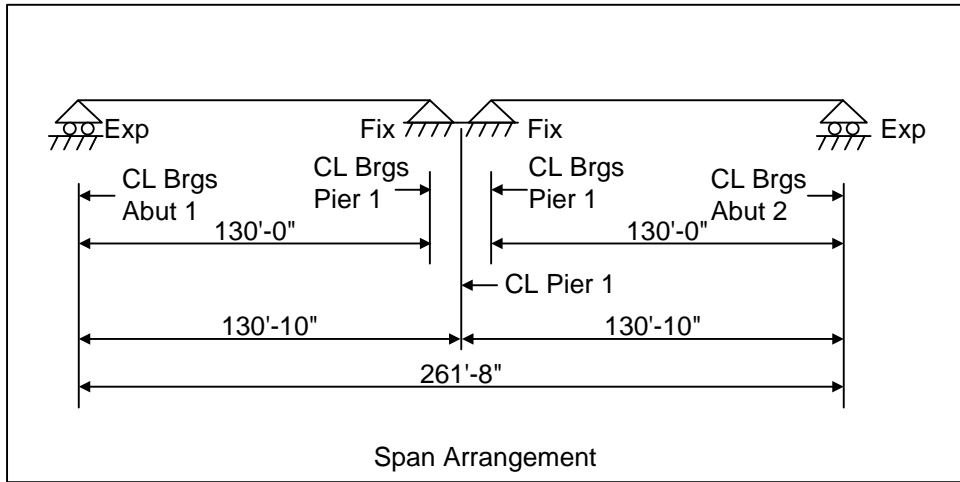
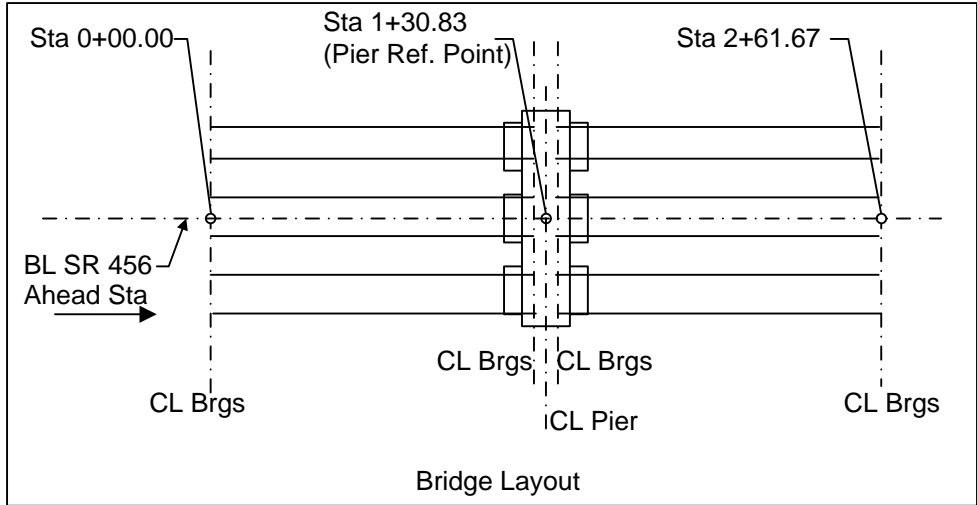


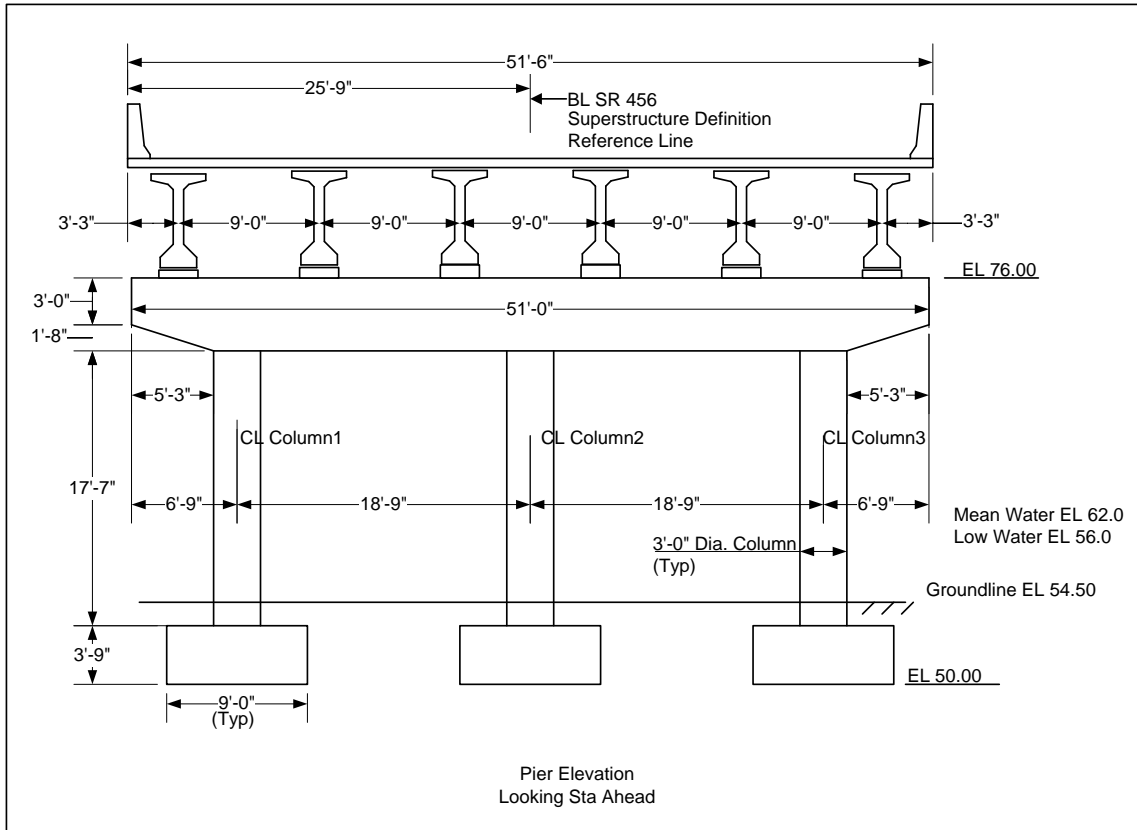
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*AASHTOWare BrDR 7.5.1*  
*Substructure Tutorial*  
*Pier2 – Frame Pier Example*

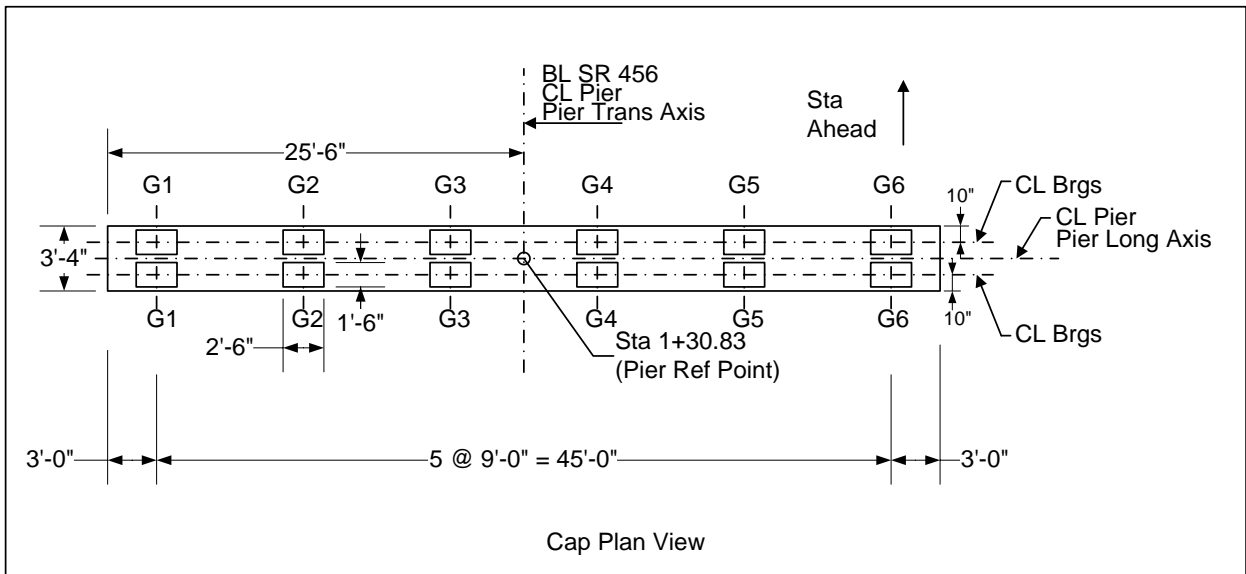
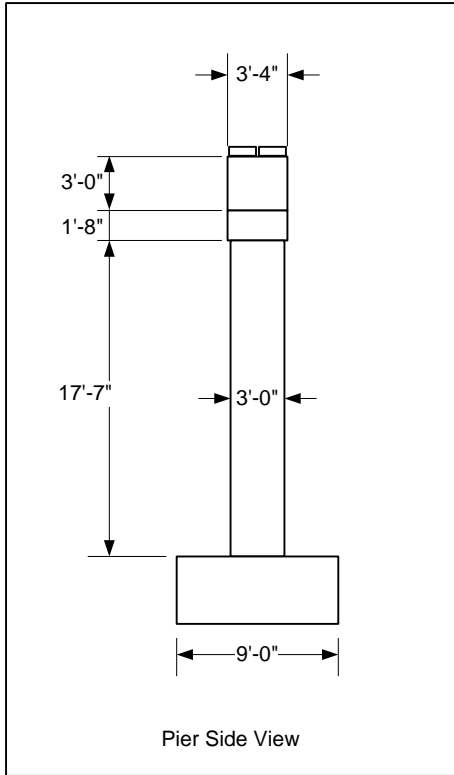
Pier2 – Frame Pier Example



# Pier2 – Frame Pier Example



# Pier2 – Frame Pier Example



## Pier2 – Frame Pier Example

### BrDR Substructure Training

Example features:

- Two independent simple span prestress I beam superstructures
- Reinforced concrete, three column frame pier, independent footings
- Pier skew – 0 degrees
- Pier subject to stream flow

Items covered in this series:

Topic 1:

- BrDR Substructure Capabilities
- Locating Substructure Units for Two Independent Superstructures

Topic 2:

- Bridge Data Related to Piers
- Pier Alternatives
- Pier Geometry
- Pier 3D Schematic
- Validating a Pier Alternative

Topic 3:

- Superstructure Loads
- Superstructure Environmental Loads
- Substructure Loads
- Load Calculation Reports

Topic 4:

- BrDR Substructure Toolbar
- Finite Element Model
- Pier Analysis
- Viewing Results in 3D Schematic
- Tabular Results
- Additional Reports

Using AASHTO LRFD Bridge Design Specifications, 5th Edition, with 2010 interims

Note: It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

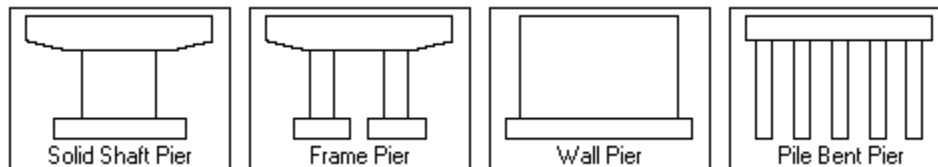
## Pier2 – Frame Pier Example

### Topic 1 - Pier 2 – Frame Pier Example

This topic is the first of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load, so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

### BrDR Substructure Capabilities

The BrDR Substructure module currently has the capability to describe the pier gross geometry, compute loads acting on the pier, perform a finite element analysis of the pier and compute the load combination results. Four types of reinforced concrete pier alternatives can be described: solid shaft (hammerhead) piers, frame piers, wall piers and pile bent piers.



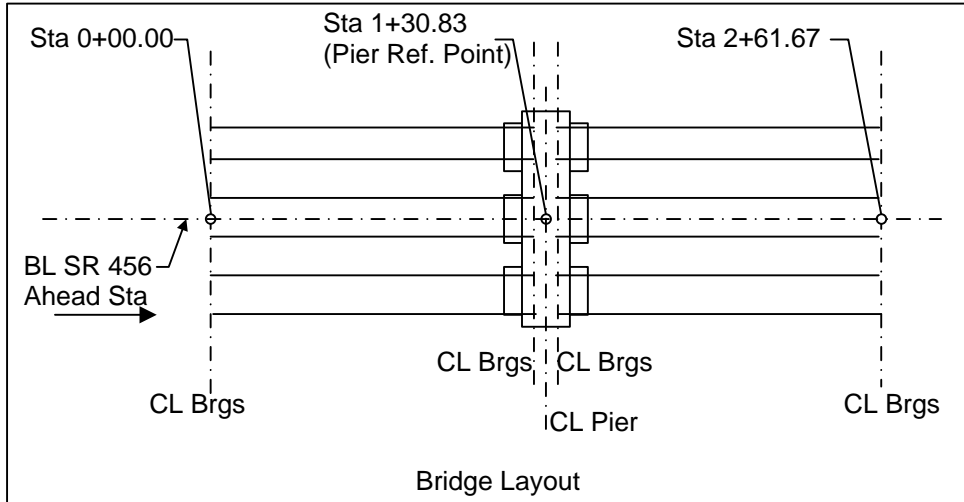
A three-dimensional schematic is available where a -scale drawing of the pier alternative can be viewed. BrDR can compute the loads acting on the pier, or override forces can be entered. Superstructure dead load and live load reactions are computed based on the superstructure definition assigned to the superstructure supported by the pier. BrDR generates a three-dimensional finite element model of the pier based on modeling parameters that are input. A finite element analysis of the pier is performed, and load combination results are generated based on the limit states chosen. The analysis results can be viewed in a text output and also be viewed on the three-dimensional schematic of the pier. Future releases of BrDR Substructure will have the capability to describe the reinforcement in the pier and perform a specification-check or design the reinforcement in the pier.

## Pier2 – Frame Pier Example

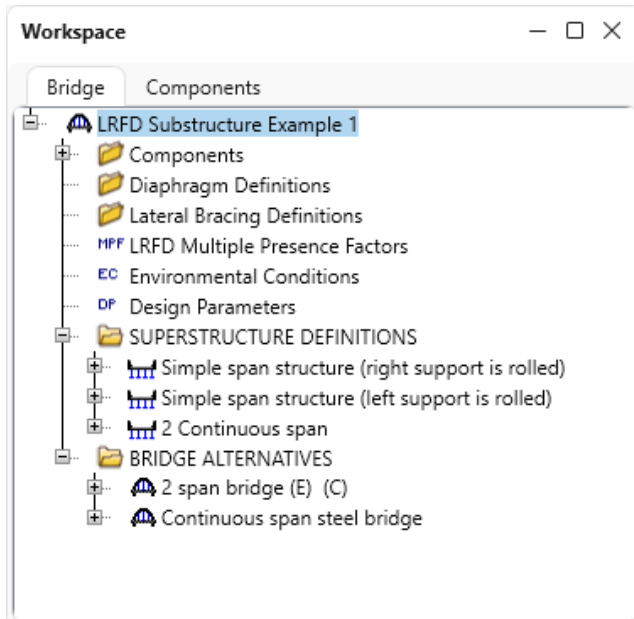
### Locating Substructure Units for Two Independent Superstructures

In BrDR, substructures are defined relative to bridge alternatives and the superstructures in a bridge alternative. Through this arrangement, loads from the superstructure can be carried down to the substructures.

This example has the following bridge layout:



In this tutorial, a bridge alternative and pier will be described in BrDR Substructure by adding a bridge alternative to the bridge **BID 20** in the sample database. From the **Bridge Explorer**, double click on **BID20** to open the bridge. The partially expanded **Bridge Workspace** tree is shown below. This bridge already contains several superstructure definitions and bridge alternatives. The superstructure definitions will be reused, and a new bridge alternative and a new pier will be created.



## Pier2 – Frame Pier Example

### Bridge

Open the **Bridge** window for this bridge by double clicking on **LRFD Substructure Example 1** on the **Bridge Workspace** tree.

The screenshot shows a software window titled "LRFD Substructure Example 1". At the top, there are input fields for "Bridge ID:" (containing "LRFD Substructure Examp") and "NBI structure ID (8):" (containing "LRFD\_EX1\_sub"). To the right of these fields are two checkboxes: "Template" (unchecked) and "Bridge completely defined" (unchecked). Further right is a "Bridge Workspace View" panel with three checkboxes: "Superstructures" (checked), "Culverts" (unchecked), and "Substructures" (checked). Below this is a tabbed interface with tabs for "Description", "Description (cont'd)", "Alternatives", "Global reference point", "Traffic", and "Custom agency fields". The "Description" tab is active, showing fields for "Name:" (LRFD Substructure Example 1), "Year built:" (empty), "Description:" (LRFD Substructure Example 1), "Location:" (empty), "Length:" (empty) ft, "Facility carried (7):" (empty), "Route number:" (empty), "Feat. intersected (6):" (empty), "Mi. post:" (empty), and "Default units:" (US Customary). At the bottom left, there is a "Bridge association..." dropdown menu and three checkboxes: "BrR" (checked), "BrD" (checked), and "BrM" (unchecked). At the bottom right, there are "OK", "Apply", and "Cancel" buttons.

No change of data is required on the **Description** tab of this window.



## Pier2 – Frame Pier Example

Navigate to the **Global reference point** tab.

The screenshot shows a software dialog box titled "LRFD Substructure Example 1". At the top, there are two input fields: "Bridge ID:" with the value "LRFD Substructure Examp1" and "NBI structure ID (8):" with the value "LRFD\_EX1\_sub". To the right of these fields are two checkboxes: "Template" (unchecked) and "Bridge completely defined" (unchecked). In the top right corner, there is a "Bridge Workspace View" panel with three checkboxes: "Superstructures" (checked), "Culverts" (unchecked), and "Substructures" (checked). Below these fields is a tabbed interface with five tabs: "Description", "Description (cont'd)", "Alternatives", "Global reference point" (which is the active tab), "Traffic", and "Custom agency fields". The "Global reference point" tab contains several input fields: "X:" with a value of "0" and unit "ft", "Y:" with a value of "0" and unit "ft", "Elevation:" with an empty field and unit "ft", "Longitude:" with an empty field and unit "Degrees", and "Latitude:" with an empty field and unit "Degrees". Below these fields are two buttons: "Open location" and "Location confirmed" (with an unchecked checkbox). At the bottom left of the dialog, there is a "Bridge association..." button and three checkboxes: "BrR" (checked), "BrD" (checked), and "BrM" (unchecked). At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

This tab contains an **X** and **Y** coordinate field for the bridge global reference point. This data could be used to describe the state plane coordinates for the bridge. When reviewing the **Pier** window later in this example, it is worth noting that, BrDR computes the coordinates for the pier based on this bridge global reference point. For this example, leave the X and Y coordinates as zero. Click **Cancel** to close the **Bridge** window without making any changes to it.

## Pier2 – Frame Pier Example

### Bridge Alternatives

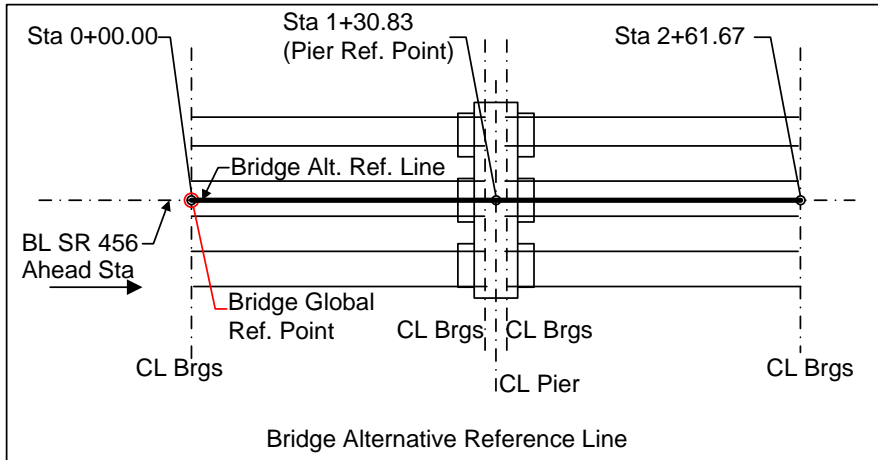
Double click on the **BRIDGE ALTERNATIVES** node in the **Bridge Workspace** tree to create a new bridge alternative and enter the following information.

The screenshot shows a dialog box titled "Bridge Alternative" with the following fields and options:

- Alternative name: Training Alt
- Substructures tab selected
- Description: (empty text box)
- Horizontal curvature:
- Reference line length: 261.67 ft
- Start bearing:  End bearing:
- Starting station: 0 ft
- Bearing: N 90° 0' 0.00" E
- Global positioning: Distance, Offset, Elevation (all empty)
- Bridge alignment:  Curved,  Tangent, curved, tangent,  Tangent, curved,  Curved, tangent
- Start tangent length, Curve length, Radius, End tangent length (all empty)
- Direction: Left (dropdown menu)
- Buttons: Superstructure wizard..., Culvert wizard..., OK, Apply, Cancel

The data on this tab orients the bridge alternative reference line. The substructure units for this example will be located with respect to this bridge alternative reference line. The bridge alternative is 261.67 feet long and the starting station is 0+00. The default bearing of N 90° 0' 0" E is acceptable for this example. The **Global positioning** data orients the bridge alternative reference line with respect to the bridge global reference point. since this bridge alternative is not offset to the bridge global reference point, this section can be left blank in this tutorial.

## Pier2 – Frame Pier Example



Switch to the **Substructures** tab and enter the following information to locate the abutments and piers. The substructure units are located by entering the location of the substructure unit reference point relative to the bridge alternative reference line. The substructure unit reference point is the point where the superstructure reference line intersects the pier longitudinal axis or centerline of bearing at an abutment. The location of abutments in BrDR Substructure can be specified but cannot currently describe the geometry of the abutments.

**Bridge Alternative** \_ □ ×

Alternative name:

Description **Substructures**

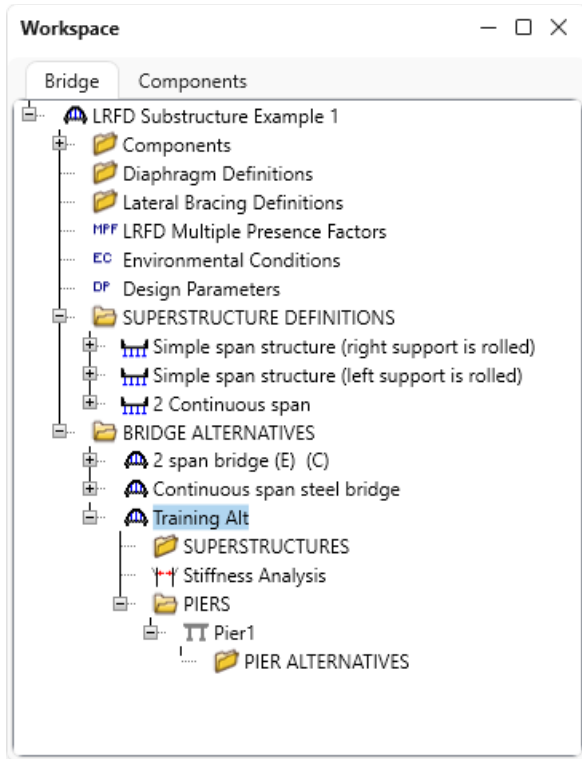
Substructure unit name	Station (ft)	Offset (ft)	Unit type
Abut1	0	0	Abutment ▾
Pier1	130.83	0	Pier ▾
> Abut2	261.67	0	Abutment ▾

Click F1 while the Substructures tab is active to open the BrDR Help file which contains examples for locating substructure units.

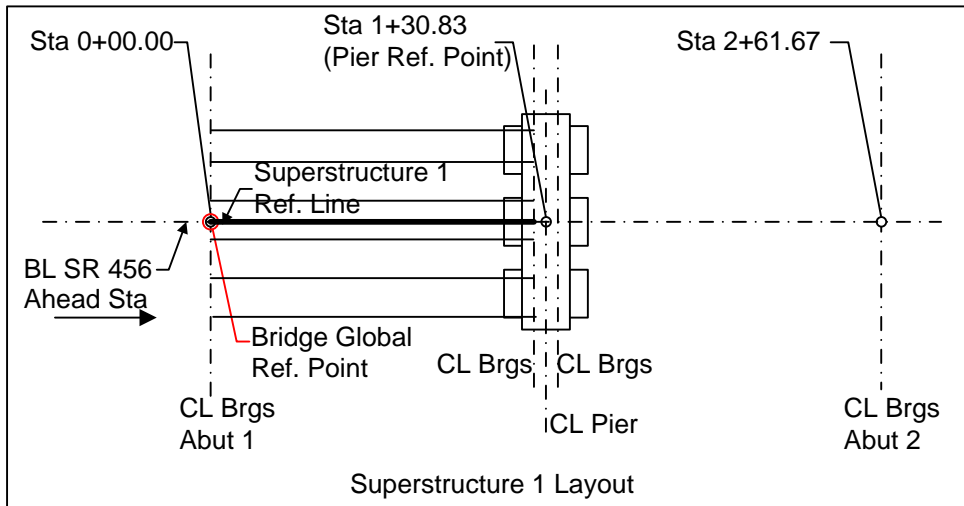
Click **OK** to apply the data and close the window.

## Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** is shown below.



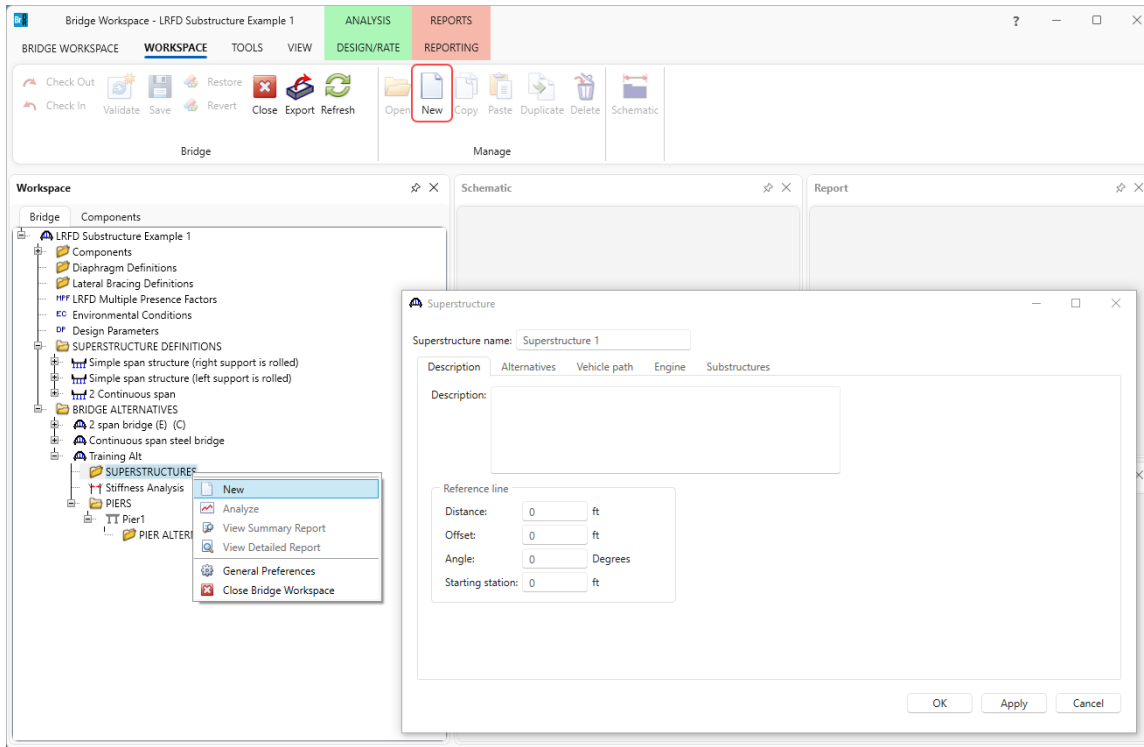
The layout of superstructure 1 is shown as follows.



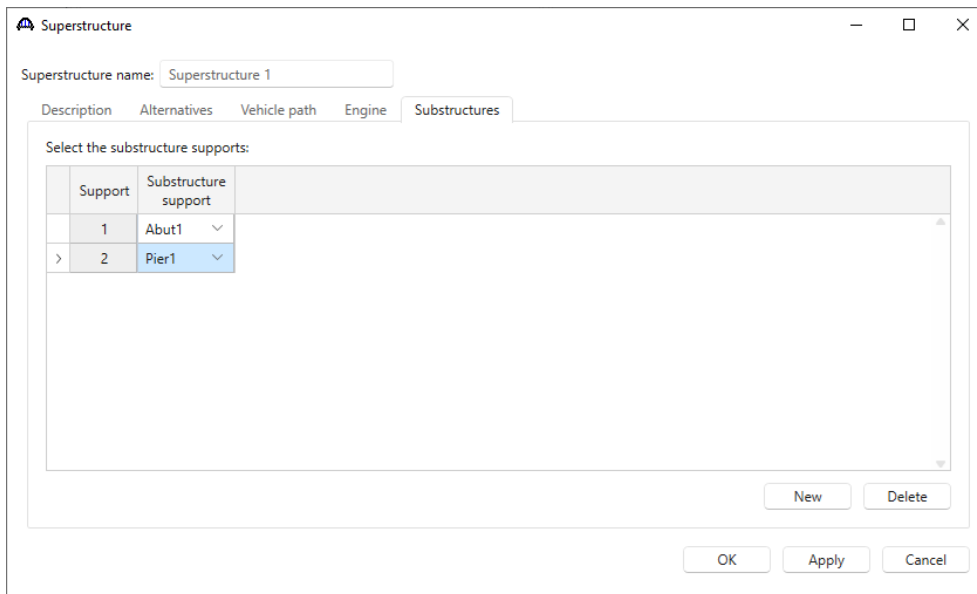
## Pier2 – Frame Pier Example

### Superstructure

Double click the **SUPERSTRUCTURES** node (or click **New** from the **WORKSPACE** ribbon or right click and select **New**) to create a new superstructure. Enter the following information to describe the first superstructure in this bridge alternative.



Navigate to the **Substructures** tab of this window and enter details as shown below.

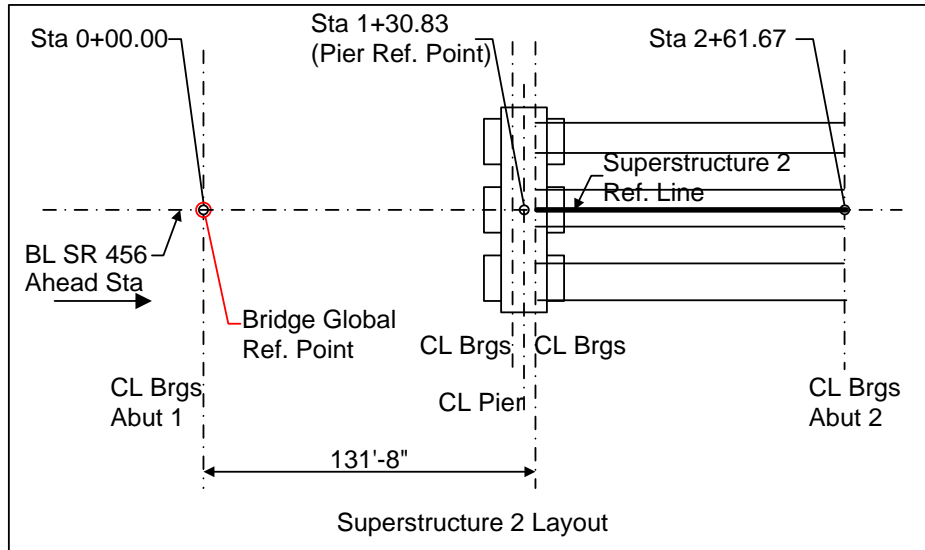


Click **OK** to add the first superstructure definition and close this window.

## Pier2 – Frame Pier Example

Similarly add another superstructure. The first superstructure is located at the start of the bridge alternative reference line, so no data is required for the reference line distance or offset. For the second superstructure, enter the span length of the superstructure and select the substructure supports.

The layout of superstructure 2 is shown as follows.



Double click on the **SUPERSTRUCTURES** node to create another new superstructure for the second superstructure in this bridge alternative. Enter data as shown below.

The screenshot shows the "Superstructure" dialog box with the following fields and values:

- Superstructure name: Superstructure 2
- Reference line:
  - Distance: 131.67 ft
  - Offset: 0 ft
  - Angle: 0 Degrees
  - Starting station: 131.67 ft

Buttons: OK, Apply, Cancel

## Pier2 – Frame Pier Example

Switch to the **Substructures** tab of this window and enter details as shown below.

Superstructure name:

Description Alternatives Vehicle path Engine **Substructures**

Select the substructure supports:

Support	Substructure support
1	Pier1
2	Abut2

New Delete

OK Apply Cancel

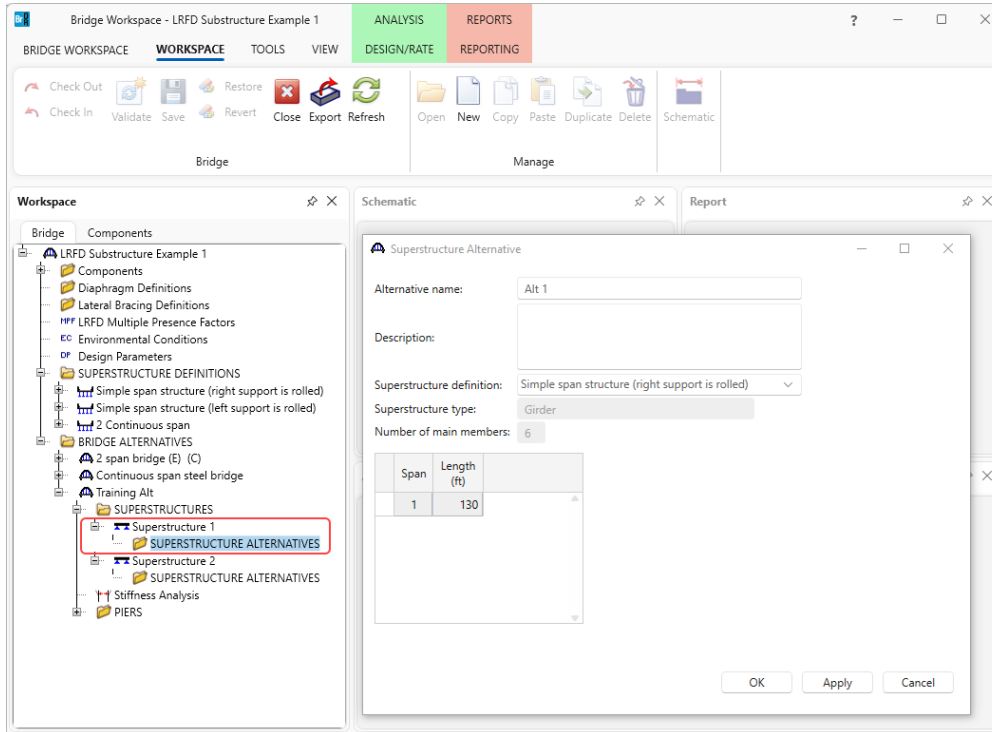
Click **OK** to add the superstructure definitions and close the window.

The second superstructure is located 131'-8" from the start of the bridge alternative reference line. The superstructure reference line created by data in this window will later be used to locate the superstructure definition on the pier cap. For piers that support 2 independent superstructures, the pier reference point is located by the intersection of the ahead span superstructure reference line and the pier longitudinal axis.

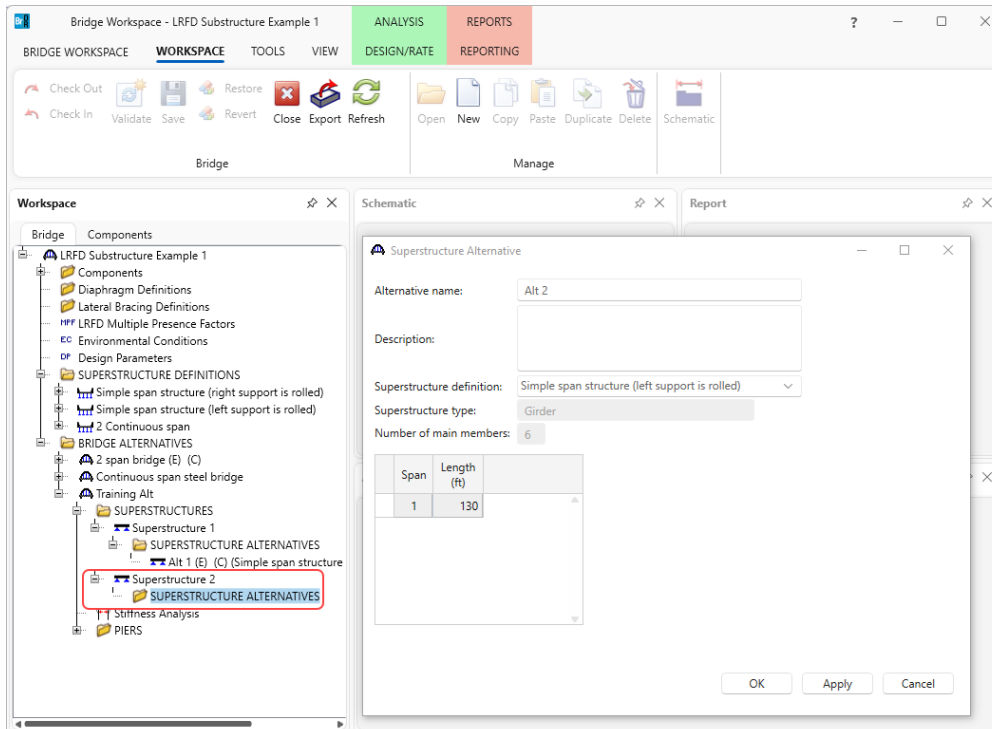
## Pier2 – Frame Pier Example

### Superstructure alternatives

Double click the **SUPERSTRUCTURE ALTERNATIVES** node under **Superstructure 1** to create a new superstructure alternative. It is important to assign a superstructure definition to the alternative so BrDR will know what superstructure definitions are carried by the pier. Enter the following data and click **OK**.



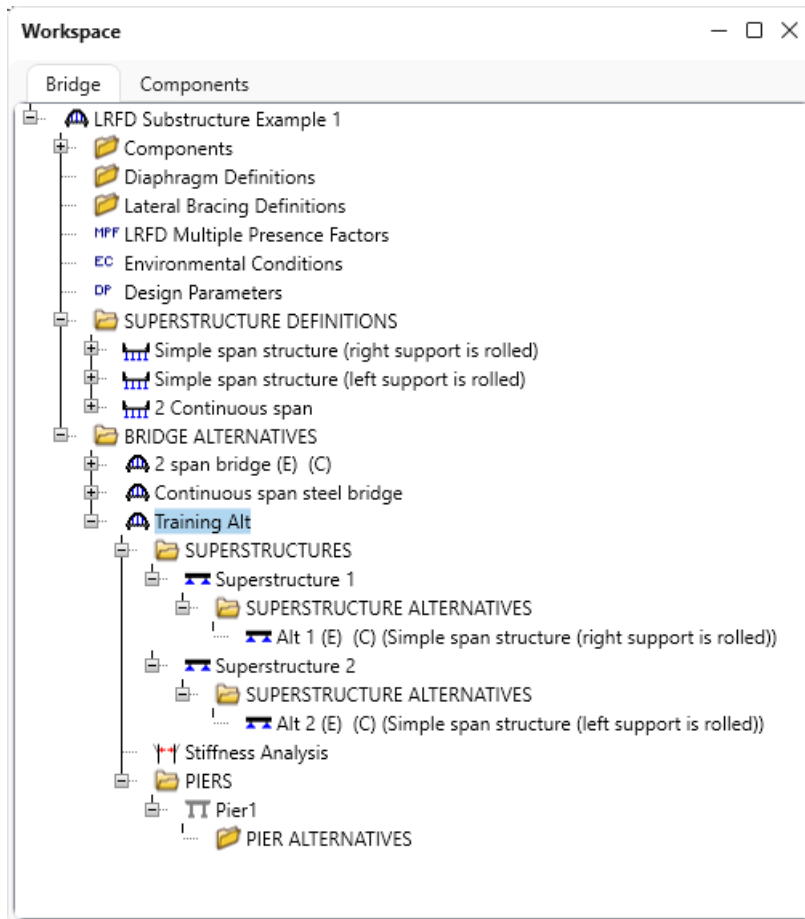
Do the same thing to create the following superstructure alternative for **Superstructure 2**.





## Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** is shown below.



## Pier2 – Frame Pier Example

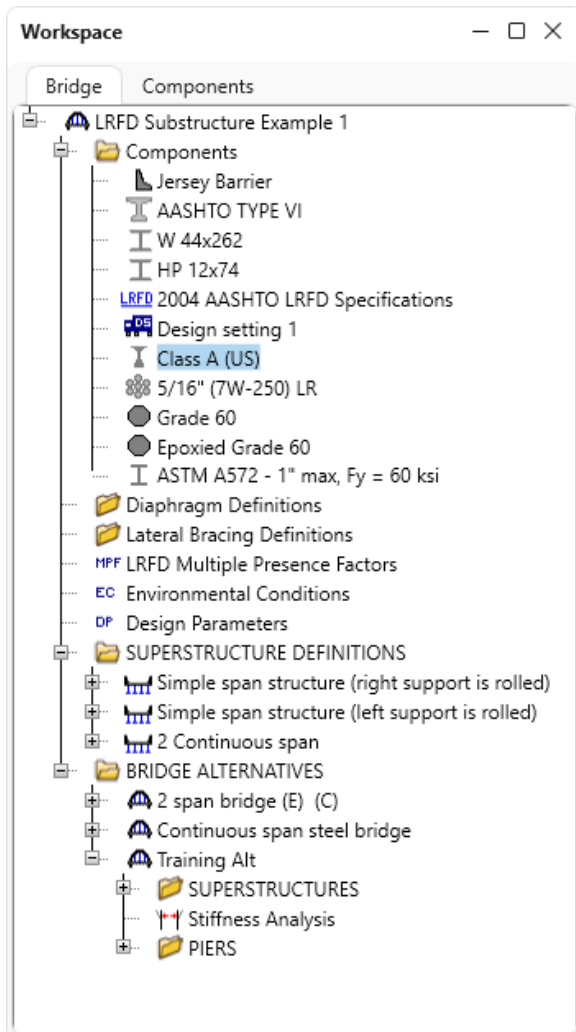
### Topic 2 - Pier 2 – Frame Pier Example

This topic is the second of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load, so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topic 1 must be completed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

### Bridge Data Related to Piers

This bridge already contains the following materials. **Class A (US)** concrete will be used in this pier alternative, so no new material need to be added. The partially expanded **Bridge Workspace** tree is shown below.



## Pier2 – Frame Pier Example

### LRFD Multiple Presence Factors

Double click on the **LRFD Multiple Presence Factors** node in the **BWS** tree. This window displays the multiple presence factors from AASHTO LRFD Table 3.6.1.1.2-1. These factors will be used when BrDR Substructure combines multiple loaded lanes. No adjustment to these values are needed so click **Cancel** to close the window.

	Number of loaded lanes	Multiple presence factors "m"
>	1	1.2
	2	1
	3	0.85
	>3	0.65

Reduce based on ADTT if applicable

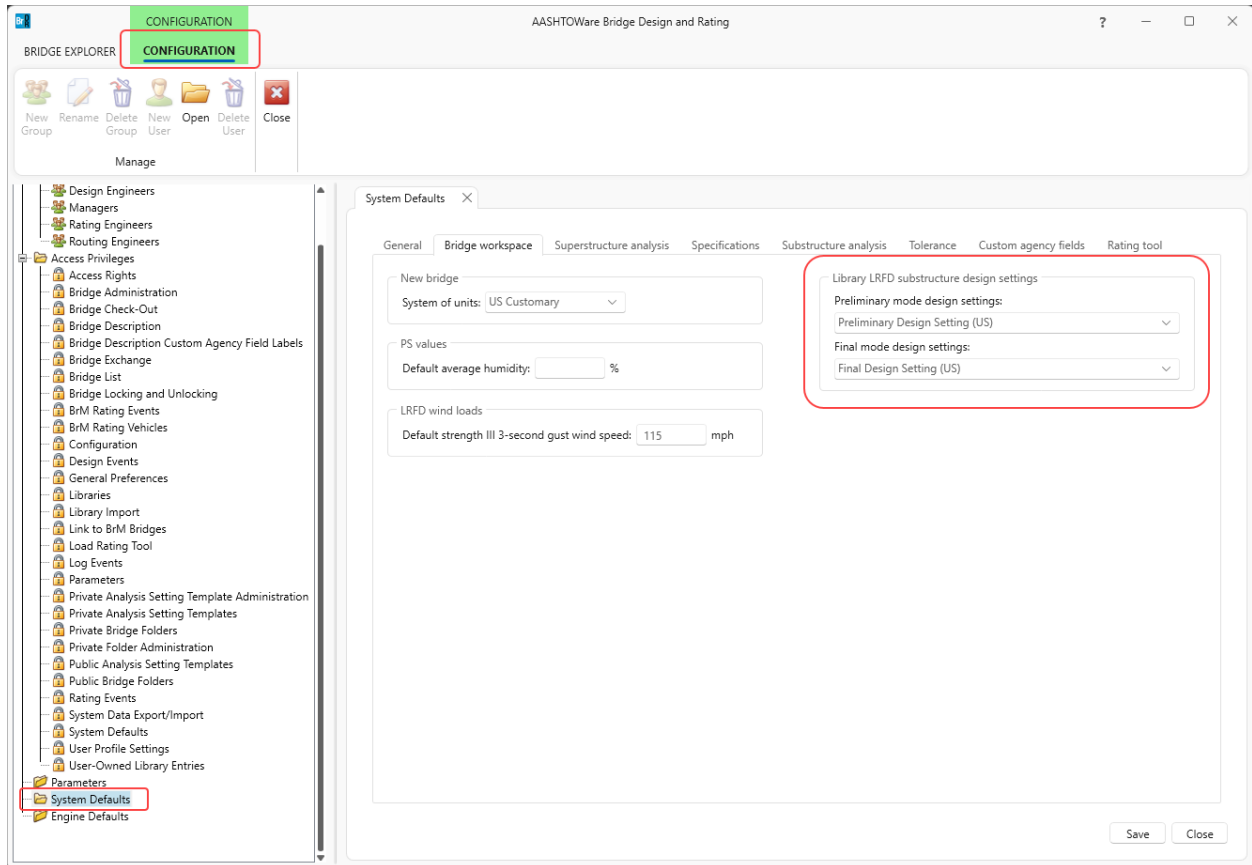
OK Apply Cancel

## Pier2 – Frame Pier Example

### LRFD Substructure Design Settings

LRFD Substructure Design Settings contain a set of LRFD factors, limit states to be included in the analysis and vehicles to be used in the analysis. BrDR Substructure uses these design settings when analyzing a pier.

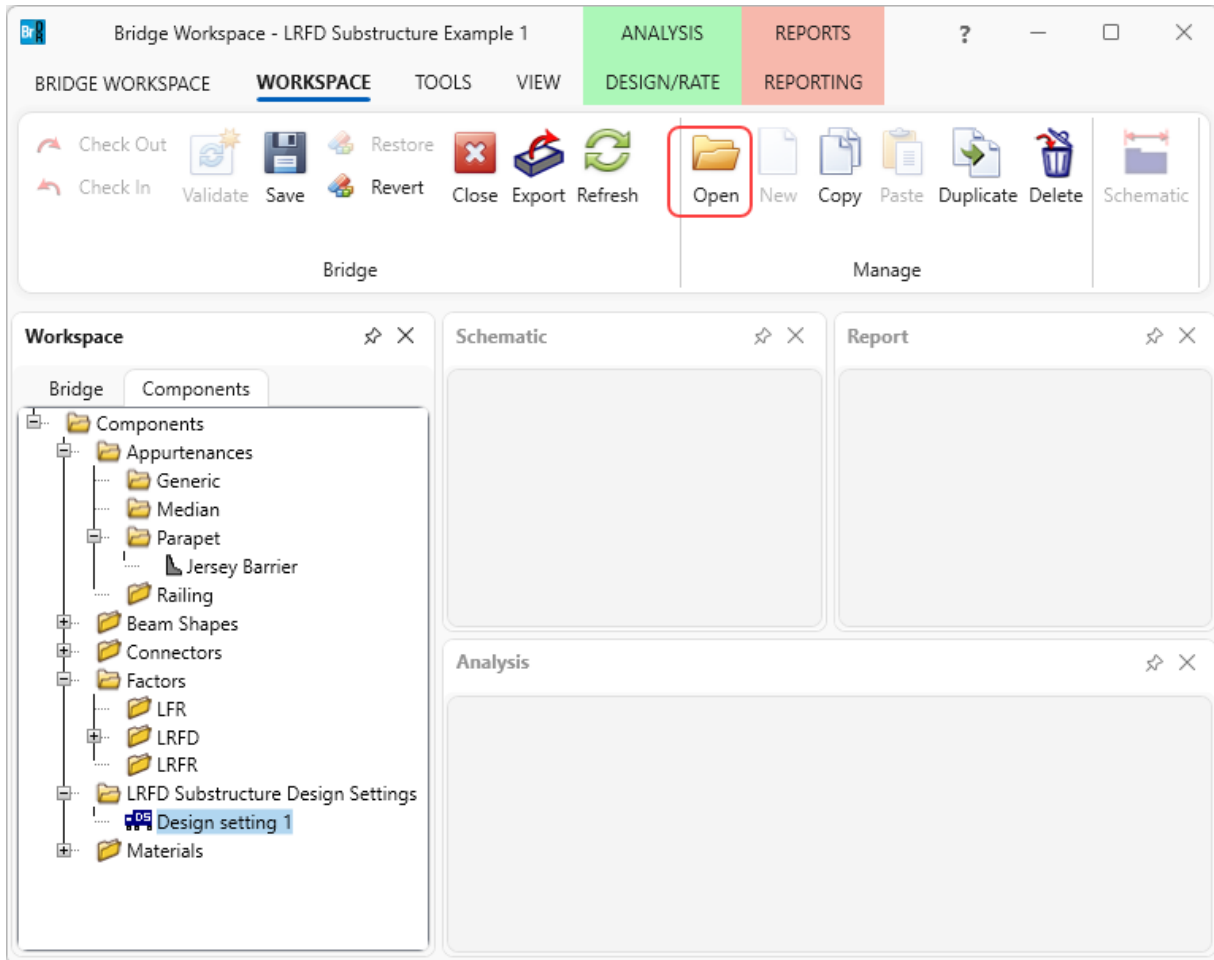
BrDR has system default **LRFD Substructure Design Settings** as specified on the **System Defaults** window in the **Configuration Browser** shown below.



These default design settings will not be used. For this example, bridge level design settings specific will be created and used.

## Pier2 – Frame Pier Example

To create design settings, navigate to the **Components** tab of the **BWS** tree, expand **LRFD Substructure Design Settings** node and double click on **Design setting 1** (or click and select **Open** from the **WORKSPACE** ribbon) as shown below.



## Pier2 – Frame Pier Example

Select the **Design setting type** as **Preliminary**. Based on this selection, whether is preliminary design or final design, appropriate design setting is used during the pier analysis. This selection can help minimize the time of the pier analysis.

LRFD Substructure Design Settings

Name: Design setting 1

Description:

Design setting type

- Preliminary
- Final

Limit states | Vehicles | Substructure loading

Analysis method type	Analysis module	Spec version	Factors
> LRFD	AASHTO LRFD	LRFD 5th 2010i	2004 AASHTO LRFD Specifications

Choose the limit states to be included in the analysis:

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

Dynamic load allowance

Fatigue and fracture limit states: 15 %

All other limit states: 33 %

Copy from library... OK Apply Cancel

The limit states belonging to the factor are displayed. Since this design setting is for use in the Preliminary mode, only the Strength-I limit state is selected. When the pier is analyzed with this design setting only the Strength-I limit state load combinations will be computed. This can save significant time in the analysis in the preliminary pier geometry sizing stage.

## Pier2 – Frame Pier Example

The vehicles to be used in the analysis are chosen on the **Vehicles** tab.

The screenshot shows the 'LRFD Substructure Design Settings' dialog box with the 'Vehicles' tab selected. The 'Name' field is 'Design setting 1'. The 'Design setting type' section has 'Preliminary' checked and 'Final' unchecked. The 'Vehicles' tab contains a tree view of vehicle options and a 'Vehicle summary' box. The tree view shows '2004 AASHTO LRFD Specifications' expanded to 'Vehicles', which is further expanded to 'Standard'. Under 'Standard', several options are listed, including 'HL-93 (US)'. The 'Vehicle summary' box shows 'All limit states except Strength-II and Fatigue' expanded to 'HL-93 (US)', which is further expanded to 'Strength-II limit state' and 'Fatigue limit state'. Below the tree view is a table with columns 'Vehicle' and 'Consider pair of design tandems'. The table has one row with 'HL-93 (US)' and a checked checkbox. At the bottom of the dialog are buttons for 'Copy from library...', 'OK', 'Apply', and 'Cancel'.

Name:

Description:

Design setting type  
 Preliminary  
 Final

Limit states | **Vehicles** | Substructure loading

LRFD factors:  
2004 AASHTO LRFD Specifications

Vehicle selection:

- Vehicles
  - Standard
    - Alternate Military Loading
    - EV2
    - EV3
    - HL-93 (SI)
    - HL-93 (US)
    - HS 20 (SI)
    - HS 20-44
    - LRFD Fatigue Truck (SI)
    - LRFD Fatigue Truck (US)
  - Agency Defined
  - User Defined
  - No vehicle

Vehicle summary:  
All limit states except Strength-II and Fatigue

- HL-93 (US)
  - Strength-II limit state
  - Fatigue limit state

	Vehicle	Consider pair of design tandems
1	HL-93 (US)	<input checked="" type="checkbox"/>

Copy from library... OK Apply Cancel

## Pier2 – Frame Pier Example

The **Substructure loading** tab allows to describe how the vehicle single lane reactions are applied to the substructure. If the axle load P is entered as zero, the entire single lane reaction will be applied to the deck as a uniform load spread over the lane width. If a value other than zero is entered, the single lane reaction applied to the deck will contain two concentrated loads each equal to P/2 at the wheel locations within the lane width and the remainder of the single lane reaction will be applied as a uniform load spread over the lane width.

LRFD Substructure Design Settings
— □ ×

Name:

Description:

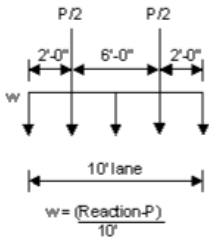
Design setting type

Preliminary

Final

Limit states
Vehicles
Substructure loading

Vehicle single lane reactions will be applied to the deck as shown below:



Vehicle	Vehicle type	Axle load P (kip)
HL-93 (US)	Design Truck	32
HL-93 (US)	Design Tandem	25
HL-93 (US)	Design Lane	0
> HL-93 (US)	Truck Pair	32
HL-93 (US)	Tandem Pair	25

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



## Pier2 – Frame Pier Example

### Environmental Conditions

Navigate back to the **Bridge** tab of the **Bridge Workspace**. Double click on the **Environmental Conditions** node in the **BWS** tree. The following window appears.

Wind load basis

Gust speed  Fastest-mile speed

Store unit as

US  SI

Wind exposure category

B  C  D

Table 3.8.1.2-1

Design 3-second gust wind speed

Load combinations	3-second gust wind speed, V (mph)
> Strength III	Value from system defaults
Strength V	80
Service I	70

Table 3.8.1.2-2

Drag coefficient, CD

Component	Windward	Leeward
> I-girder and box-girder bridge superstructures	1.3	N/A
Truss columns and arches-sharp edged member	2	1
Truss columns and arches-round member	1	0.5
Bridge substructure	1.6	N/A
Sound barriers	1.2	N/A

Specify the surface conditions for the bridge. All other data on this tab defaults to the AASHTO specs.

Table 3.8.1.2.1-1

Gust effect factor

Structure type	Gust effect factor, G
> Sound barriers	0.85
All other structures	1

Table 3.8.1.2.3a-1

Skew coefficients for various skew angles of attack

Skew angle of wind (Degrees)	Trusses, columns, and arches		Girders	
	Transverse skew coefficient	Longitudinal skew coefficient	Transverse skew coefficient	Longitudinal skew coefficient
> 0	1	0	1	0
15	0.933	0.16	0.88	0.12
30	0.867	0.373	0.82	0.24
45	0.627	0.547	0.66	0.32
60	0.32	0.667	0.34	0.38

Table 3.8.1.3-1

Wind components on live load

Skew angle (Degrees)	Normal component (kip/ft)	Parallel component (kip/ft)
> 0	0.1	0
15	0.088	0.012
30	0.082	0.024
45	0.066	0.032

Vertical upward wind pressure

Strength III:  ksf

Strength IV:  ksf

Simplified wind loading

Transverse wind on superstructure, % of computed value:  %

Longitudinal wind on superstructure, % of transverse value:  %

Wind on live load, transverse:  kip/ft

Wind on live load, longitudinal:  kip/ft

OK Apply Cancel

This window lists the environmental conditions acting on the bridge. The wind pressure values on the **Wind** tab default to values from the AASHTO LRFD Specifications.

## Pier2 – Frame Pier Example

Navigate to the **Temperature** tab. The temperature ranges on this tab default to those in AASHTO LRFD Table 3.12.2.1-1. Enter the setting temperature and select the climate type as shown below.

Environmental Conditions

Wind load basis:  Gust speed  Fastest-mile speed

Store unit as:  US  SI

Wind-gust Wind-fastest **Temperature** Stream

Setting temperature: 20 F

Climate:  Moderate  Cold

Temperature ranges

Climate	Steel or aluminium		Concrete		Wood	
	Min (Degrees F)	Max (Degrees F)	Min (Degrees F)	Max (Degrees F)	Min (Degrees F)	Max (Degrees F)
> Moderate	0	120	10	80	10	75
Cold	-30	120	0	80	0	75

OK Apply Cancel

Specify the setting temperature and climate for the bridge. All other data on this tab defaults to the AASHTO specs.

## Pier2 – Frame Pier Example

Navigate to the **Stream** tab. This tab allows to enter data describing the stream flow for this bridge. The stream drag coefficient values default to those in AASHTO LRFD Table 3.7.3.2-1 and 3.7.3.1-1. Enter the stream flow skew and the design water data shown below.

**Environmental Conditions**

Wind load basis:  Gust speed  Fastest-mile speed

Store unit as:  US  SI

Wind-gust Wind-fastest Temperature **Stream**

Stream pressure longitudinal drag coefficient

Type	CD
> Semicircular-nosed pier	0.7
Square-ended pier	1.4
Debris lodged against the pier	1.4
Wedged-nosed pier with nose angle 90 de...	0.8

Stream pressure lateral drag coefficient

Angle between direction of flow and longitudinal axis of pier (Degrees)	CL
> 0	0
5	0.5
10	0.7
20	0.9
30	1

Stream flow skew:  Degrees

Design water levels

Water level name	Consider	Water elevation (ft)	Design velocity (ft/sec)	Scour elevation (ft)
Low	<input checked="" type="checkbox"/>	56	25	
Mean	<input checked="" type="checkbox"/>	62	40	
Design Flood	<input type="checkbox"/>			
> Check Flood	<input type="checkbox"/>			

OK Apply Cancel

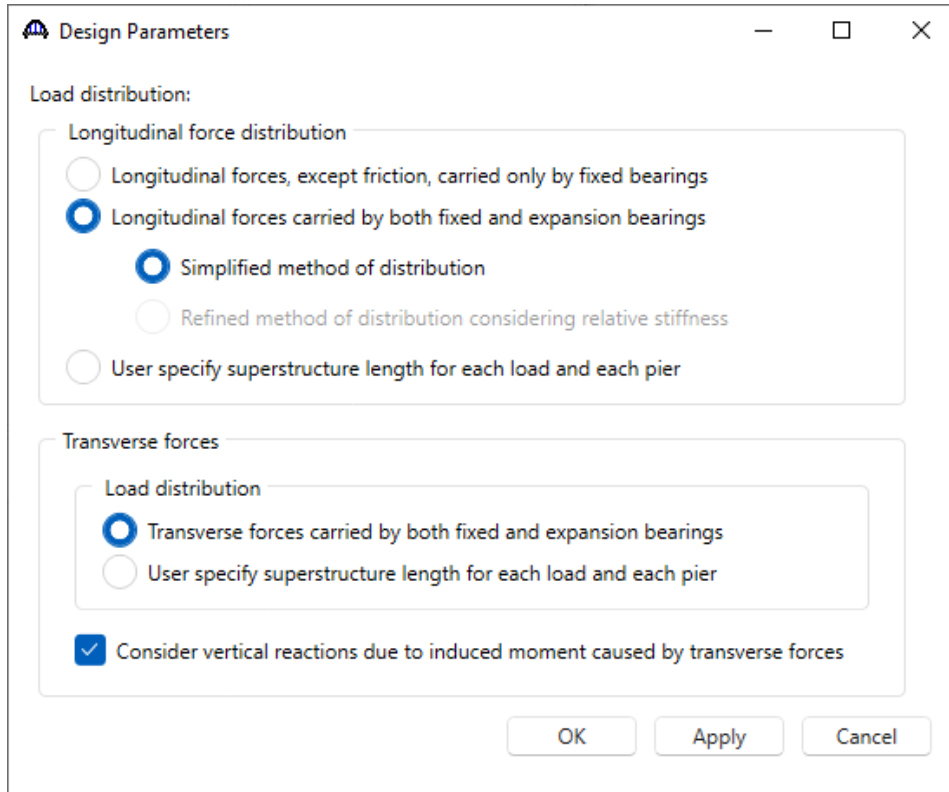
Click **OK** to apply the data and close the window.

In this example, 2 water levels are considered in pier analysis. No scour elevation is entered for these water levels. To analyze a pier for a water level that includes the effect of scour and a water level that does not include the effect of scour, separate pier alternatives must be created to model pier for scour conditions. This is because the foundation conditions change when scour is present, and these scour foundation conditions need to be described in a different pier alternative.

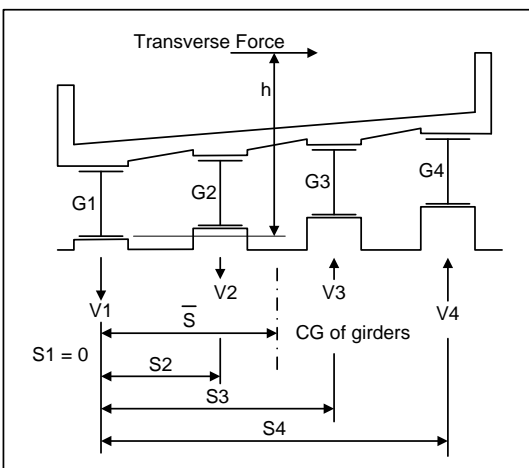
## Pier2 – Frame Pier Example

### Design Parameters

Double click on the **Design Parameters** node in the **BWS** tree. This window allows to specify how superstructure loads are distributed to the substructures.

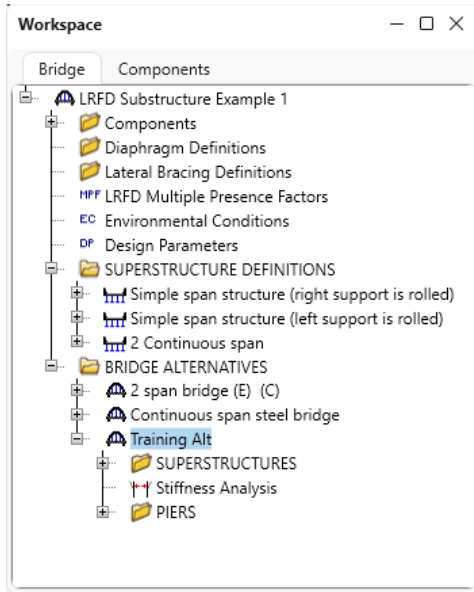


Check the consider vertical reactions checkbox if the vertical reactions on the superstructure due to the induced moment about the superstructure longitudinal axis caused by transverse forces acting on the superstructure are to be considered as shown below. Refer to the BrDR help topic for this window for more information.



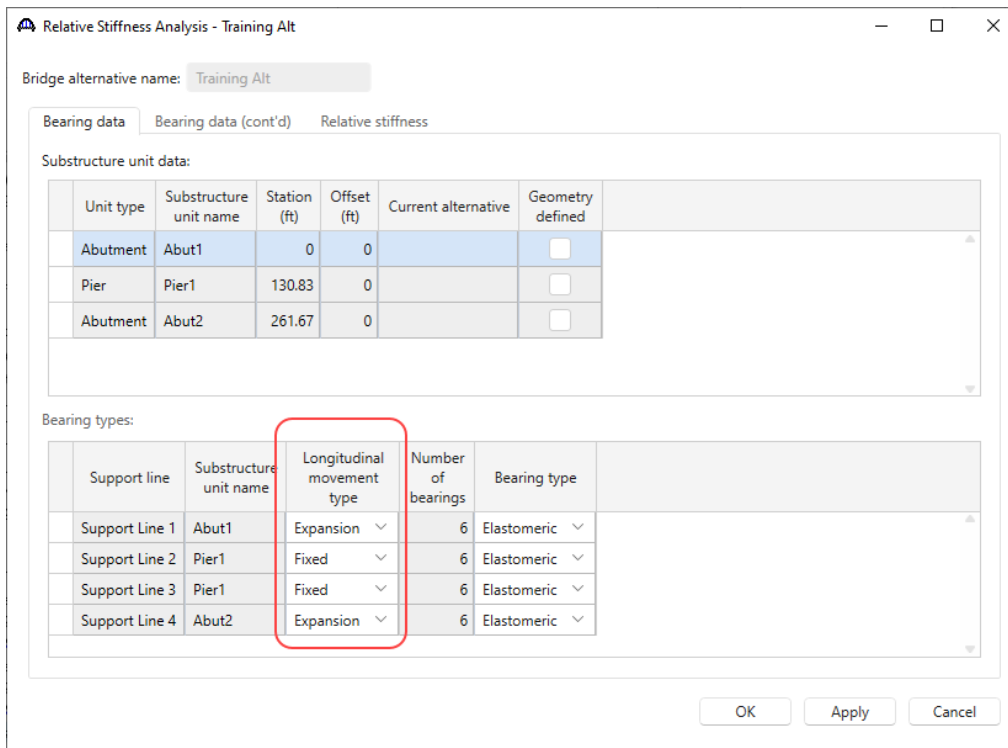
## Pier2 – Frame Pier Example

To describe the pier, navigate to the **Training Alt** bridge alternative and follow steps as shown below.



### Stiffness Analysis

Double click on the **Stiffness Analysis** node in the **BWS** tree. This window describes the bearing data at each substructure unit in the bridge alternative. This bearing data can be used by BrDR to compute the length of loaded superstructure applied to each substructure unit. Enter the data shown below. Note that Pier1 supports two superstructure support lines since this example has two independent superstructures resting on this pier.



## Pier2 – Frame Pier Example

The **Bearing data (cont'd)** tab allows to enter the coefficient of friction for sliding bearings so BrDR can compute the friction forces on the pier. Since this bridge has elastomeric bearings, the coefficient of friction is not entered for the bearings.

The **Relative stiffness** tab allows the user to specify how longitudinal superstructure loads are distributed to the substructure units. Since this bridge alternative contains two superstructures, the length needs to be specified. BrDR cannot compute these lengths. Enter the following values and click the **OK** button to apply all the changes and close the window.

Bridge alternative name: Training Alt

Bearing data Bearing data (cont'd) **Relative stiffness**

Longitudinal force distribution

- Longitudinal forces, except friction, carried only by fixed bearings
- Longitudinal forces carried by both fixed and expansion bearings
  - Simplified method of distribution
  - Refined method of distribution considering relative stiffness
- User specify superstructure length for each load and each pier
  - Specify length unit
  - Specify length percentage

Compute superstructure length to apply to each pier...

Bridge alternative contains multiple superstructures. You must specify the lengths yourself.

Substructure unit name	Superstructure length to apply to unit (ft)	Superstructure length to apply to unit (%)
> Abut1	0	
Pier1	260	
Abut2	0	

OK Apply Cancel

## Pier2 – Frame Pier Example

### Pier

Double click on the **Pier1** node in the **BWS** tree and enter the following data.

Pier name: Pier1

Description: Stream flow

Pier skew angle

Input skew angle    Skew angle: 0 Degrees    Description:

Input bearing angle

Finished groundline elevation: 54.5 ft     Superstructure defined in BrDR

Soil density:    kcf

Back superstructure longitudinal direction

Consider as fixed

Consider as expansion

Ahead superstructure longitudinal direction

Consider as fixed

Consider as expansion

Pier location relative to bridge alternative

Station: 130.83 ft    Offset: 0 ft

Computed pier location relative to structure

Station: 130.83 ft

Offset: 0 ft

Computed pier coordinates

X: 130.83 ft

Y: 0 ft

Existing	Current	Pier alternative name	Description
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OK    Apply    Cancel

## Pier2 – Frame Pier Example

Navigate to the **Stream flow** tab and enter the following data for the stream flow on this pier. Since the bridge alternative and pier were created before stream flow data was added on the **Environmental Conditions** window, the bridge environmental stream flow data was not automatically set for the pier. If the stream flow data on the bridge **Environmental Conditions** window was set prior to creating the pier, the pier would have inherited this data from the bridge.

Pier name: Pier1

Description Stream flow

Pier subject to stream flow

Stream flow skew = 0 Degrees

Stream flow direction  
 Left to right  
 Right to left

Design water levels

	Water level name	Consider	Water elevation (ft)	Design velocity (ft/sec)	Scour elevation (ft)
>	Low	<input checked="" type="checkbox"/>	56	25	0
	Mean	<input checked="" type="checkbox"/>	62	40	0
	Design Flood	<input type="checkbox"/>	0	0	0
	Check Flood	<input type="checkbox"/>	0	0	0

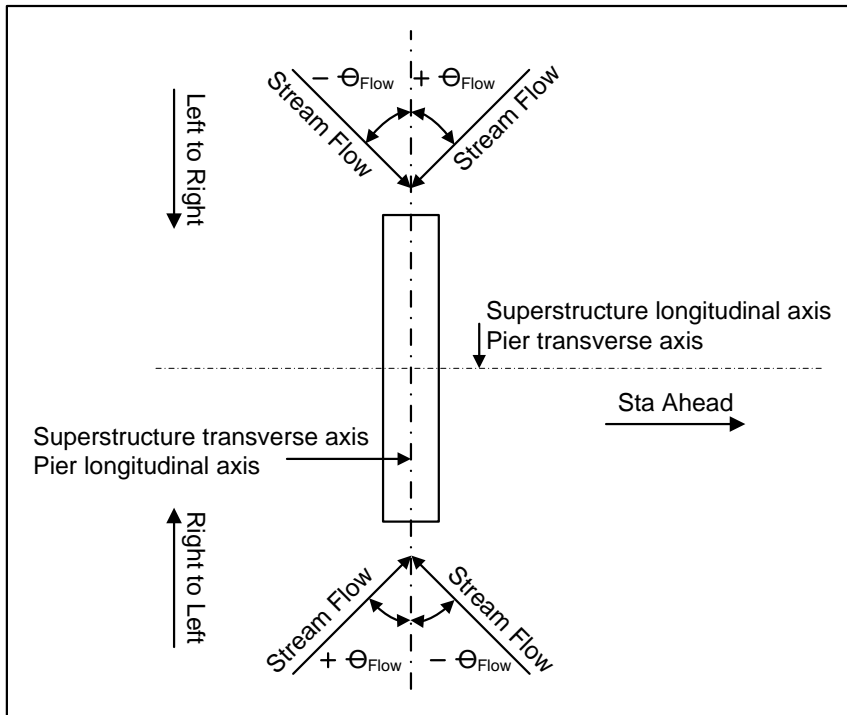
OK Apply Cancel

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



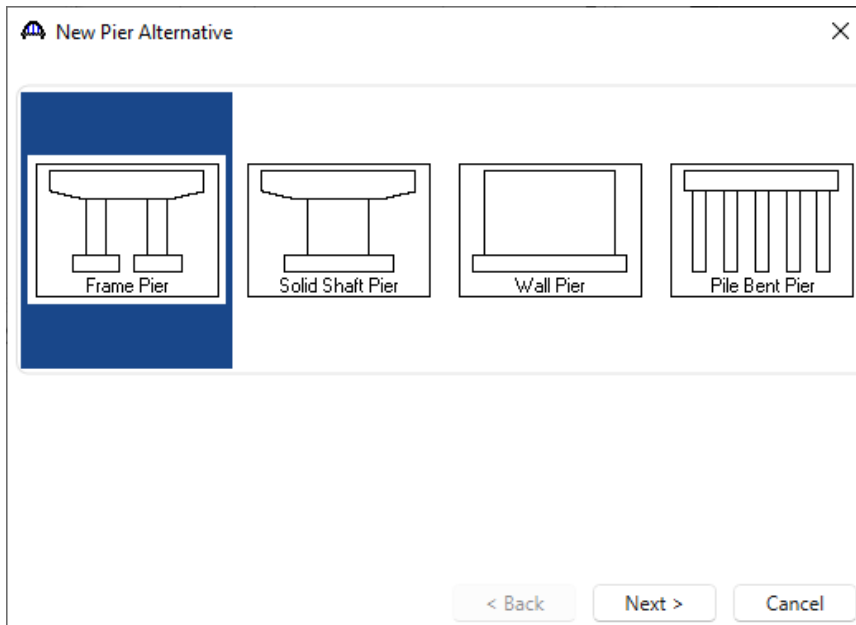
## Pier2 – Frame Pier Example

The following sketch illustrates the stream flow and skew directions.



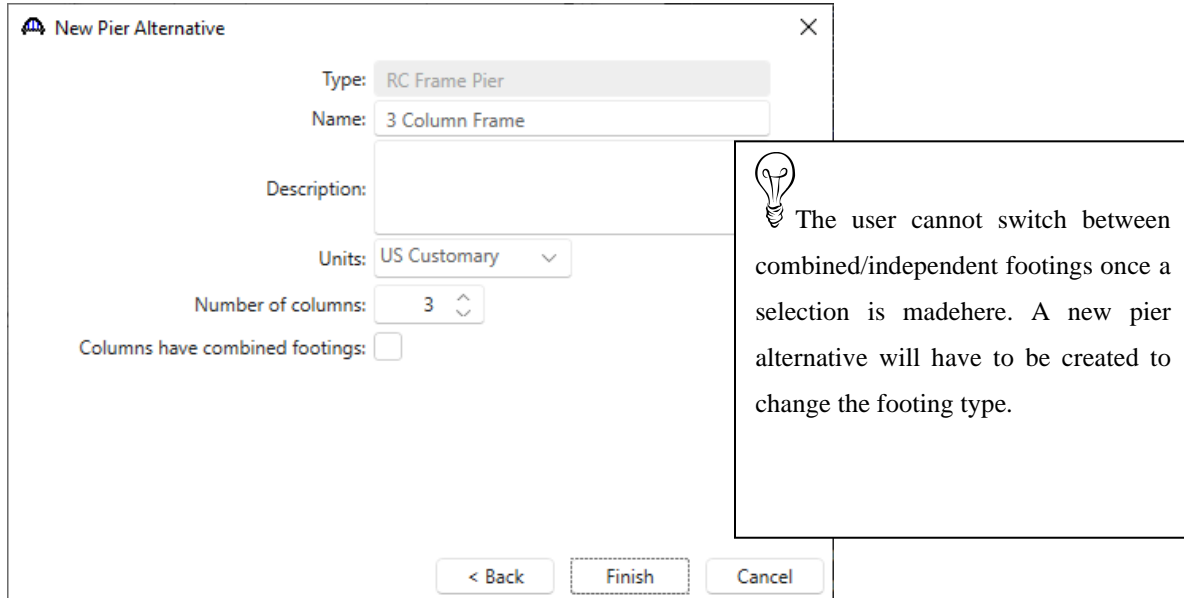
## Pier Alternatives

Double click the **PIER ALTERNATIVES** node and the following **New Pier Alternative** will open. Select the **Frame Pier** and click **Next**.



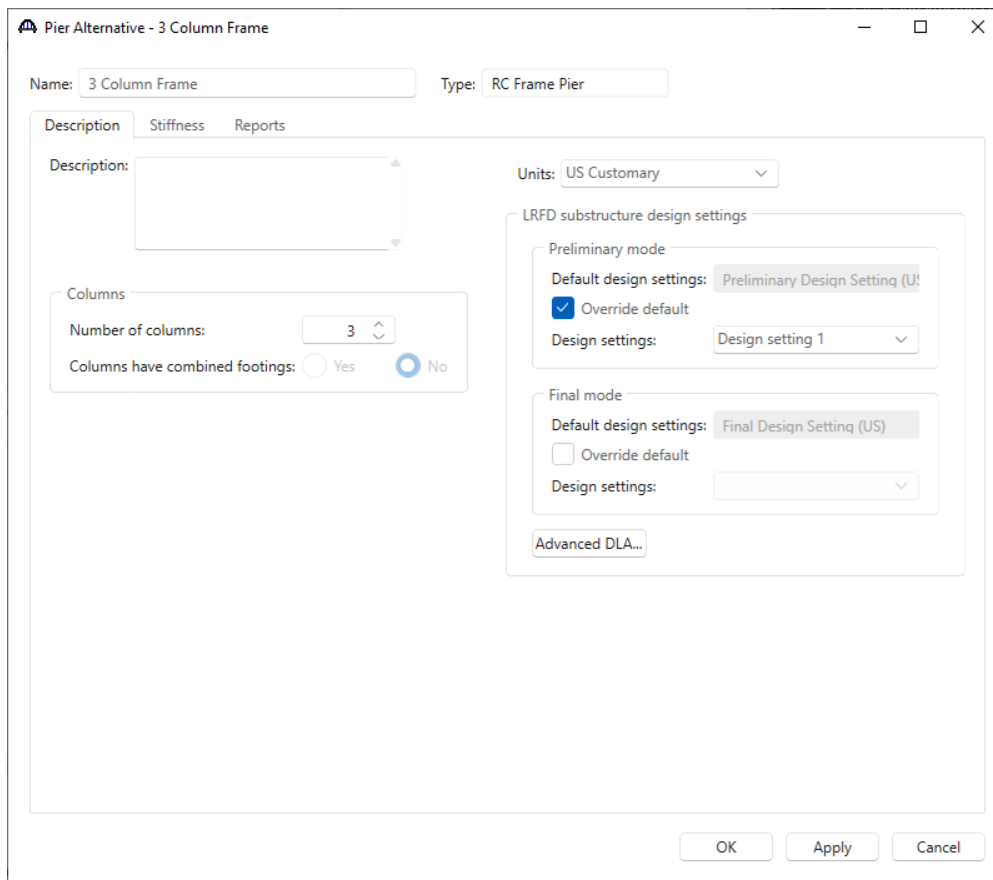
## Pier2 – Frame Pier Example

Enter a name for the pier alternative and number of columns and click **Finish** to close the wizard and create the new pier alternative.



The screenshot shows the 'New Pier Alternative' dialog box. The 'Type' is set to 'RC Frame Pier', the 'Name' is '3 Column Frame', and the 'Units' are 'US Customary'. The 'Number of columns' is set to 3. There is an unchecked checkbox for 'Columns have combined footings'. At the bottom are buttons for '< Back', 'Finish', and 'Cancel'. A callout box with a lightbulb icon contains the text: 'The user cannot switch between combined/independent footings once a selection is made here. A new pier alternative will have to be created to change the footing type.'

The **Pier Alternative** window will automatically open. Override the Preliminary mode default design setting with the design setting created earlier – **Design setting 1**.



The screenshot shows the 'Pier Alternative - 3 Column Frame' window. The 'Name' is '3 Column Frame' and the 'Type' is 'RC Frame Pier'. The 'Description' tab is active, showing a text area for the description. The 'Units' are 'US Customary'. The 'Columns' section shows 'Number of columns' set to 3 and 'Columns have combined footings' set to 'No'. The 'LRFD substructure design settings' section is expanded, showing 'Preliminary mode' with 'Default design settings' set to 'Preliminary Design Setting (US)', 'Override default' checked, and 'Design settings' set to 'Design setting 1'. The 'Final mode' section is also visible, with 'Default design settings' set to 'Final Design Setting (US)' and 'Override default' unchecked. At the bottom are buttons for 'OK', 'Apply', and 'Cancel'.

## Pier2 – Frame Pier Example

Navigate to the **Stiffness** tab of this window. This tab computes information about the stiffness of the pier to assist in determining the type of structural analysis required. Since the pier geometry data is not entered yet, BrDR cannot compute the slenderness ratio and the **Compute slenderness ratio** button is disabled. Click the **OK** button to apply the data and close this window. Do **not** click the Cancel button as that will cause the creation of the new pier alternative to be canceled.

The screenshot shows a software window titled "Pier Alternative - 3 Column Frame" with standard window controls (minimize, maximize, close). The window is divided into three tabs: "Description", "Stiffness" (which is active), and "Reports".

At the top, there are two input fields: "Name: 3 Column Frame" and "Type: RC Frame Pier".

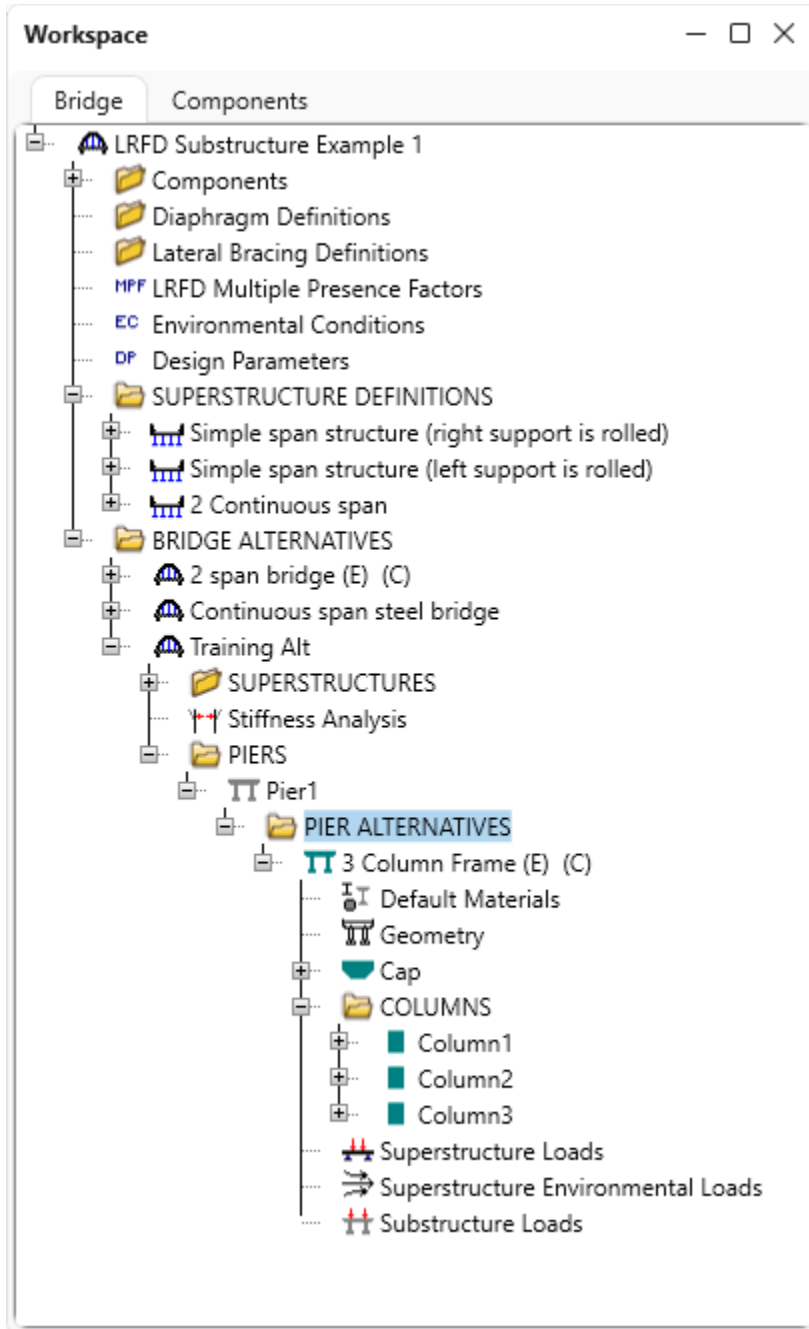
The "Stiffness" tab contains the following elements:

- A "Compute slenderness ratio" button, which is disabled (grayed out).
- An "Analysis method" section with a dropdown menu set to "Method: First Order Elastic".
- A warning message: "Slenderness values cannot be computed until the pier gross geometry is entered."
- Two main sections for axis analysis:
  - Pier longitudinal axis:** Includes a "Sidesway" section with radio buttons for "Braced" (selected) and "Unbraced". It also has input fields for "Unbraced length: [ ] ft" and "Effective length factor, K: 0.65". Below this is a "Slenderness results" section with an "Up-to-date" checkbox and input fields for "Gross area: 0 ft<sup>2</sup>", "Moment of inertia: 0 ft<sup>4</sup>", "Radius of gyration: 0 ft", and "KL/r: 0".
  - Pier transverse axis:** Includes a "Sidesway" section with radio buttons for "Braced" and "Unbraced" (selected). It also has input fields for "Unbraced length: [ ] ft" and "Effective length factor, K: 2". Below this is a "Slenderness results" section with an "Up-to-date" checkbox and input fields for "Gross area: 0 ft<sup>2</sup>", "Moment of inertia: 0 ft<sup>4</sup>", "Radius of gyration: 0 ft", and "KL/r: 0".

At the bottom right of the window, there are three buttons: "OK", "Apply", and "Cancel".

## Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** under **PIER ALTERNATIVE** is shown below.



## Pier2 – Frame Pier Example

### Pier Geometry

Double click on the **Geometry** node in the **BWS** tree. This window allows the user to define some basic pier geometry. It should be noted that the figure in this window is not drawn to scale. The location of the pier beneath the superstructure is set in this window by entering the distance from the superstructure reference line to the left end of the cap or wall. This is an important input since a bad value could result in girders not being supported by the pier. Enter the following data and click the **OK** button to apply the data and close the window.

Pier Geometry - Pier1 - 3 Column Frame

Superstructure Reference Line

Distance from left end of cap to superstructure reference line: 25.5 ft

Distance from left end of cap to centerline of leftmost column: 6.75 ft

Column bay

Distance from centerline of rightmost column to right end of cap: 6.75 ft

Elevation View


	Column bay	Column spacing (ft)
	1	18.75
>	2	18.75

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

 The left edge of the pier cap is located based on the ahead span superstructure.

In this window, the location of the pier beneath the superstructure is set in this window by entering the distance from the superstructure reference line to the left end of the cap or wall. This is a very important dimension to input correctly since a bad value could result in girders not being supported by the pier. Since the pier supports two independent superstructures, the left edge of the cap is located based on the ahead span superstructure.

## Pier2 – Frame Pier Example

### Cap Properties

Double click on the **Cap** node in the **BWS** tree and enter the following data.

Cap Properties - Pier1 - 3 Column Frame
— □ ×

Description

Additional loads

Cap type: Beam Shape Cap    Cap top configuration: Sloped    Cap material: Class A (US) ▾

Pedestals      Exposure factor: 1

Back span:

Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)
G1	130	90	76.5	2.5	1.5
G2	130	90	76.68	2.5	1.5
G3	130	90	76.86	2.5	1.5
G4	130	90	76.86	2.5	1.5
G5	130	90	76.68	2.5	1.5
> G6	130	90	76.5	2.5	1.5

Ahead span:

Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)
> G1	131.67	90	76.5	2.5	1.5
G2	131.67	90	76.68	2.5	1.5
G3	131.67	90	76.86	2.5	1.5
G4	131.67	90	76.86	2.5	1.5
G5	131.67	90	76.68	2.5	1.5
G6	131.67	90	76.5	2.5	1.5

OK
Apply
Cancel

Don't forget to pick the cap concrete material!

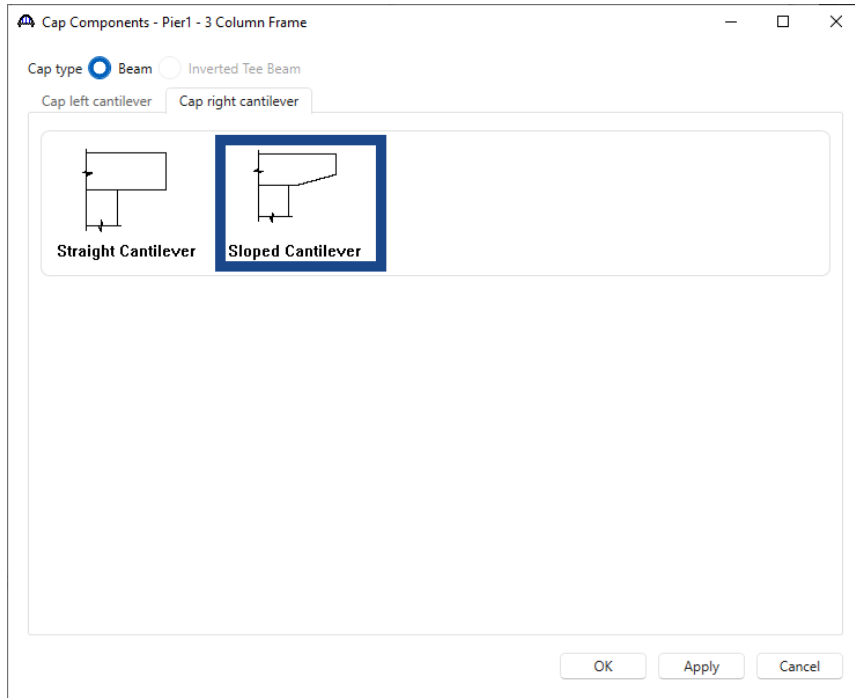
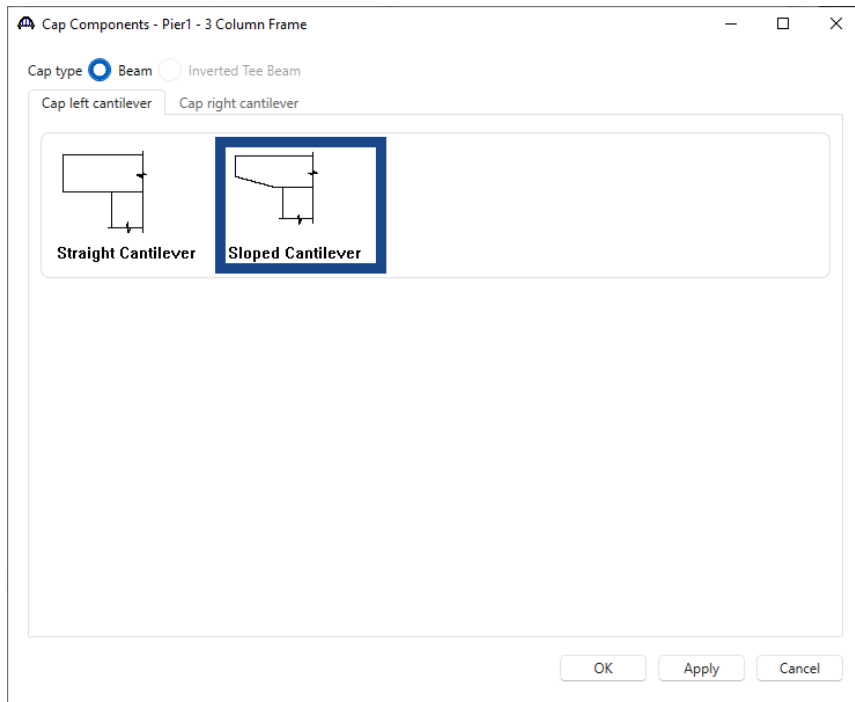
The loads from the superstructure will be applied at the bearing seat elevations specified on this tab.

The **Additional loads** tab allows 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

## Pier2 – Frame Pier Example

### Cap Components

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



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

## Pier2 – Frame Pier Example

### Cap Geometry

Double click on the **Geometry** node to open the **Cap Geometry** window and enter the following cap geometry data.

Cap width:  ft

Cap length:  ft

Location	Cantilever type	Elevation (ft)	Dimension (ft)		
			D1	D2	D3
Left	Sloped	76	3	1.67	5.25
Right	Sloped	76	3	1.67	5.25

OK    Apply    Cancel

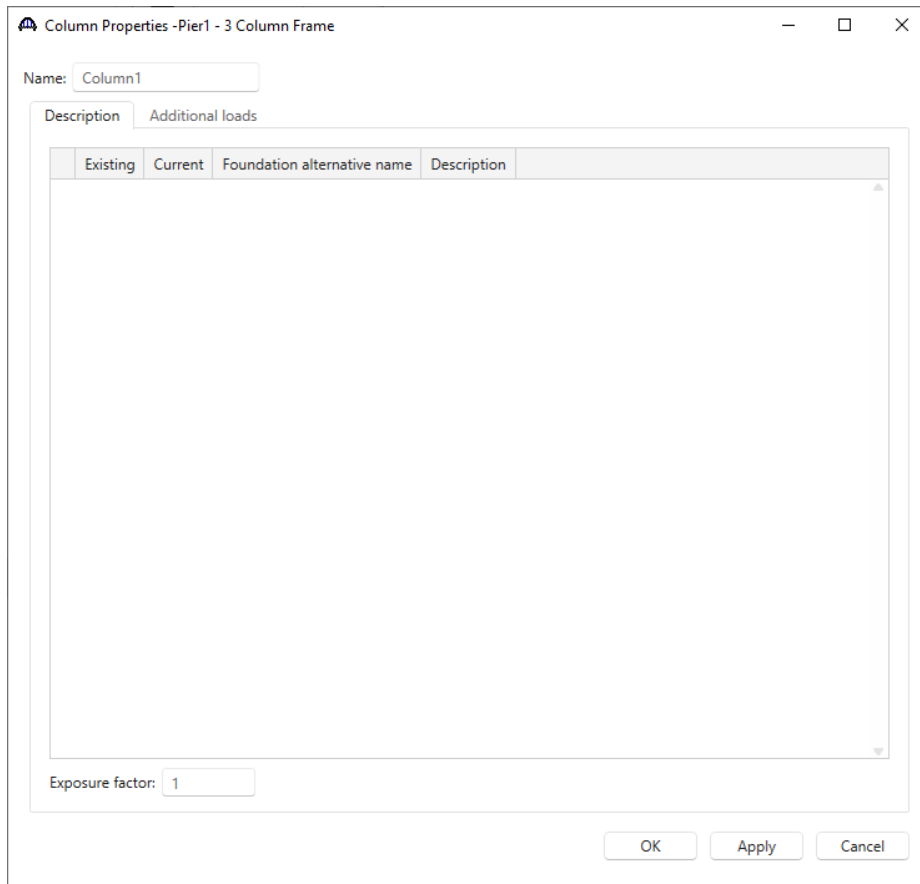
Click **OK** to apply the data and close the window.



## Pier2 – Frame Pier Example

### Column Properties

Expand the node for **Column1**. Double click on the **Column1** node to open the **Column Properties** window. Enter the **Exposure Factor** as shown below.



Column Properties - Pier1 - 3 Column Frame

Name:

Description  Additional loads

Existing	Current	Foundation alternative name	Description
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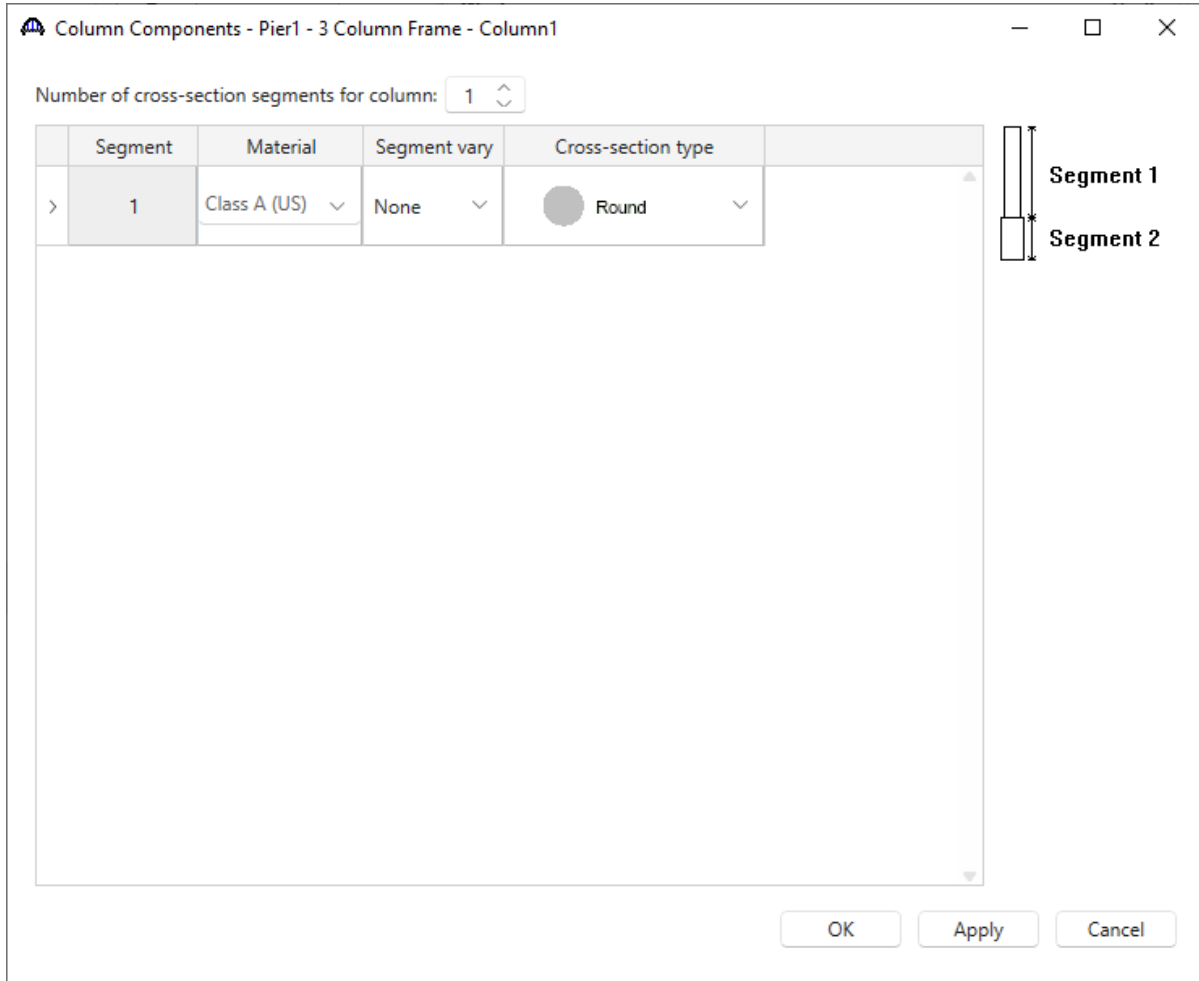
Exposure factor:

There is no additional data to enter on the column window so click **OK** to close this window.

## Pier2 – Frame Pier Example

### Column Components

Double click on the **Components** node in the **BWS** tree for **Column1**. The **Column Components** window allows the user to 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 a new column is created. Since this pier has round columns, this assumption is correct. Click **OK** to close this window.

## Pier2 – Frame Pier Example

### Column Geometry

Double click on the **Geometry** node in the BWS tree for **Column1**. Enter the following column geometry data.

Column Geometry - Column1
— □ ×

**Plan View**

Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	● Round	Top	71.33	3					
>			Bottom	53.75	3					

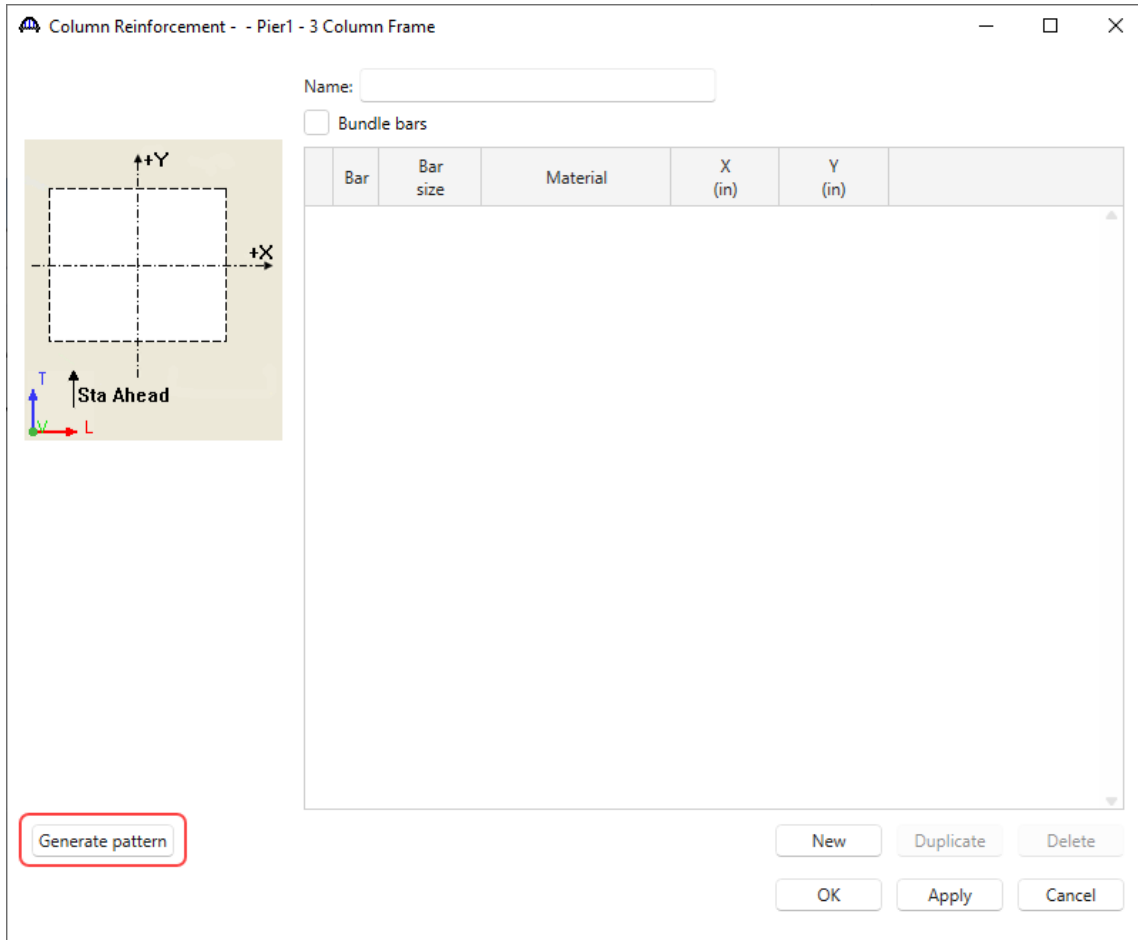
OK Apply Cancel

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

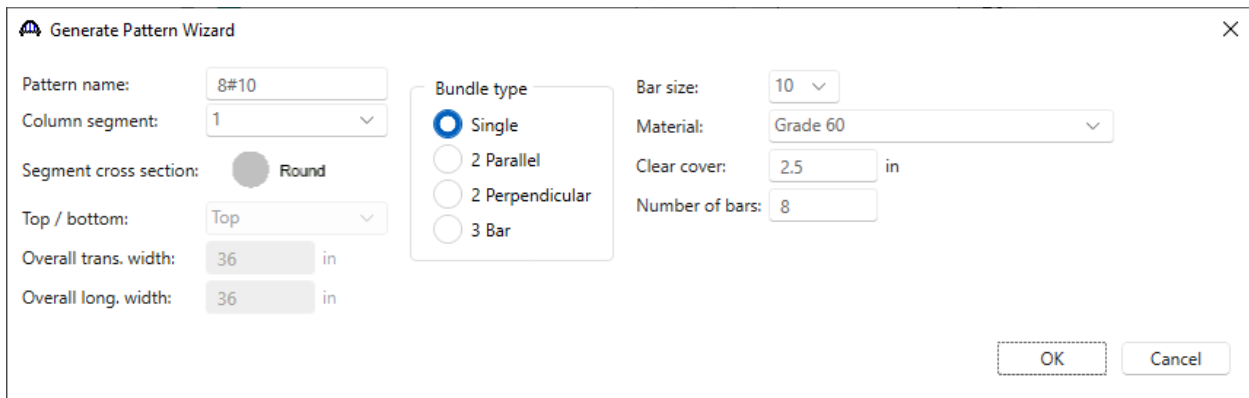
## Pier2 – Frame Pier Example

### Reinforcement Definitions

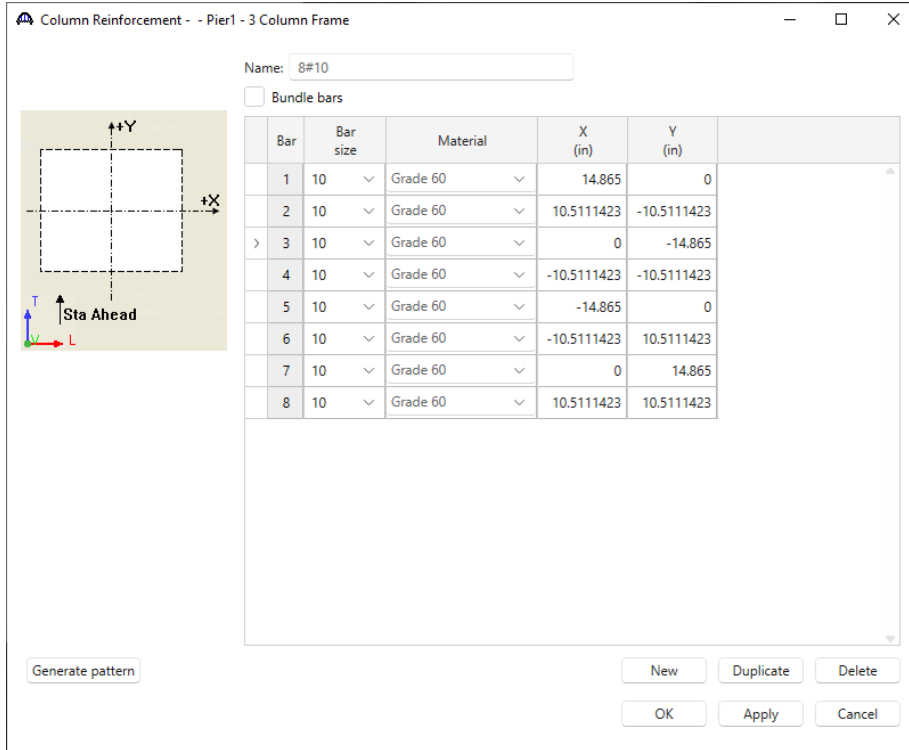
Double click on the **Reinforcement Definitions** node and create a reinforcement definition for the column using the **Pattern Wizard** as shown below.



Enter the following details in the **Generate Pattern Wizard** window and click **OK** to close this window and create the reinforcement definition.



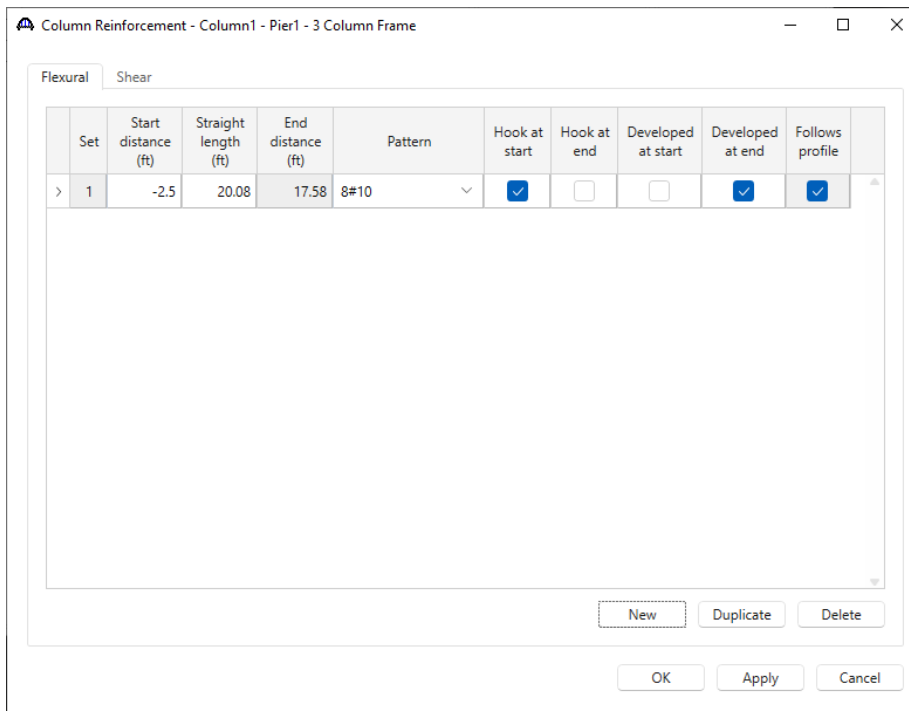
## Pier2 – Frame Pier Example



Uncheck the **Bundle bars** checkbox and click **OK** to create the reinforcement definition and close the window.

### Reinforcement

Double click on the **Reinforcement** node in the **BWS** tree for **Column1** and assign the column reinforcement as shown below.



## Pier2 – Frame Pier Example

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

The screenshot shows a software dialog box titled "Column Reinforcement - Column1 - Pier1 - 3 Column Frame". It has two tabs: "Flexural" and "Shear", with "Shear" selected. Under "Shear reinforcement type", there are three radio buttons: "Ties", "Spirals" (which is selected), and "Spirals designed as ties". Below this is a table with the following data:

Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
> 4	3	Epoxied Grade 60	0	17.58	17.58

At the bottom of the dialog, there are buttons for "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

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

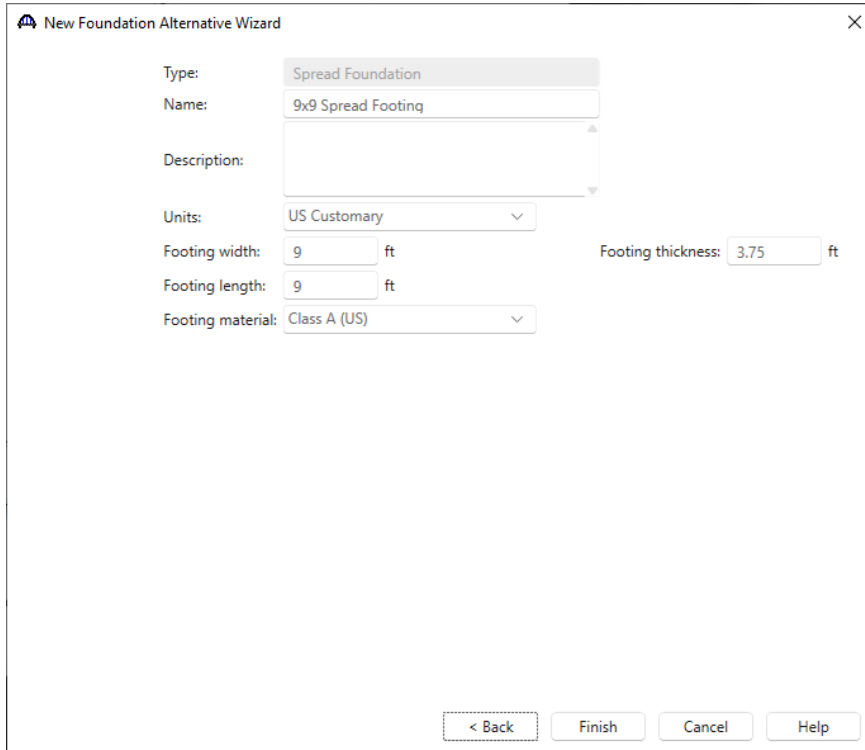
### FOUNDATION ALTERNATIVES

Double click on the **FOUNDATION ALTERNATIVES** node in the **BWS** tree and the **New Foundation Alternatives Wizard** will open. Select **Spread Footing** and click **Next**.

The screenshot shows a "New Foundation Alternative Wizard" dialog box. It contains three options, each with a schematic diagram: "Spread Footing" (highlighted with a blue border), "Pile Footing", and "Single Drilled Shaft". At the bottom of the dialog, there are buttons for "< Back", "Next >", "Cancel", and "Help".

## Pier2 – Frame Pier Example

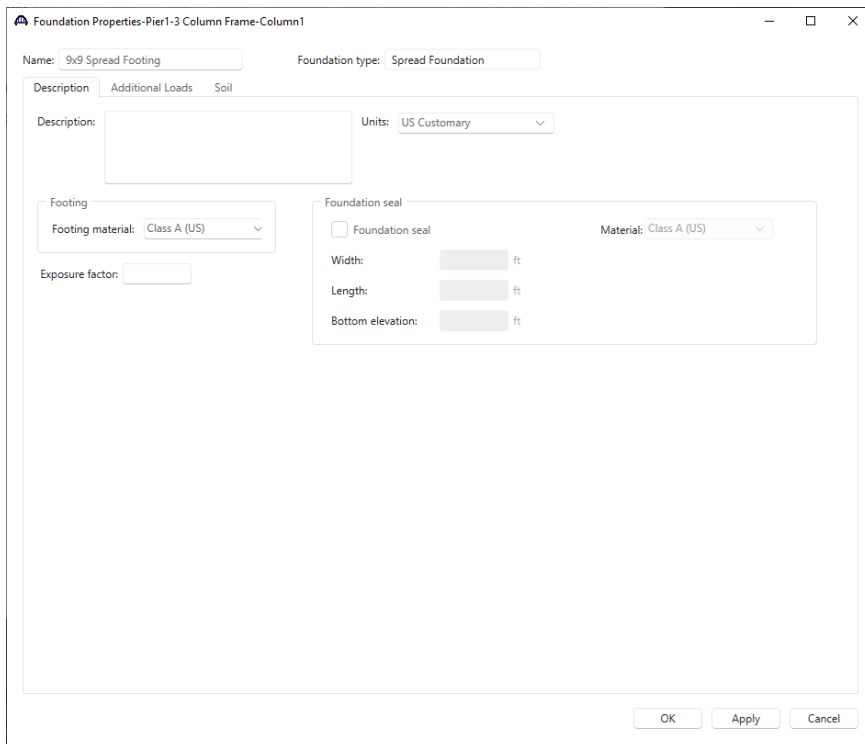
Enter the following description of the foundation and click **Finish** to open the **Foundation Properties** window as shown below.



The 'New Foundation Alternative Wizard' dialog box is shown with the following settings:

- Type: Spread Foundation
- Name: 9x9 Spread Footing
- Description: (empty text box)
- Units: US Customary
- Footing width: 9 ft
- Footing length: 9 ft
- Footing thickness: 3.75 ft
- Footing material: Class A (US)

Buttons at the bottom: < Back, Finish, Cancel, Help



The 'Foundation Properties-Pier1-3 Column Frame-Column1' dialog box is shown with the following settings:

- Name: 9x9 Spread Footing
- Foundation type: Spread Foundation
- Description: (empty text box)
- Units: US Customary
- Footing material: Class A (US)
- Exposure factor: (empty text box)
- Foundation seal:  Foundation seal
- Material: Class A (US)
- Width: (empty text box) ft
- Length: (empty text box) ft
- Bottom elevation: (empty text box) ft

Buttons at the bottom: OK, Apply, Cancel



Foundations are not included in the finite element model of the pier but can be described in BrDR.

There is no additional information to enter so click the **OK** button. Do **not** click the Cancel button as that will cause the creation of the new foundation alternative to be canceled.

## Pier2 – Frame Pier Example

### Foundation Geometry

Double click on the **Geometry** node in the **BWS** tree for the foundation alternative just added.

Foundation Geometry - 9x9 Spread Footing

Pier Transverse Axis  
Column Transverse Axis

Pier Longitudinal Axis  
Column Longitudinal Axis

D2

D1

T  
V  
L

↑ STA. AHEAD

Plan View

	Location	Elevation (ft)	Dimension (ft)	
			D1	D2
	Top	53.75	9	9
>	Bottom	50	9	9

OK Apply Cancel

Enter the bottom of footing elevation and click the **OK** button.

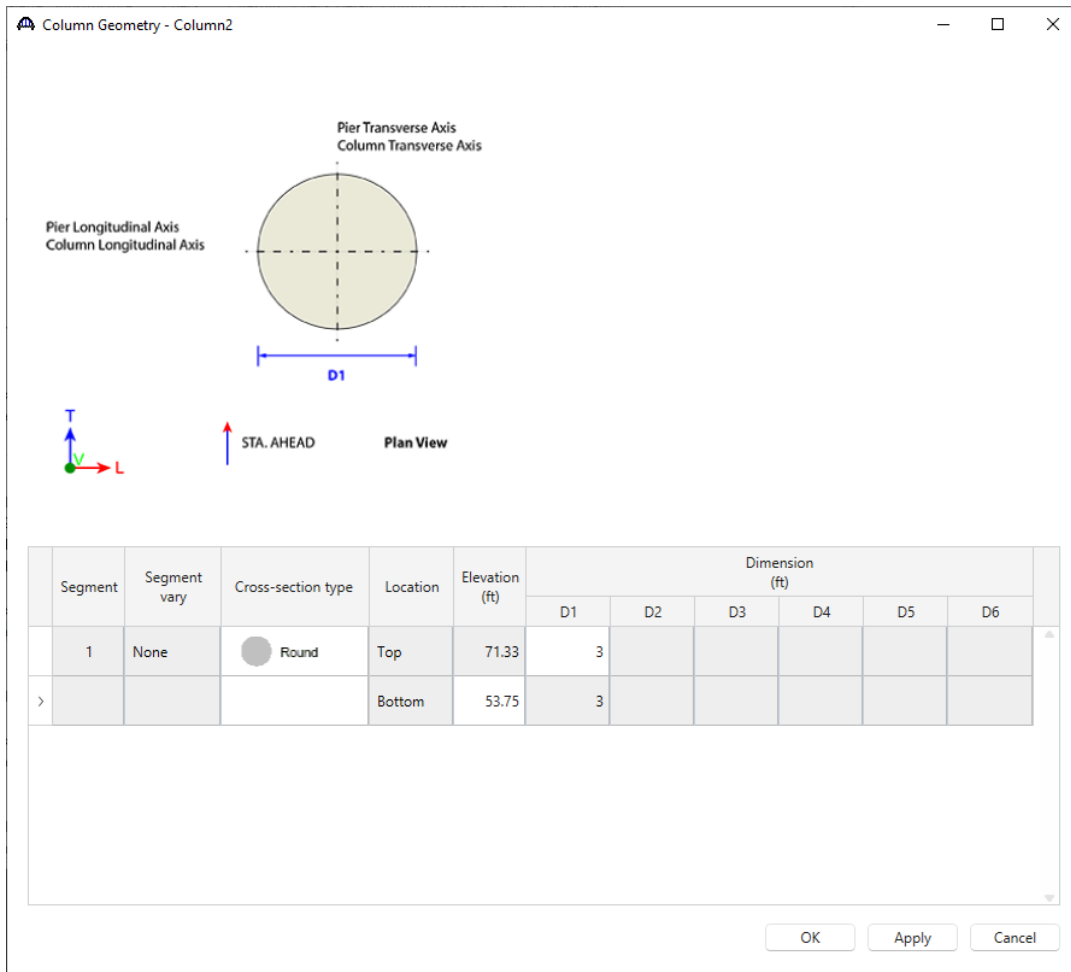
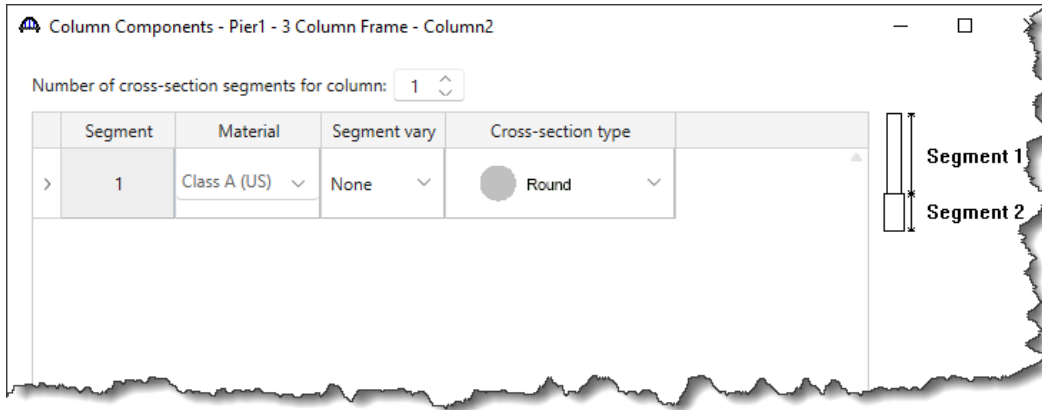


## Pier2 – Frame Pier Example

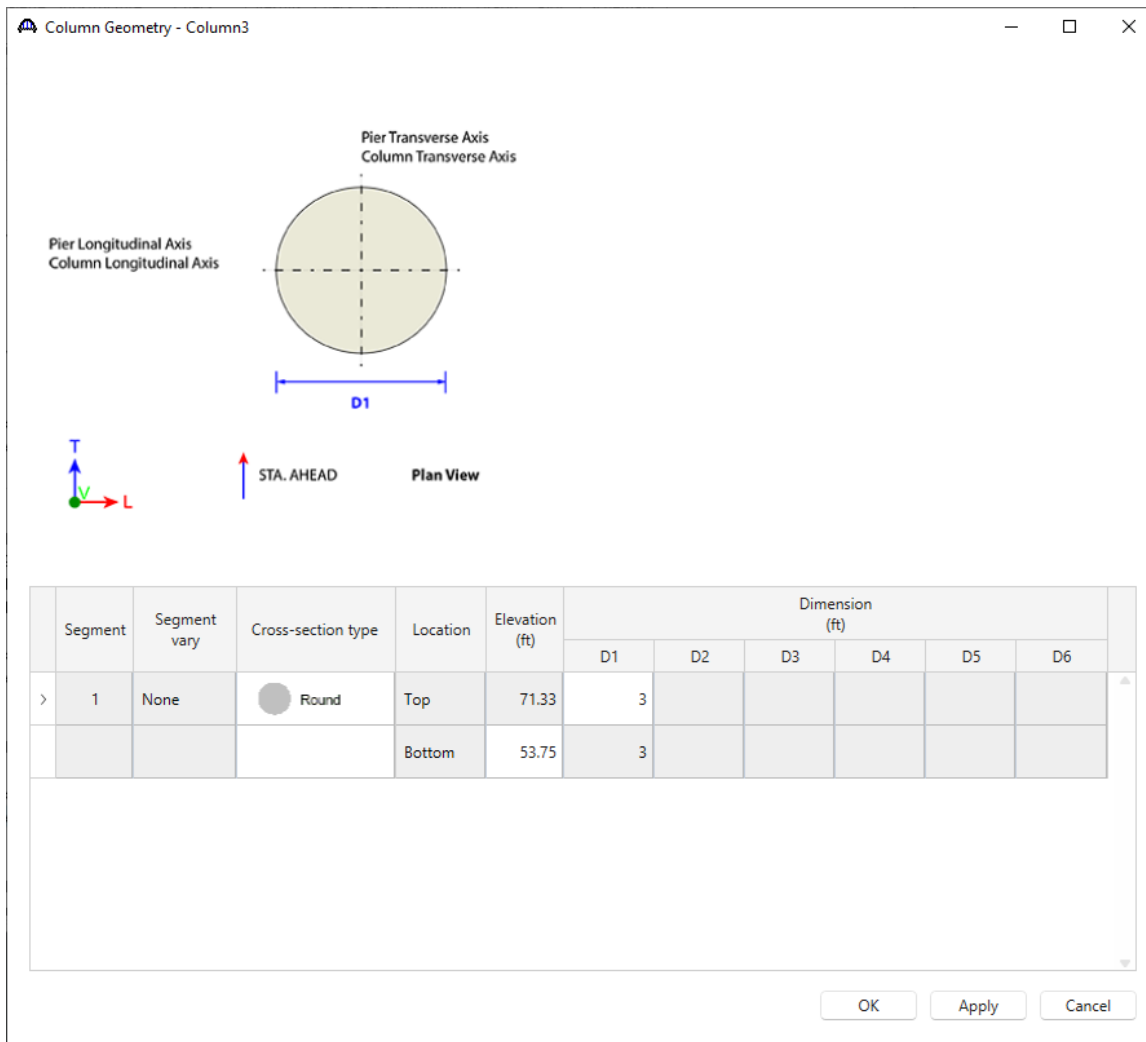
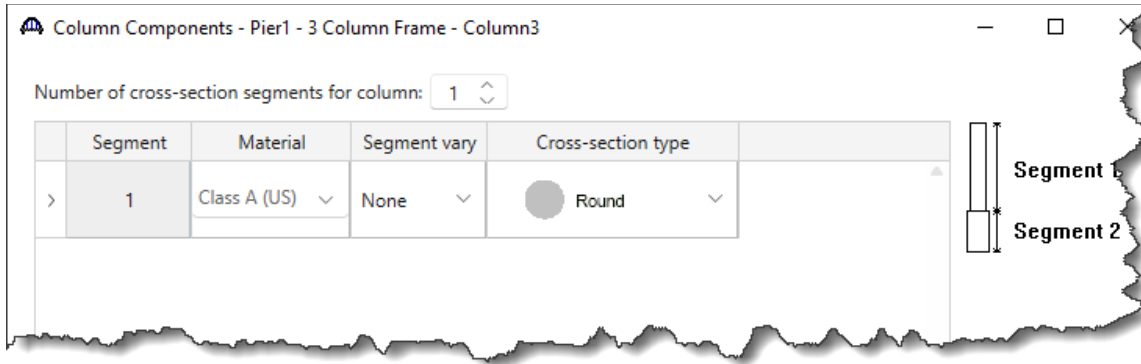
Similarly define the properties for **Column2** and **Column3**.

### Column Components and Geometry – Column 2 and Column 3

Open the **Column Components** window for each column and select the column concrete material and cross section type. Then define the geometry in each **Column Geometry** window as shown below.



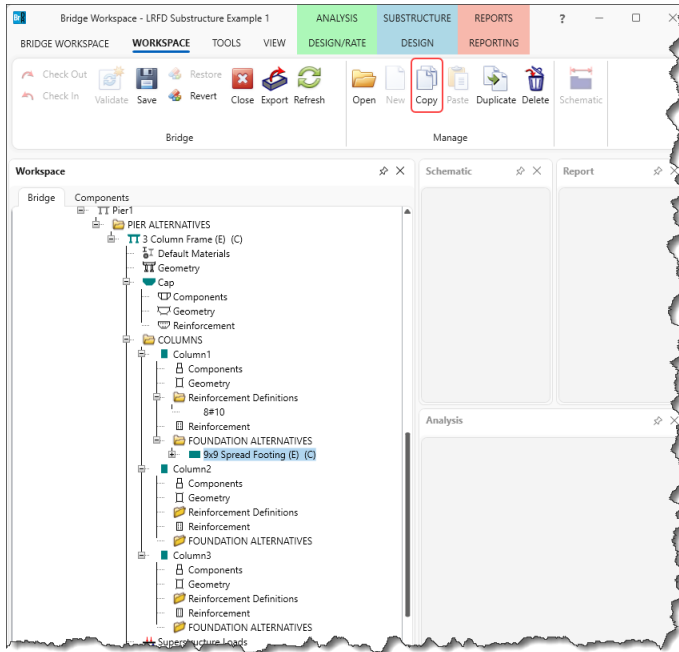
## Pier2 – Frame Pier Example



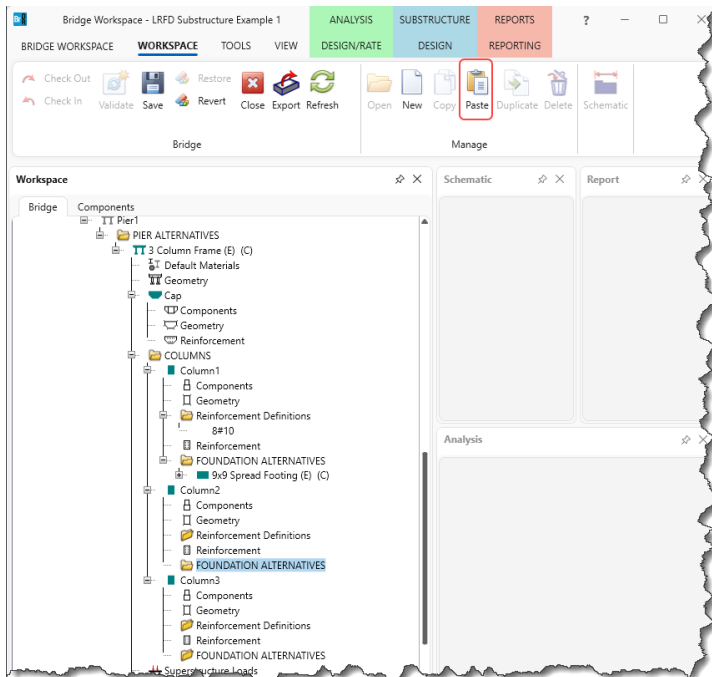
## Pier2 – Frame Pier Example

### Copy Footing

Now the footing can be copied from **Column1** to the other two columns. Click on the **9x9 Spread Footing** alternative and select the **Copy** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **Copy**.



Now select the **FOUNDATION ALTERNATIVE** node for **Column2** and click the **Paste** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **Paste**.



Repeat this process for **Column3** as well.



## Pier2 – Frame Pier Example

### Pier Alternative – Stiffness

Now that the pier geometry is defined, reopen the **Pier Alternative** window by double clicking on the **3 Column Frame** node in the **BWS** tree, navigate to the **Stiffness** tab and evaluate the slenderness of the pier.

**Pier Alternative - 3 Column Frame**

Name: 3 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: 17.58 ft Effective length factor, K: 0.65

Slenderness results  
 Up-to-date

Gross area: 21.20576 ft<sup>2</sup> Moment of inertia: 11.9282346 ft<sup>4</sup> Radius of gyration: 0.75 ft

KL/r: 15.236

Pier transverse axis

Sidesway  
 Braced  Unbraced

Unbraced length: 22.25 ft Effective length factor, K: 2

Slenderness results  
 Up-to-date

Gross area: 21.20576 ft<sup>2</sup> Moment of inertia: 47.7129384 ft<sup>4</sup> Radius of gyration: 1.5 ft

KL/r: 29.66667

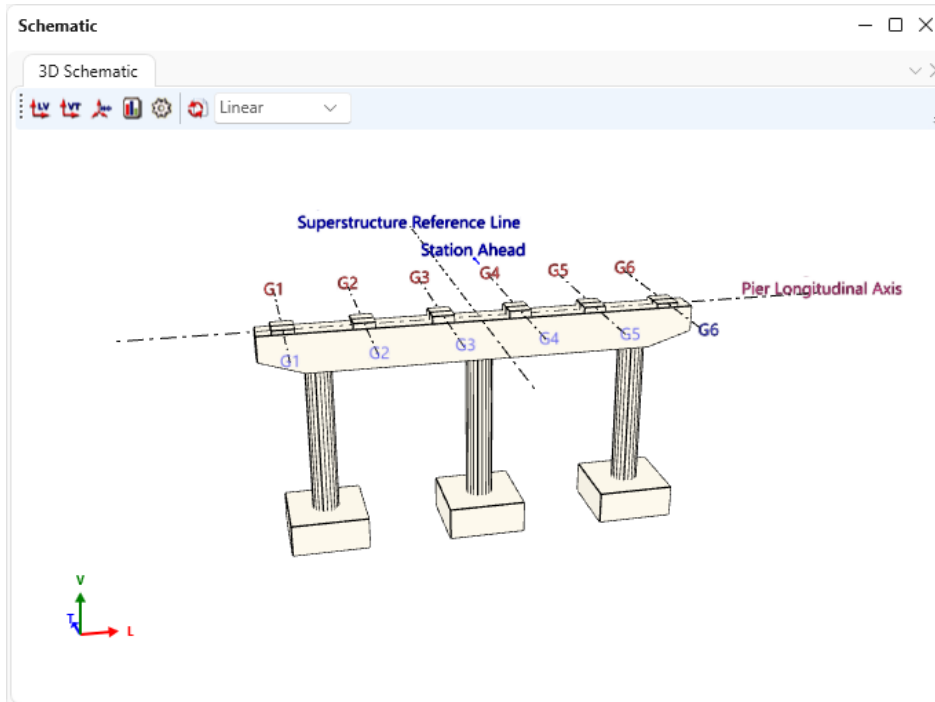
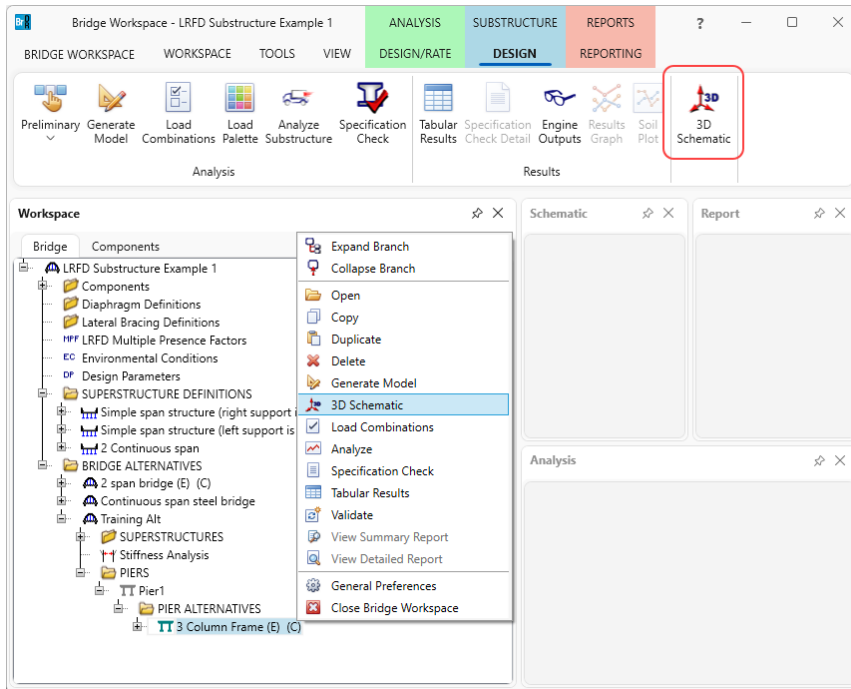
OK Apply Cancel

BrDR computes the KL/r ratios for the pier longitudinal and transverse axes based on the pier alternative geometry. These KL/r ratios can be independently evaluated 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.

## Pier2 – Frame Pier Example

### Pier 3D Schematic

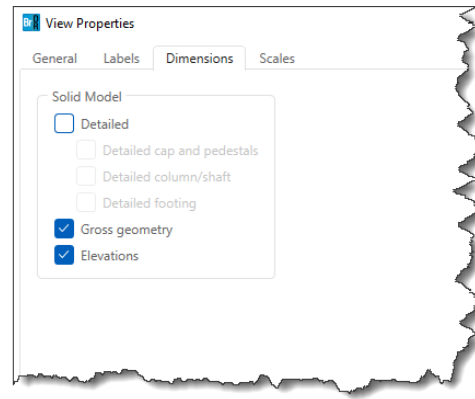
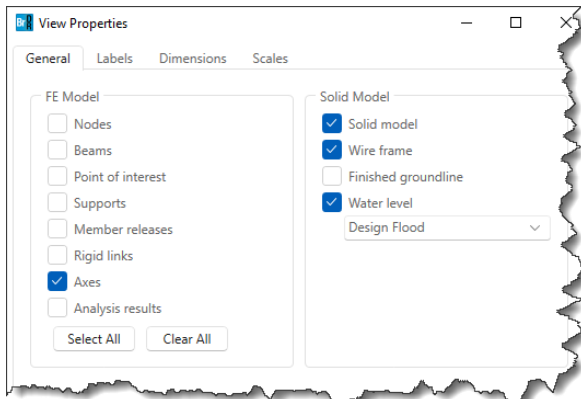
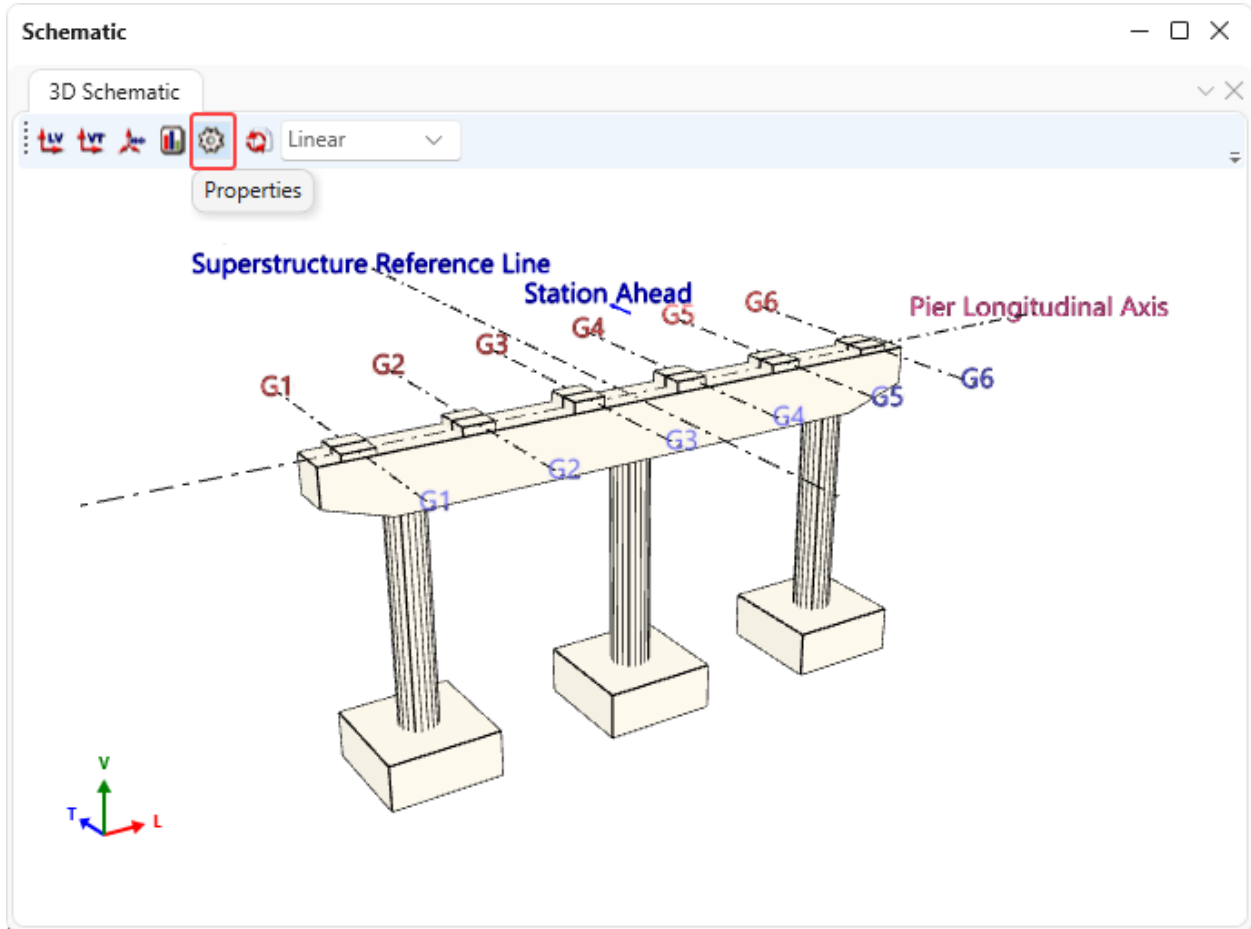
With the pier alternative **3 Column Frame** selected, click on the **3D Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon or right click and select **3D Schematic** as shown below.



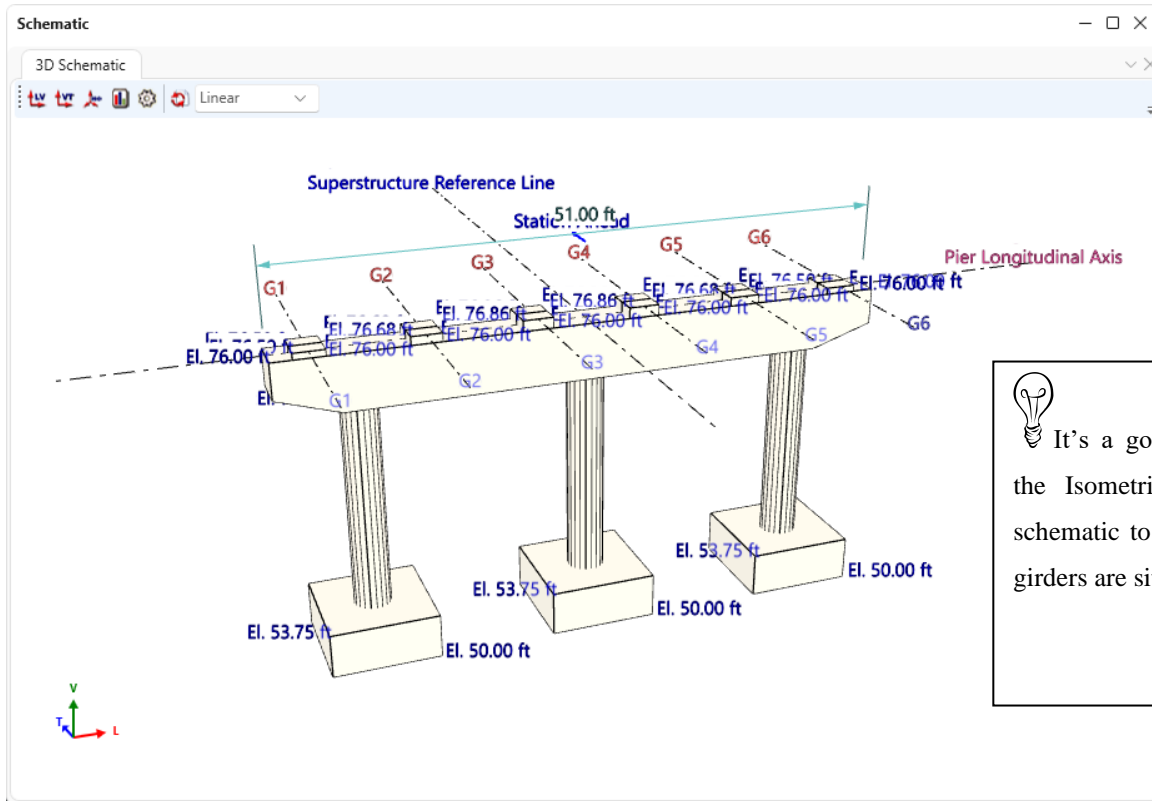
This **3D schematic** is a to-scale drawing of the pier alternative. This schematic view has a lot of useful features like rotating, scaling, and dimensioning.

## Pier2 – Frame Pier Example

Select the **Properties** button to open a window to select what features to display in the **3D Schematic**. The schematic shown below was created by selecting to display the gross geometry dimensions and elevations on the **View Properties: Dimensions** tab and selecting the **Design Flood Water Level** on the **View Properties: General** tab.

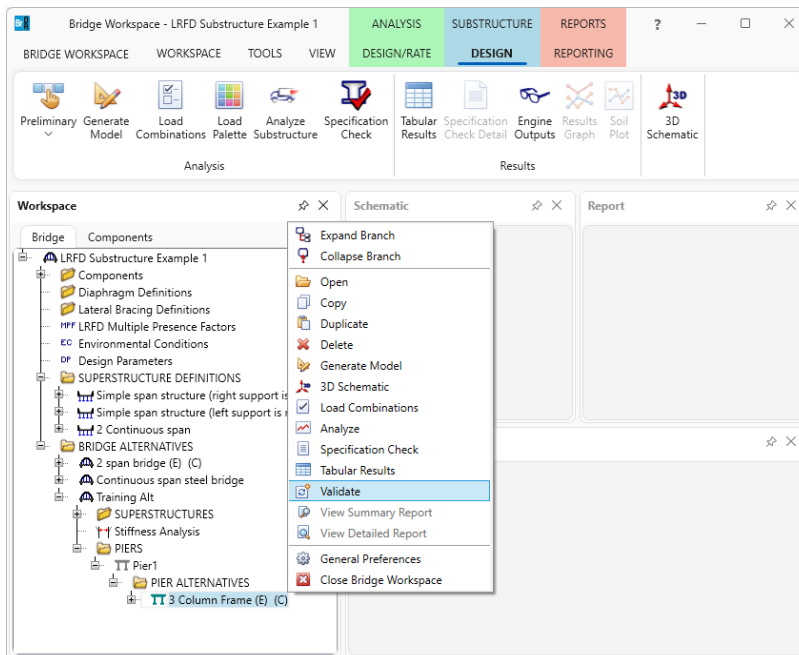


## Pier2 – Frame Pier Example



## Validating a Pier Alternative

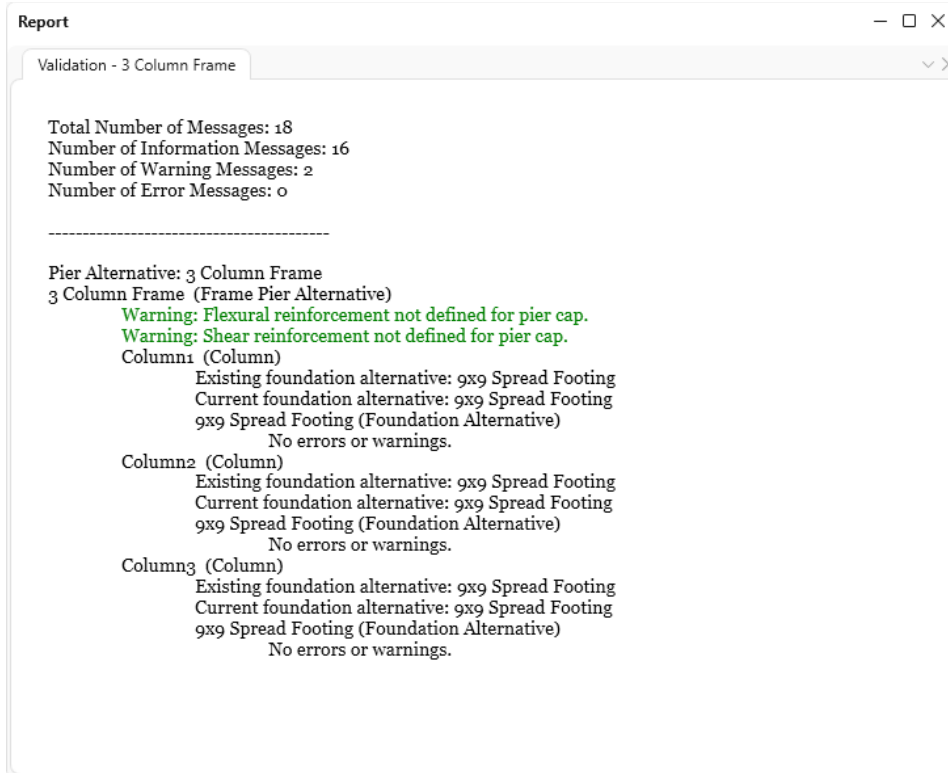
Another useful feature is to validate the pier alternative once the geometry is defined. The validation process alerts the user to any missing or incorrect data in the pier description. To validate, right click on the pier alternative and select **Validate** as shown below.





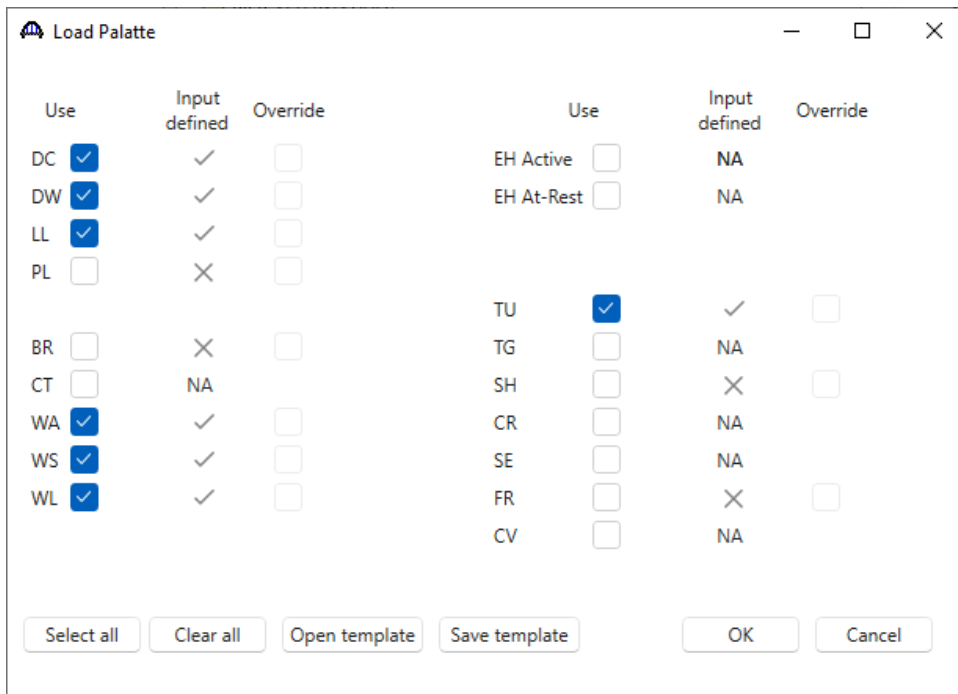
## Pier2 – Frame Pier Example

This opens a window which contains warnings and errors if the pier alternative description is in error or missing data.



### Load Palette

Click on the **Load Palette** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon. Apply the following selections and click **OK** to close the window.



## Pier2 – Frame Pier Example

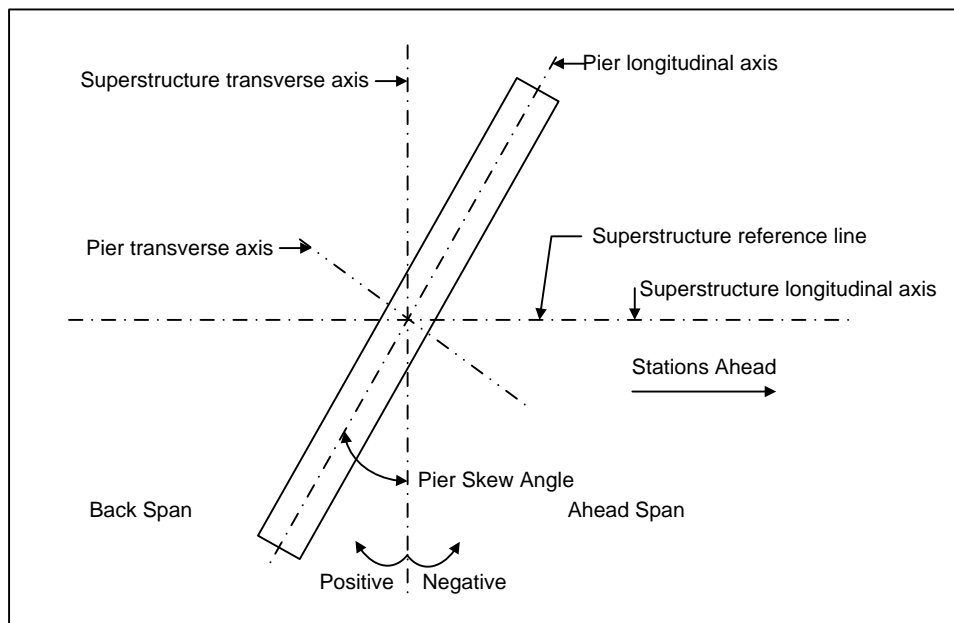
### Topic 3 - Pier 2 – Frame Pier Example

This topic is the third of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1 and 2 in the series must be completed before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

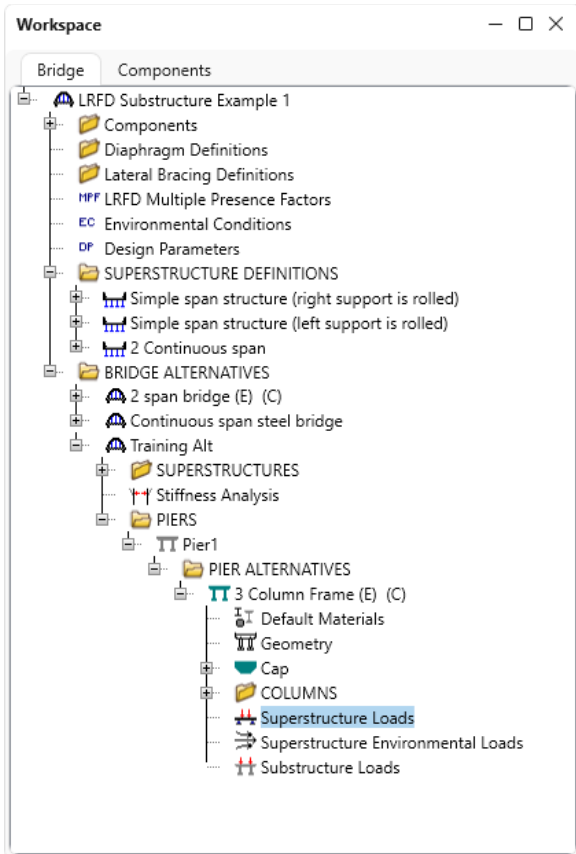
### Superstructure Loads

This section discusses loads acting on the pier. The first thing to review is the following axis convention that is used for the superstructure and pier axes.

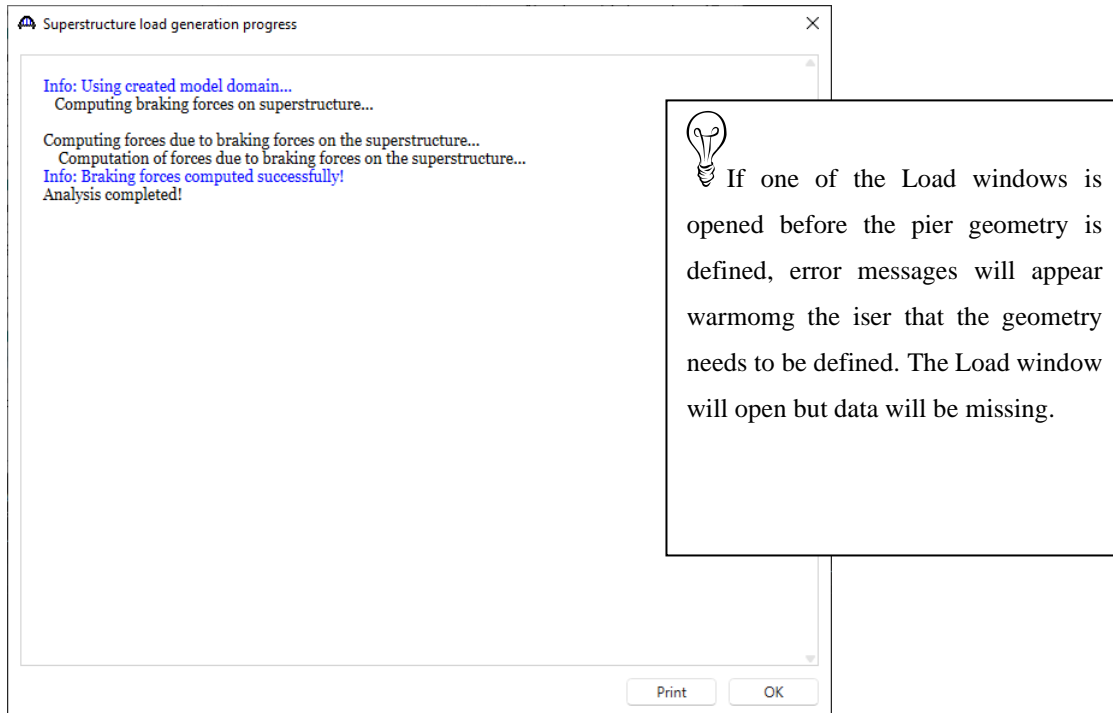


## Pier2 – Frame Pier Example

For the **3 Column Frame**, double click on the **Superstructure Loads** node as shown below.



The **Superstructure load generation progress** window appears as shown below.



Click **OK** to open the **Superstructure Loads** window.

## Pier2 – Frame Pier Example

BrDR computes some of the superstructure loads on the pier 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.

Superstructure Loads-Pier1-3 Column Frame

Back span: Span no.: 1  
Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1  
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Computed reactions

Result up to date  
Results timestamp: [ ]

Back span

Computed reactions (kip)

	DC load	G1	G2	G3	G4	G5	
> Non-composite (Stage 1)							
Composite (long term) (Stage 2)							

Computed reactions (kip)

	DW load	G1	G2	G3	G4	G5	
> Non-composite (Stage 1)							
Composite (long term) (Stage 2)							

Override reactions

Use override values

Back span

Override reactions (kip)

	G1	G2	G3	G4	G5	G6	
> DC							
DW							

Compute DL reactions Compute LL reactions

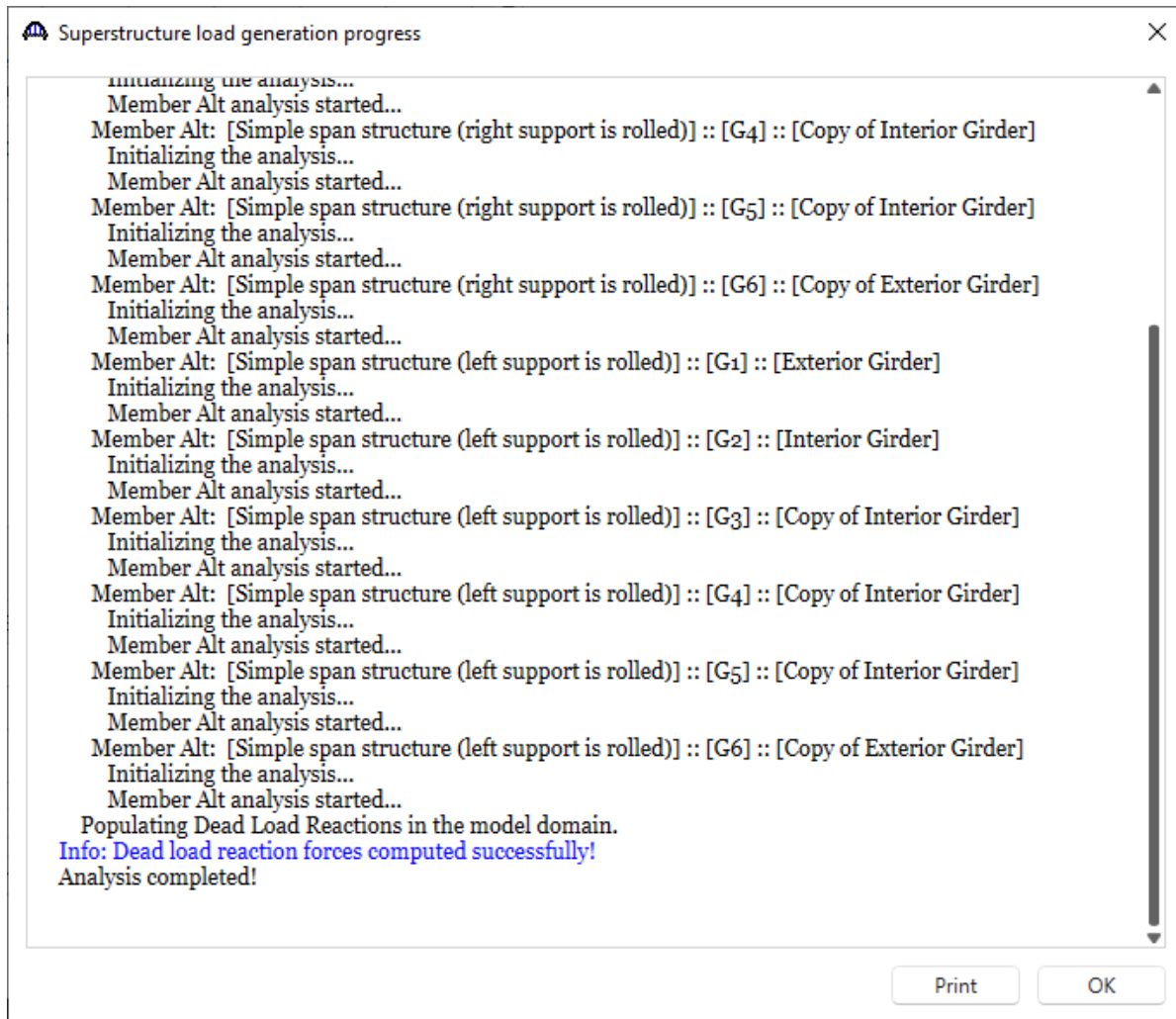
OK Apply Cancel



**Check Use override values** if the user-defined loads are to be used in the pier finite element analysis.

## Pier2 – Frame Pier Example

The **Compute DL reactions** button will launch a batch superstructure analysis. **Superstructure load generation progress** window opens detailing the analysis progress. BrDR Substructure will then compute the friction forces if the pier contains sliding bearings.



## Pier2 – Frame Pier Example

The computed dead load reactions will be displayed in this window and the computed friction forces will be displayed on the **FR** tab. This bridge has elastomeric bearings, so the friction forces are not computed.

Since this pier supports two independent superstructures, this tab displays the dead load reactions for both the back and ahead span superstructures.

An option is available to the user to override the values computed by BrDR for the loads. Check the checkbox **Use override values** for these override values to be used in the pier finite element analysis.

Superstructure Loads-Pier1-3 Column Frame

Back span  
Span no.: 1  
Superstructure definition: Simple span structure (right support is rolled)

Ahead span  
Span no.: 1  
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Computed reactions

Result up to date  
Results timestamp: Thursday, December 28, 2023 11:06:38

Back span

Computed reactions (kip)				
DC load	G1	G2	G3	G4
> Non-composite (Stage 1)	125.0416667	134.6510417	134.6510417	134.6510417
Composite (long term) (Stage 2)	10.9461806	10.9461806	10.9461806	10.9461806

Ahead span

Computed reactions (kip)						
DW load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)						
Composite (long term) (Stage 2)						

Override reactions

Use override values

Back span

Override reactions (kip)						
	G1	G2	G3	G4	G5	G6
> DC						
DW						

Compute DL reactions Compute LL reactions

OK Apply Cancel

## Pier2 – Frame Pier Example

The friction loads would be displayed on the **FR** tab shown below if this bridge had sliding bearings. The **Override** button opens a window where the user can override values for the friction 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. The **Calcs** button will open a report detailing the calculations BrDR performed to compute the friction forces.

Superstructure Loads-Pier1-3 Column Frame

Back span  
Span no.: 1  
Superstructure definition: Simple span structure (right support is rolled)

Ahead span  
Span no.: 1  
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Input  
AASHTO LRFD spec article 3.13 friction force  
Moment  
 Consider moment  
 Companion flat surface  
Bearing radius: in

Loads  
Display  
 Computed  Override  Use override values

Back span  
Superstructure does not exist and thus no force is computed.  
Superstructure longitudinal force (kip)

	G1	G2	G3	G4	G5	G6	
>							

Ahead span  
Superstructure does not exist and thus no force is computed.  
Superstructure longitudinal force (kip)

	G1	G2	G3	G4	G5	G6	
>							

## Pier2 – Frame Pier Example

The **LL settings** tab allows the user to specify loading constraints for the transverse live load analysis. Enter data as shown below.

Superstructure Loads-Pier1-3 Column Frame

Back span  
Span no.: 1  
Superstructure definition: Simple span structure (right support is rolled)

Ahead span  
Span no.: 1  
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR **LL settings** LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Live loading type  
 User defined lanes  Automated  
 Scan for controlling load positions

Transverse Loading  
Vehicle increment in lane: 2 ft  
Lane increment: 4 ft  
Move vehicle right to left across travelway:

Load pattern description

Load pattern	Description
> 1	1 lane positive moment
2	1 lane centered
3	1 lane pushed to left
4	2 lane positive moment
5	2 lane centered
6	3 lanes
7	4 lanes


New Duplicate Delete

Live load positions  
Load pattern: 1  
Number of vehicles: 1

Vehicle	Distance from left edge of travelway (ft)
> 1	9.62

Compute DL reactions Compute LL reactions

OK Apply Cancel

 The settings on this tab greatly affect the time required for a pier analysis.

Each transverse live load position is a load case in the finite element analysis. The data entered on this tab can greatly affect the time required for analysis. If there is a wide travelway and small values for the vehicle increment and lane increment, the analysis will take a longer time than if having larger values for the vehicle and lane increment. Likewise, checking the box to move the vehicles from right to left across the travelway will double the number of live load cases in the pier finite element analysis. If user defined lanes are selected as live loading type, the user can create their own load patterns at the bottom. If **Scan for controlling load positions** is not checked, the analysis will check all the live load positions defined.



## Pier2 – Frame Pier Example

The **Compute LL reactions** button in the **LL-reaction** tab will initiate a longitudinal live load analysis of the superstructure carried by the pier and compute the braking forces acting on the pier.

DL FR LL settings **LL-reaction** LL distribution back LL distribution ahead LL distribution back ahead BR

Computed reactions

**Back span**

Result up to date  
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	66.8307692
HL-93 (US)	Truck Pair	66.8307692
HL-93 (US)	Lane	41.6
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	64.2307692

**Ahead span**

Result up to date  
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	66.8307692
HL-93 (US)	Truck Pair	66.8307692
HL-93 (US)	Lane	41.6
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	64.2307692

**Back and ahead span**

Result up to date  
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	67.6923077
HL-93 (US)	Truck Pair	100.8
HL-93 (US)	Lane	83.2
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	88.4615385

Calcs...

Compute DL reactions Compute LL reactions

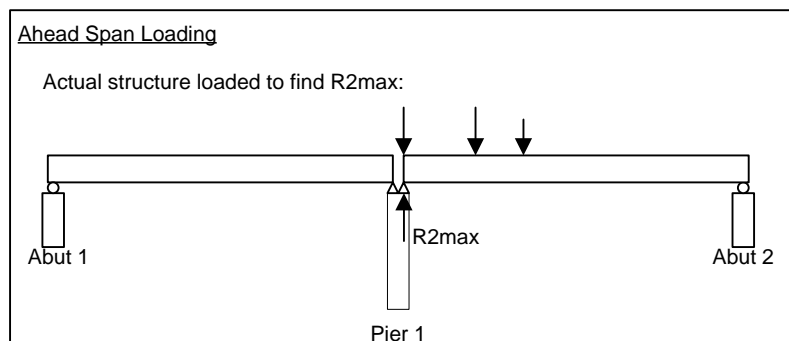
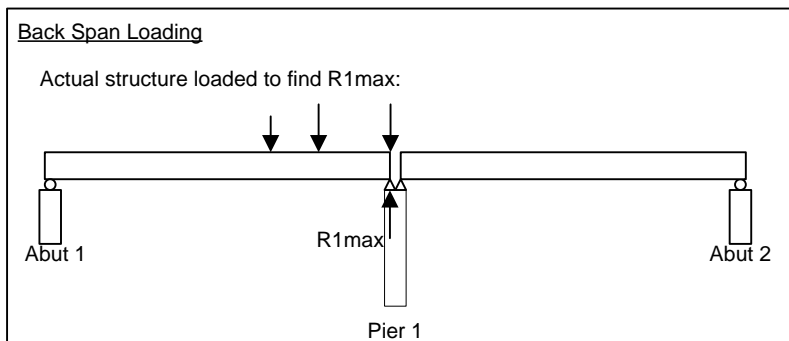
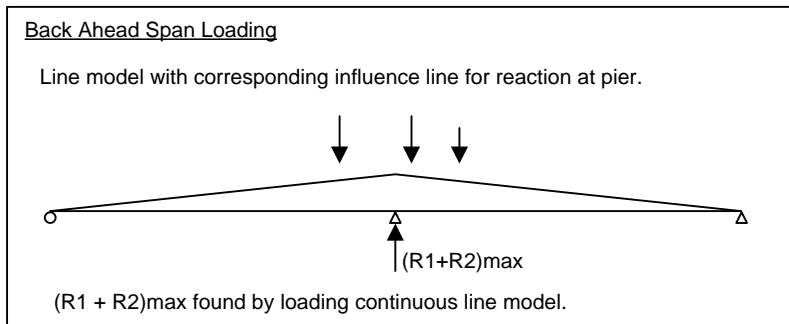
OK Apply Cancel

The vehicles used in the analysis are dependent on 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.

## Pier2 – Frame Pier Example

Since the pier supports two independent superstructures, BrDR finds the single lane reactions for the following load cases: back and ahead span modeled as a continuous line model, back span only loaded, ahead span only loaded.



## Pier2 – Frame Pier Example

The **LL-Distribution** tabs (back and ahead) allow the user to view the BrDR computed live load reactions distributed for a pier analysis or enter distributed live load reactions.

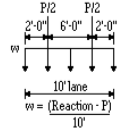
Superstructure Loads-Pier1-3 Column Frame

Back span: Span no.: 1 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1 Superstructure definition: Simple span structure (left support is rolled) Pier skew: 0 Degrees

DL FR LL settings LL-reaction **LL distribution back** LL distribution ahead LL distribution back ahead 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	108.4307692	32	7.6430769
HL-93 (US)	Tandem + Lane	90.8307692	25	6.5830769
HL-93 (US)	90%(Truck Pair + Lane)	97.5876923	28.8	6.8787692
HL-93 (US)	100%(Tandem Pair + ...)	105.8307692	25	8.0830769

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	20.33939	130.4849231	38.5086039	9.1976319
HL-93 (US)	Tandem + Lane	17.88618	107.0769231	29.4715447	7.7605378
HL-93 (US)	90%(Truck Pair + Lane)	20.33939	117.4364308	34.6577435	8.2778687
HL-93 (US)	100%(Tandem Pair + ...)	20.02835	127.0269231	30.0070868	9.7019836

# Pier2 – Frame Pier Example

Superstructure Loads-Pier1-3 Column Frame

Back span: Span no.: 1  
 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1  
 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Distribution method: Tributary Area

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	108.4307692	32	7.6430769
HL-93 (US)	Tandem + Lane	90.8307692	25	6.5830769
HL-93 (US)	90%(Truck Pair + Lane)	97.5876923	28.8	6.8787692
HL-93 (US)	100%(Tandem Pair + ...)	105.8307692	25	8.0830769

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	20.33939	130.4849231	38.5086039	9.1976319
HL-93 (US)	Tandem + Lane	17.88618	107.0769231	29.4715447	7.7605378
HL-93 (US)	90%(Truck Pair + Lane)	20.33939	117.4364308	34.6577435	8.2778687
HL-93 (US)	100%(Tandem Pair + ...)	20.02835	127.0269231	30.0070868	9.7019836

Compute DL reactions Compute LL reactions

OK Apply Cancel

## Pier2 – Frame Pier Example

Superstructure Loads-Pier1-3 Column Frame

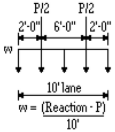
Back span: Span no.: 1  
 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1  
 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Distribution method: Tributary Area



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	150.8923077	32	11.8892308
HL-93 (US)	Tandem + Lane	132.4307692	25	10.7430769
HL-93 (US)	90%(Truck Pair + Lane)	165.6	28.8	13.68
HL-93 (US)	100%(Tandem Pair + ...)	171.6615385	25	14.6661538

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	14.80424	173.2307692	36.7373573	13.6493412
HL-93 (US)	Tandem + Lane	12.26766	148.6769231	28.0669145	12.0610009
HL-93 (US)	90%(Truck Pair + Lane)	18.07826	195.5376	34.0065391	16.1531061
HL-93 (US)	100%(Tandem Pair + ...)	17.00574	200.8538462	29.2514339	17.1602412

Compute DL reactions Compute LL reactions

OK Apply Cancel

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

## Pier2 – Frame Pier Example

### Superstructure Environmental Loads

Double click on the **Superstructure Environmental Loads** node to open the **Superstructure Environmental Loads** window as shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

WS-super back WS-super ahead WS-over WL back WL ahead TU SH

Input

AASHTO LRFD Spec Article 3.8.1.2.2 Loads from Superstructure

Transverse load distribution option: Fixed & Expansion Bearings

Transverse superstructure length: 65 ft

Superstructure design elevation: 81.485 ft

Design height, Z: 25.485 ft

Override design height, Z: ft

Friction velocity, VO: 8.2 mph

Friction length, ZO: 0.23 ft

Base design wind velocity, VB: 100 mph

V30: 100 mph

Loads for wind from left to right

Display:  Computed  Override  Use override values

Superstructure longitudinal force (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	5.0104167	5.0104167	5.0104167	5.0104167	5.0104167	5.0104167
15	4.4091667	4.4091667	4.4091667	4.4091667	4.4091667	4.4091667
30	4.1085417	4.1085417	4.1085417	4.1085417	4.1085417	4.1085417
45	3.306875	3.306875	3.306875	3.306875	3.306875	3.306875
60	1.7035417	1.7035417	1.7035417	1.7035417	1.7035417	1.7035417

Superstructure transverse force (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	0	0	0	0	0	0
15	-0.60125	-0.60125	-0.60125	-0.60125	-0.60125	-0.60125
30	-1.2025	-1.2025	-1.2025	-1.2025	-1.2025	-1.2025
45	-1.60333...	-1.60333...	-1.60333...	-1.60333...	-1.60333...	-1.60333...
60	-1.90395...	-1.90395...	-1.90395...	-1.90395...	-1.90395...	-1.90395...

Vertical Reaction due to transverse (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	2.378756	1.4272536	0.4757512	-0.4757512	-1.4272536	-2.378756
15	2.0933053	1.259832	0.4186611	-0.4186611	-1.259832	-2.0933053
30	1.9505799	1.1703479	0.390116	-0.390116	-1.1703479	-1.9505799
45	1.5699789	0.9419874	0.3139958	-0.3139958	-0.9419874	-1.5699789
60	0.808777	0.4852662	0.1617554	-0.1617554	-0.4852662	-0.808777

Compute

OK Apply Cancel

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 BrDR allows to override some of this data. The bottom of the screen displays loads on the superstructure members for wind blowing from left to right. BrDR allows users to specify which direction the wind should blow in the actual pier finite element analysis in the **Load Combination Settings** window. This will be discussed later in the tutorial.

## Pier2 – Frame Pier Example

The overturning wind on the **WS-over** tab of the **Superstructure Environmental Loads** window is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

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

Input

AASHTO LRFD sec article 3.8.2 vertical wind pressure

Back span transverse superstructure length: 65 ft Ahead span transverse superstructure length: 65 ft

Back span deck width: 51.5 ft Ahead span deck width: 51.5 ft

Vertical upward wind pressure: 0.02 ksf

Loads for wind from left to right

Display:  Computed  Override  Use override values

Back span

Overturning force: 66.95 kip

Vertical reaction due to overturning force (kip)					
	G1	G2	G3	G4	G5
	24.8405813	19.3676821	13.8947829	8.4218837	2.9489846

Ahead span

Overturning force: 66.95 kip

Vertical reaction due to overturning force (kip)					
	G1	G2	G3	G4	G5
	24.8405813	19.3676821	13.8947829	8.4218837	2.9489846

Compute

OK Apply Cancel

# Pier2 – Frame Pier Example

The wind on the **WL back** tab is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

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

Input: AASHTO LRFD Spec Article 3.8.1.3 Wind pressure on vehicles  
 Transverse load distribution option: Fixed & Expansion Bearing  
 Transverse superstructure length: 65 ft

Loads for wind from left to right

Display:  Computed  Override  Use override values

Superstructure longitudinal force (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	0	0	0	0	0	0
15	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
30	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26
45	-0.34666...	-0.34666...	-0.34666...	-0.34666...	-0.34666...	-0.34666...
60	-0.41166...	-0.41166...	-0.41166...	-0.41166...	-0.41166...	-0.41166...

Superstructure transverse force (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	1.0833333	1.0833333	1.0833333	1.0833333	1.0833333	1.0833333
15	0.9533333	0.9533333	0.9533333	0.9533333	0.9533333	0.9533333
30	0.8883333	0.8883333	0.8883333	0.8883333	0.8883333	0.8883333
45	0.715	0.715	0.715	0.715	0.715	0.715
60	0.3683333	0.3683333	0.3683333	0.3683333	0.3683333	0.3683333

Vertical reaction due to transverse force (kip)						
Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	1.3354239	0.8012543	0.2670848	-0.26708...	-0.80125...	-1.33542...
15	1.175173	0.7051038	0.2350346	-0.23503...	-0.70510...	-1.175173
30	1.0950476	0.6570285	0.2190095	-0.21900...	-0.65702...	-1.09504...
45	0.8813797	0.5288278	0.1762759	-0.17627...	-0.52882...	-0.88137...
60	0.4540441	0.2724265	0.0908088	-0.09080...	-0.27242...	-0.45404...

Compute

OK Apply Cancel



## Pier2 – Frame Pier Example

The superstructure temperature load tab (TU) is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

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

Input

AASHTO LRFD spec article 3.12.2 uniform temperature

Back span: Temperature rise: 60 F, Temperature fall: 10 F, Computed based on concrete super.

Ahead span: Temperature rise: 60 F, Temperature fall: 10 F, Computed based on concrete super.

Application type:  Force

Loads

Back span: Temperature rise force: kip, Temperature fall force: kip

Superstructure longitudinal force (kip)							
	G1	G2	G3	G4	G5	G6	
> Rise	0	0	0	0	0	0	
Fall							

Ahead span: Temperature rise force: kip, Temperature fall force: kip

Superstructure longitudinal force (kip)							
	G1	G2	G3	G4	G5	G6	
> Rise							
Fall							

Compute

OK Apply Cancel

BrDR does not compute the superstructure temperature load. These values must be entered.

## Pier2 – Frame Pier Example

The superstructure shrinkage tab (**SH**) is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

WS-super back WS-super ahead WS-over WL back WL ahead TU SH

Input: AASHTO LRFD spec article 3.12 shrinkage Application type:  Force

Loads: Back span Shrinkage force: 0 kip

Superstructure longitudinal force (kip)						
G1	G2	G3	G4	G5	G6	
0	0	0	0	0	0	

Ahead span Shrinkage force: 0 kip

Superstructure longitudinal force (kip)						
G1	G2	G3	G4	G5	G6	
0	0	0	0	0	0	

Compute

OK Apply Cancel

BrDR does not compute the superstructure shrinkage load. These values must be entered.

Click **OK** to close the window.

# Pier2 – Frame Pier Example

## Substructure Loads

Double click on the **Substructure Loads** node in the **BWS** tree to open the window shown below.

Substructure Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

WS-Sub WA TU & SH

Input  
AASHTO LRFD Spec Article 3.8.1.2.3 Forces Applied Directly to the Substructure

Base wind pressure: 0.04 ksf Friction velocity, V0: 8.2 mph  
 Top of cap elevation: 76 ft Friction length, Z0: 0.23 ft  
 Bottom of cap elevation: 71.33 ft Base design wind velocity, VB: 100 mph  
 V30: 100 mph

Water level	Low	Mean	Design flood	Check flood
> Elevation (ft)	56.00	62.00	NA	NA

Loads for wind from left to right

Display:  Computed  Override  Use override values

Water level: Low

Component	Design height Z (ft)	PD (ksf)
> Cap		0.04
Column1		0.04
Column2		0.04
Column3		0.04

Component	Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)	
	0		15		30		45		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	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641
Column1	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641

Compute

OK Apply Cancel

## Pier2 – Frame Pier Example

Since the pier is subject to stream flow, the **WA** tab for water loads on the pier is available. An option is available to enter drag and computing the loads by clicking on the **Compute** button.

Substructure Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis:  Gust speed  Fastest-mile speed

WS-Sub **WA** TU & SH

Input

AASHTO LRFD Spec Article 3.7.2 Buoyancy  
 Consider footing buoyancy  
 Specific weight of water: 0.0624 kcf

AASHTO LRFD Spec Article 3.7.3 Stream Pressure  
 Stream flow skew: 0 Degrees Lateral drag coefficient:   
 Stream flow direction: Left to Right Longitudinal drag coefficient:

Water level name	Water Elevation (ft)	Design velocity (ft/sec)
Low	56.00	25.00
Mean	62.00	40.00
Design Flood	NA	NA
Check Flood	NA	NA

Loads

Display:  Computed  Override  Use override values

Buoyancy

Component	Low		Mean	
	Submerged volume (ft <sup>3</sup> )	Force (kip)	Submerged volume (ft <sup>3</sup> )	Force (kip)

Stream Pressure

Water level name	P long. (ksf)	P tran. (ksf)
Low	0.4375	0
Mean	1.12	0

## Pier2 – Frame Pier Example

The substructure temperature and shrinkage tab (**TU & SH**) is shown below.

The screenshot shows the 'Substructure Loads - Pier1 - 3 Column Frame' dialog box. The 'TU & SH' tab is active. The 'Input' section contains two columns of settings:

- AASHTO LRFD Spec Article 3.12.2 Uniform Temperature:**  Apply to foundation. Temperature rise: 60 F. Temperature fall: 10 F.
- AASHTO LRFD Spec Article 3.12.2 Shrinkage:**  Apply to foundation. Coefficient of shrinkage: [empty field].

The 'Loads' section has 'Display' set to 'Computed'. Below are two tables:

**Uniform Temperature**

Component	Strain due to temp. rise	Strain due to temp. fall
Cap	0.00036	-6E-05
Column1	0.00036	-6E-05
Column2	0.00036	-6E-05
Column3	0.00036	-6E-05

**Shrinkage**

Component	Axial strain
Cap	0
Column1	0
Column2	0
Column3	0

Buttons: Compute, OK, Apply, Cancel.

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

An option is available to enter a value for the coefficient of shrinkage and click the **Compute** button to have BrDR recompute the loads.

## Pier2 – Frame Pier Example

### Topic 4 – Pier 2 – Frame Pier Example

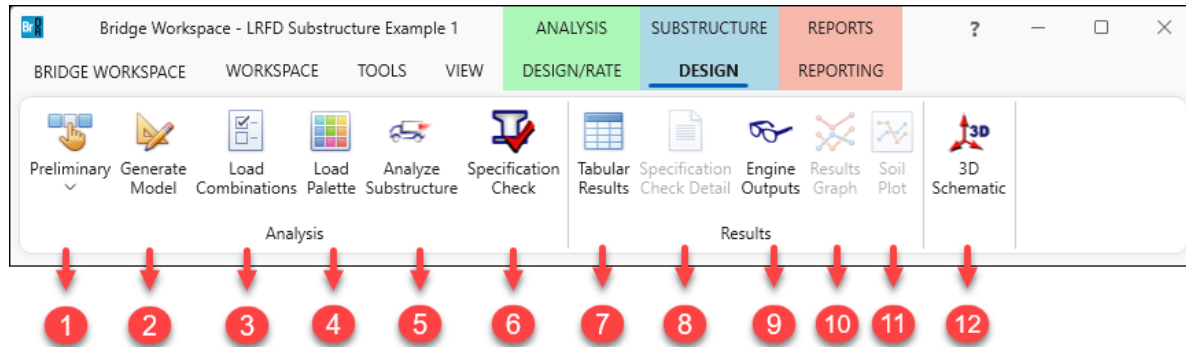
This topic is the fourth of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1, 2 and 3 must be completed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

## Pier2 – Frame Pier Example

### BrDR SUBSTRUCTURE DESIGN Ribbon

The following ribbon is available in BrDR Substructure when the pier alternative is selected in the Bridge Workspace tree.



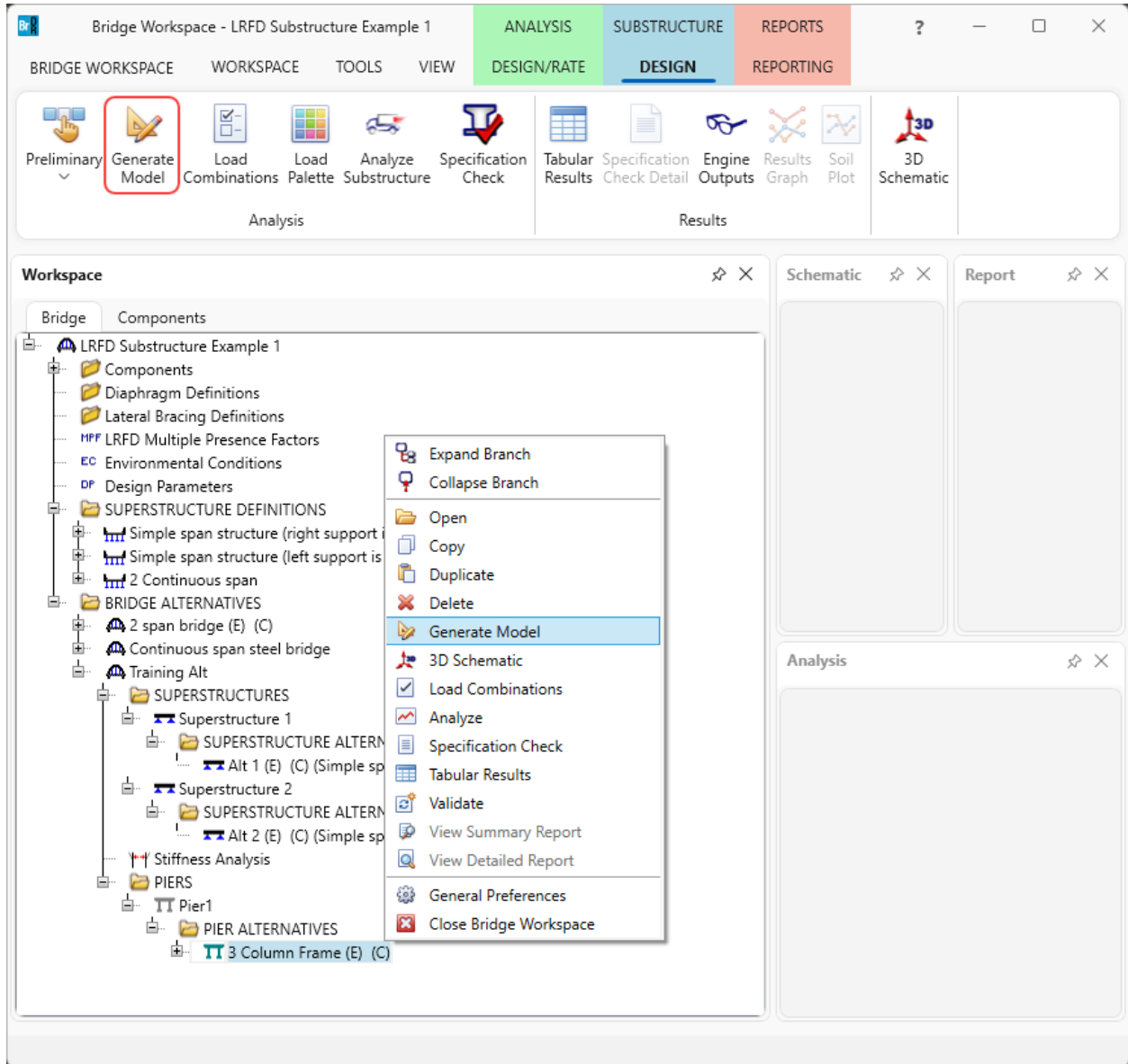
1. **Design Mode** – Specify the design mode as either Preliminary or Final. This determines which **LRFD Substructure Design Settings** are used in the pier analysis based on the design settings chosen on the **Pier Alternative: Description** tab.
2. **Generate Model** – Opens the **Model Settings** window which allows the user to define parameters BrD/BrDR will use to generate the finite element model of the pier alternative.
3. **Load Combinations** – Opens the **Load Combination Settings** window where the user can specify the load conditions to be considered when BrDR performs a pier analysis.
4. **Load Palette** – Opens the **Load Palette** window where the user select the load types to be included in the finite element analysis of a pier alternative.
5. **Analyze Substructure** – Initiates the finite element analysis of the pier alternative.
6. **Specification Check** – Conduct LRFD specification check for the pier alternative.
7. **Tabular Results** – Opens the **Tabular Results** window where the user can create summary reports of analysis output data for the pier finite element analysis.
8. **Specification Check Detail** – It allows the user to review the LRFD specification checks based on the LRFD analysis results.
9. **Engine Outputs** – Opens a window displaying all the result files generated for the analyzed member.
10. **Results Graph** – Opens the **Results Graph** for the analyzed member.
11. **Soil Plot** – Opens the **Soil Plot** window for the selected foundation alternative
12. **3D Schematic**. Open the pier alternative 3D schematic for viewing the pier alternative.

## Pier2 – Frame Pier Example

### Finite Element Model

This section describes the creation of our finite element model and analyze our pier.

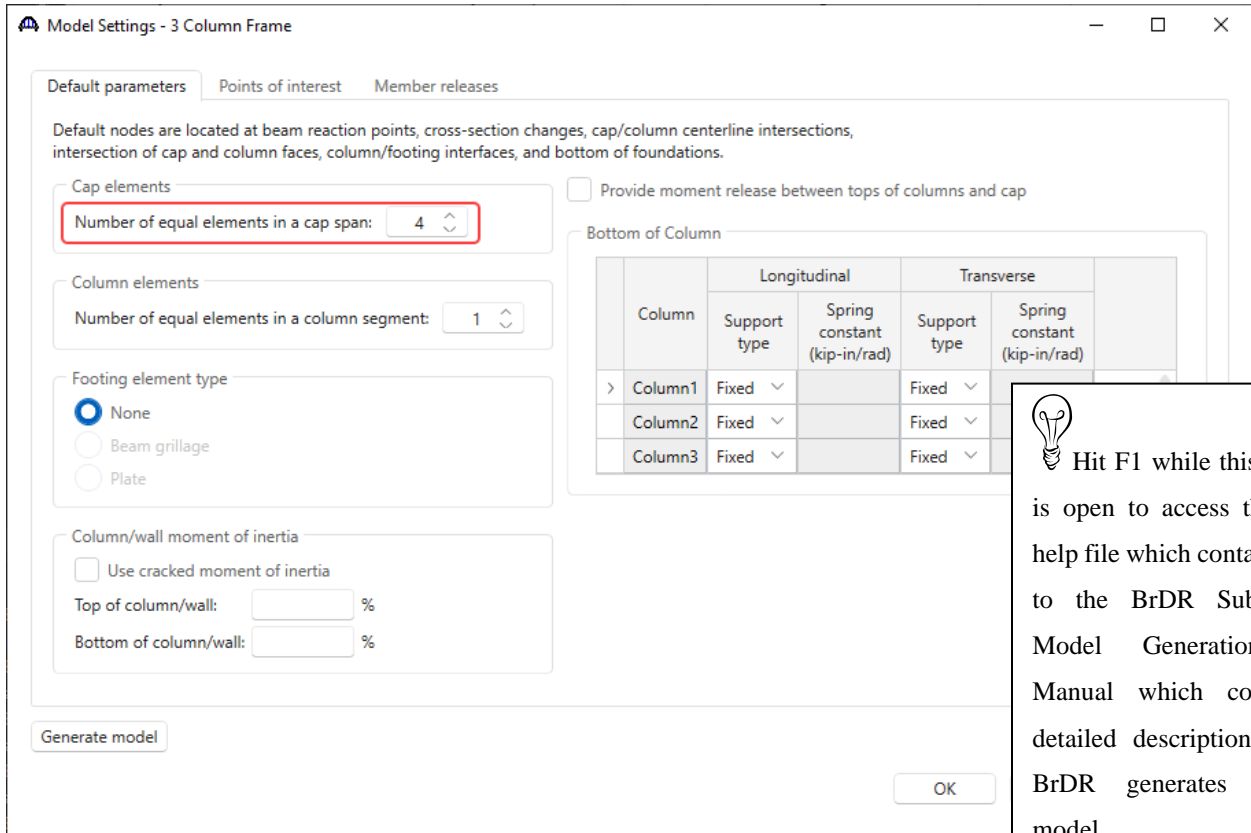
Select the pier alternative – **3 Column Frame** in the bridge workspace tree and click on the **Generate Model** button from the Analysis group of the SUBSTRUCTURE DESIGN tab or right click and select Generate Model as shown below.



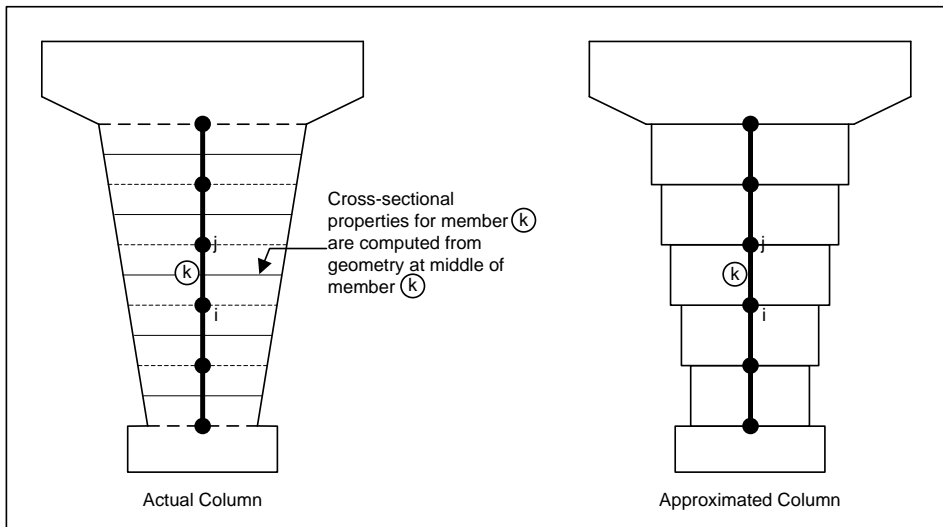


## Pier2 – Frame Pier Example

The **Model Settings** window will appear. This window allows the user to define the parameters BrDR will use to generate the finite element model of the pier.

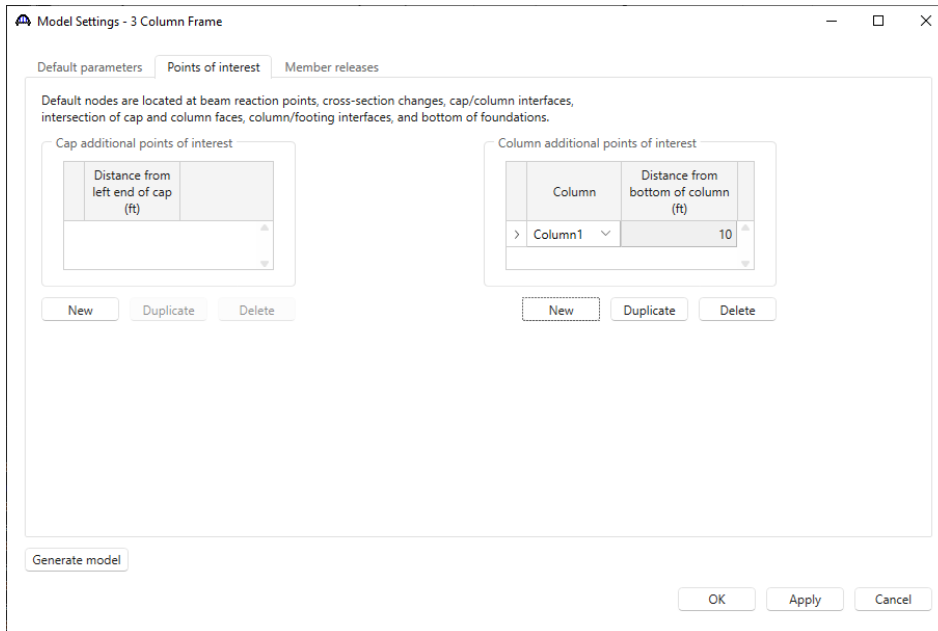


Increase the number of elements in the cap as shown above. For components whose cross section properties vary over the length of the component, increasing the number of elements will result in a closer match between the finite element model properties and the actual pier properties as shown below.

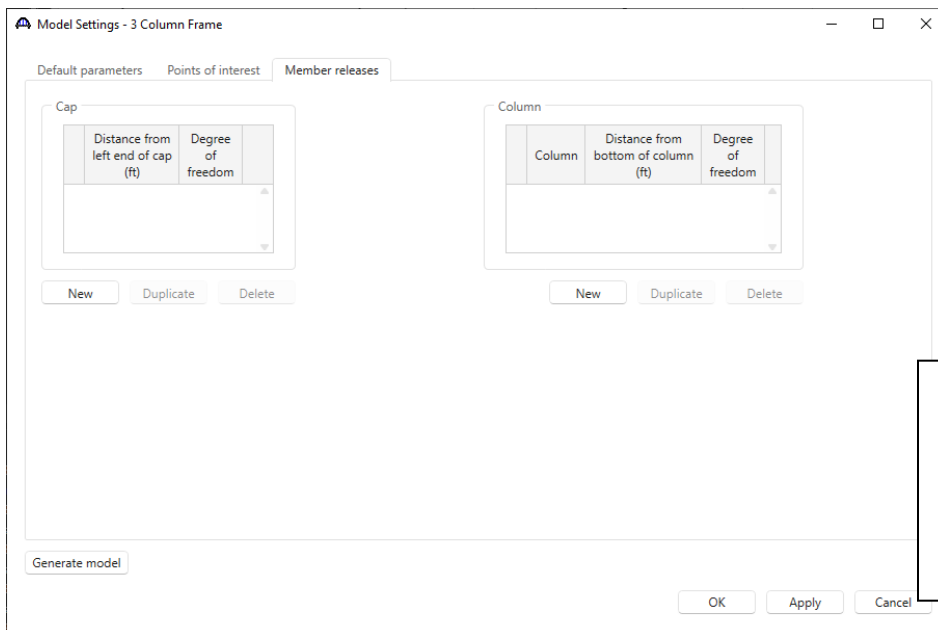



## Pier2 – Frame Pier Example

The **Points of interest** tab allows the user to define additional nodes in the pier finite element model in addition to the default nodes generated by BrDR Substructure. Add a point of interest 10 feet from the bottom of Column1 as shown below.



The **Member releases** tab allows the user to define member releases in the finite element model of the pier alternative. Adding a member release on this window creates a node at that location with the corresponding releases. In this example, no member releases will be added.

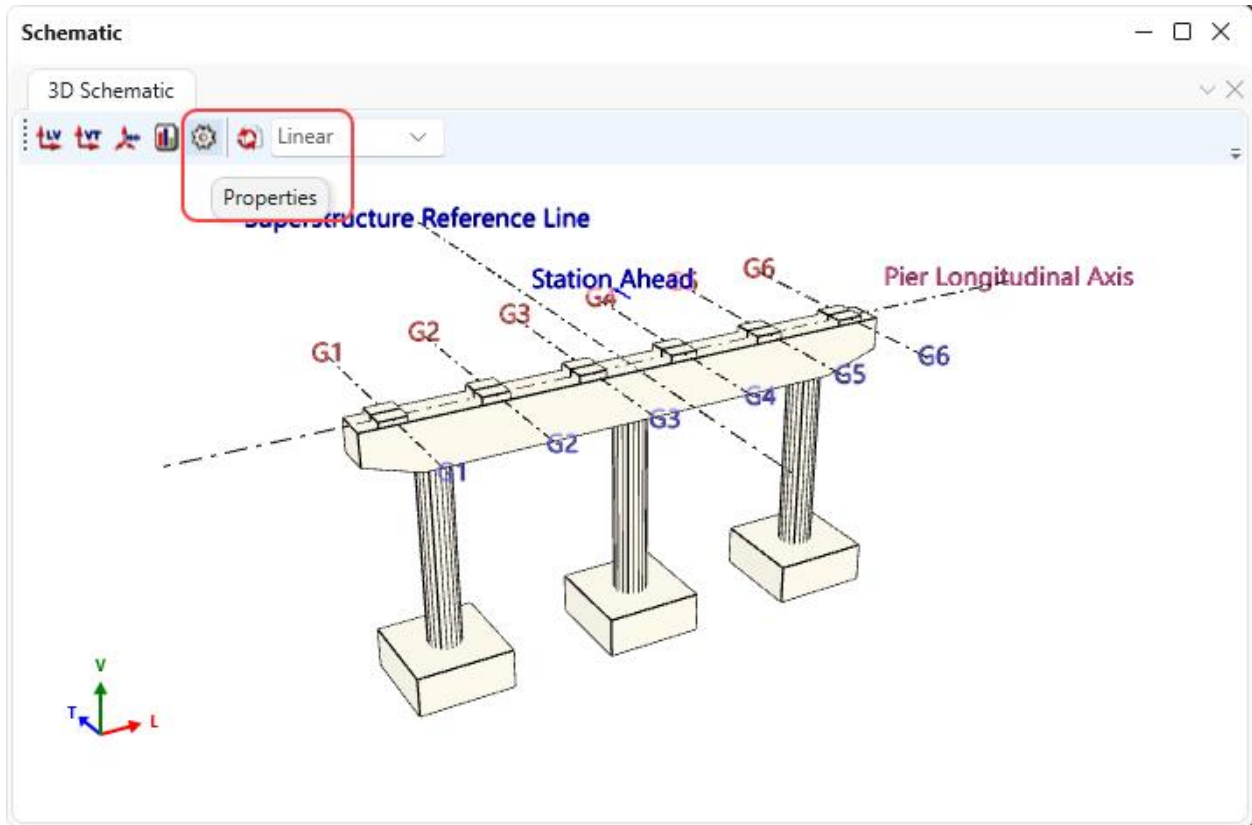


 These member releases are in the local member coordinate system.

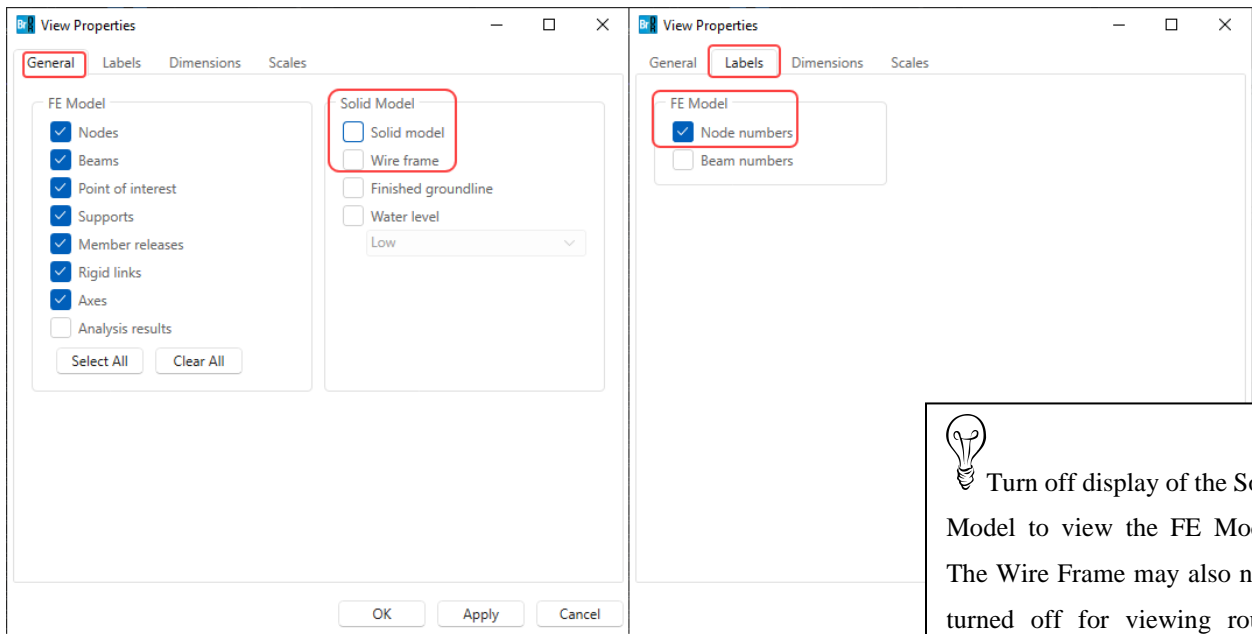
Click **Apply** to apply the data on this window. Then click the **Generate Model** button to generate the FE model. Then click **OK** to close the window.

## Pier2 – Frame Pier Example

Open the pier alternative **3D schematic** and view the FE model generated by BrDR. Select the Properties button on the 3D schematic ribbon.

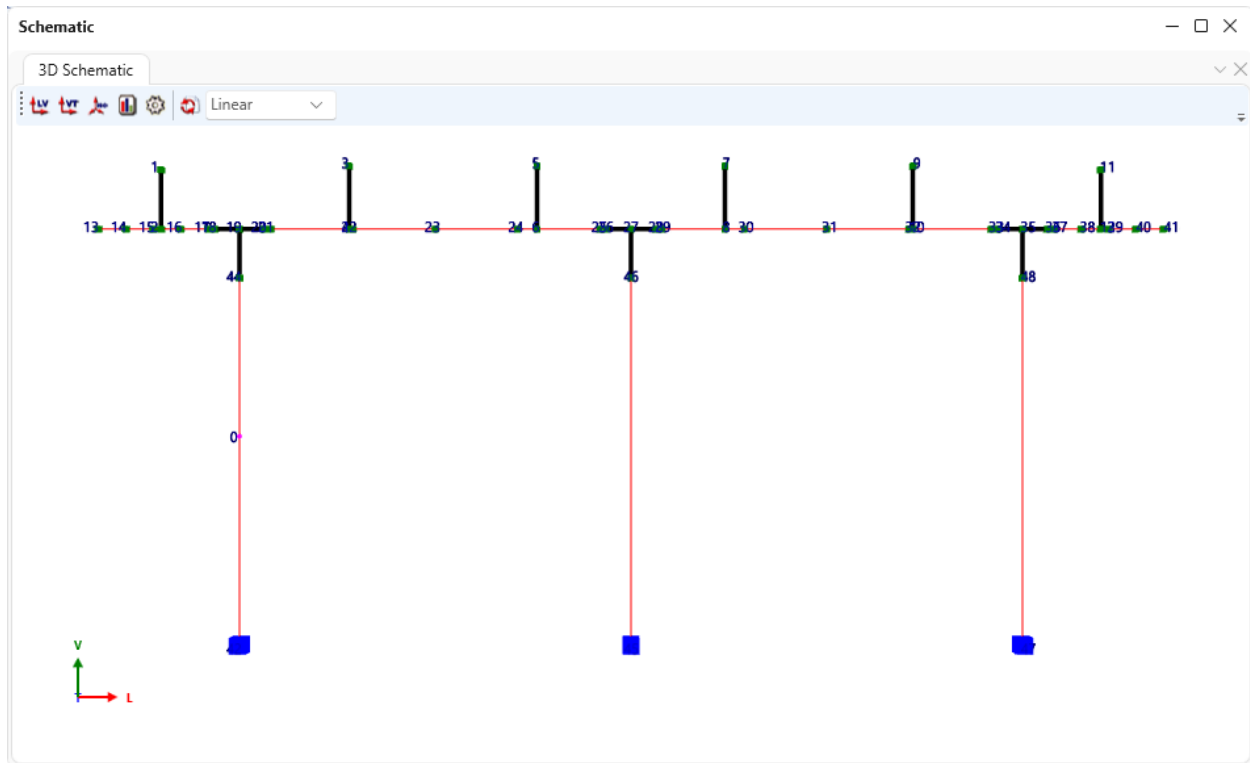


Select the following settings to turn on display of the FE model in the schematic. Also select **Nodes** on the **Labels** tab to include the node numbers in the schematic.



## Pier2 – Frame Pier Example

Click **OK** and the 3D schematic appears as follows.



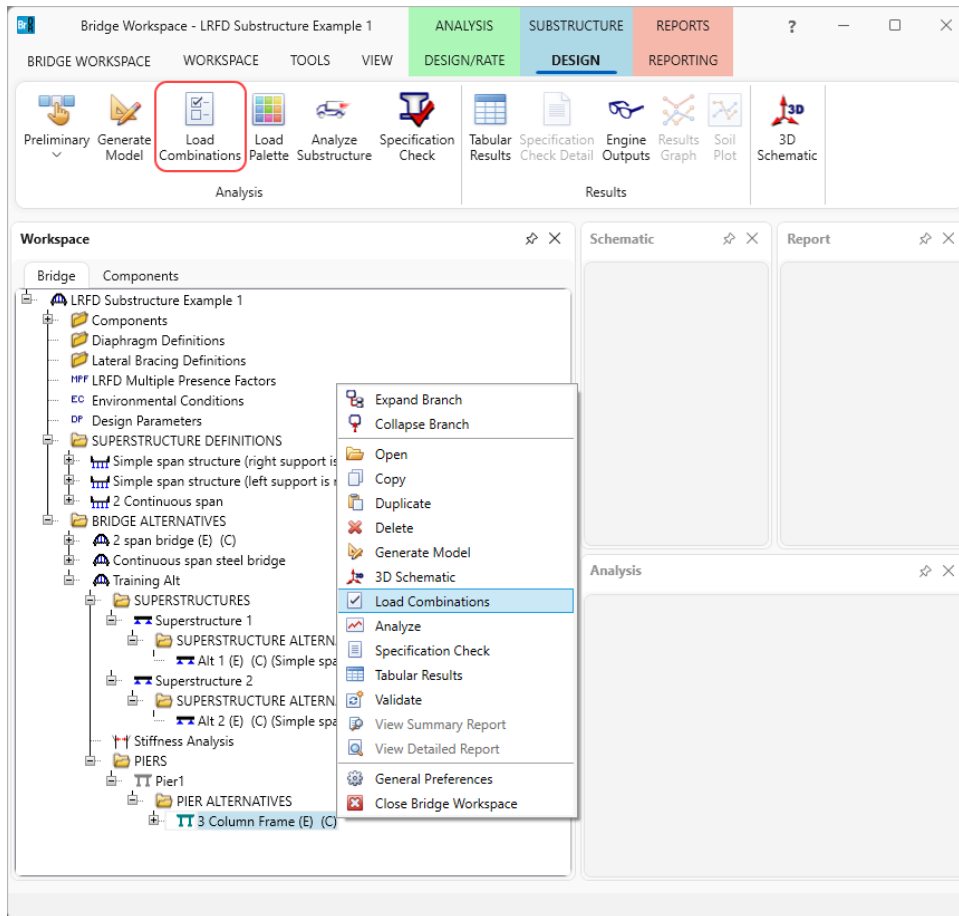
Notice node 0 in Column1. This is the point of interest added 10' above the bottom of the column.

## Pier2 – Frame Pier Example

### Pier Analysis

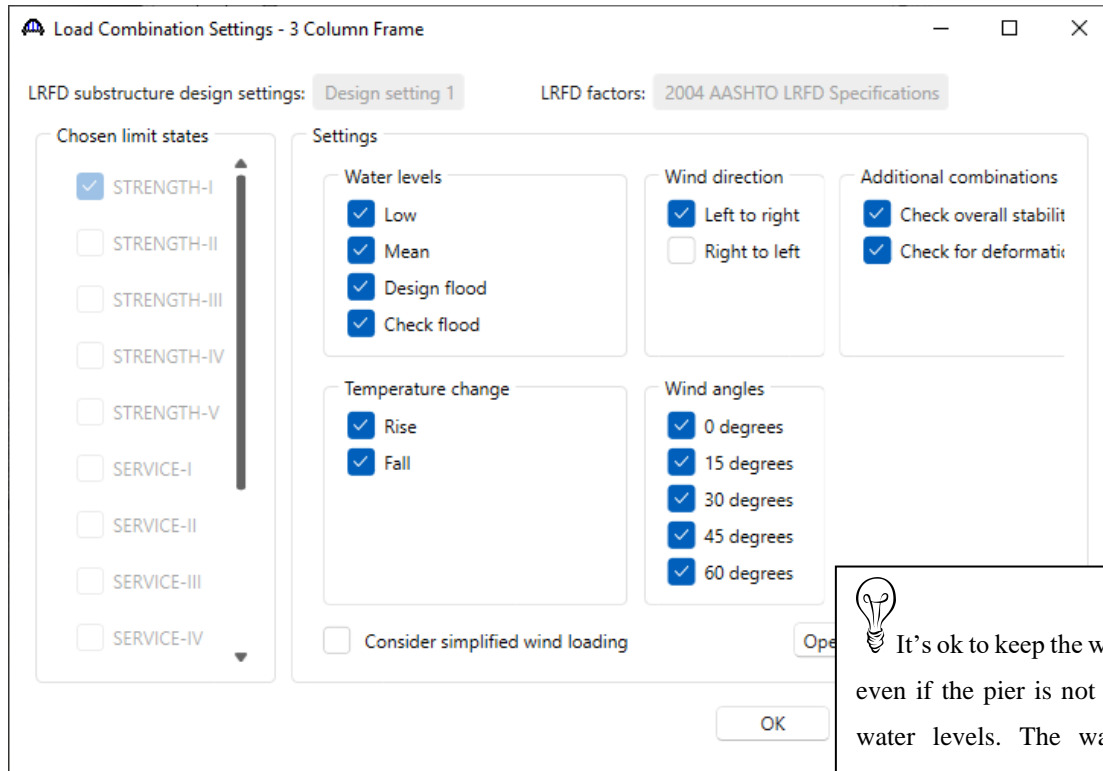
#### Loads

To select the loads to be included in the analysis, open the **Load Combination Settings** window from the right-click menu for the pier alternative or from the **SUBSTRUCTURE DESIGN** ribbon as shown below.



## Pier2 – Frame Pier Example

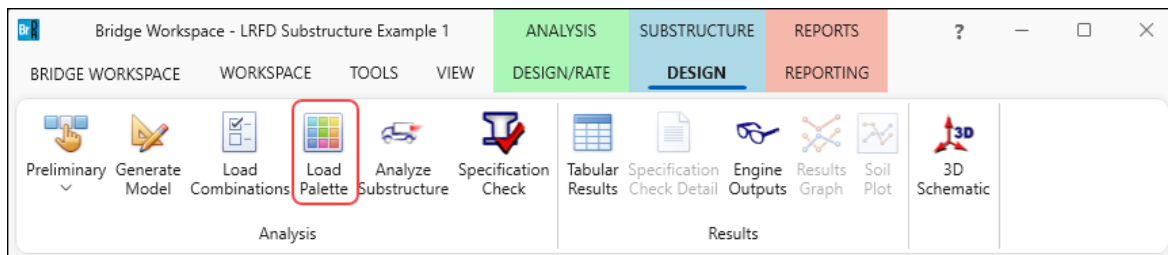
This window allows the user to specify the load conditions to be considered when BrDR performs the pier analysis. Make the following selections and click **OK**.



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

### Load Palette

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 on Load Palette in the **SUBSTRUCTURE DESIGN** ribbon.



## Pier2 – Frame Pier Example

Use	Input defined	Override	Use	Input defined	Override
DC <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	EH Active <input checked="" type="checkbox"/>	NA	
DW <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	EH At-Rest <input checked="" type="checkbox"/>	NA	
LL <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>			
PL <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>	TU <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>
BR <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	TG <input checked="" type="checkbox"/>	NA	
CT <input checked="" type="checkbox"/>	NA		SH <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>
WA <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	CR <input checked="" type="checkbox"/>	NA	
WS <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	SE <input checked="" type="checkbox"/>	NA	
WL <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	FR <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>
			CV <input checked="" type="checkbox"/>	NA	

Select all Clear all Open template Save template OK Cancel

If a load type is unchecked, the load combinations for the limit states containing that load type will still be computed but that load type will have zero loading.

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

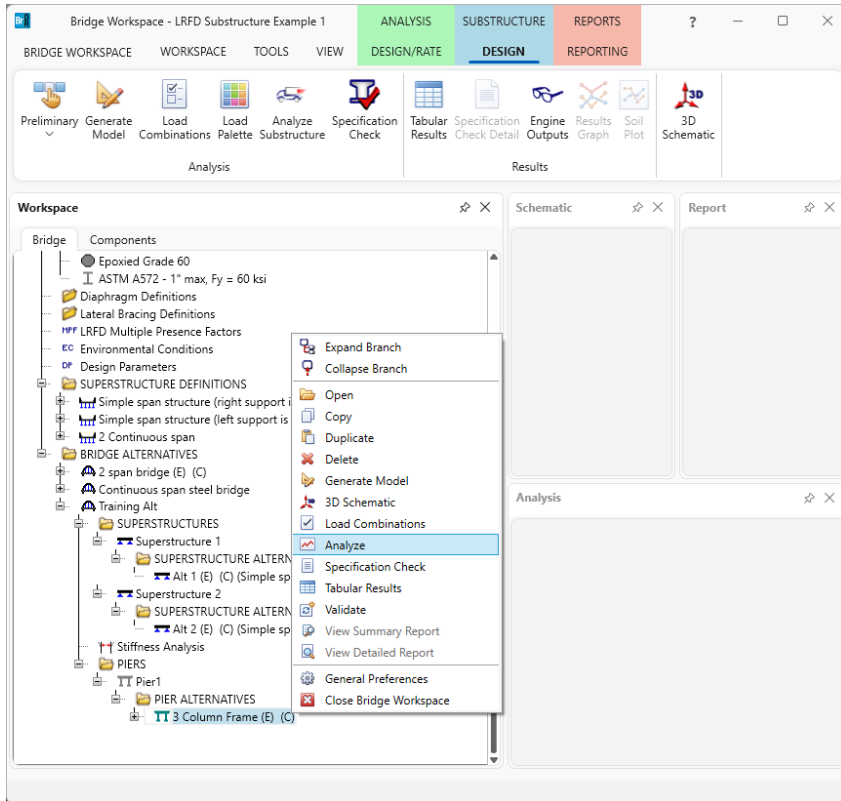
The Load Palette can be very useful in evaluating individual load types on the pier and to minimize the time required for analysis.

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

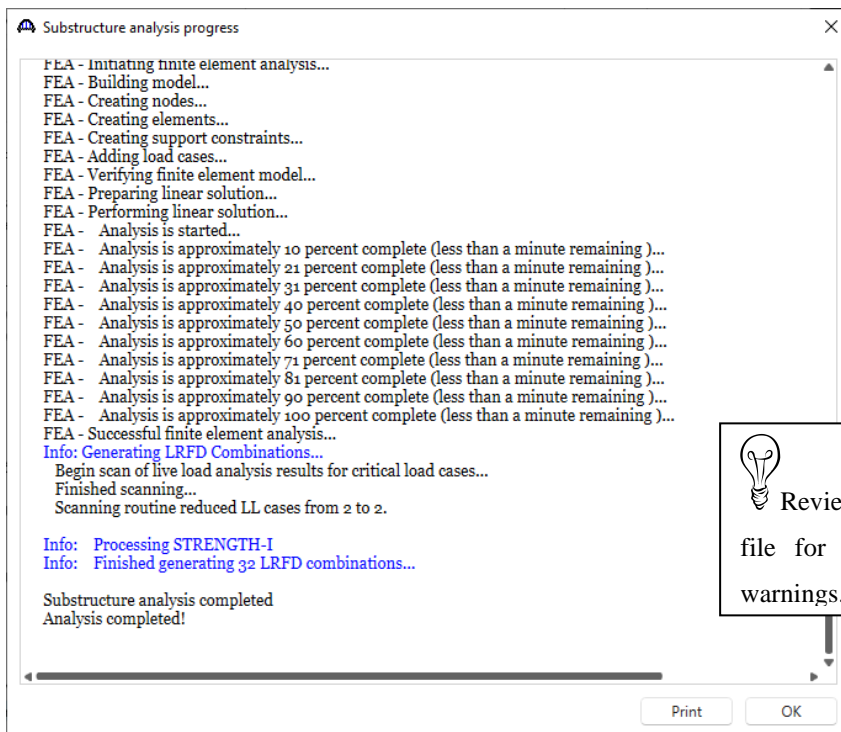
It is ok to keep the **Use** box checked for load types that do not apply to the pier. They will be ignored if they do not apply to the pier.


## Pier2 – Frame Pier Example

Now that the loads are selected, pier is ready to be analyzed. Select **Analyze** from the right-click menu.



The **Substructure analysis progress** window will open as shown below. Click **OK** once the analysis completes.



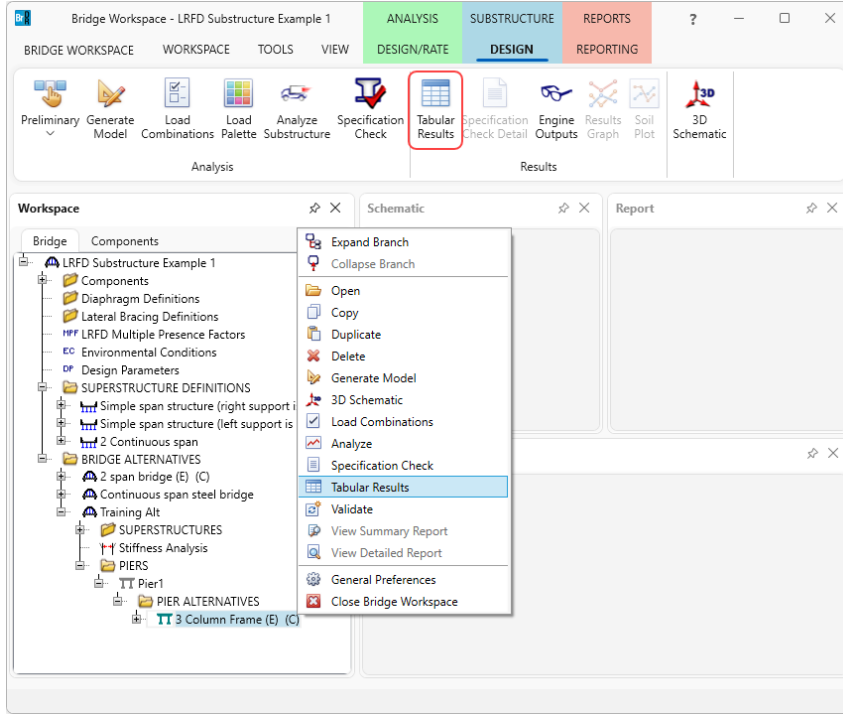
 Review this log file for errors and warnings.



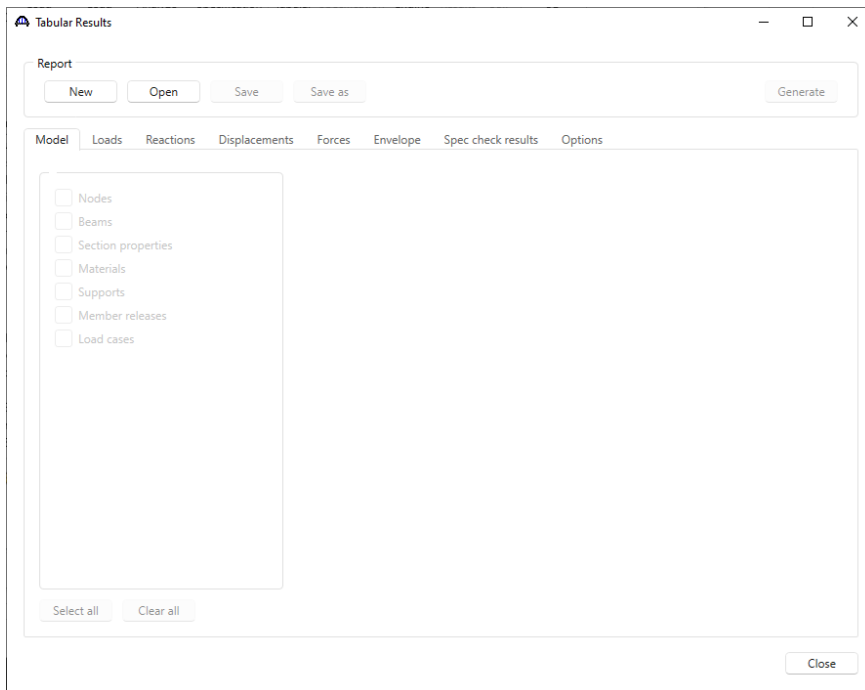
# Pier2 – Frame Pier Example

## Tabular Results

Results can also be viewed in a tabular form by clicking on the **Tabular Results** button from the ribbon or right click and select **Tabular Results** when the pier alternative is selected. The following window will open.

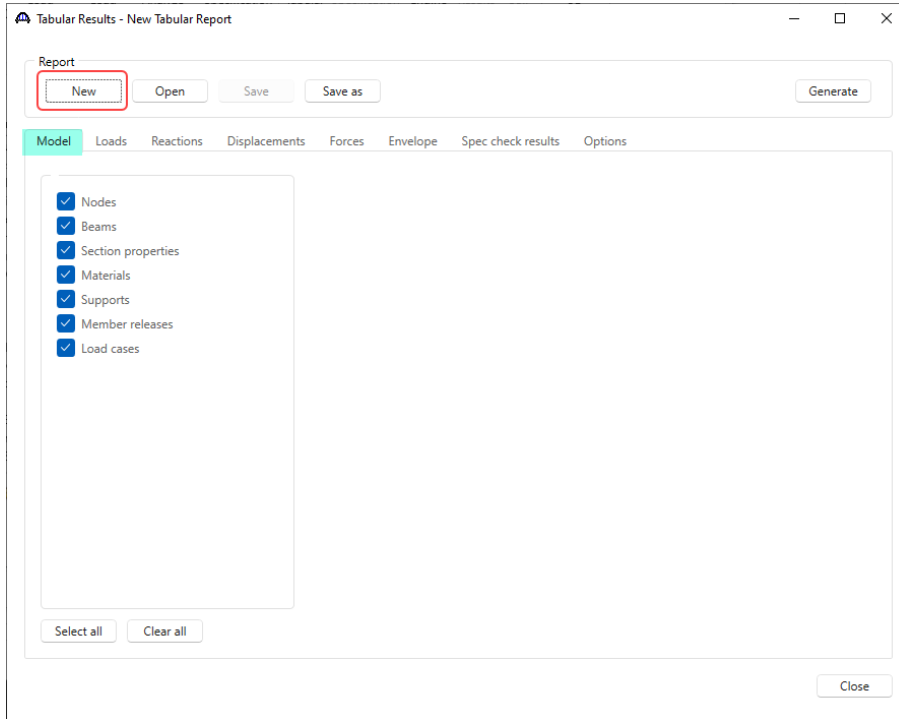


This window allows the user to create summary reports of analysis output data for the pier finite element analysis and save these report definitions for future use.

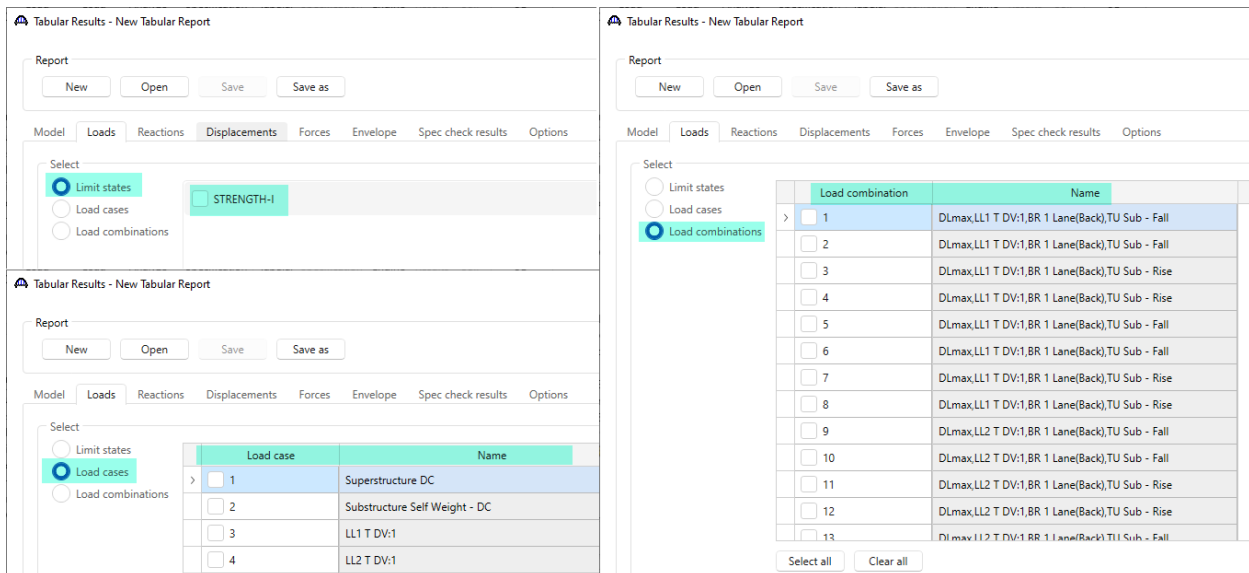


## Pier2 – Frame Pier Example

Select **New** to create a new report definition. The first tab permits the selection of FE model information to include in the report.

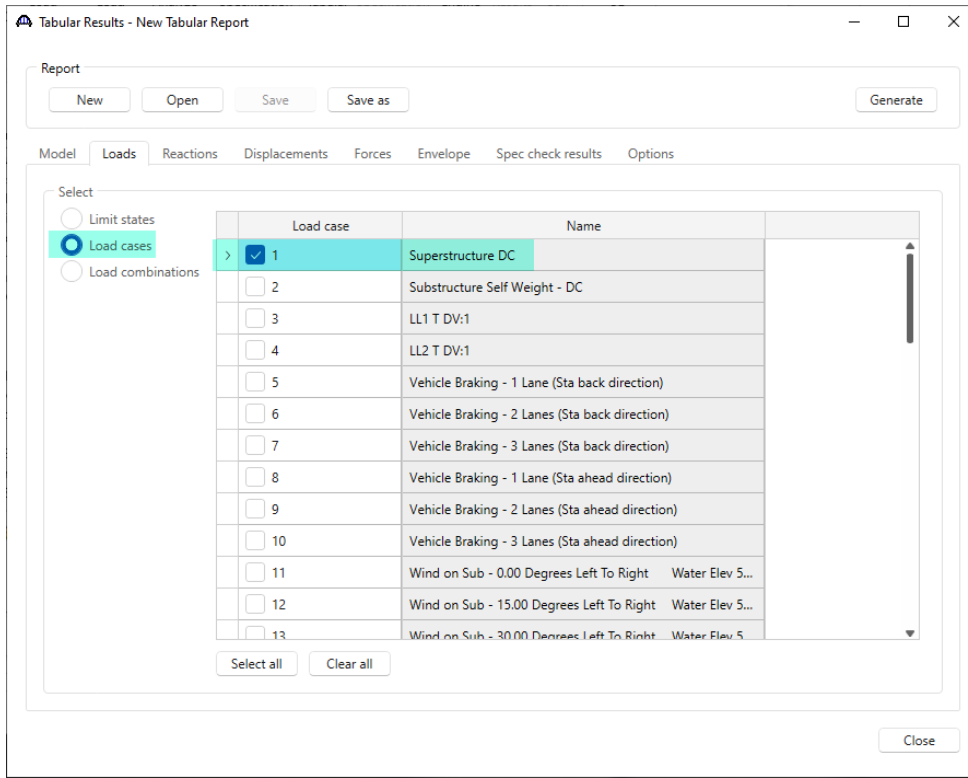


The default settings are okay. Switch to the **Loads** tab. This tab allows the user to select how the FE analysis output (reactions, displacements, element forces) is organized in the report. Selecting the Limit States filter permits the selection of limit states output to be included in the report. Selecting the Load Cases filter permits the users to select individual load cases output to be included in the report. Selecting the Load Combinations permits the user to pick individual load combinations output to be included in the report.

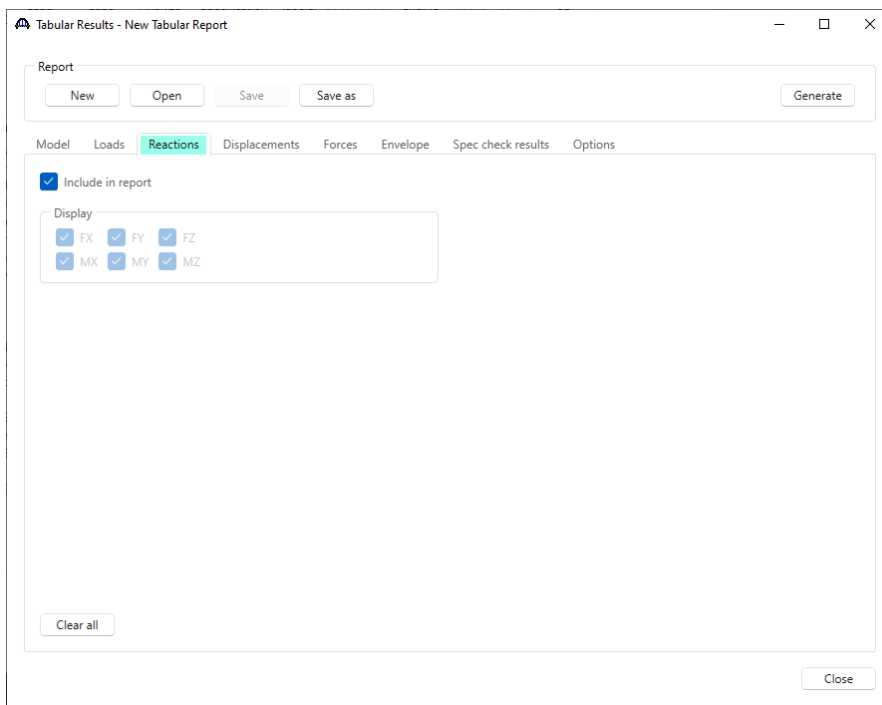


## Pier2 – Frame Pier Example

Select the **Load cases** filter and then select **Load case 1**. This results in a report that will contain the reactions, displacements, and forces for only this Load case 1.

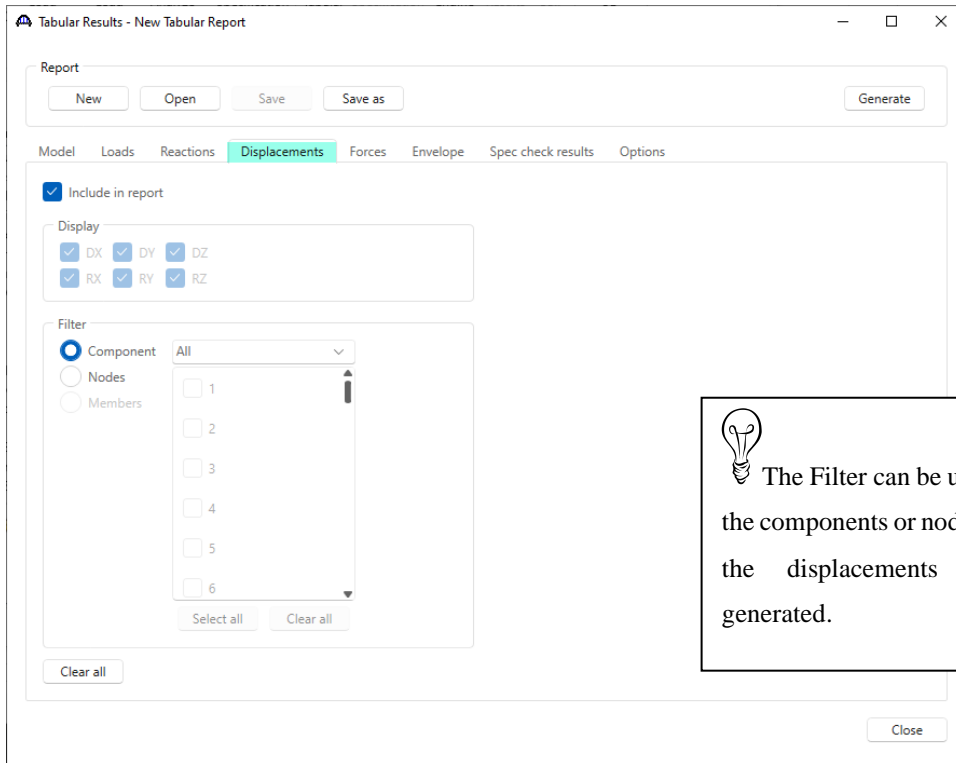



The **Reactions** tab lets the user specify if reactions should be included in the report. The reactions will be output for the loadings specified on the **Loads** tab.



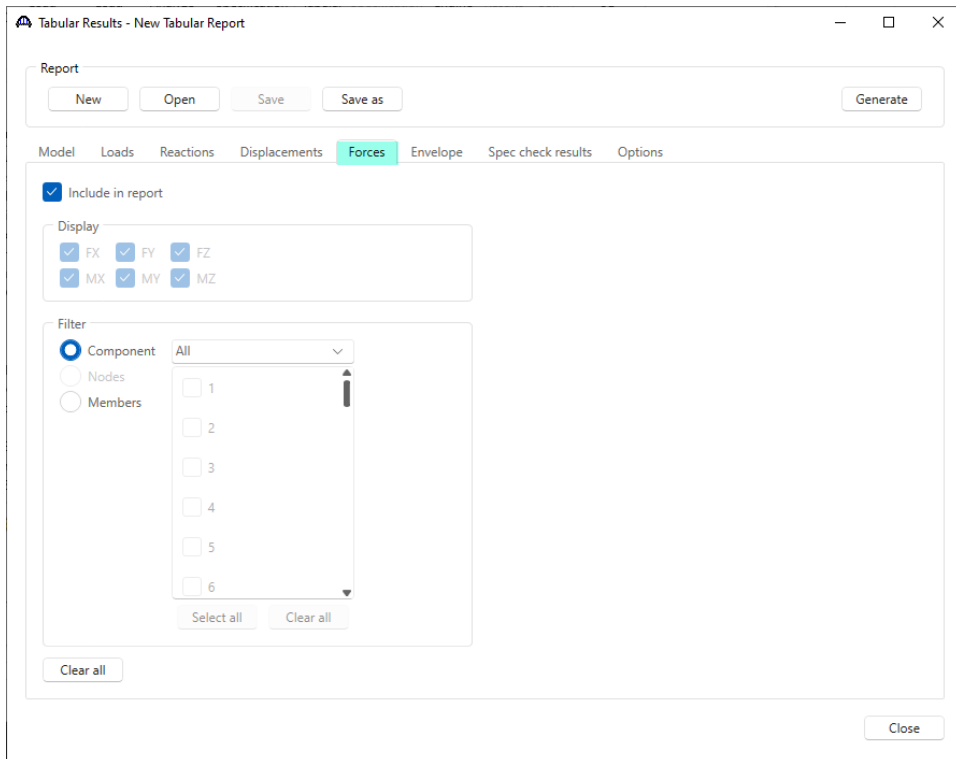
## Pier2 – Frame Pier Example

The **Displacements** tab lets the user specify if the node displacements should be included in the report. The displacements will be output for the loadings specified on the **Loads** tab.



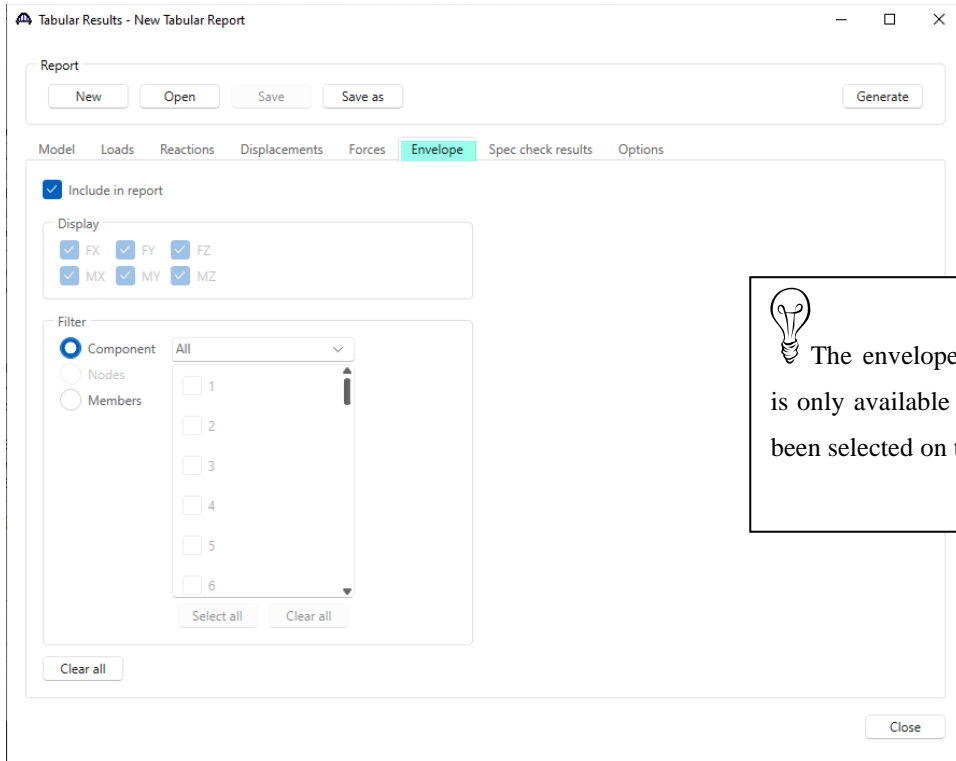
 The Filter can be used to select the components or nodes for which the displacements output is generated.


The **Forces** tab lets the user specify if the element forces should be included in the report. The element forces will be output for the loadings specified on the **Loads** tab.



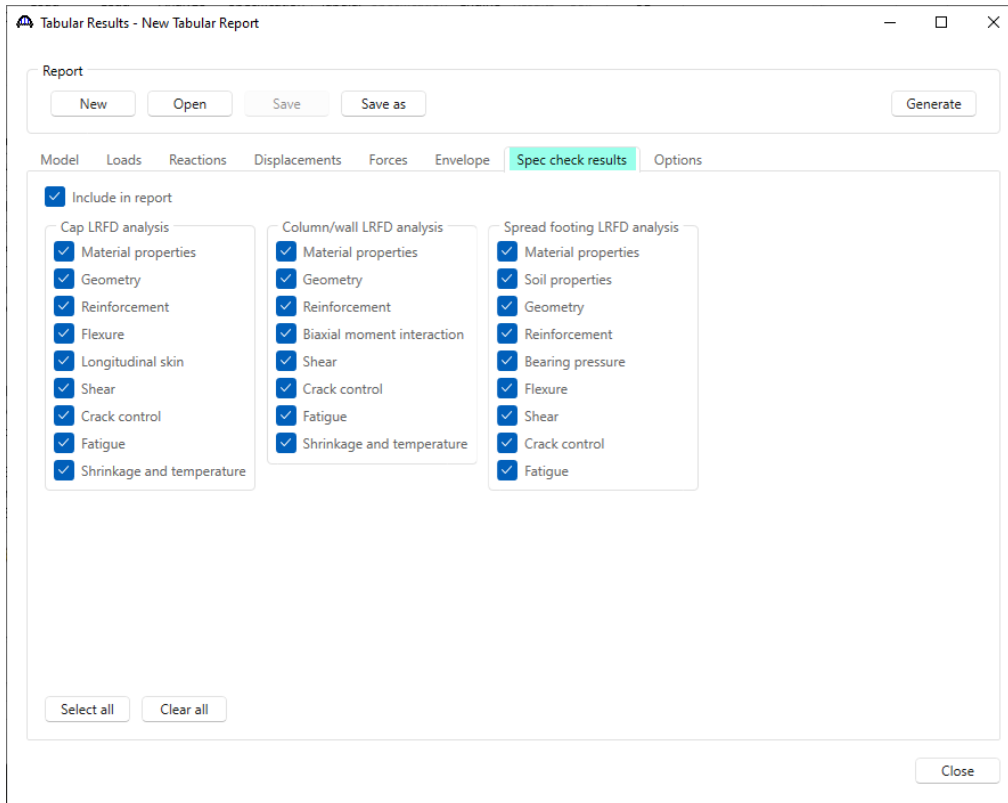
## Pier2 – Frame Pier Example

The **Envelope** tab lets the user specify if the envelope of the element forces should be included in the report. The envelope will be output for the limit states specified on the **Loads** tab.



 The envelope of element forces is only available if limit states have been selected on the Loads tab.

The **Spec checks results** tab allows the user to specify what to be included in the report.



## Pier2 – Frame Pier Example

The **Options** tab allows the user to specify formatting and output options for the report.

Tabular Results - New Tabular Report

Report

New Open Save Save as Generate

Model Loads Reactions Displacements Forces Envelope Spec check results Options

General

Report heading

User name  Timestamp

Description:

Generate linked table of contents

Note: Do not select this option if the generated xml file is for creating Crystal Reports Report (RPT) file.

Units

Units: US Customary

Input

Length: ft

Section properties: in

Strength: ksi

Spring constant: ft-kip/Deg

Loads/results

Force: kip

Moments: kip-ft

Displacement: in

Rotation: Radians

Close

To save the settings on these tabs as a report definition that can be re-used in the future, select the **Save As** button. This would save the settings on these tabs as a report definition file. It would not save the FE analysis output report for this pier.

Select the **Generate** button to view the FE analysis output report for this pier. An xml file containing the data for this report is created and given the name **New Tabular Report.xml**. This file is overwritten each time the **Generate** button is clicked.

## Pier2 – Frame Pier Example

### Additional Reports

With pier alternative selected in the bridge workspace tree, click on the **Engine Outputs** button from the ribbon as shown below. The following window will appear. This window contains a listing of the output files BrDR created when it computed the pier loads and when it performed the finite element analysis. Double click on any file to open it.

