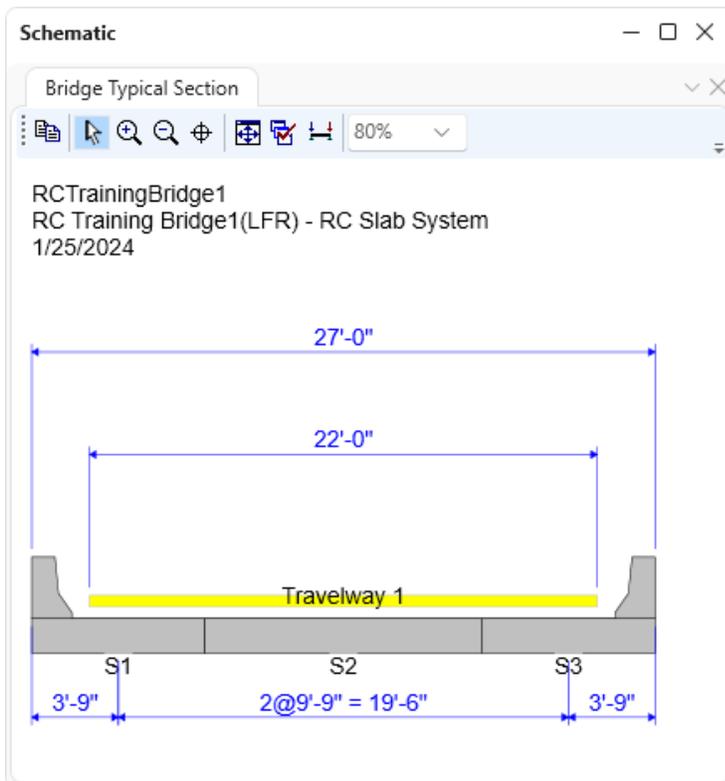
RC Pier Supporting Slab System Example

Schematic - Structure Typical Section

With **Structure Typical Section** selected in the **Bridge Workspace** tree, click on the **Schematic** button from the **WORKSPACE** ribbon (or right click and select **Schematic**).



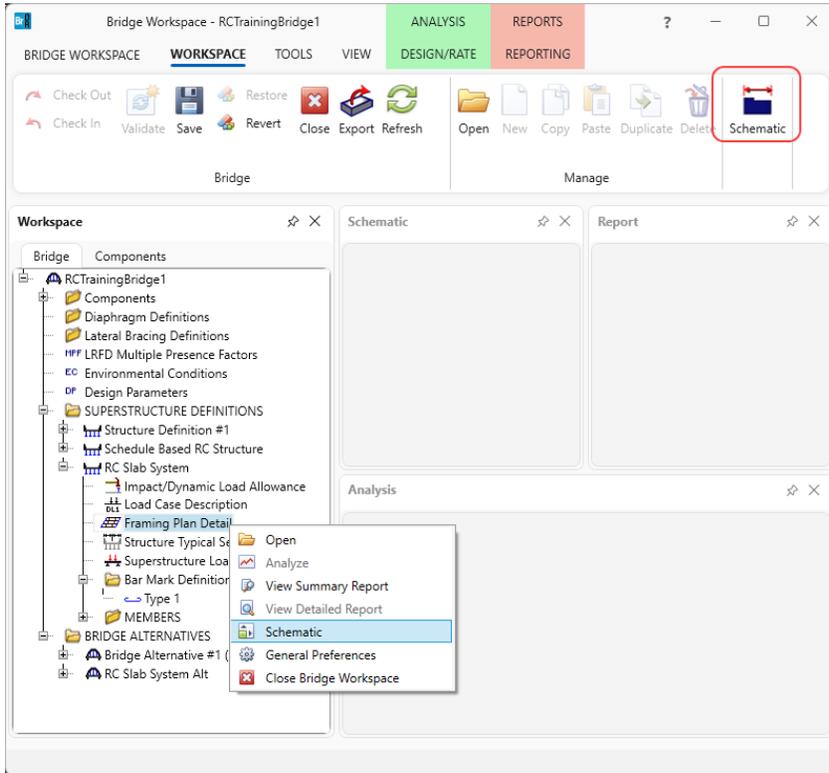
The figure below shows the cross section view of the reinforced concrete slab system superstructure.



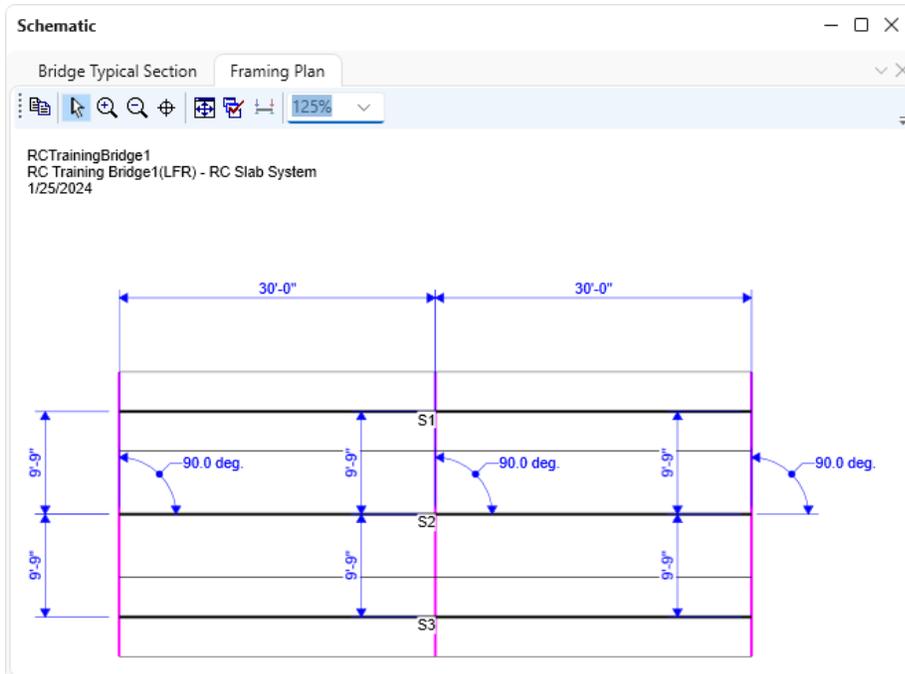
RC Pier Supporting Slab System Example

Schematic – Framing Plan Detail

With **Framing Plan Detail** selected in the **Bridge Workspace** tree, click on the **Schematic** button from the **WORKSPACE** ribbon (or right click and select **Schematic**).



The figure below shows the framing plan of the reinforced concrete slab system superstructure.

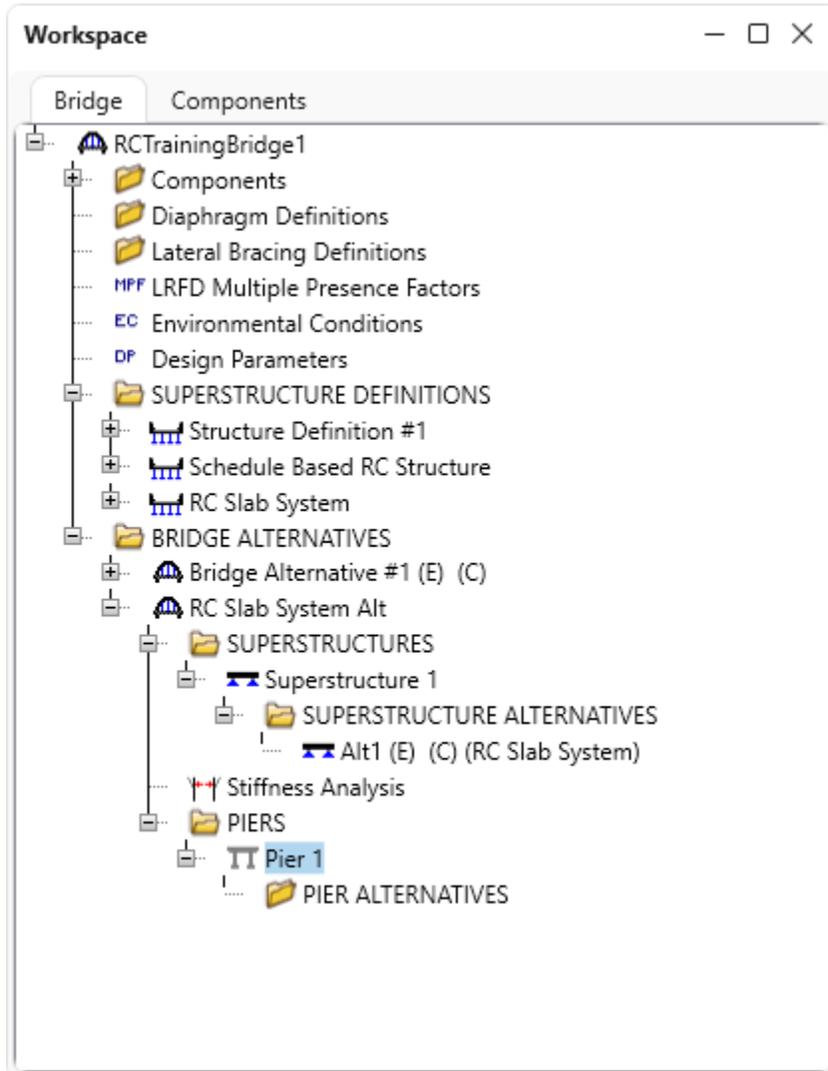


RC Pier Supporting Slab System Example

Substructure: Pier Alternative

The **BrDR Substructure** module has the capability to describe the pier gross geometry and reinforcement, compute loads acting on the pier, perform a finite element analysis of the pier, compute the load combination results and perform specification checks for the reinforcement.

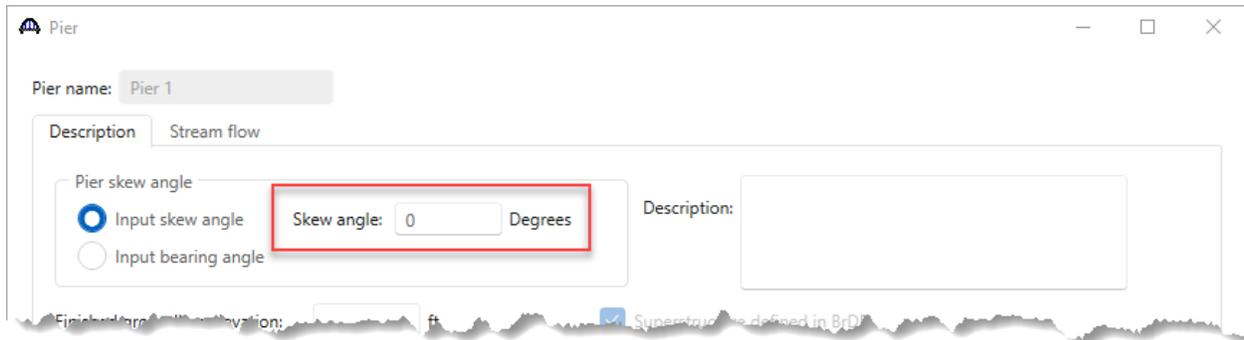
The partially expanded Bridge Workspace tree is shown below.



RC Pier Supporting Slab System Example

Pier

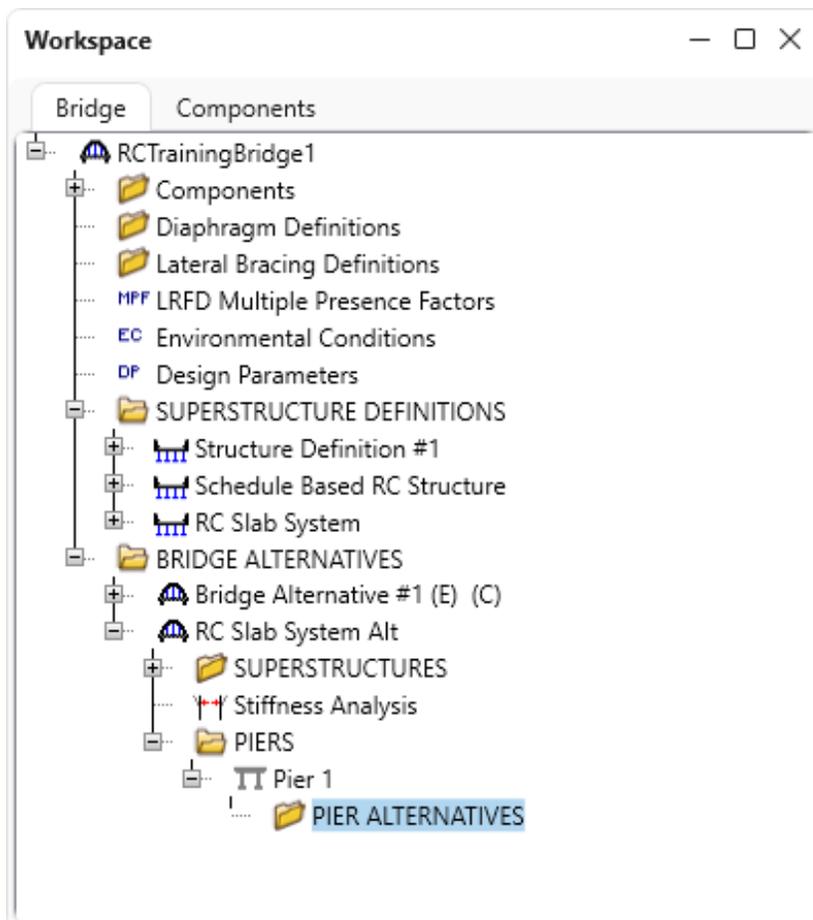
Double click on the **Pier 1** node in the Bridge Workspace tree to open the **Pier** window and verify that the **Skew angle** is 0 degrees.



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

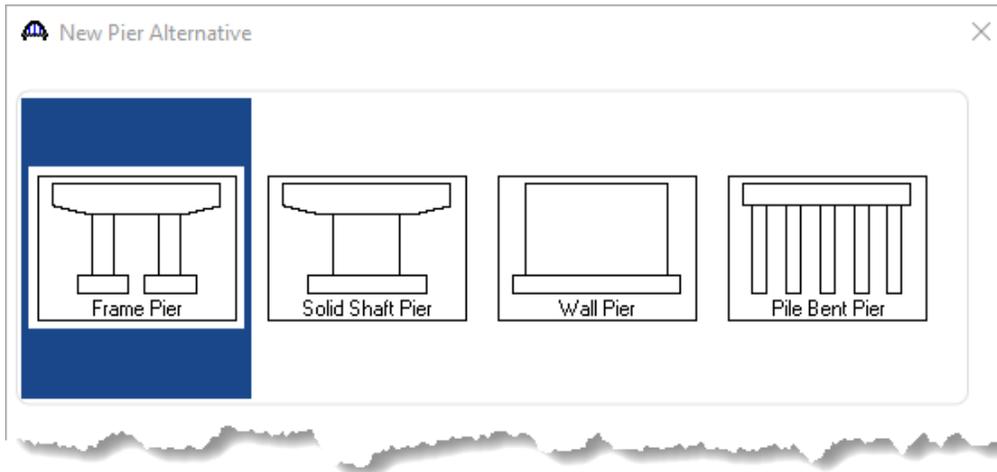
Pier Alternative

Double click on **PIER ALTERNATIVES** in the Bridge Workspace tree to create a new pier alternative.



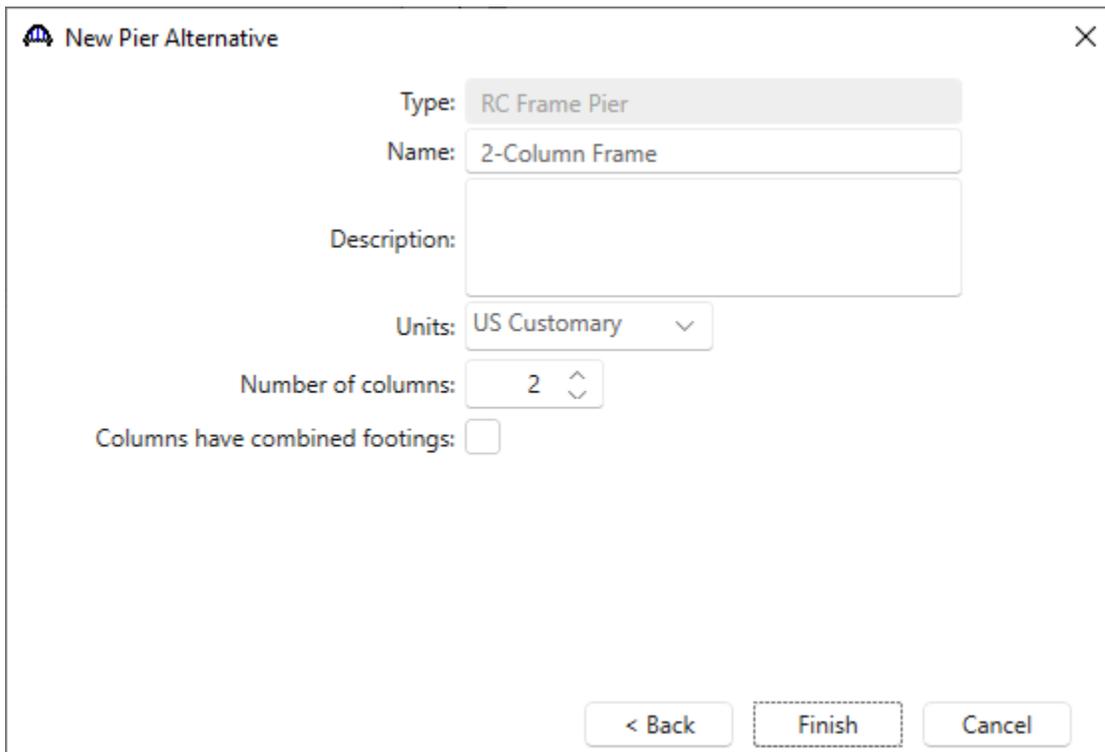
RC Pier Supporting Slab System Example

Four types of reinforced concrete pier alternatives can be described: frame piers, solid shaft (hammerhead) piers, wall piers and pile bent piers, as shown in the figure below.



In this example, the two span continuous reinforced concrete slab system superstructure is supported by a 2-column frame pier. Select the **Frame Pier** and click the **Next** button.

Enter a **Name** for the pier alternative, change the **Number of columns** to **2** as shown below.

A screenshot of the "New Pier Alternative" dialog box with the following configuration:

- Type: RC Frame Pier
- Name: 2-Column Frame
- Description: (empty text box)
- Units: US Customary
- Number of columns: 2
- Columns have combined footings:

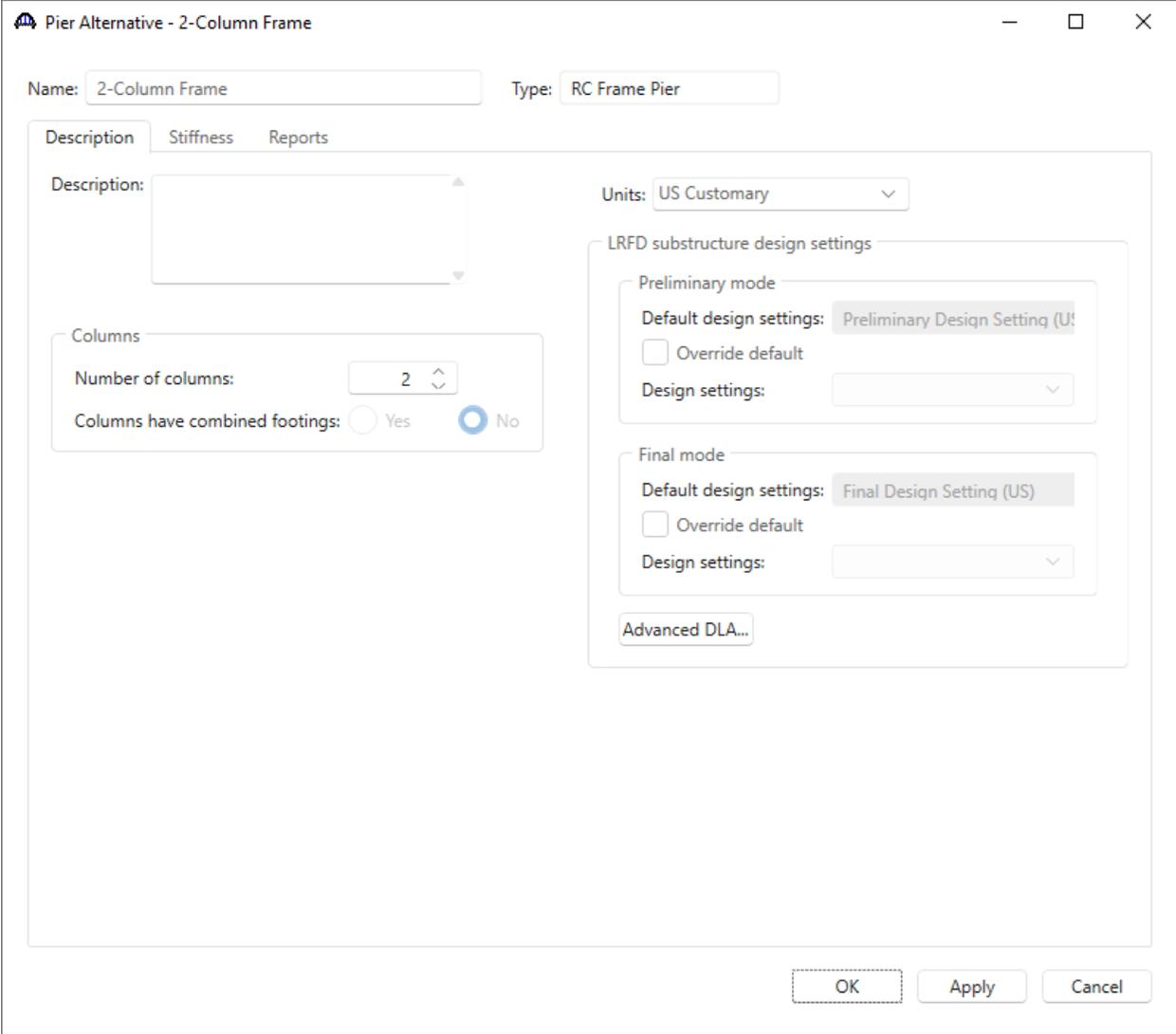
At the bottom, there are three buttons: "< Back", "Finish", and "Cancel".

Click **Finish** to close the wizard and create the new pier alternative.

Please note that switching between combined/independent footings is not permitted once a selection is made here. A new pier alternative will have to be created to change the footing type.

RC Pier Supporting Slab System Example

The **Pier Alternative** window will automatically open.



Overriding the default design settings can be done on this window.

RC Pier Supporting Slab System Example

Navigate to the **Stiffness** tab. This tab computes information about the stiffness of the pier to assist in determining the type of structural analysis required. Since pier geometry is not entered by the user yet, BrDR cannot compute the slenderness ratio and the **Compute slenderness ratio** button is disabled.

Pier Alternative - 2-Column Frame

Name: 2-Column Frame Type: RC Frame Pier

Description **Stiffness** Reports

Compute slenderness ratio

Analysis method
Method: First Order Elastic

Slenderness values cannot be computed until the pier gross geometry is entered.

Pier longitudinal axis

Sidesway
 Braced Unbraced

Unbraced length: ft Effective length factor, K: 0.65

Slenderness results

Up-to-date

Gross area: 0 ft² Moment of inertia: 0 ft⁴ Radius of gyration: 0 ft

KL/r: 0

Pier transverse axis

Sidesway
 Braced Unbraced

Unbraced length: ft Effective length factor, K: 2

Slenderness results

Up-to-date

Gross area: 0 ft² Moment of inertia: 0 ft⁴ Radius of gyration: 0 ft

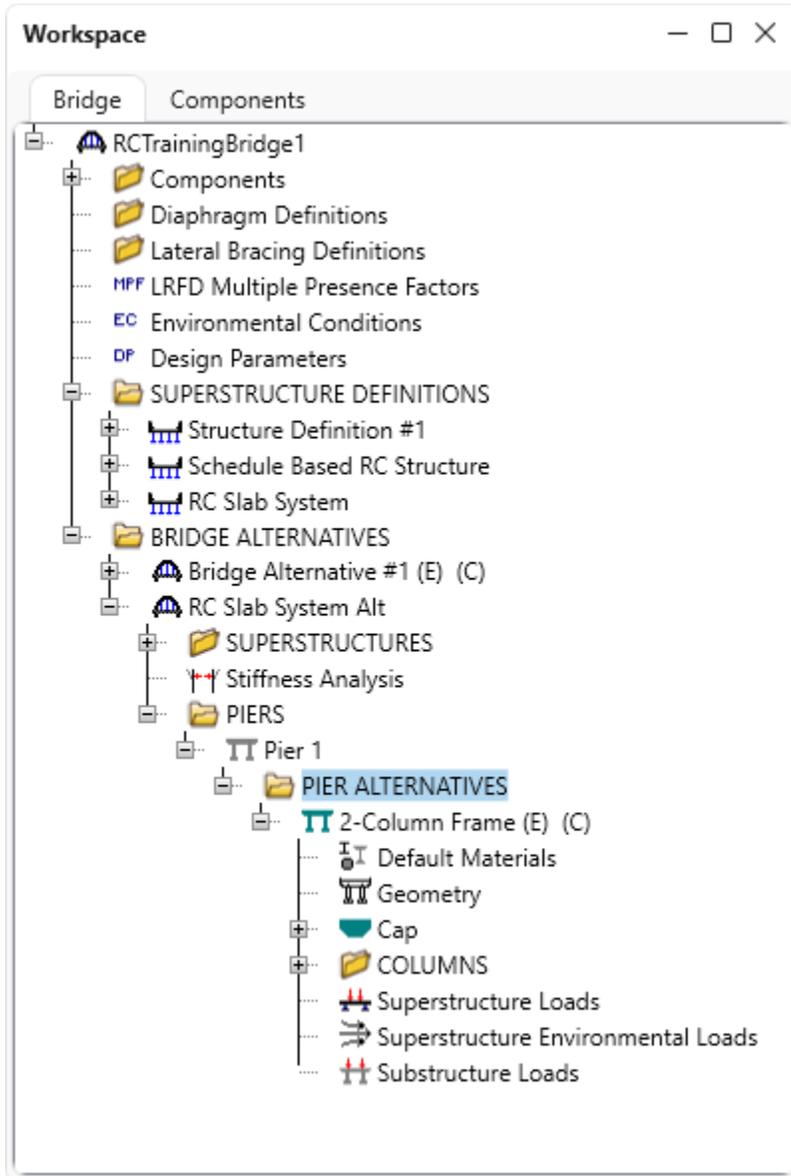
KL/r: 0

OK Apply Cancel

There is no data to be entered in this window so click the **Ok** button to close this window. Do not click the Cancel button as that will cause the creation of the new pier alternative to be canceled.

RC Pier Supporting Slab System Example

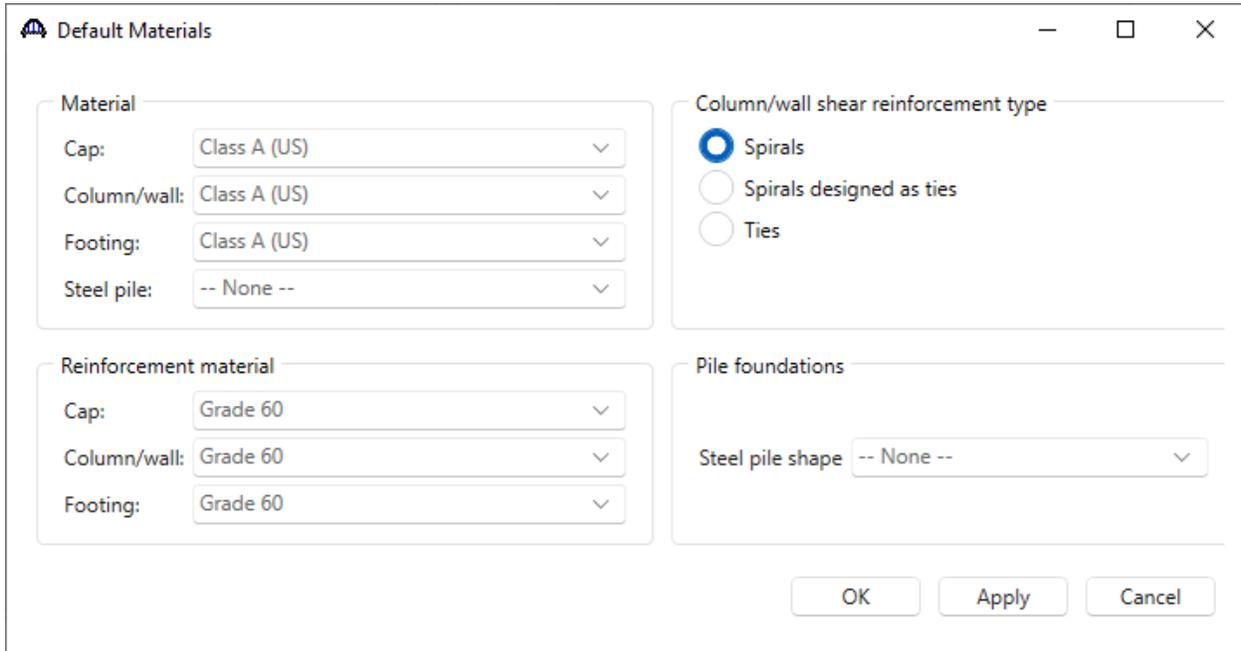
The bridge workspace under Pier Alternative is shown below.



RC Pier Supporting Slab System Example

Default Materials

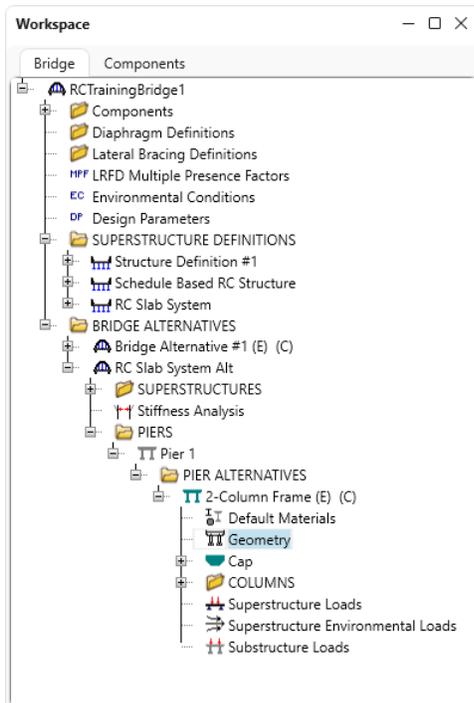
The **Default Materials** window permits the selection of materials that will be used as default selections for the pier components.



No changes need to be made, click **OK** to close the window.

Pier Geometry

Double click on the **Geometry** window to open it.



RC Pier Supporting Slab System Example

This window allows the user to define some basic **pier geometry**. The window is not drawn to scale.

Enter the data as shown below to define the **2-Column Frame** geometry.

Pier Geometry - Pier 1 - 2-Column Frame

Distance from left end of cap to superstructure reference line: 13.5 ft

Distance from left end of cap to centerline of leftmost column: 3.5 ft

Distance from centerline of rightmost column to right end of cap: 3.5 ft

Elevation View

	Column bay	Column spacing (ft)
>	1	20

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

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

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

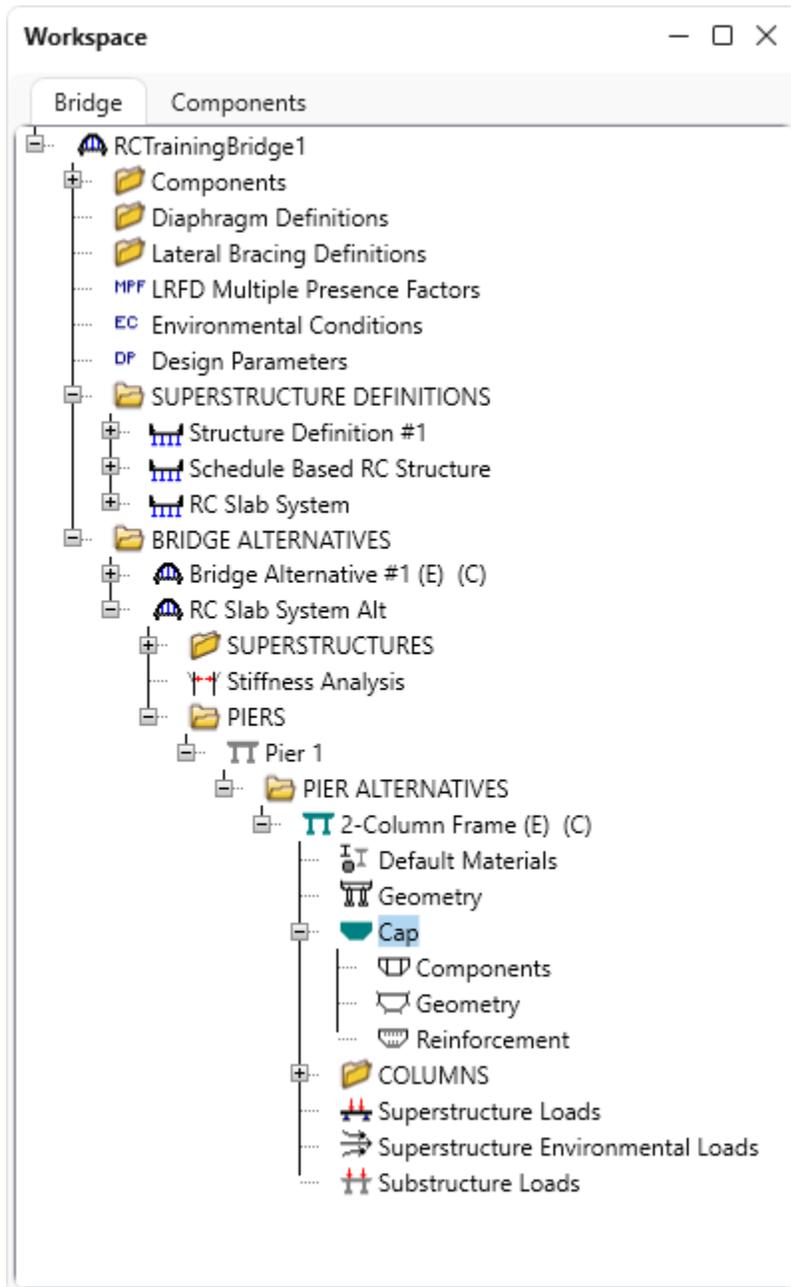
OK Apply Cancel

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

RC Pier Supporting Slab System Example

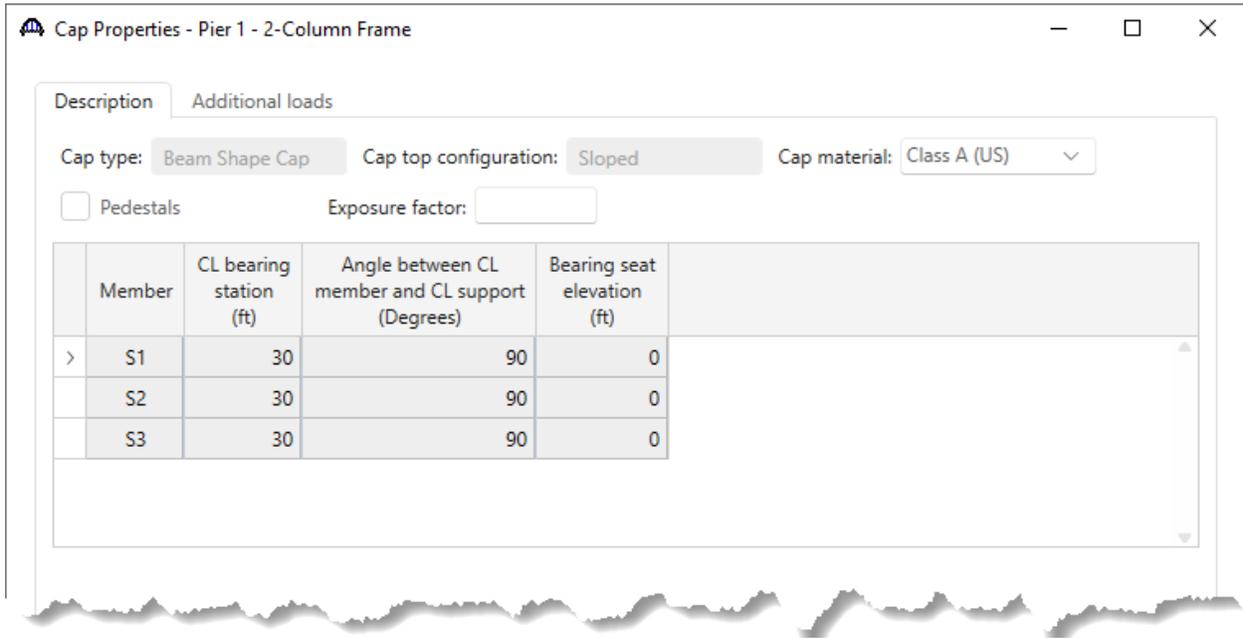
Cap

Double click on **Cap** in the Bridge Workspace tree.



RC Pier Supporting Slab System Example

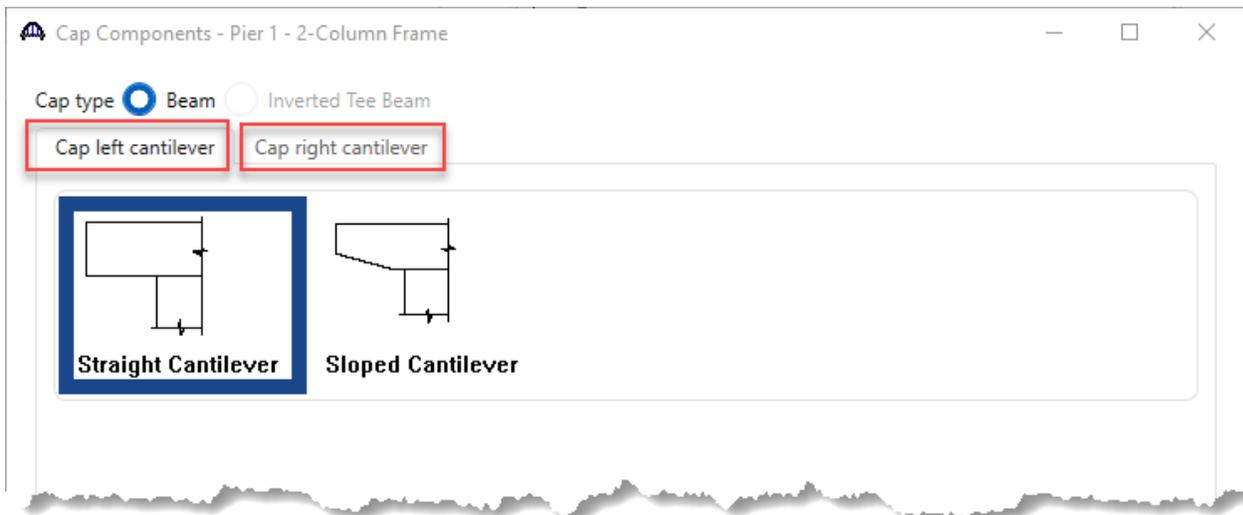
The **Cap Properties** window will open with data populated as shown below.



The **Additional loads** tab allows the user to define additional user defined loads on the cap. This example does not contain any additional loads on the cap. Click the **OK** button to apply the data and close the window.

Cap Components

Expand the bridge workspace tree under the **Cap** label and double click on **Components** to open the window. Select the following type of cap cantilever component for both the left and right cantilevers.



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

RC Pier Supporting Slab System Example

Cap Geometry

Double click on **Cap Geometry** and enter the following cap geometry data.

Cap width: ft

Cap length: ft

Location	Cantilever type	Elevation (ft)	Dimension (ft)		
			D1	D2	D3
> Left	Straight	18	3		
Right	Straight	18	3		

OK Apply Cancel

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

RC Pier Supporting Slab System Example

Cap Reinforcement

Double click on **Cap Reinforcement** and enter the following reinforcement data.

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	3	10	5	Grade 60	0.5	26	26.5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Bottom	3	10	5	Grade 60	0.5	26	26.5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Navigate to the **Shear** tab of this window and enter the following data to describe the **shear** reinforcement for the left half of the pier cap.

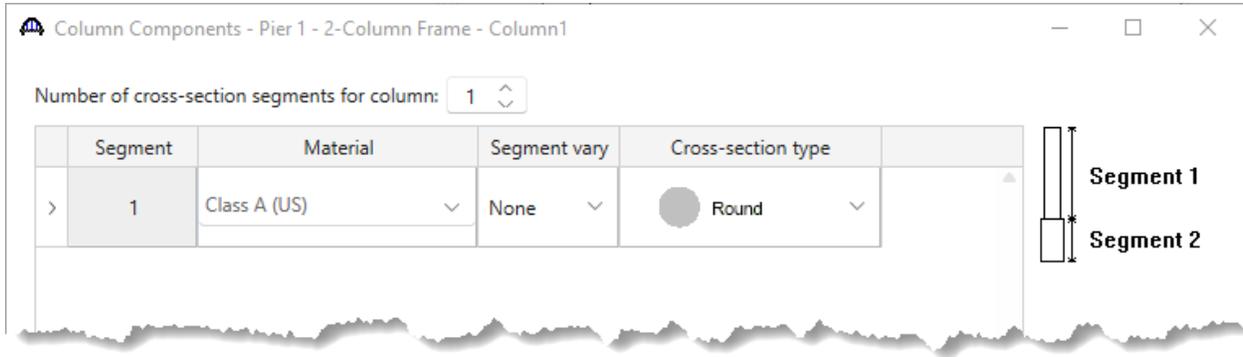
Bar size	Number of legs	Material	Measure from	Direction	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
5	4	Grade 60	Left Edge of Cap	Right	0.5	1	0	0	0.5
5	4	Grade 60	Left Edge of Cap	Right	0.5	25	6	12.5	13
5	4	Grade 60	Left Edge of Cap	Right	13.5	25	6	12.5	26
5	4	Grade 60	Left Edge of Cap	Right	26.5	1	0	0	26.5

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

RC Pier Supporting Slab System Example

Column1 Components

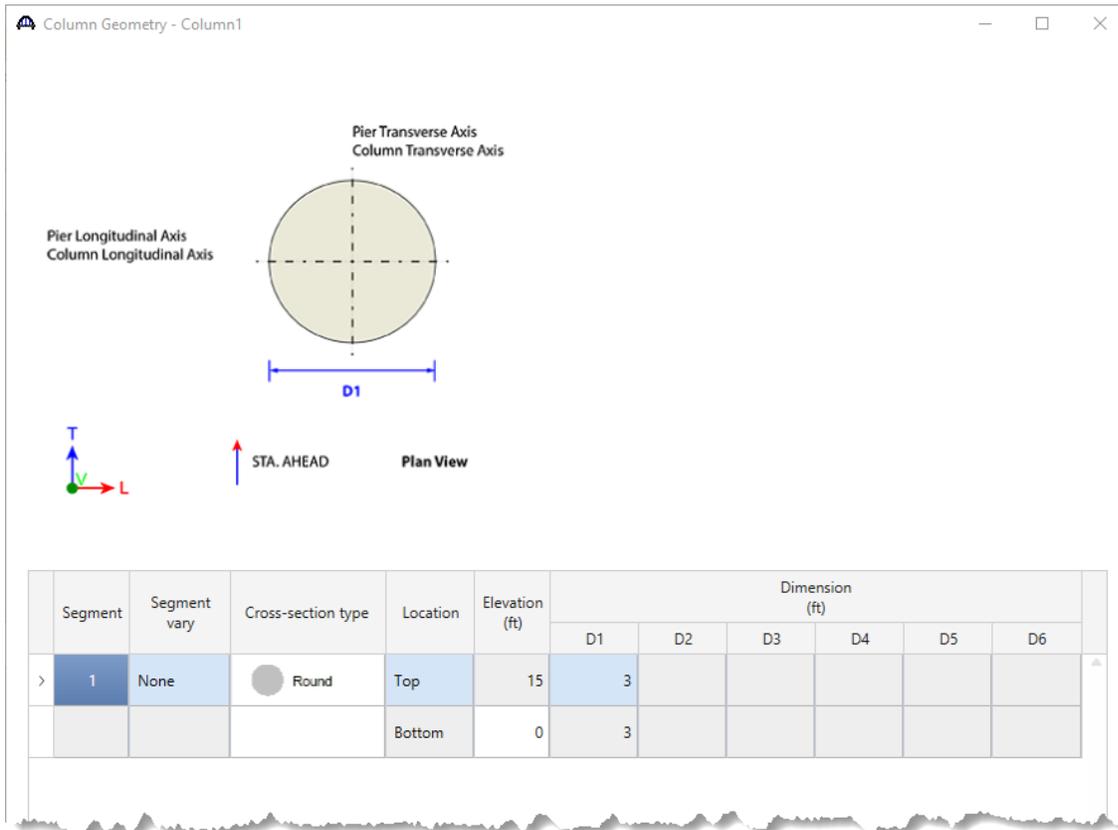
Double click **Column1 Components** in the tree to open the window below. Specify the cross-section segments in the column. Segment cross-sections can vary linearly over their height. In this example, the cross-section is constant over its height.



BrDR assumes the column cross section type is round when creating a new column. Since in this example the pier has round columns, this assumption is correct. Click the **OK** button to apply the data and close the window.

Column1 Geometry

Open the **Column1 Geometry** window and enter the following column geometry data.

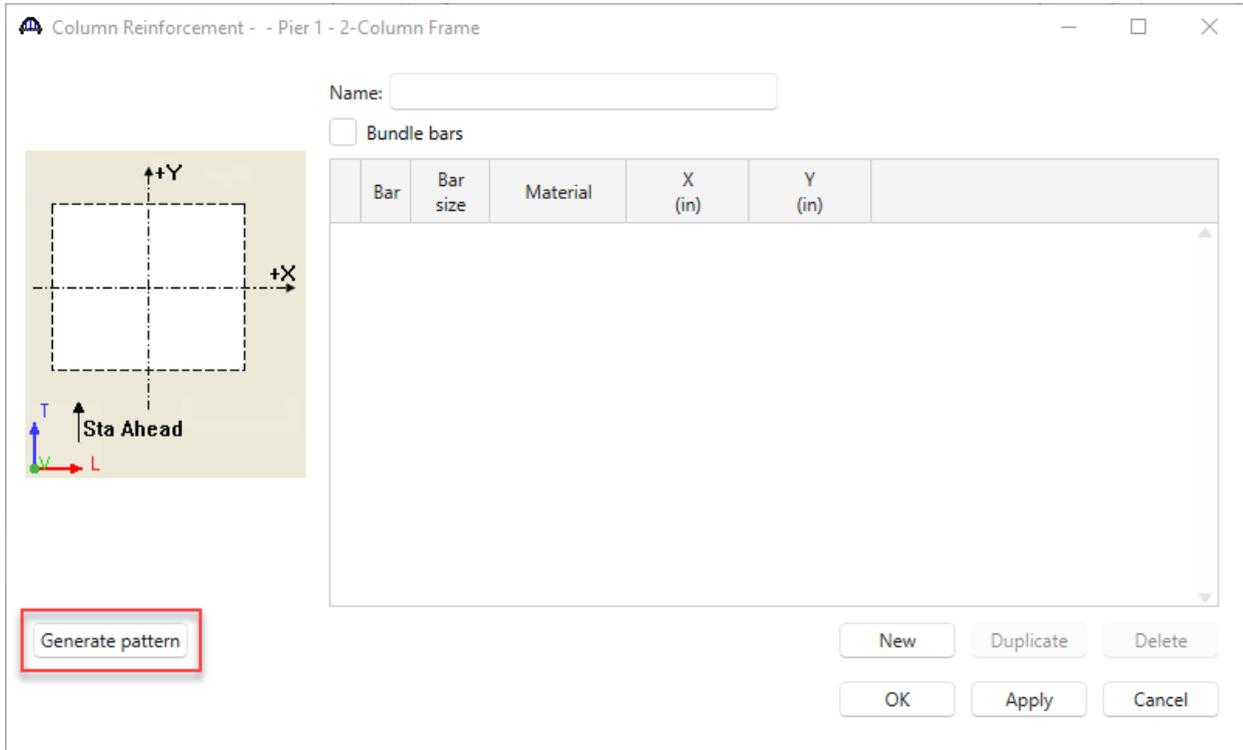


Click the **OK** button to apply the data and close the window.

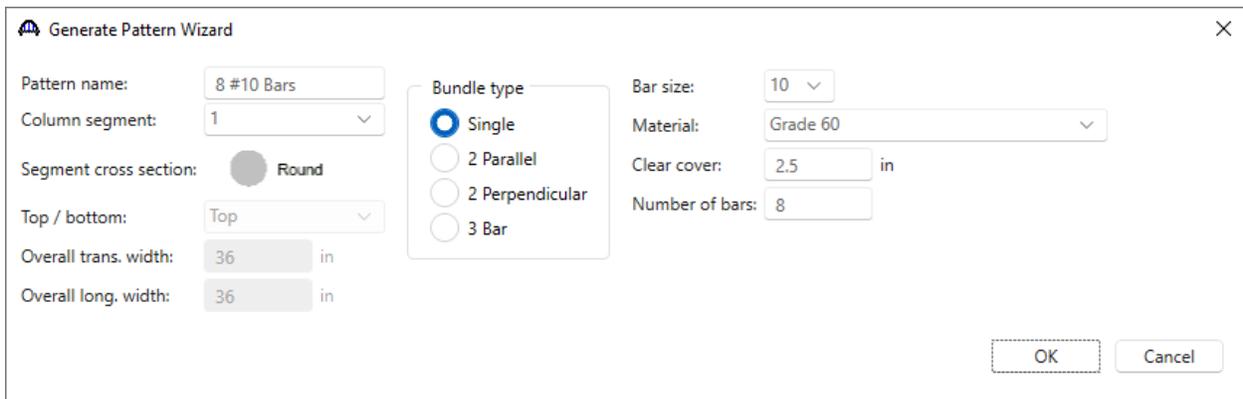
RC Pier Supporting Slab System Example

Reinforcement Definitions

Double click the **Reinforcement Definitions** label to create a new reinforcement definition for the column. The reinforcement definition will be later assigned to ranges over the height of the column.



Click the **Generate Pattern** button above to use the pattern wizard to create a pattern of reinforcement. Enter the following data. The clear cover measured to the face of the flexural reinforcement is 2” cover to face of spiral plus 1/2” for the spiral diameter. After data is entered click the **OK** button.



RC Pier Supporting Slab System Example

The following bar locations are generated for this pattern. Uncheck the **Bundle Bars** checkbox.

The screenshot shows a software window titled "Column Reinforcement - - Pier 1 - 2-Column Frame". The window contains a "Name" field with the value "8 #10 Bars" and an unchecked "Bundle bars" checkbox. On the left, there is a diagram of a square column with a coordinate system where +Y is vertical and +X is horizontal. A "Sta Ahead" label with an upward arrow is also present. The main part of the window is a table with 8 rows of bar data. At the bottom, there are buttons for "Generate pattern", "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

Bar	Bar size	Material	X (in)	Y (in)
1	10	Grade 60	14.865	0
2	10	Grade 60	10.5111423	-10.5111423
3	10	Grade 60	0	-14.865
4	10	Grade 60	-10.5111423	-10.5111423
5	10	Grade 60	-14.865	0
6	10	Grade 60	-10.5111423	10.5111423
7	10	Grade 60	0	14.865
8	10	Grade 60	10.5111423	10.5111423

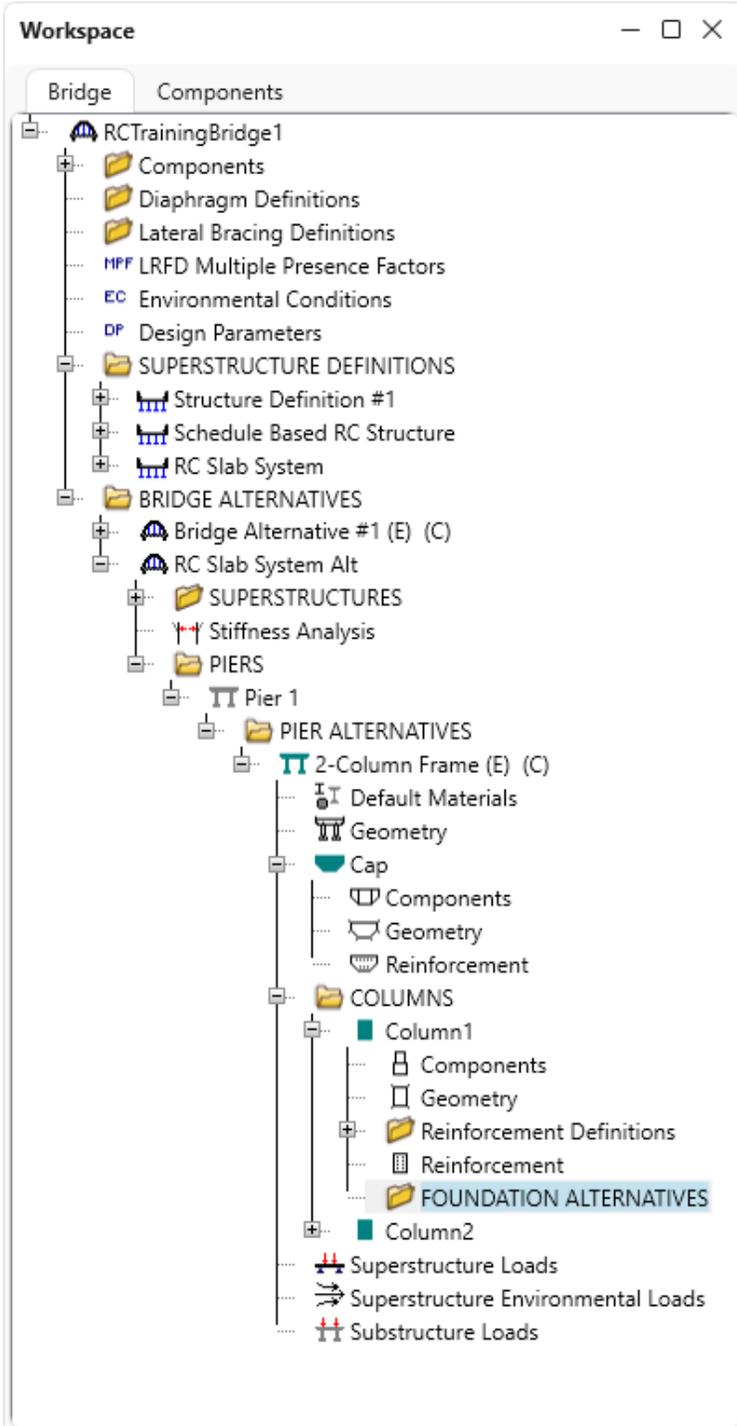
Click the **OK** button to apply the data and close the window.

In this example the column reinforcement is going to extend down into the footing so next create a Foundation Alternative and then come back to assign this pattern to the column. Otherwise, a validation message will be generated stating that the column rebar does not fit inside the footing.

RC Pier Supporting Slab System Example

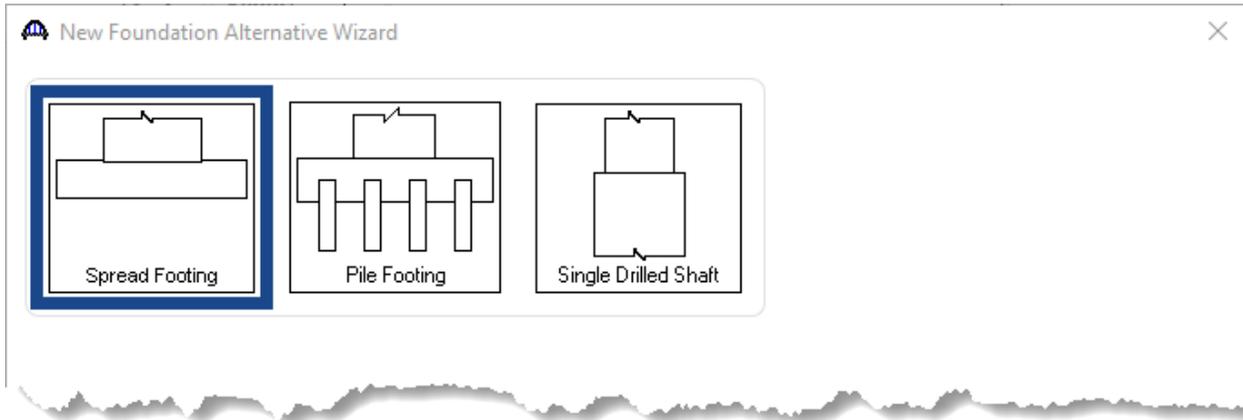
Foundation Alternatives

Double click **FOUNDATION ALTERNATIVES** and the **New Foundation Alternatives wizard** will open.



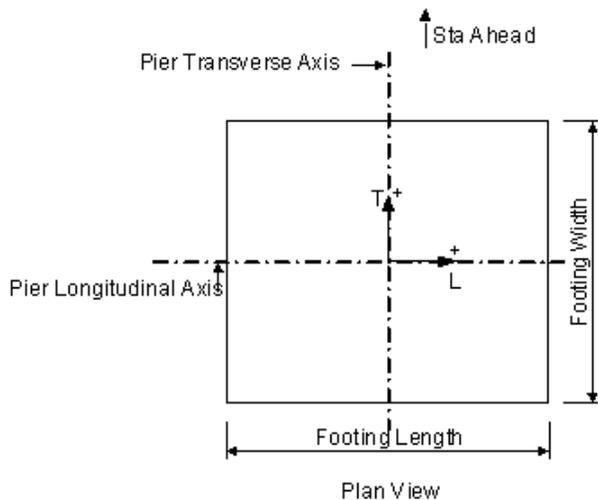
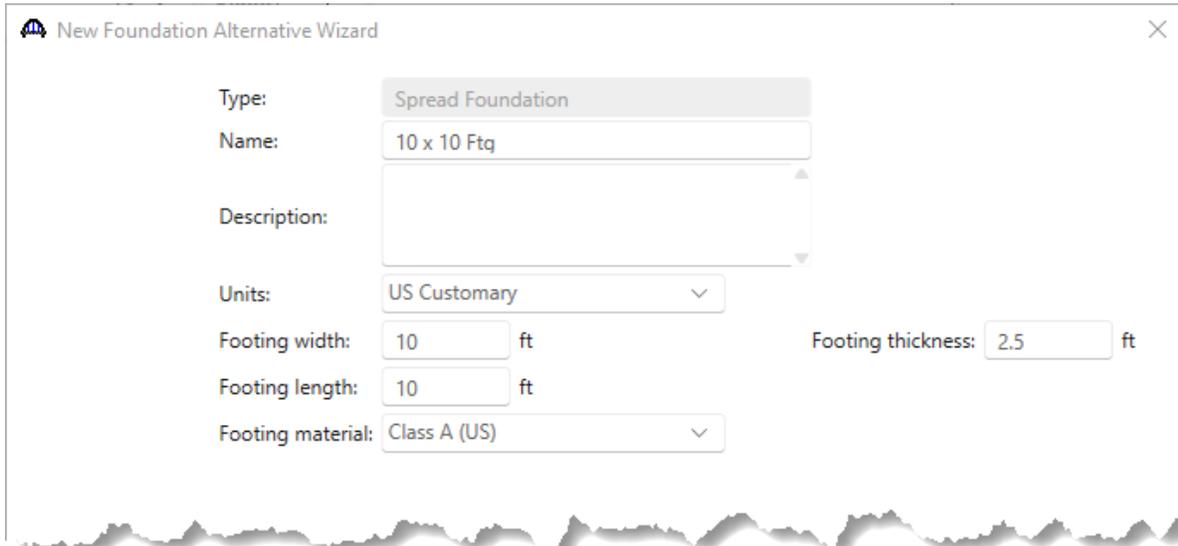
RC Pier Supporting Slab System Example

Select the **Spread Footing**.



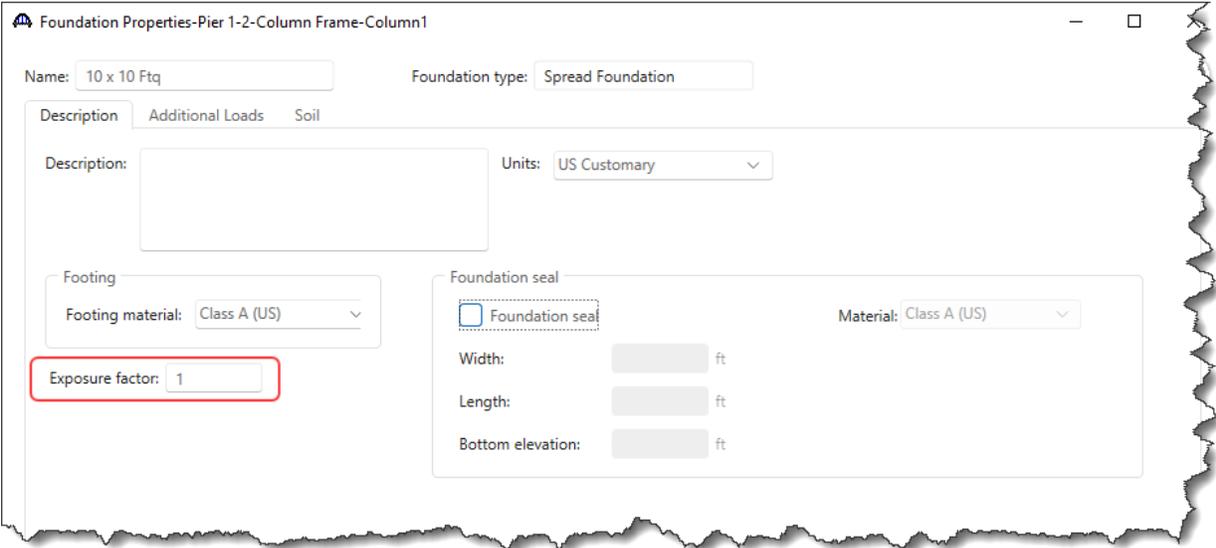
Click the **Next** button.

Enter the following description of the foundation.

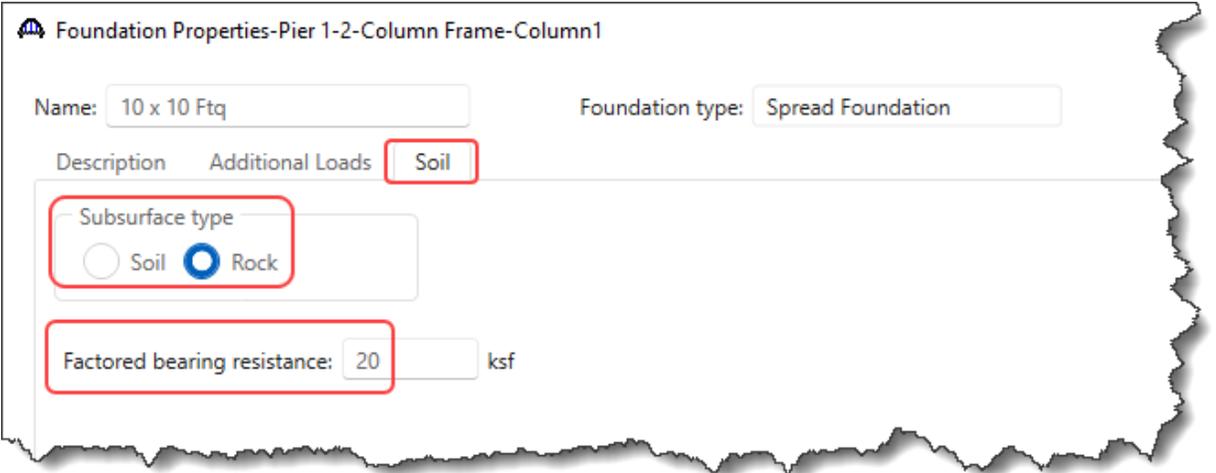


RC Pier Supporting Slab System Example

Click **Finish** and the **Foundation Properties** window will open. Enter the **Exposure Factor**.



Navigate to the **Soil** tab of this window and enter the **Subsurface type** as **Rock** and enter the **Factored bearing resistance** as shown below.



Click the **OK** button to apply the data and close the window. Do not click the **Cancel** button as that will cause the creation of the new foundation alternative to be canceled.

RC Pier Supporting Slab System Example

Foundation Geometry

Open the **Foundation Geometry** window.

	Location	Elevation (ft)	Dimension (ft)	
			D1	D2
>	Top	0	10	10
	Bottom	-2.5	10	10

There is no additional data to enter so click the **OK** button.

RC Pier Supporting Slab System Example

Foundation Reinforcement

Open **Foundation Reinforcement** and enter the following reinforcement data for the footing.

Foundation Reinforcement - Pier 1 - 2-Column Frame - Column1 - 10x 10 Ftg

Direction of topmost rebar: Longitudinal | Top bar clear cover: 3 in | End cover: 3 in

Direction of bottommost rebar: Longitudinal | Bottom bar clear cover: 3 in | Material: Grade 60

Top longitudinal reinforcement
Bar size: 5 | Number: 10
 Hooked
 Fully developed

Top transverse reinforcement
Bar size: 5 | Number: 10
 Hooked
 Fully developed

Bottom longitudinal reinforcement
Bar size: 9 | Number: 15
 Hooked
 Fully developed

Bottom transverse reinforcement
Bar size: 9 | Number: 15
 Hooked
 Fully developed

OK Apply Cancel

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

Column 1 - Column Reinforcement

Navigate back to the **Column Reinforcement** window for Column1 and assign the reinforcement pattern as follows.

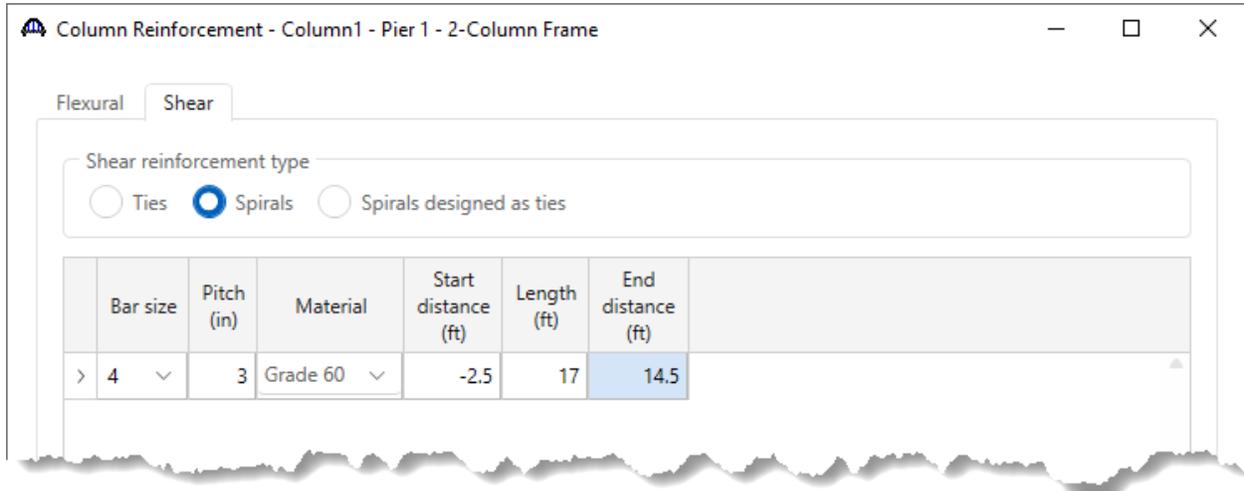
Column Reinforcement - Column1 - Pier 1 - 2-Column Frame

Flexural | Shear

Set	Start distance (ft)	Straight length (ft)	End distance (ft)	Pattern	Hook at start	Hook at end	Developed at start	Developed at end	Follows profile
> 1	-2.5	17	14.5	8 #10 Bars	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

RC Pier Supporting Slab System Example

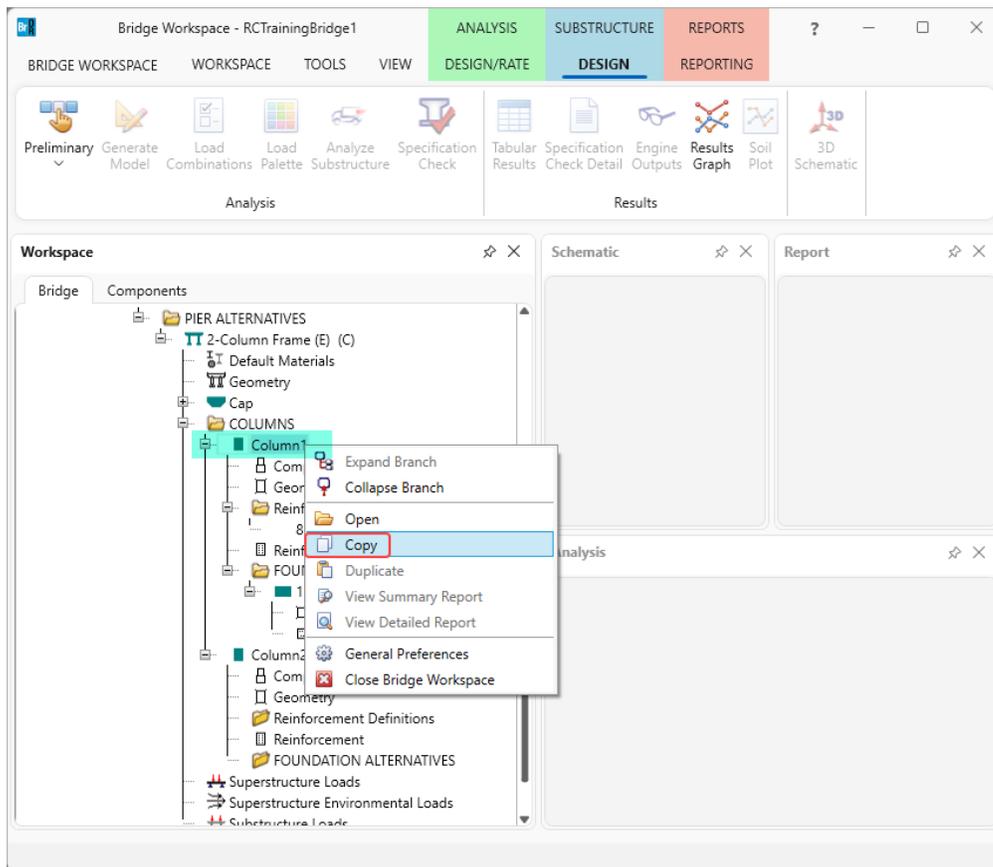
Define the following shear reinforcement in Column1. The stirrups extend into the footing, but BrDR will not consider the shear reinforcement in the footing or cap when performing specification checks.



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

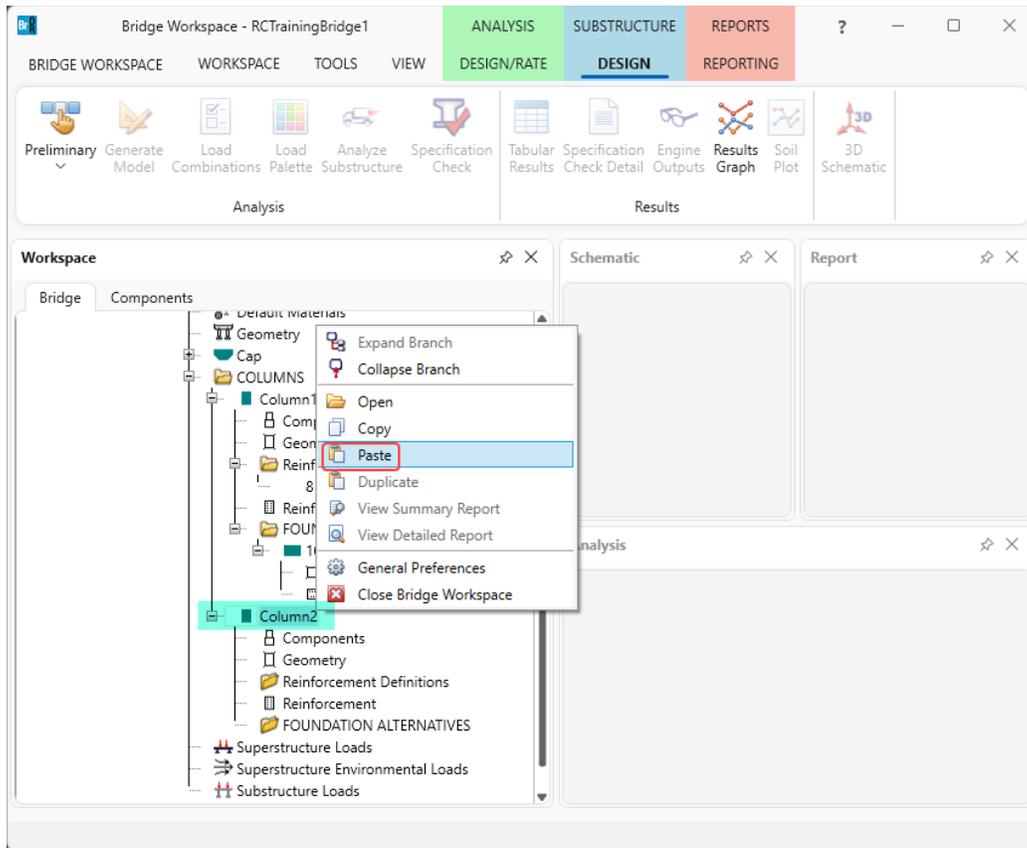
The description of Column 1 is complete. Copy Column 1 to Column 2 by following these steps:

1. Right click on **Column1** in the Bridge Workspace tree and click on the **Copy** button.

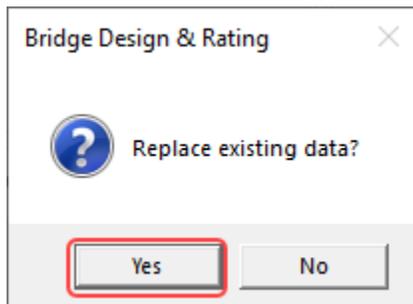


RC Pier Supporting Slab System Example

2. Right click on the **Column2** node in the Bridge Workspace tree and click on the **Paste** button.



3. The following message appears. Click **Yes** to copy all data from Column1 to Column2.



Similarly copy the foundation **10 x 10 Ftq** from **Column1** to **Column2**.

RC Pier Supporting Slab System Example

Pier Alternative – Stiffness tab

Now that the pier geometry is defined, re-open the **Pier Alternative - Stiffness tab** and evaluate the slenderness of the pier.

Pier Alternative - 2-Column Frame

Name: 2-Column Frame Type: RC Frame Pier

Description Stiffness Reports

Compute slenderness ratio

Analysis method
Method: First Order Elastic

Pier longitudinal axis

Sidesway
 Braced Unbraced Unbraced length: 15 ft Effective length factor, K: 0.65

Slenderness results
 Up-to-date
Gross area: 14.137173 ft² Moment of inertia: 7.9521564 ft⁴ Radius of gyration: 0.75 ft
KL/r: 13

Pier transverse axis

Sidesway
 Braced Unbraced Unbraced length: 15 ft Effective length factor, K: 2

Slenderness results
 Up-to-date
Gross area: 14.137173 ft² Moment of inertia: 31.8086256 ft⁴ Radius of gyration: 1.5 ft
KL/r: 20

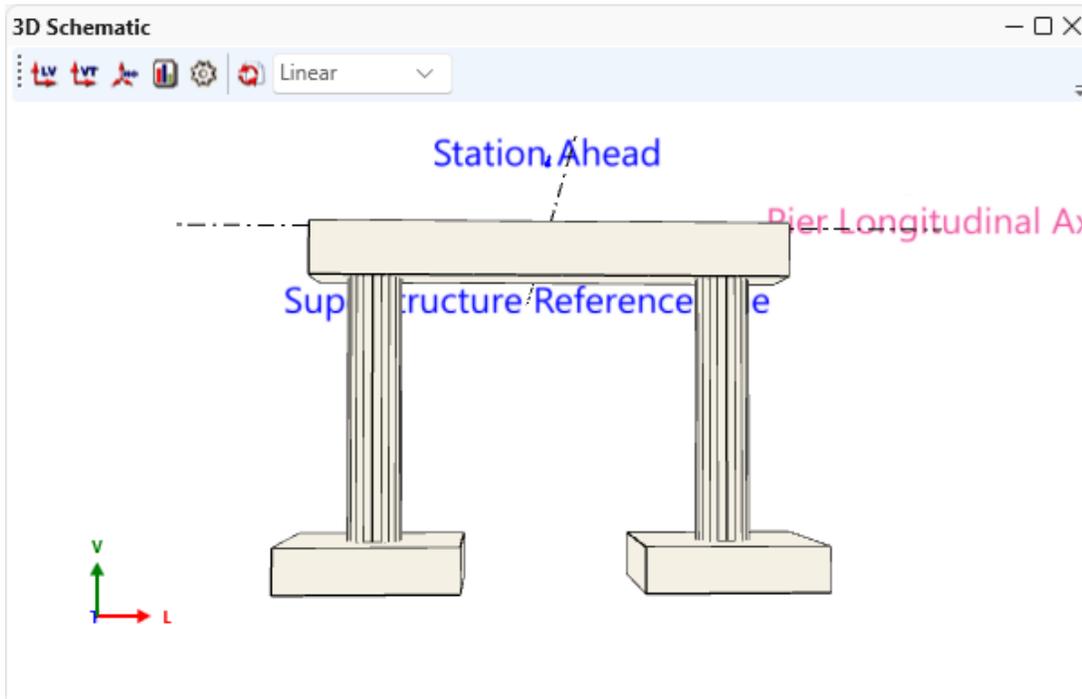
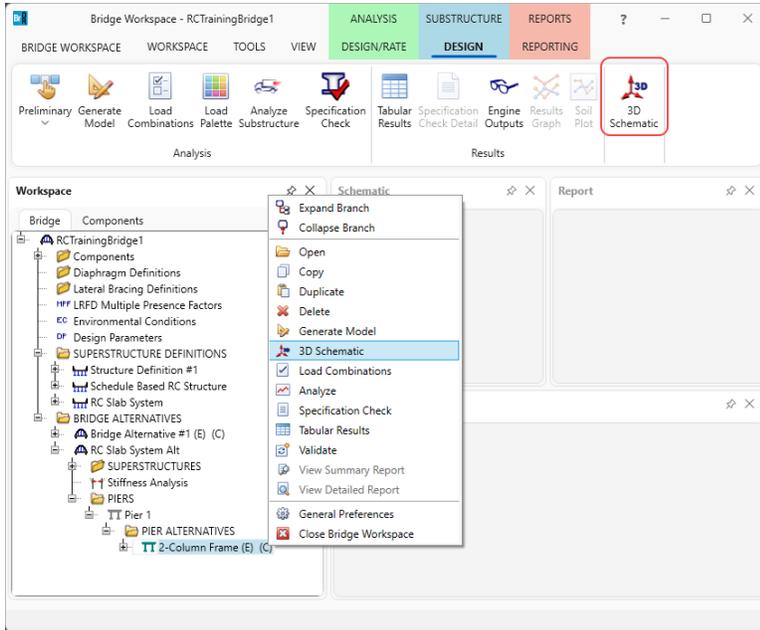
OK Apply Cancel

BrDR computes the KL/r ratios for the pier longitudinal and transverse axes based on the pier alternative geometry that was input. Independent evaluation of KL/r ratios can be done in accordance with AASHTO LRFD Article 5.7.4.3 to determine if the first order elastic analysis performed by BrDR is satisfactory for this pier.

RC Pier Supporting Slab System Example

Schematic – Pier Alternative

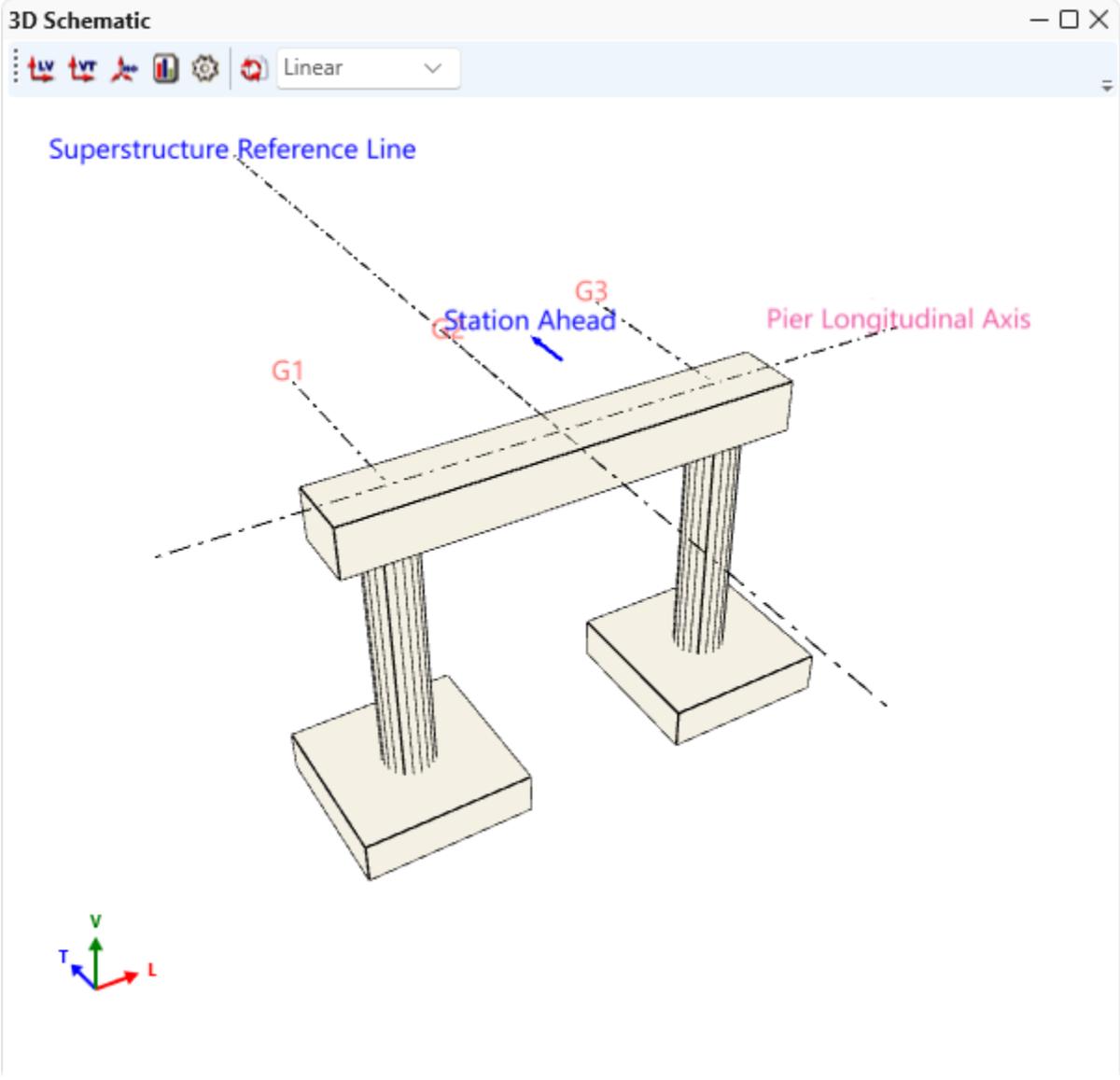
To view the 3D schematic of the pier alternative, right click on pier alternative **2-Column Frame** in the bridge workspace tree and click on **3D Schematic** (or select **2-Column Frame** and click on the **3D Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon).



This 3D schematic is a to-scale drawing of the pier alternative. This schematic view has a lot of useful features like rotating, scaling, and dimensioning.

RC Pier Supporting Slab System Example

It's a good idea to rotate and see the isometric view in the schematic to be sure that the girders are sitting on the pier.

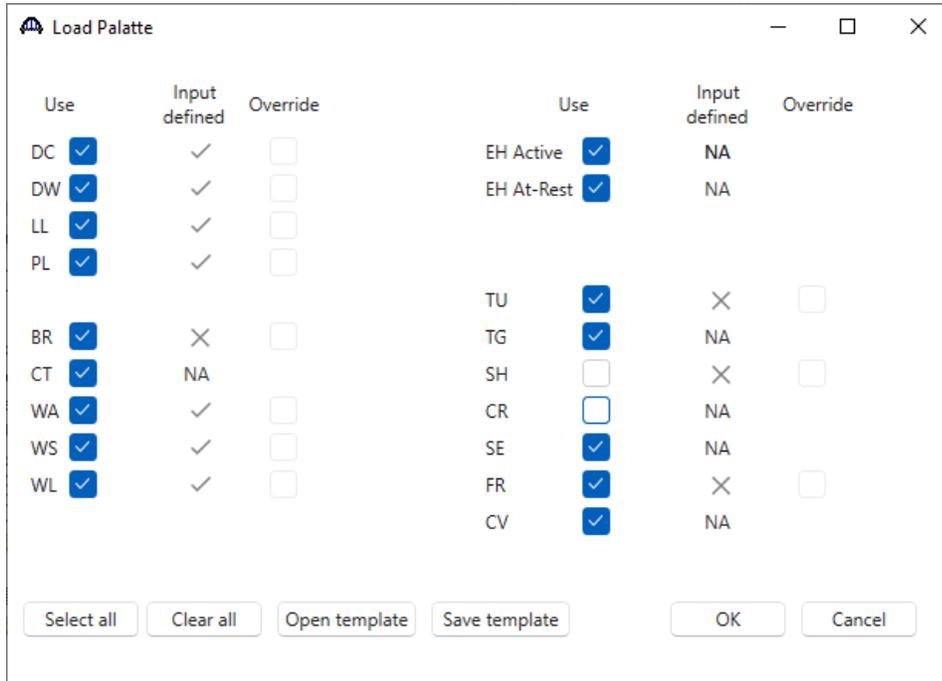


The description of the pier is complete.

RC Pier Supporting Slab System Example

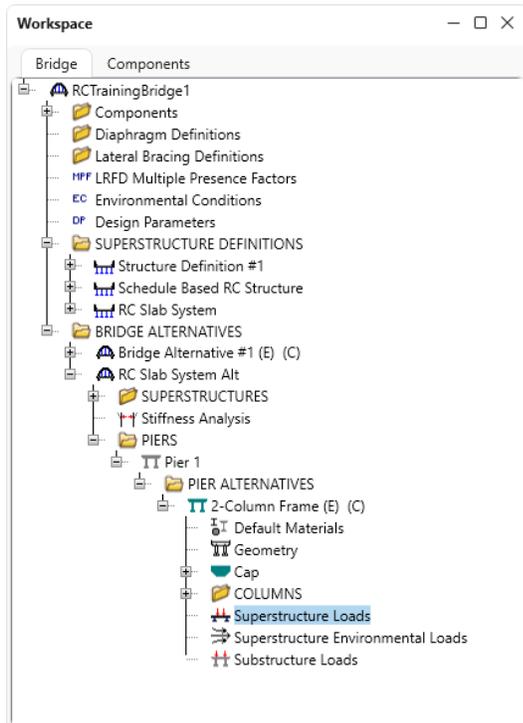
Load Palette

Click on the **Load Palette** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon and make selections as shown below.



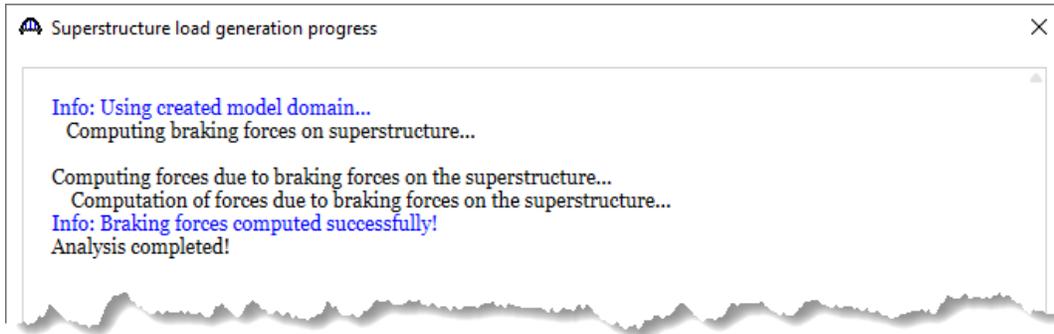
Superstructure Loads

Open the **Superstructure Loads** window.



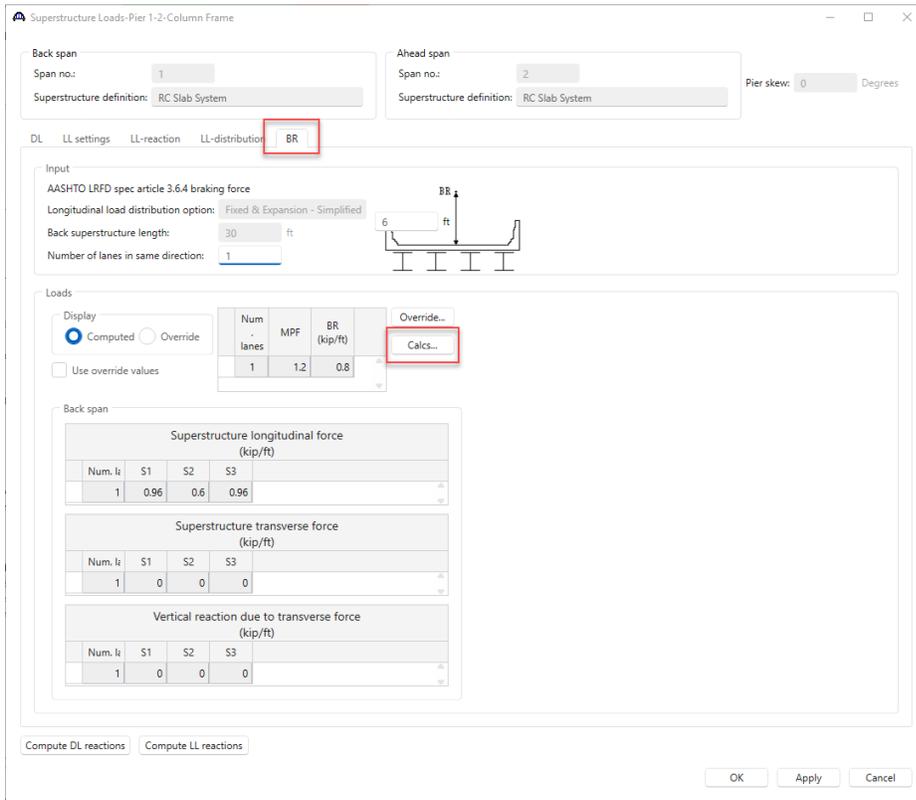
RC Pier Supporting Slab System Example

The first thing that appears is the following dialog.



BrDR computes some of the superstructure loads on the pier for the user when the Superstructure Loads window is opened. This window lists details about how BrDR computes the loads and may contain warning and error messages. This window always appears after BrDR computes any loads for the user. Click **OK** to close this window.

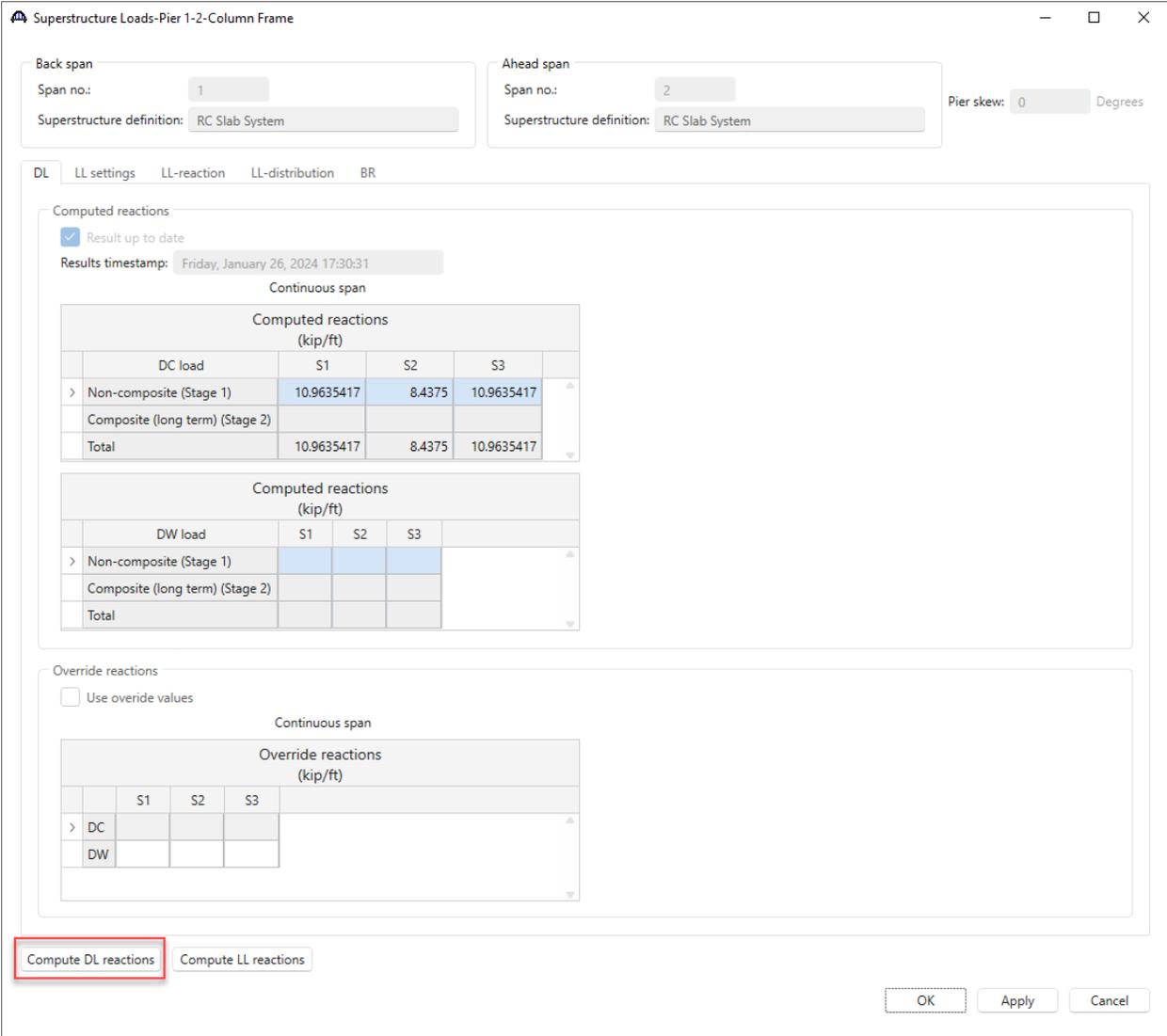
The figure below shows the **BR** tab of the **Superstructure Loads** window which displays the BrDR computed superstructure braking loads or enter user defined superstructure braking loads. Please note that the braking load is divided by number of slab strips by strip width, and is applied as a distributed load to pier cap.



The **Calcs** button will open a report detailing the calculations BrDR performed to compute the friction forces.

RC Pier Supporting Slab System Example

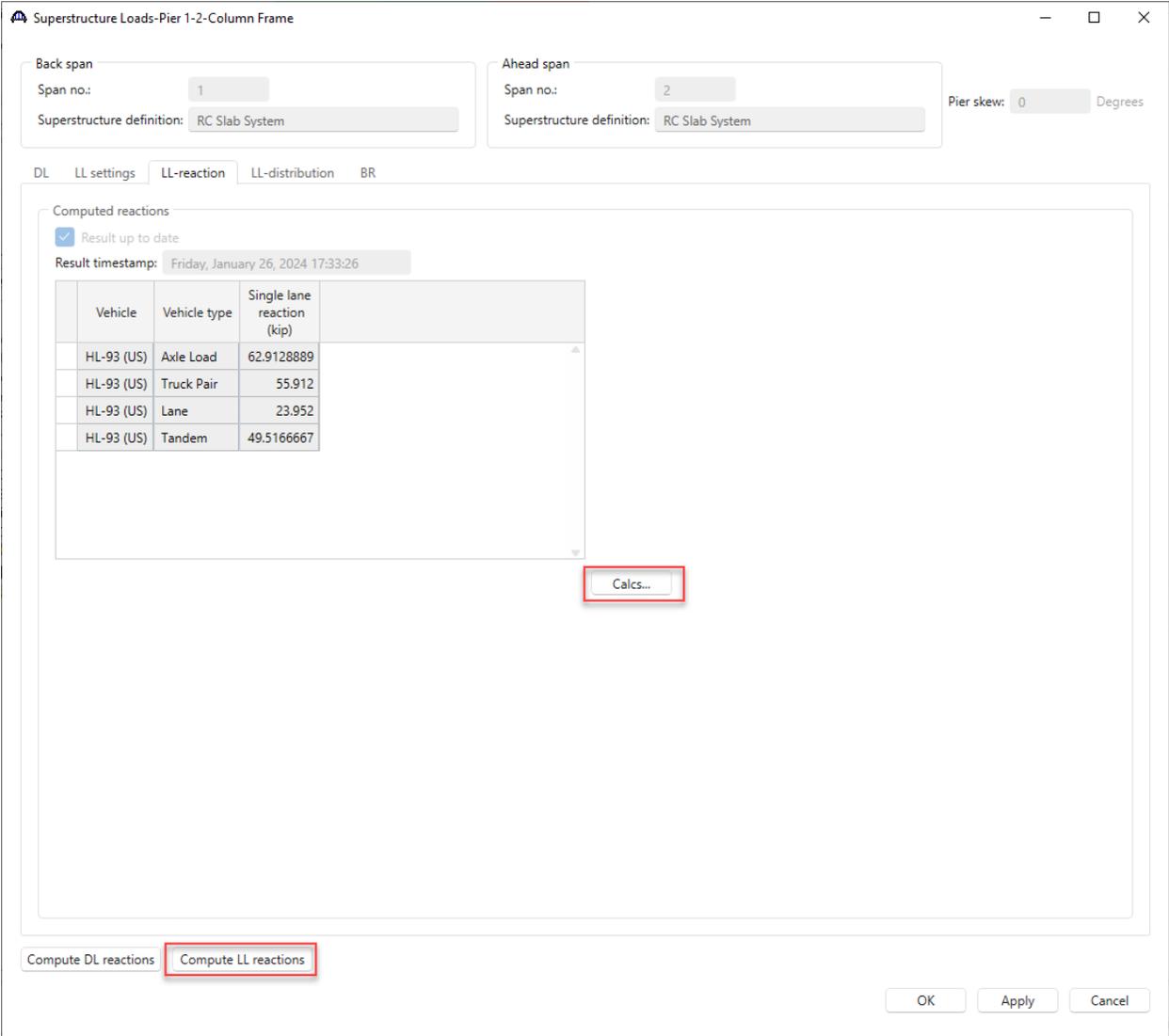
Navigate to the **DL** tab of this window. The **Compute DL reactions** button will launch a batch superstructure analysis. The friction forces are not available for the piers supporting reinforced concrete slab system superstructure.



The **Override Reactions** grid permits to enter user-defined override values for the dead loads. Remember, these values will only be used in the pier finite element analysis if the **Use override values** box is checked on this window.

RC Pier Supporting Slab System Example

Navigate to the **LL-reaction** tab. The **Compute LL Reactions** button will initiate a longitudinal live load analysis of the superstructure carried by the pier.



The vehicles used in the analysis are dependent on both the Design Mode selected on the **BrDR Substructure** ribbon and the **LRFD Substructure Design Settings** chosen on the **Pier Alternative: Description** window.

This longitudinal live load analysis computes the single lane reaction for each vehicle. The **Calcs** button displays a report of the single lane reactions computed by BrDR.

RC Pier Supporting Slab System Example

The **LL-Distribution** tab displays the BrDR computed live load reactions distributed for a pier analysis or enter distributed live load reactions.

Superstructure Loads-Pier 1-2-Column Frame

Back span: Span no.: 1, Superstructure definition: RC Slab System

Ahead span: Span no.: 2, Superstructure definition: RC Slab System

Pier skew: 0 Degrees

DL LL settings LL-reaction **LL-distribution** BR

Distribution method: Tributary area, Lever rule, Rigid deck action

Loads

Display: Computed, Override, Use override values,

Without dynamic load allowance

Vehicle	Vehicle type	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
HL-93 (US)	Truck + Lane	86.8648889	32	5.4864889
HL-93 (US)	Tandem + Lane	73.4686667	25	4.8468667
HL-93 (US)	90%(Truck Pair + Lane)	71.8776	28.8	4.30776

With dynamic load allowance

Vehicle	Vehicle type	Weighted DLA (%)	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
HL-93 (US)	Truck + Lane	23.90063	107.6261422	39.6482007	6.7977941
HL-93 (US)	Tandem + Lane	22.24145	89.8091667	30.5603636	5.9248803
HL-93 (US)	90%(Truck Pair + Lane)	23.10298	88.483464	35.4536568	5.3029807

Compute DL reactions Compute LL reactions

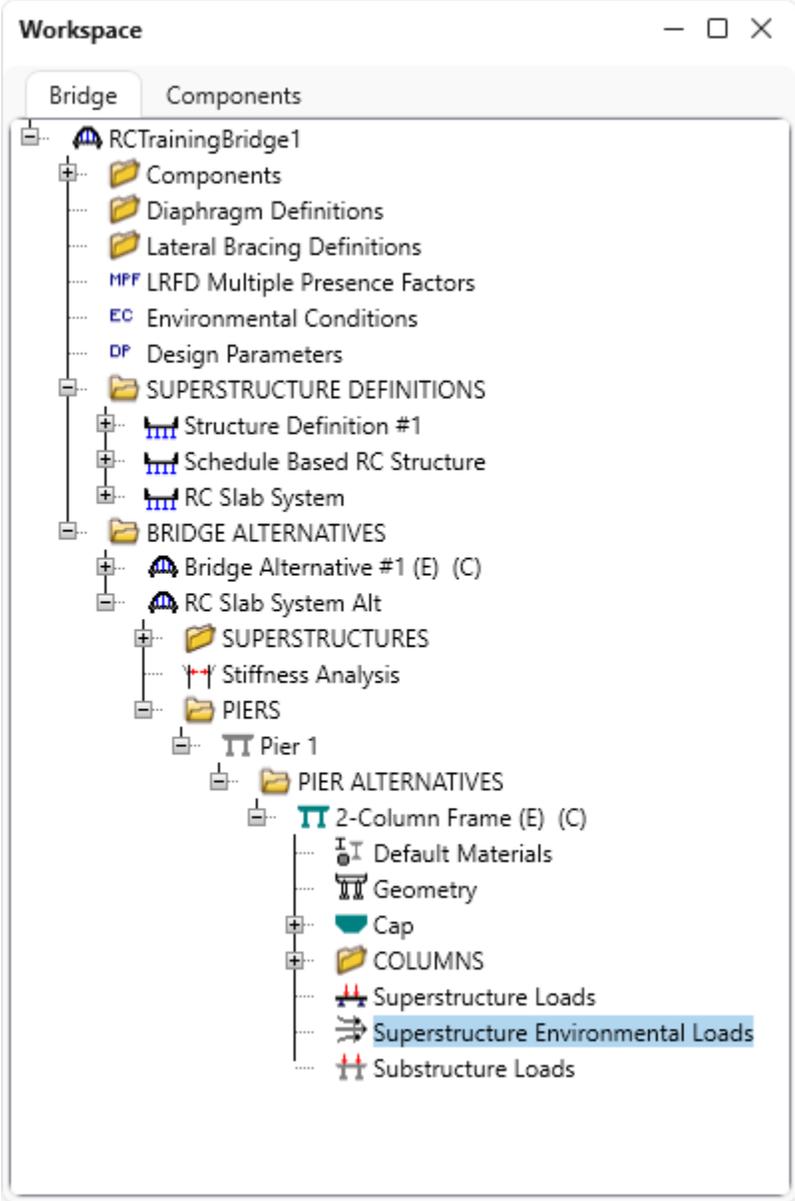
OK Apply Cancel

Click **OK** to close this window.

RC Pier Supporting Slab System Example

Superstructure Environmental Loads

Open the **Superstructure Environmental Loads** window.



RC Pier Supporting Slab System Example

The **Superstructure Environmental Loads** window shows the following data:

Back span

Span no.:

Superstructure definition:

Ahead span

Span no.:

Superstructure definition:

Pier skew: Degrees

Wind load basis

Gust speed Fastest-mile speed

WS-super WS-over WL TU SH

Input

AASHTO LRFD Spec Article 3.8.1.2.2 Loads from Superstructure

Transverse load distribution option:

Friction velocity, VO: mph

Transverse superstructure length: ft

Friction length, ZO: ft

Superstructure design elevation: ft

Base design wind velocity, VB: mph

Design height, Z: ft

V30: mph

Override design height, Z:

Loads for wind from left to right

Display Computed Override Use override values

Superstructure longitudinal force (kip)				
Wind skew angle (Degrees)	S1	S2	S3	
0	0.4	0.25	0.4	
15	0.2444444	0.1527778	0.2444444	
30	0.2277778	0.1423611	0.2277778	
45	0.1833333	0.1145833	0.1833333	
60	0.0944444	0.0590278	0.0944444	

Superstructure transverse force (kip)				
Wind skew angle (Degrees)	S1	S2	S3	
0	0	0	0	
15	-0.03333...	-0.02083...	-0.03333...	
30	-0.06666...	-0.04166...	-0.06666...	
45	-0.08888...	-0.05555...	-0.08888...	
60	-0.10555...	-0.06597...	-0.10555...	

Vertical Reaction due to transverse (kip)				
Wind skew angle (Degrees)	S1	S2	S3	
0	0.1282052	0	-0.12820...	
15	0.0783476	0	-0.07834...	
30	0.0730057	0	-0.07300...	
45	0.0587607	0	-0.05876...	
60	0.0302707	0	-0.03027...	

The top of the screen displays values computed by BrDR that are used to compute the wind on superstructure loads on the pier and in some cases lets the user override some of this data. The bottom of the screen displays loads on the superstructure members for wind blowing from left to right. The user can specify which direction the wind should blow in the actual pier finite element analysis in **the Load Combination Settings** window which will be discussed later in this tutorial.

RC Pier Supporting Slab System Example

The **overturning wind** on superstructure load window is shown below.

The screenshot shows a software window titled "Superstructure Environmental Loads - Pier 1 - 2-Column Frame". It contains several input fields and a table of results.

Back span: Span no.: 1, Superstructure definition: RC Slab System

Ahead span: Span no.: 2, Superstructure definition: RC Slab System

Pier skew: 0 Degrees

Wind load basis: Gust speed, Fastest-mile speed

Input: AASHTO LRFD sec article 3.8.2 vertical wind pressure
Transverse superstructure length: 30 ft
Deck Width: 27 ft
Vertical upward wind pressure: 0.02 ksf

Loads for wind from left to right: Display: Computed, Override, Use override values,

Overturning force: 16.2 kip

	S1	S2	S3
	1.4676926	0.45	-0.0276926

Buttons: Compute, OK, Apply, Cancel

RC Pier Supporting Slab System Example

The **wind on live load** tab is shown below.

Superstructure Environmental Loads - Pier 1 - 2-Column Frame
— □ ×

Back span

Span no.:

Superstructure definition:

Ahead span

Span no.:

Superstructure definition:

Pier skew: Degrees

Wind load basis

Gust speed Fastest-mile speed

WS-super WS-over **WL** TU SH

Input

AASHTO LRFD Spec Article 3.8.1.3 Wind pressure on vehicles

Transverse load distribution option:

Transverse superstructure length: ft

Loads for wind from left to right

Display

Computed Override Use override values

Superstructure longitudinal force (kip)			
Wind skew angle (Degrees)	S1	S2	S3
0	0.1333333	0.0833333	0.1333333
15	0.1173333	0.0733333	0.1173333
30	0.1093333	0.0683333	0.1093333
45	0.088	0.055	0.088
60	0.0453333	0.0283333	0.0453333

Vertical reaction due to transverse force (kip)			
Wind skew angle (Degrees)	S1	S2	S3
0	0.1538462	0	-0.15384...
15	0.1353847	0	-0.13538...
30	0.1261539	0	-0.12615...
45	0.1015385	0	-0.10153...
60	0.0523077	0	-0.05230...

Superstructure transverse force (kip)

Wind skew angle (Degrees)	S1	S2	S3
0	0	0	0
15	-0.016	-0.01	-0.016
30	-0.032	-0.02	-0.032
45	-0.04266...	-0.02666...	-0.04266...
60	-0.05066...	-0.03166...	-0.05066...

Vertical reaction due to transverse force (kip)

Wind skew angle (Degrees)	S1	S2	S3
0	0.1538462	0	-0.15384...
15	0.1353847	0	-0.13538...
30	0.1261539	0	-0.12615...
45	0.1015385	0	-0.10153...
60	0.0523077	0	-0.05230...

RC Pier Supporting Slab System Example

The **superstructure temperature load** tab is shown below.

Superstructure Environmental Loads - Pier 1 - 2-Column Frame

Back span: Span no.: 1, Superstructure definition: RC Slab System

Ahead span: Span no.: 2, Superstructure definition: RC Slab System

Pier skew: 0 Degrees

Wind load basis: Gust speed Fastest-mile speed

WS-super WS-over WL **TU** SH

Input: AASHTO LRFD spec article 3.12.2 uniform temperature

Temperature rise: [] Temperature fall: []

Application type: Force

Unable to compute temperature change.

Loads: Temperature rise force: 100 kip, Temperature fall force: 100 kip

Superstructure longitudinal force (kip)			
	S1	S2	S3
> Rise	0.3703704	0.2314815	0.3703704
Fall	0.3703704	0.2314815	0.3703704

Compute [OK] [Apply] [Cancel]

BrDR does not compute the superstructure temperature load. Values for these loads must be entered manually.

RC Pier Supporting Slab System Example

The **superstructure shrinkage** tab is shown below.

Superstructure Environmental Loads - Pier 1 - 2-Column Frame

Back span: Span no.: 1, Superstructure definition: RC Slab System

Ahead span: Span no.: 2, Superstructure definition: RC Slab System

Pier skew: 0 Degrees

Wind load basis: Gust speed Fastest-mile speed

WS-super WS-over WL TU **SH**

Input: AASHTO LRFD spec article 3.12 shrinkage

Application type: Force

Loads: Shrinkage force: 100 kip

Superstructure longitudinal force (kip)		
S1	S2	S3
33.3333333	33.3333333	33.3333333

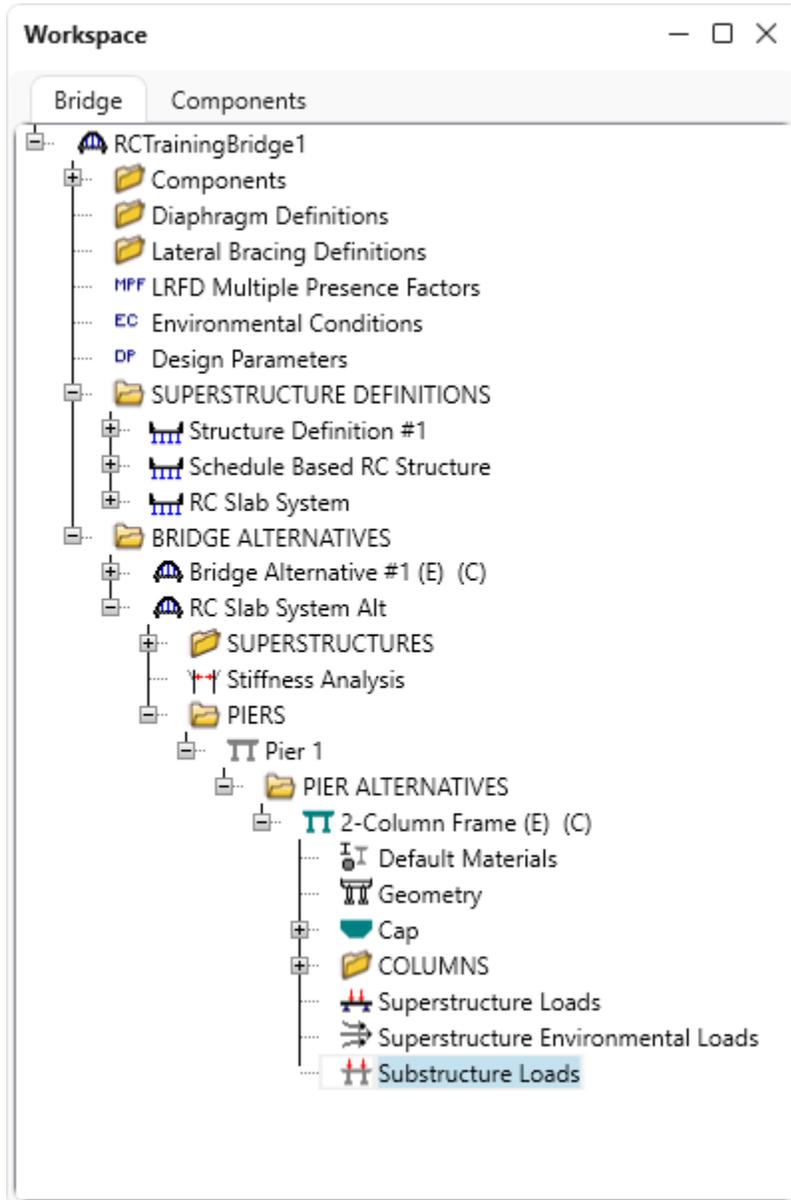
Compute OK Apply Cancel

BrDR does not compute the superstructure shrinkage load. Values for these loads must be entered manually.

RC Pier Supporting Slab System Example

Substructure Loads

Open the **Substructure Loads** window.



RC Pier Supporting Slab System Example

The **Substructure Loads** window shows the following data:

Back span

Span no.:

Superstructure definition:

Ahead span

Span no.:

Superstructure definition:

Pier skew: Degrees

Wind load basis

Gust speed Fastest-mile speed

WS-Sub:

Input

AASHTO LRFD Spec Article 3.8.1.2.3 Forces Applied Directly to the Substructure

Base wind pressure: ksf Friction velocity, V0: mph

Top of cap elevation: ft Friction length, Z0: ft

Bottom of cap elevation: ft Base design wind velocity, VB: mph

Ground elevation: ft V30: mph

Loads for wind from left to right

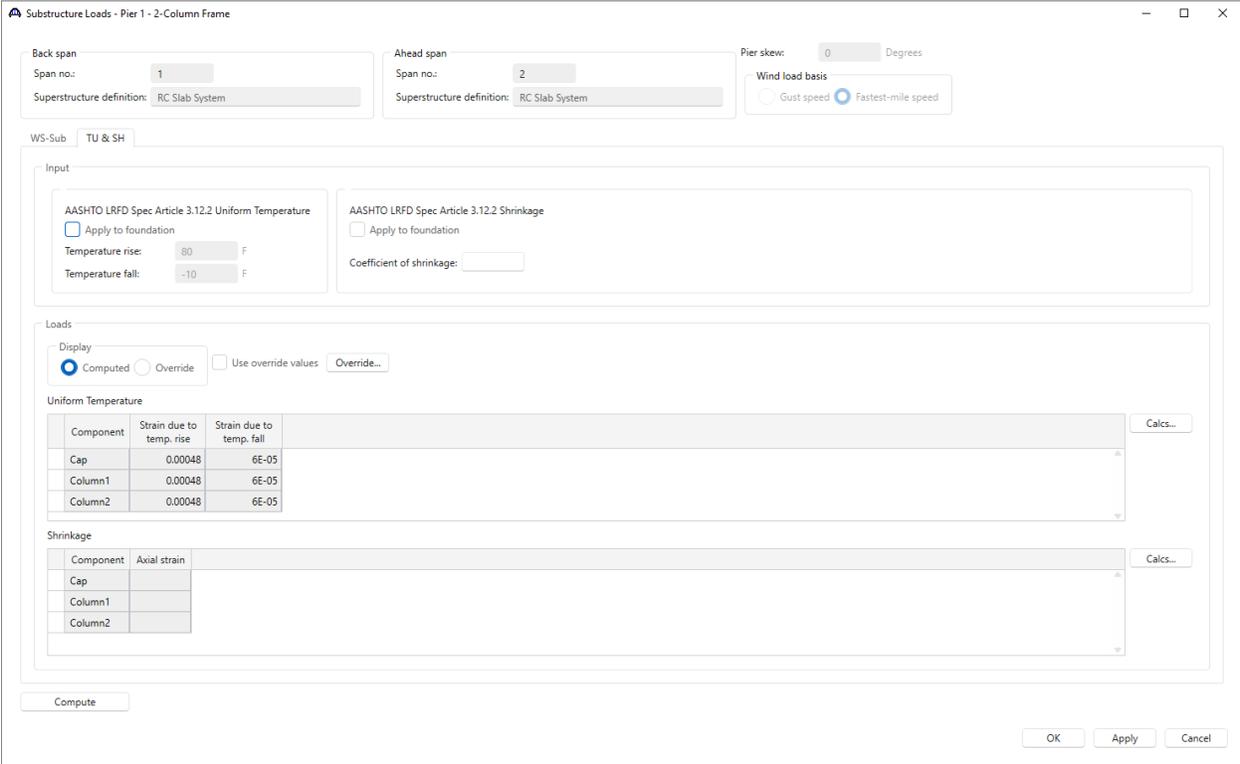
Display: Computed Override Use override values

Component	Design height Z (ft)	PD (ksf)
Cap		0.04
Column1		0.04
Column2		0.04

Component	Wind skew angle (deg) 0		Wind skew angle (deg) 15		Wind skew angle (deg) 30		Wind skew angle (deg) 45		Wind skew angle (deg) 60	
	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)
Cap	0.04	0	0.038...	-0.01...	0.034...	-0.02	0.028...	-0.02...	0.02	-0.03...
Column1	0.04	0	0.038...	-0.01...	0.034...	-0.02	0.028...	-0.02...	0.02	-0.03...
Column2	0.04	0	0.038...	-0.01...	0.034...	-0.02	0.028...	-0.02...	0.02	-0.03...

RC Pier Supporting Slab System Example

The **substructure temperature and shrinkage** tab is shown below.

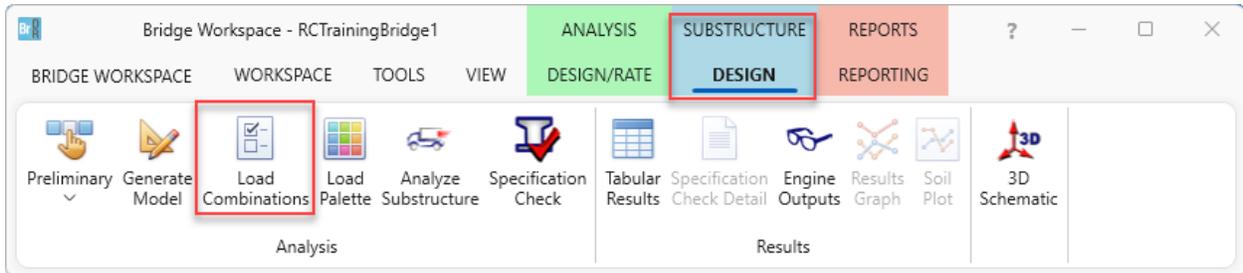


Click **OK** to close the window.

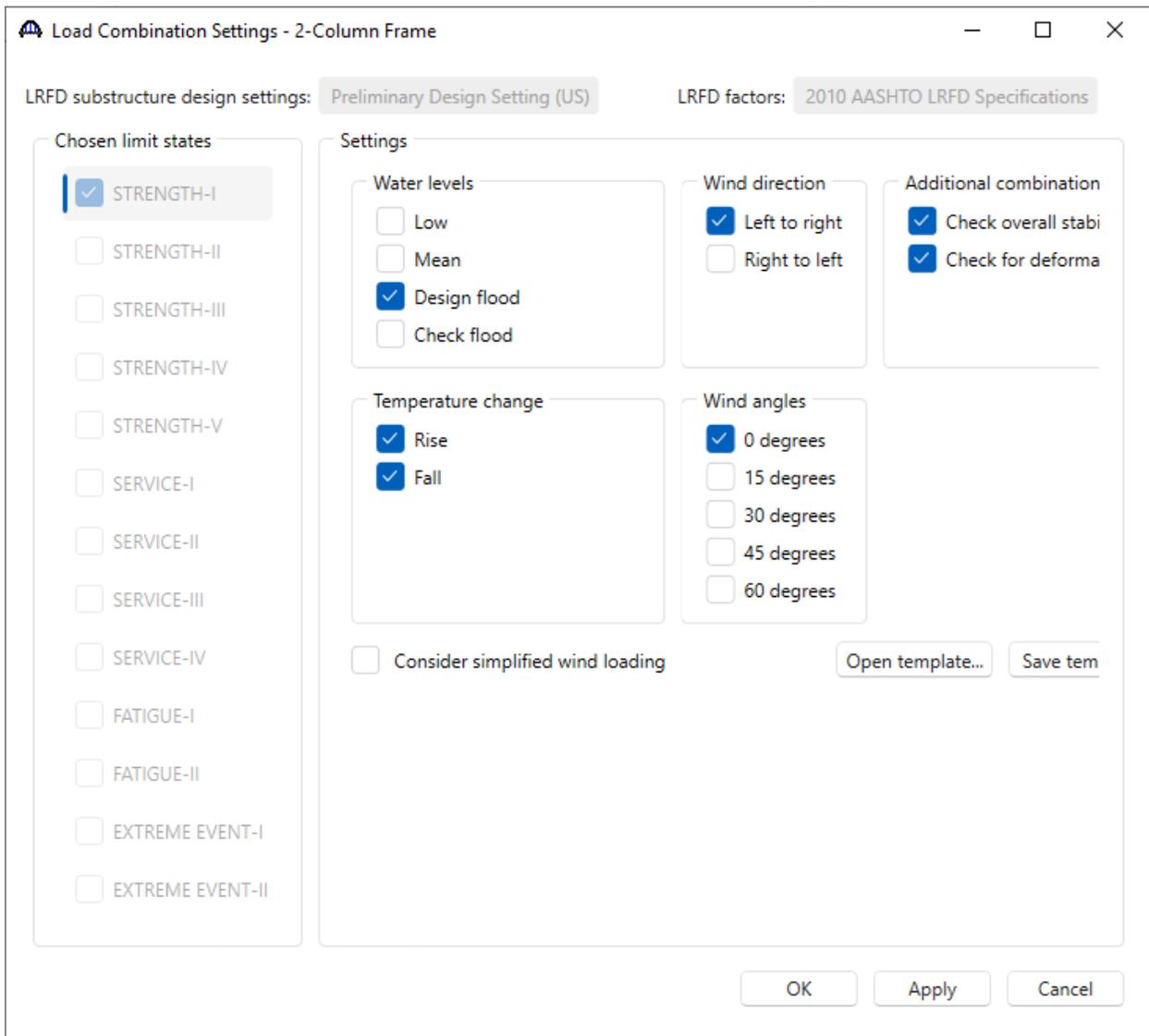
RC Pier Supporting Slab System Example

Pier Analysis

Select the loads to be included in our analysis. With the focus on the Pier Alternative **2-Column Frame**, open the **Load Combination** window from the right-click menu or from the BrDR **Substructure** ribbon.

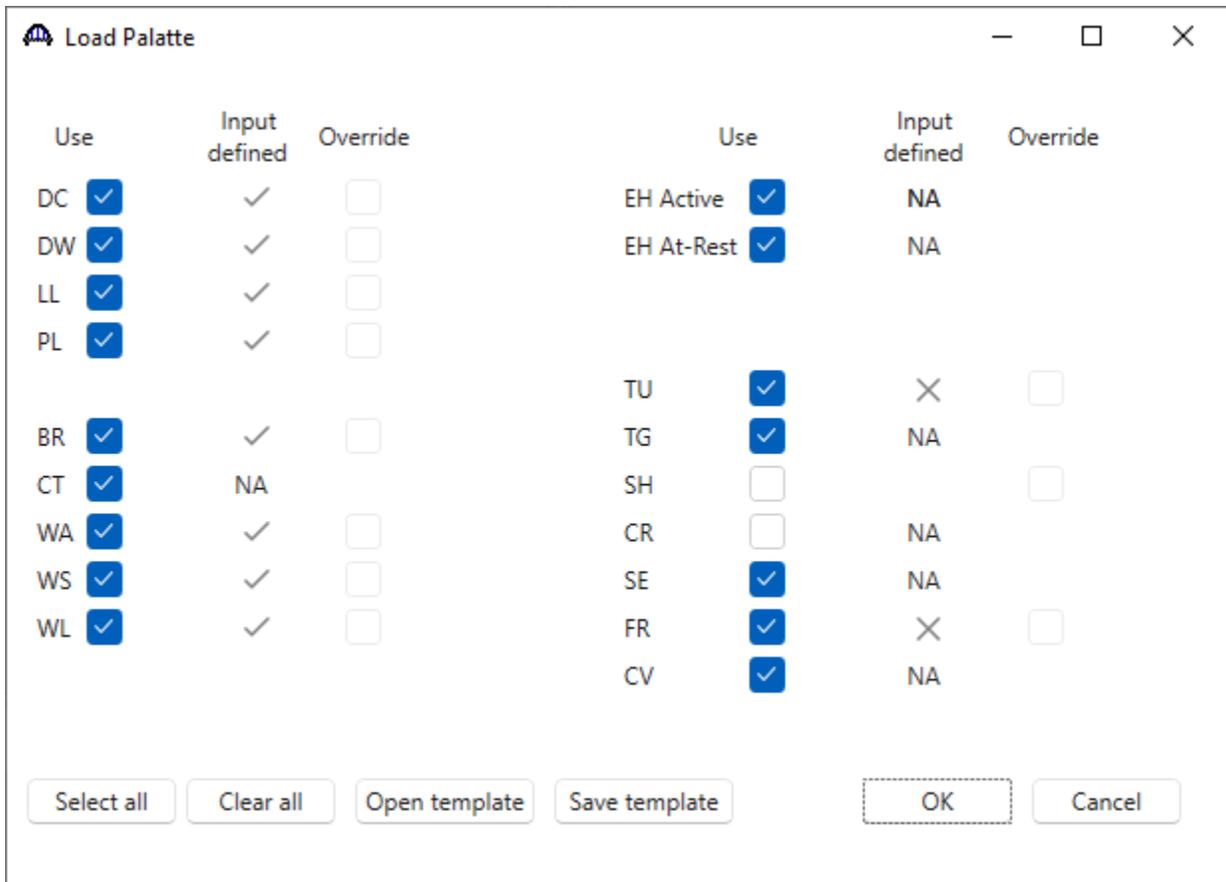
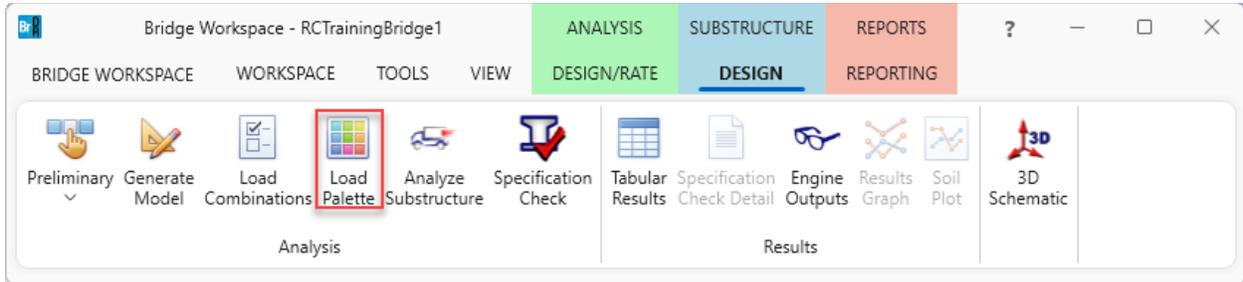


This window allows the user to specify the load conditions to be considered when BrDR performs the pier analysis. Use the following default selections.



RC Pier Supporting Slab System Example

Another window that allows the user to specify the load types to be included in the pier analysis is the **Load Palette** window. This window can be accessed by selecting the name of the pier alternative in the bridge workspace tree and clicking the **Load Palette** button.



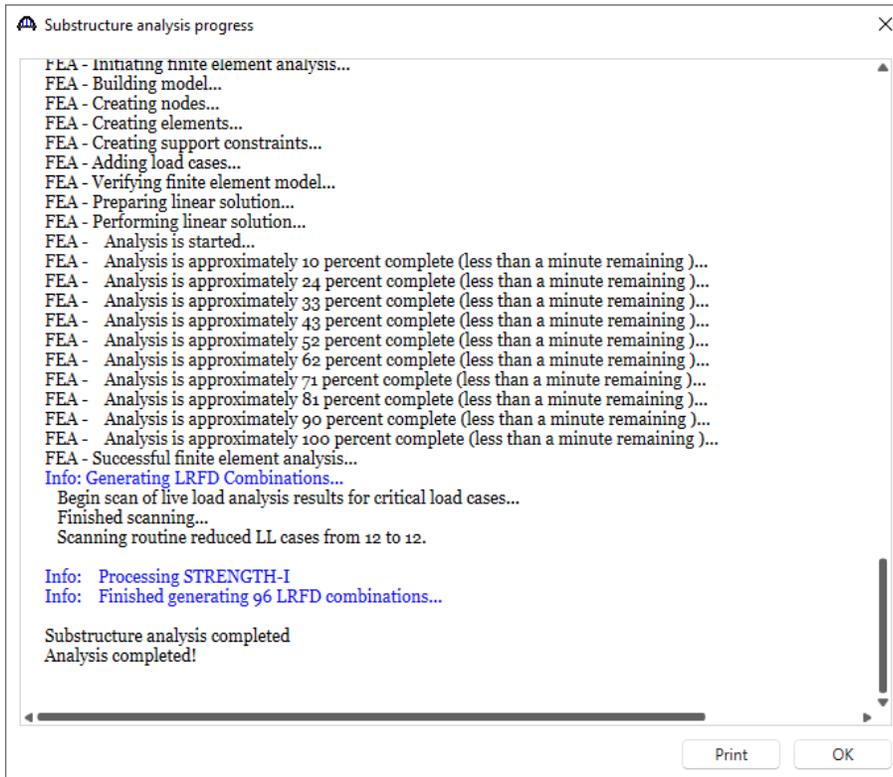
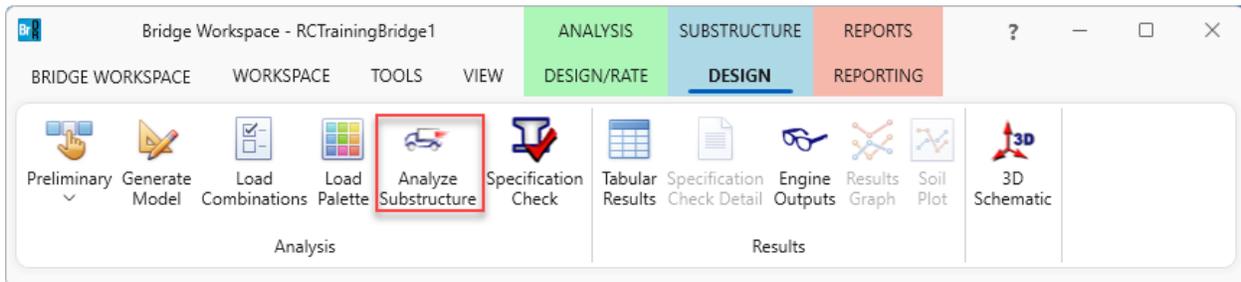
The **Load Palette** can be very useful for evaluating individual load types on the pier and when minimizing the time required for analysis is needed.

RC Pier Supporting Slab System Example

If the **Use** box is not checked for a load type, the load type will not be included in the pier analysis nor in the load combinations computed by BrDR. Results for the limit states which contain that load type will still be computed but the loading for that load type will be missing.

It is ok to keep the **Use** box checked for load types that do not apply to the pier. They will be ignored if they do not apply to the pier.

The pier can be analyzed by selecting the name of the pier alternative in the bridge workspace tree and clicking the **Analyze Substructure** button.



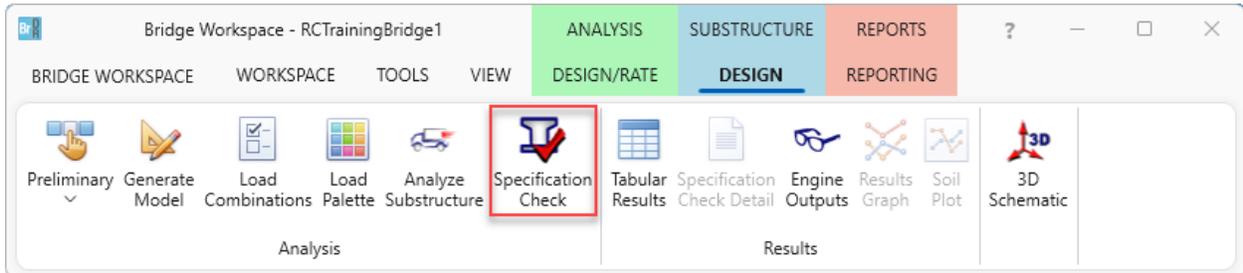
If the pier was analyzed successfully, the **Analysis completed!** message will be displayed in the **Substructure Analysis Progress** window.

RC Pier Supporting Slab System Example

Specification Checking

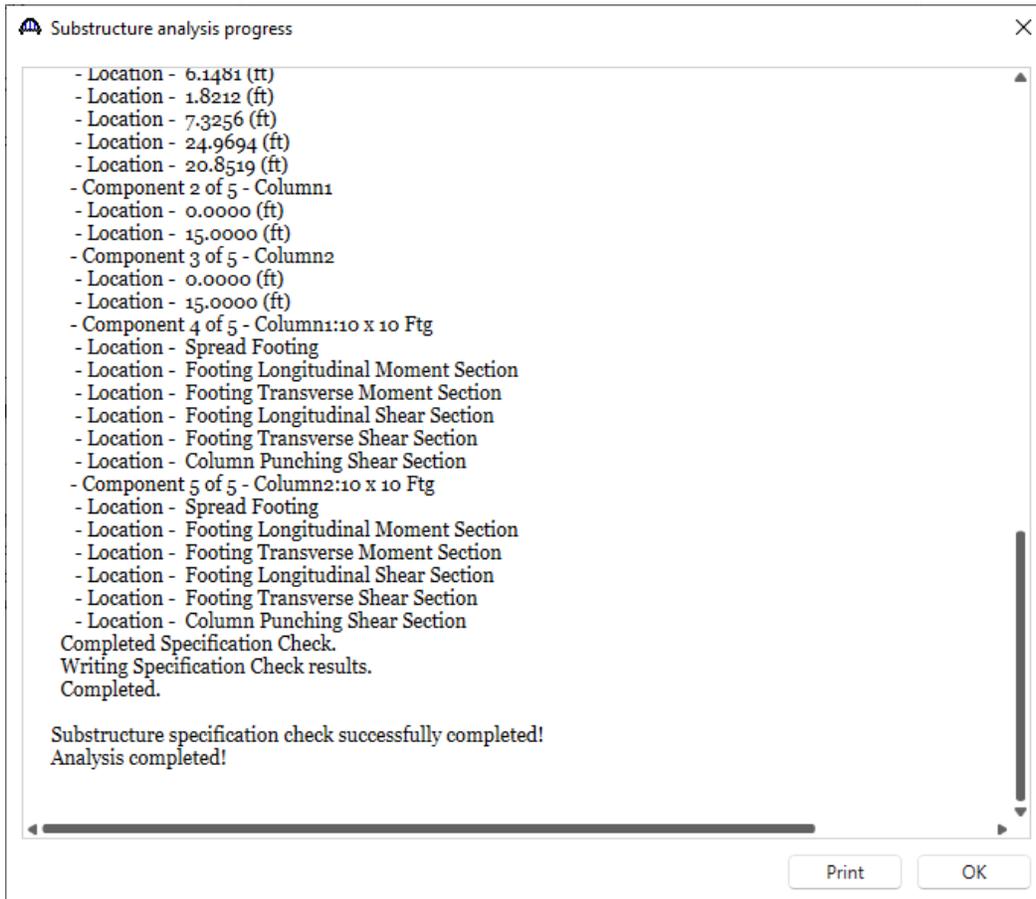
Now that the loads have been selected, analyze the pier and do a specification check.

Select **Spec Check** button.



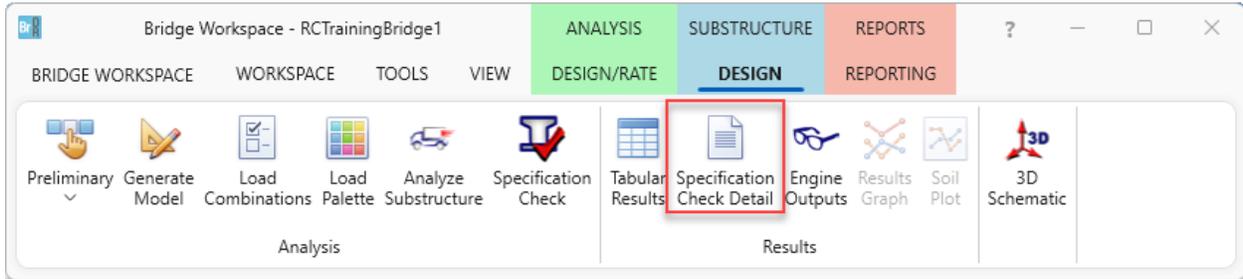
The **Validation** window will appear to alert the user to any missing data. Click the **Continue spec check** button to continue with the specification check.

The **Substructure Analysis Progress** dialog will open as shown below. The FE analysis of the pier will occur first followed by the specification check of the pier.



RC Pier Supporting Slab System Example

The specification checks can be viewed by selecting the **Spec Check Detail** button.



The screenshot shows the 'Specification Checks for 2-Column Frame - 303 of 423' window. The window displays a list of specification checks for a 'Cap' component. The table below shows the details of these checks.

Specification reference	Limit State	Flex. Sense	Pass/Fail
✓ 5.10.8 Shrinkage and Temperature Reinforcement		N/A	Passed
5.4.2.5 Poisson's Ratio		N/A	General Cor
5.4.2.6 Modulus of Rupture		N/A	General Cor
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Cor
5.7.2.2 Rectangular Stress Distribution		N/A	General Cor
✓ 5.7.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.7.3.3.2 Minimum Reinforcement		N/A	Passed
NA 5.7.3.4 Control of Cracking by Distribution of Reinforcement		N/A	Not Require
✓ 5.7.3.4(a) Longitudinal Skin Reinforcement		N/A	Passed
✓ 5.8.2.1 Torsion		N/A	Passed
Cracked_Moment_of_Inertia Section Property Calculations		Positive Flexure	General Cor
Cracked_Moment_of_Inertia Section Property Calculations		Negative Flexure	General Cor
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Cor
5.7.2.2 Rectangular Stress Distribution		N/A	General Cor
✓ 5.7.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.8.2.5 Minimum Transverse Reinforcement		N/A	Passed
✓ 5.8.2.7 Maximum Spacing of Transverse Reinforcement		N/A	Passed
✓ 5.8.3.3 Nominal Shear Resistance		N/A	Passed
5.8.3.4 Procedures for Determining Shear Resistance		N/A	General Cor
✓ 5.8.3.5 Longitudinal Reinforcement		N/A	Passed
✓ 5.10.8 Shrinkage and Temperature Reinforcement		N/A	Passed
5.4.2.5 Poisson's Ratio		N/A	General Cor
5.4.2.6 Modulus of Rupture		N/A	General Cor
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Cor
5.7.2.2 Rectangular Stress Distribution		N/A	General Cor
✓ 5.7.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.7.3.3.2 Minimum Reinforcement		N/A	Passed
NA 5.7.3.4 Control of Cracking by Distribution of Reinforcement		N/A	Not Require
✓ 5.7.3.4(a) Longitudinal Skin Reinforcement		N/A	Passed
✓ 5.8.2.1 Torsion		N/A	Passed

Double click on the article **5.7.3.2 Flexural Resistance (Reinforced Concrete)** for Cap at location 0.00 ft

RC Pier Supporting Slab System Example

Spec Check Detail for 5.7.3.2 Flexural Resistance (Reinforced Concrete)

5 Concrete Structures
 5.7 Material Properties
 5.7.3 Flexural Members
 5.7.3.2 Flexural Resistance
 (AASHTO LRFD Bridge Design Specifications, Fifth Edition - 2010, with 2010 interims)

Pier Cap Section - At Location = 0.0000 (ft) - Right

Cross Section Properties

 Depth = 36.00(in)
 Width = 48.00(in)
 Area = 1728.00(in^2)

Flexural Reinforcement

 As Dist. From
 (in^2) Bottom
 (in)

f'c = 4.00 ksi

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
 Otherwise the Resistance is computed as per the Specification.

Limit State	Load Combination	Mu kip-ft	Phi	Mn kip-ft	-- Override --		Mr= Phi * Mn kip-ft	Mr/Mu	NA Depth in	Ac in^2
					Phi	Mn kip-ft				
STR-I	1	0.00	0.750	0.00	---	---	0.00	99.00	0.01	0.00
STR-I	1	0.00	0.750	0.00	---	---	0.00	99.00	0.01	0.00

All 2 load cases evaluated passed (Capacity ratio >= 1.0)

OK