2009 Roads and Bridges User Conference

SW-3

Introduction to Reinforced Concrete Substructure Design with LEAP Bridge

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Introduction to Reinforced Concrete Substructure Design

Overview

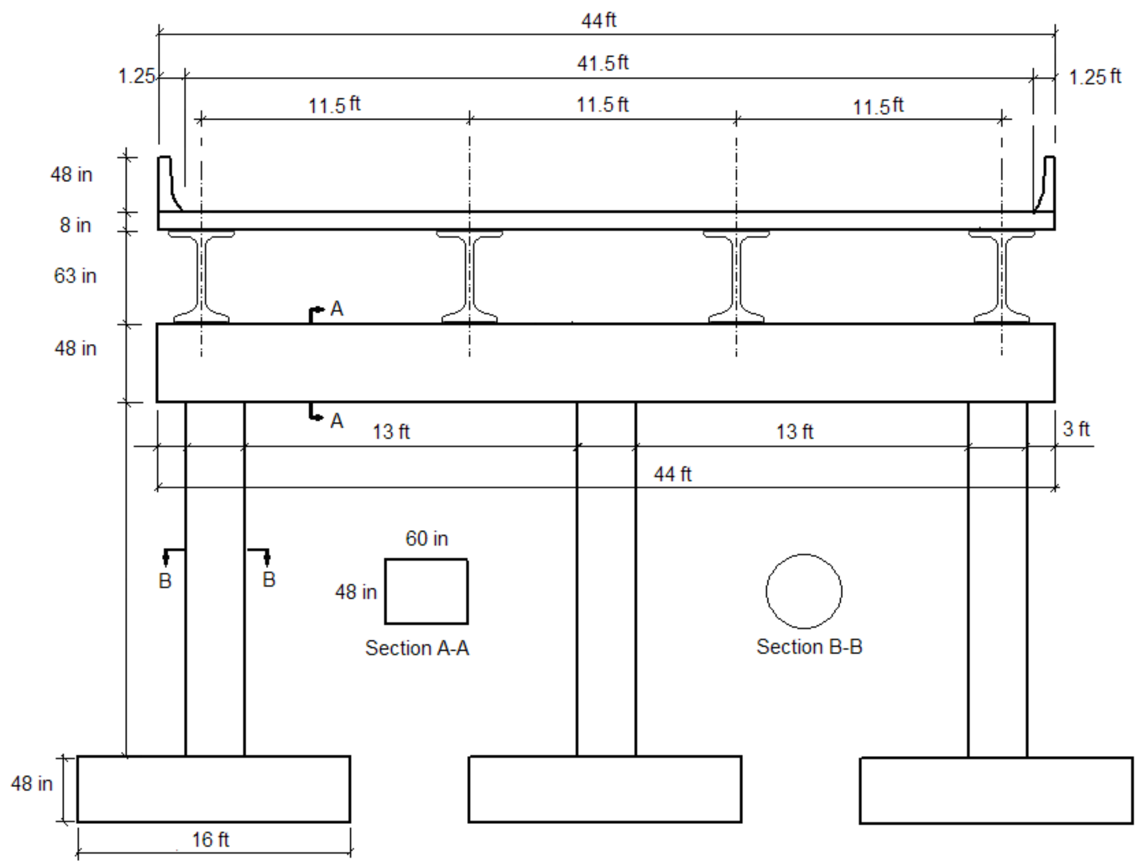
This workshop focuses on the LEAP Bridge application, RCPIER, for the design of reinforced concrete bridge substructures and foundations. Learn how to use the options to design a multi-column pier as well as the footing types that are supported with this product.

Objectives

After completing this course, you will be able to:

- Use the ABC wizard in LEAP Bridge to quickly layout superstructure and substructure of a bridge.
- How to auto-generate dead load, live load, and wind load.
- How to design cap beam.
- How to design column.
- How to design isolated spread footings.

Details



Elevation of Bridge Pier with Cross Section for Cap and Column

Problem Data

Concrete Strength

Cap f'c = 4000 psi
Columns f'c = 4000 psi
Footings f'c = 4000 psi

Concrete Density

Cap ρ = 150 pcf
Columns ρ = 150 pcf

Footings	ρ = 150 pcf

Steel Yield Strength

Cap f_y = 60 ksi	
Columns	f_y = 60 ksi
Footings	f_y = 60 ksi

Concrete Type

Cap Normal	
Columns	Normal
Footings	Normal

Other Parameters

Cap Crack Control Factor	z = 170 kips/in
Footing Crack Control Factor	z = 130 kips/in

Superstructure Parameters

Number of lanes	= 3
Number of Beams	= 4
Beam Height	= 63 in
Beam Section Area	= 713 in^2
Beam Section Ycg	= 32.12 in
Beam Section Inertia Ixx	= 392638 in^4
Beam Section Inertia Iyy	= 40543 in^4
Barrier Height	= 48 in
Slab Depth	= 8 in

Span Information

Total number of spans	= 3
Span Lengths	= 100, 100, 100 ft
Bridge Overall Width	= 44 ft
Curb to Curb Distance	= 41.5 ft

Substructure Parameters

Cap: Straight Cap

Length = 44 ft

Height (Y) = 48 in

Width (Z) = 60 in

Skew Angle = 0 degrees

Start Elevation = 30 ft

End Elevation = 30 ft

Factor of Reduced Moment of Inertia = 1.0 (non-cracked section)

Columns: Circular Fixed at base

Column Clear Height = 26 ft

Diameter = 48 in

Factor of Reduced Moment of Inertia:

= 1.0 (non-cracked section)

Bearings = one line with no eccentricity

Loads

Dead Load

Self-weight = 150 pcf

Slab= 150 pcf

Girder Weight = 150 pcf

Barrier Weight = 418 plf each side

Total Barrier Weight = 2 × 418 = 836 plf

Future Wearing Surface Load = 20 psf

= 20 × 41.5 = 830 plf

Live Load

AASHTO LRFD HL93

Two Design Tandem + Lane

Wind on Structure

Direction of wind = +30˚

Elevation above which wind acts = 0 ft

Wind on Live Load

Wind Angle = +30˚

Length of live load = 100 ft

Footing Surcharge

Surcharge	σ = 0.24 ksf

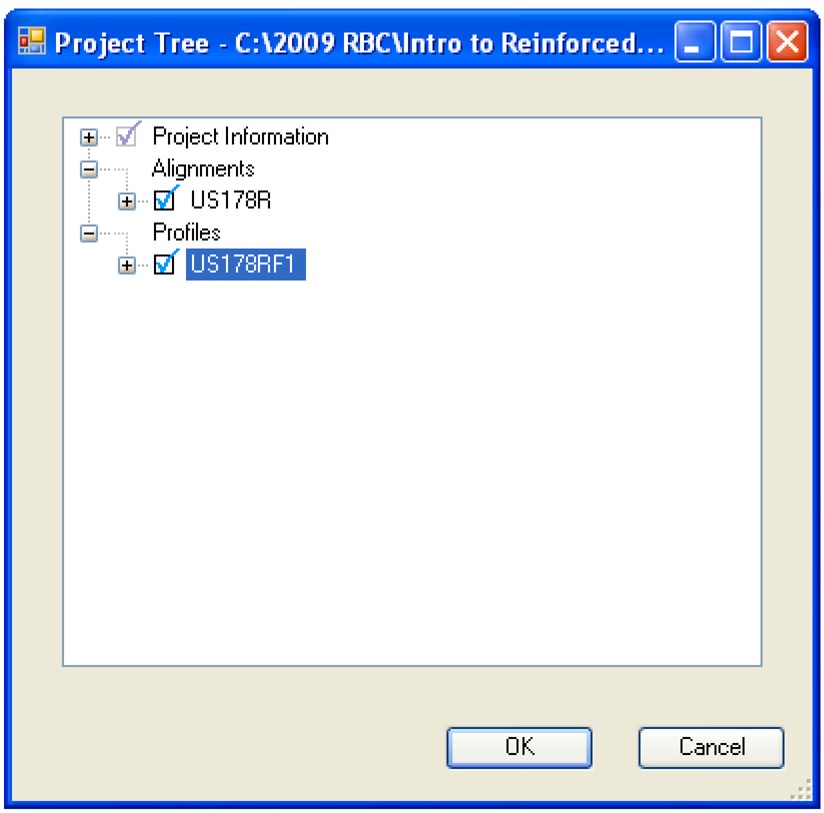
Create Bridge with ABC Wizard

These steps will walk you through using the ABC Wizard in LEAP Bridge to create a 3D model of a bridge including the super and substructure components.

➔ **Exercise: Use ABC Wizard to create an 2-70' span structure**

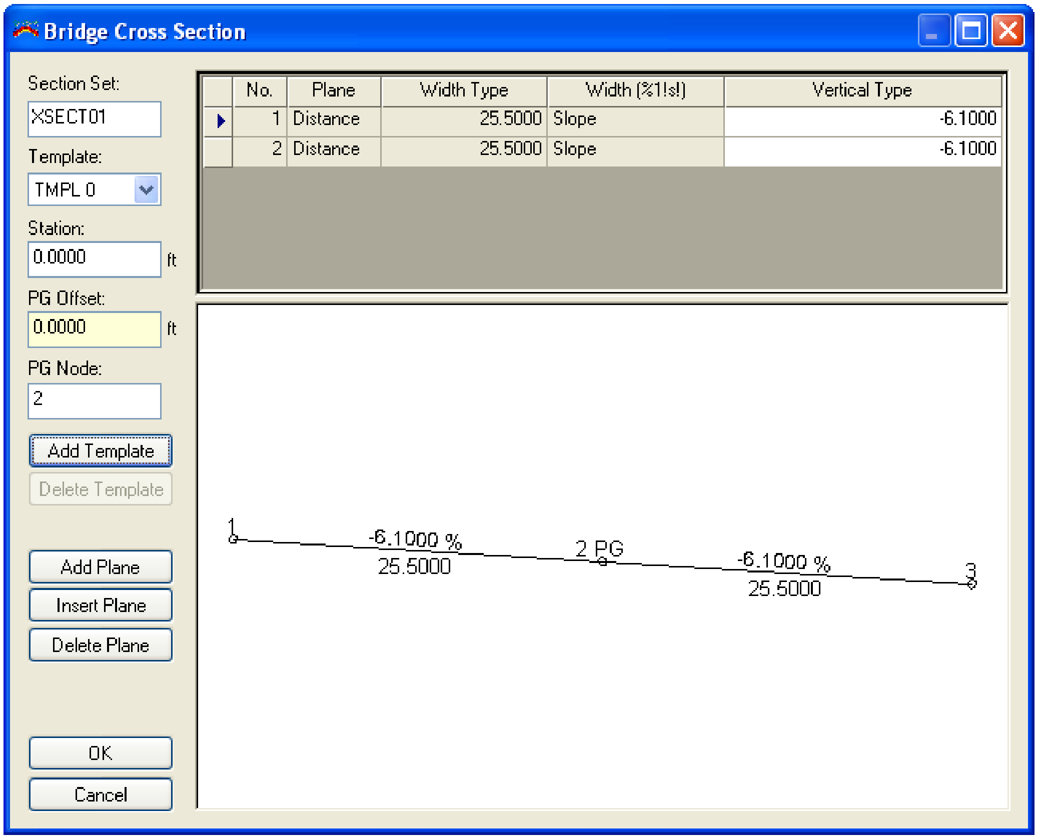
1. Start LEAP Bridge.
2. Start the ABC Wizard.

3. Select **LandXML**. Select *C:\2009 RBC\ Intro to Reinforced Concrete Substructure Design\us178r_chain.xml* from the Browse button. Select **Connect** to continue.
4. Expand the Alignments and Profiles toggles and toggle on the alignment and profile as shown below. Select **OK** to import the geometry.

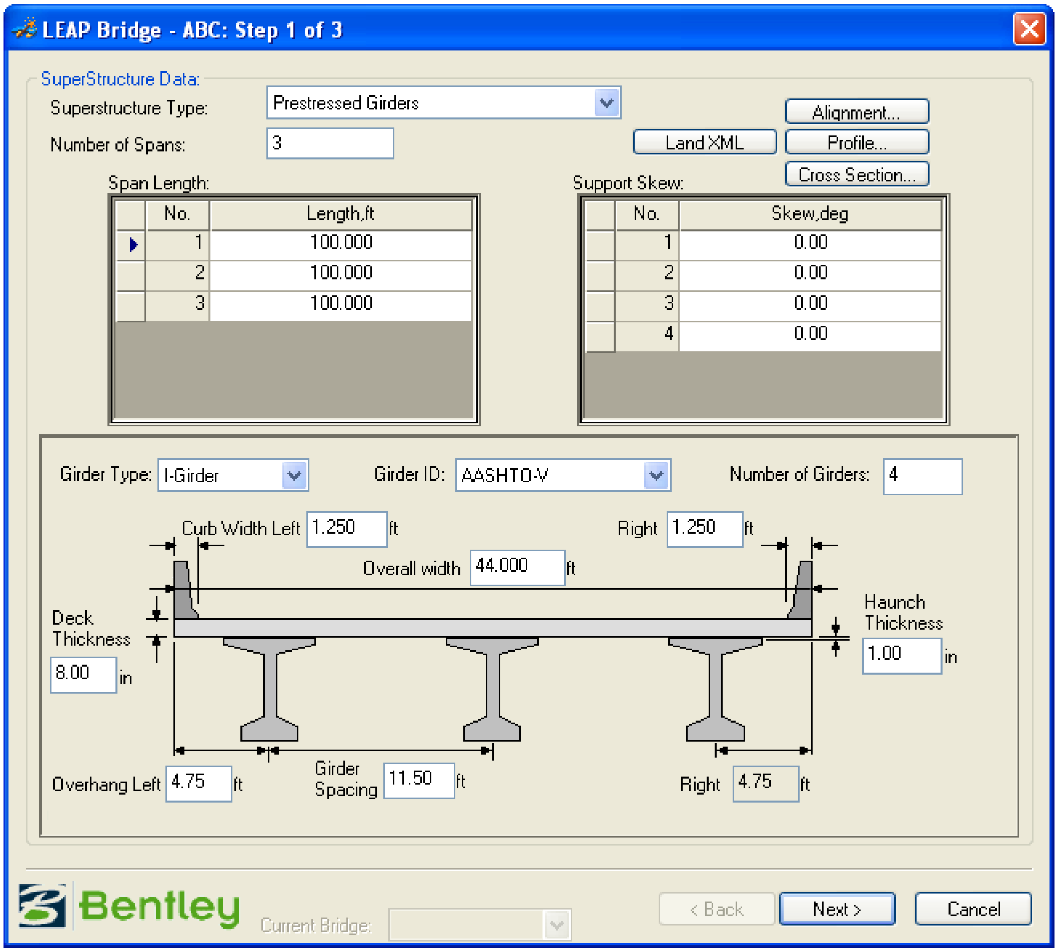


5. The bridge begins at station 379+90. Select **Alignment** and set the **Begin Bridge Station** to *379+90*. Select **OK** to accept this value.

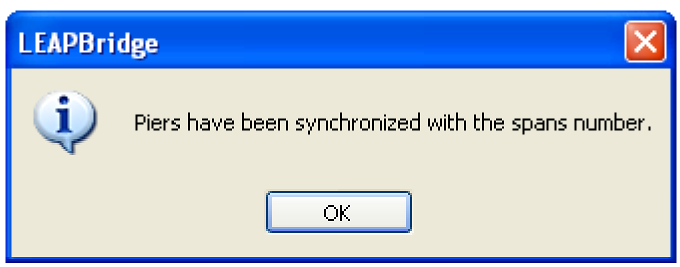
6. The Cross slope of the structure is 6.1%. Select **Cross Section…** from the Step 1 of 3 dialog. Populate the Bridge Cross Section dialog as shown and select **OK** when completed.



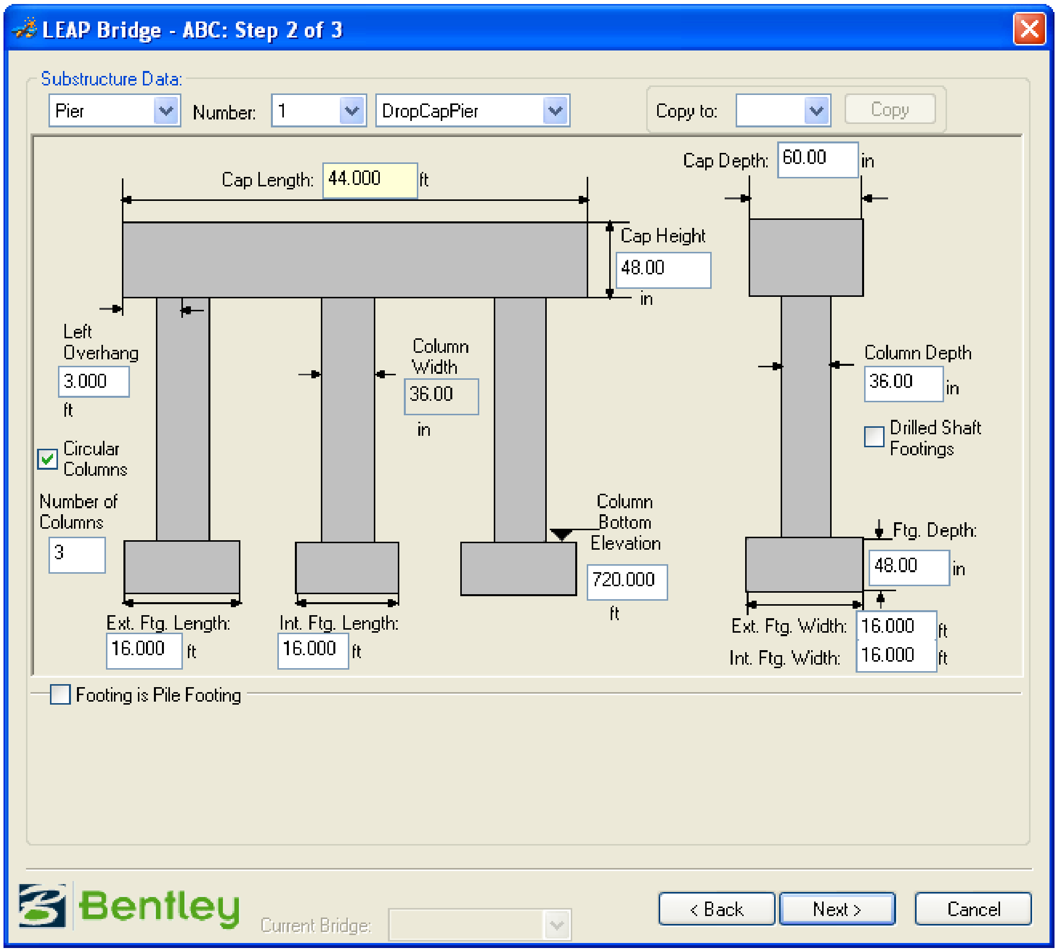
7. Populate the Step 1 of 3 dialog as shown below. Select **Next** when complete.



8. Select **OK** when prompted.



9. For Pier 1, complete the dialog as shown.



10. Set the Copy to: to Pier 2 and select **Copy**. Select **Next** to continue.

11. Select **Next** twice. Select Finish to complete the wizard.

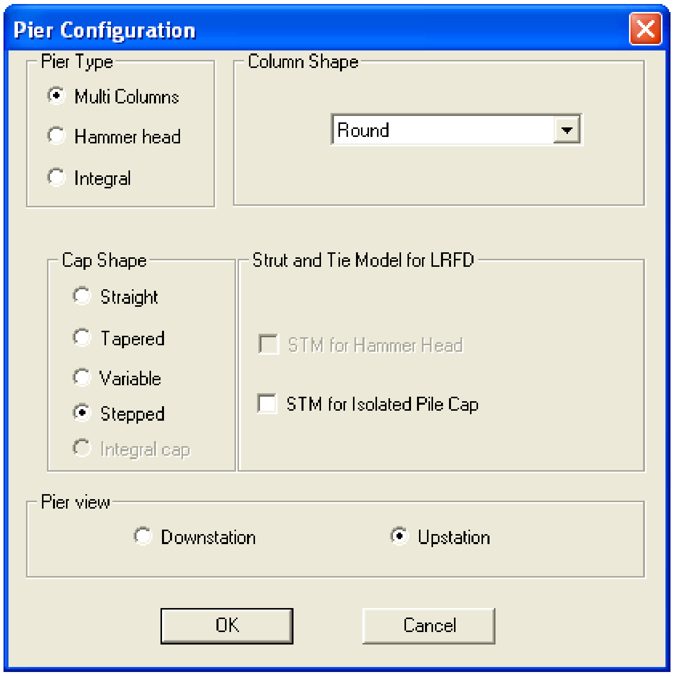
12. Select the **Geometry** tab to view a 3D model of structure.

Adjust Cap Geometry

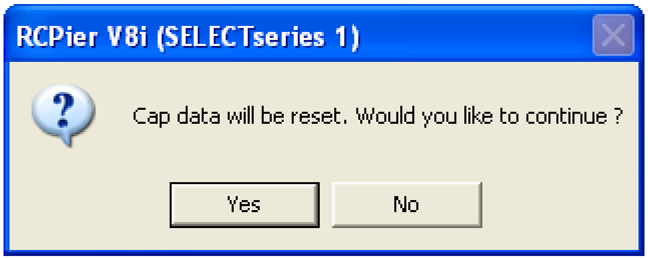
The following steps will guide you through the process of modifying the cap to a stepped cap.

➔ **Exercise: Modify Cap**

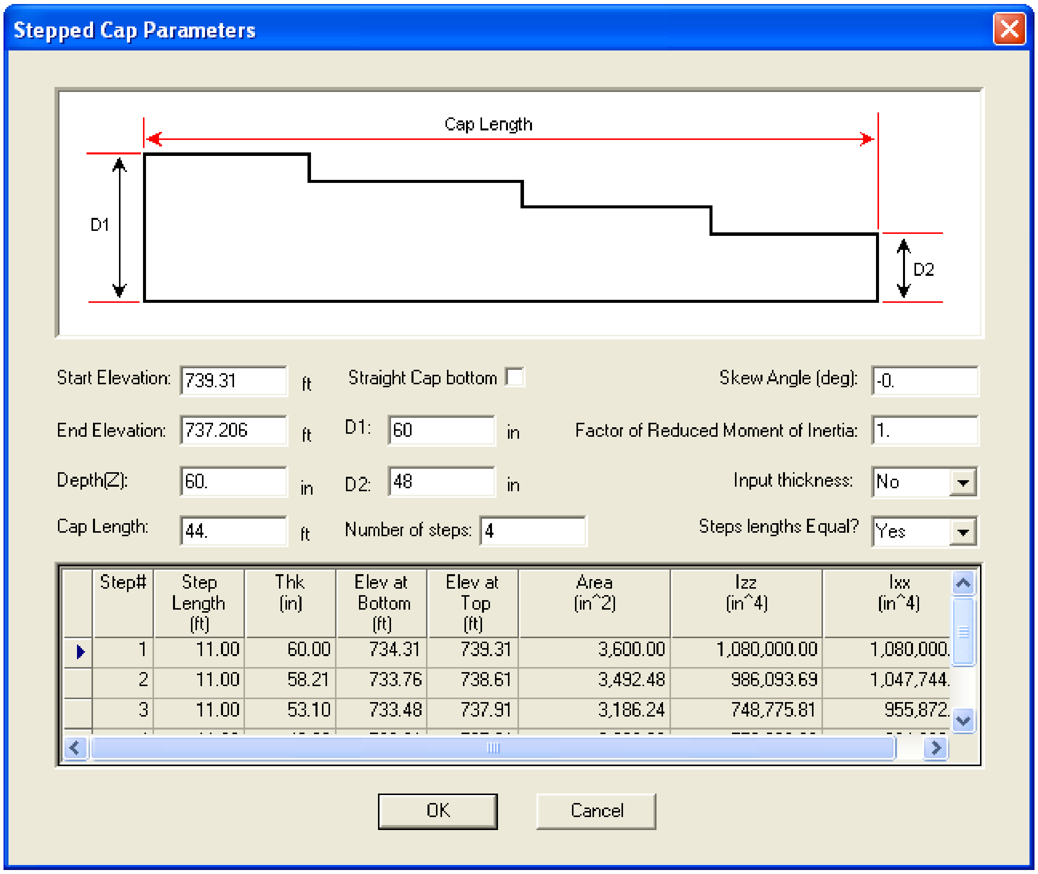
1. From the **SubStructure** tab in LEAP Bridge, select **RCPIER.**
2. From the **Geometry** tab in RC-Pier, select **Pier Config.**
3. Set the **Cap Shape** to Stepped. Select **OK**.



4. When prompted that the cap data will be reset, select **OK**.



5. Select the **Cap** tool.
6. Populate the dialog as shown in the following dialog and select **OK** to accept the changes.

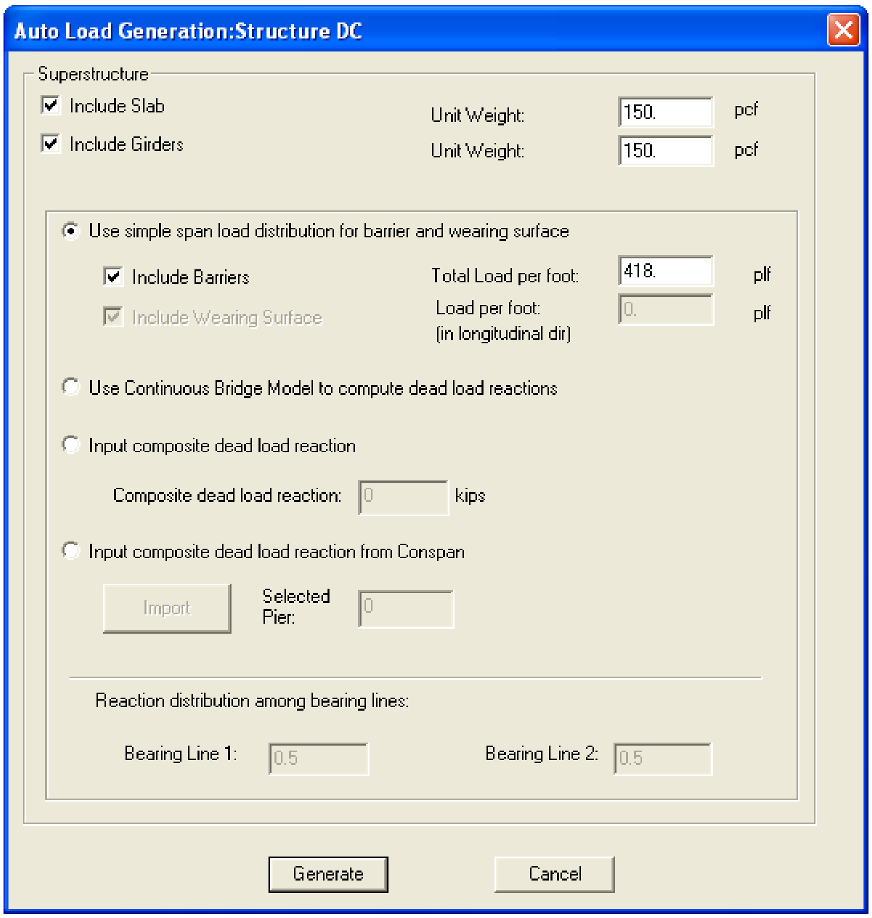

Stepped Cap Parameters
Cap Length
D1
D2
Start Elevation: 739.31 ft
Straight Cap bottom
Skew Angle (deg): -0.
End Elevation: 737.206 ft
D1: 60 in
Factor of Reduced Moment of Inertia: 1.
Depth(Z): 60. in
D2: 48 in
Input thickness: No
Cap Length: 44. ft
Number of steps: 4
Steps lengths Equal? Yes
Step# | Step Length (ft) | Thk (in) | Elev at Bottom (ft) | Elev at Top (ft) | Area (in^2) | Izz (in^4) | Ixx (in^4)
1 | 11.00 | 60.00 | 734.31 | 739.31 | 3,600.00 | 1,080,000.00 | 1,080,000.
2 | 11.00 | 58.21 | 733.76 | 738.61 | 3,492.48 | 986,093.69 | 1,047,744.
3 | 11.00 | 53.10 | 733.48 | 737.91 | 3,186.24 | 748,775.81 | 955,872.
OK
Cancel

Apply LRFD Loads to the Structure

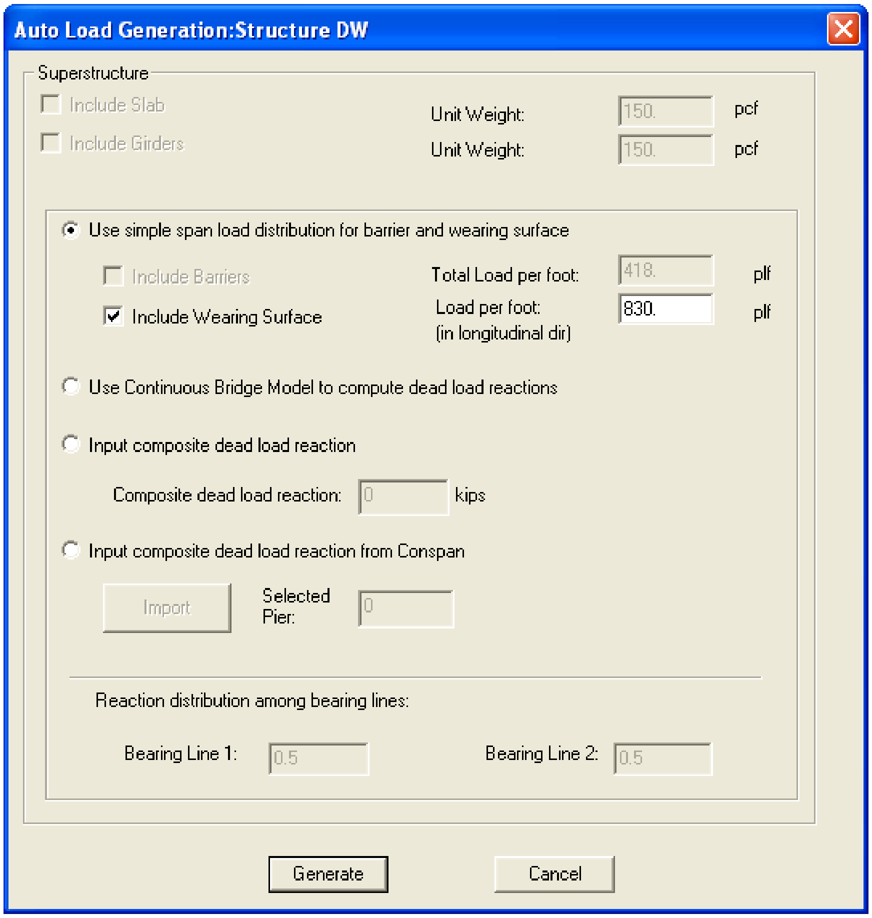
The following steps will guide you through the process of applying LRFD dead loads and live loads to the structure.

➔ **Exercise: Apply dead, live and wind loads to the structure**

1. Select the **Loads** tab in RCPier.
2. One at a time, add the following loads to the **Selected Loads** window: *DC, DW, LL, WS.*
3. Select *DC1* from the Selected Loads window and click **Edit**.
4. Click **Generate**. Populate as shown and select Generate. Select OK to accept these dead loads.

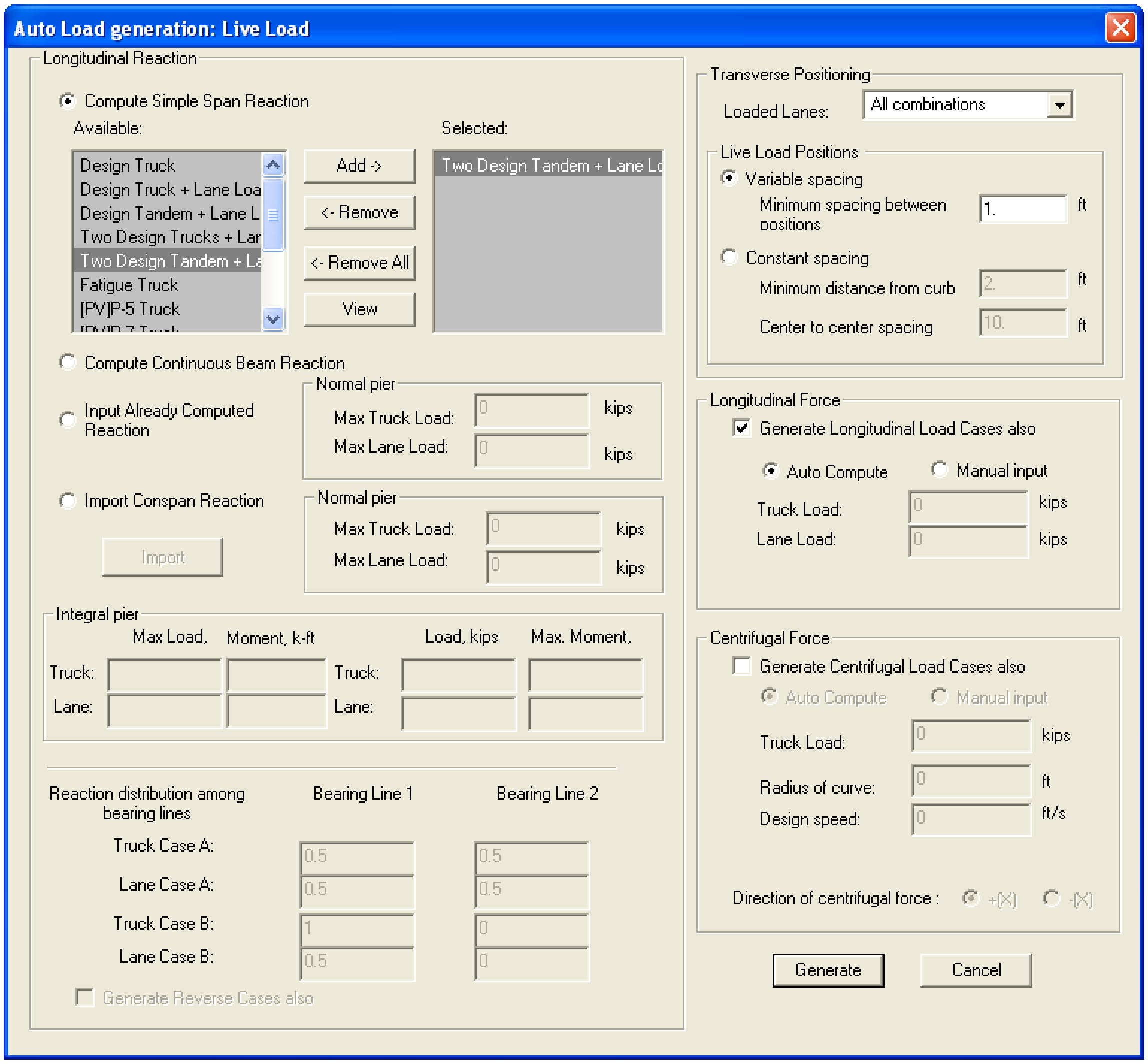


5. Select *DW1* from the Selected Loads window and click **Edit**.
6. Click **Generate**. Populate as shown and select Generate. Select OK to accept these dead loads.



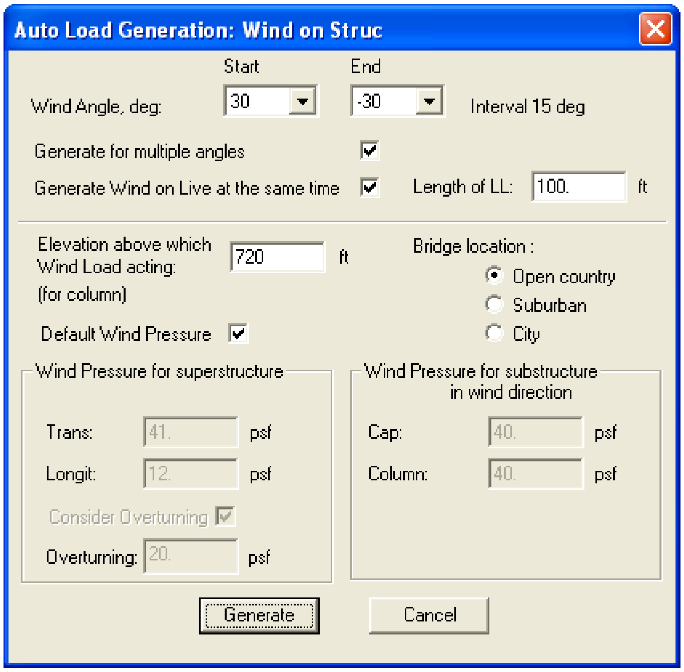
7. Select *LL1* from the Selected Loads window and click **Edit**.

8. Click **Generate**. Populate as shown and select Generate. Select OK to accept these dead loads.



9. Select *WS1* from the Selected Loads window and click **Edit**.

10. Click **Generate**. Populate as shown and select Generate. Select OK to accept these dead loads.



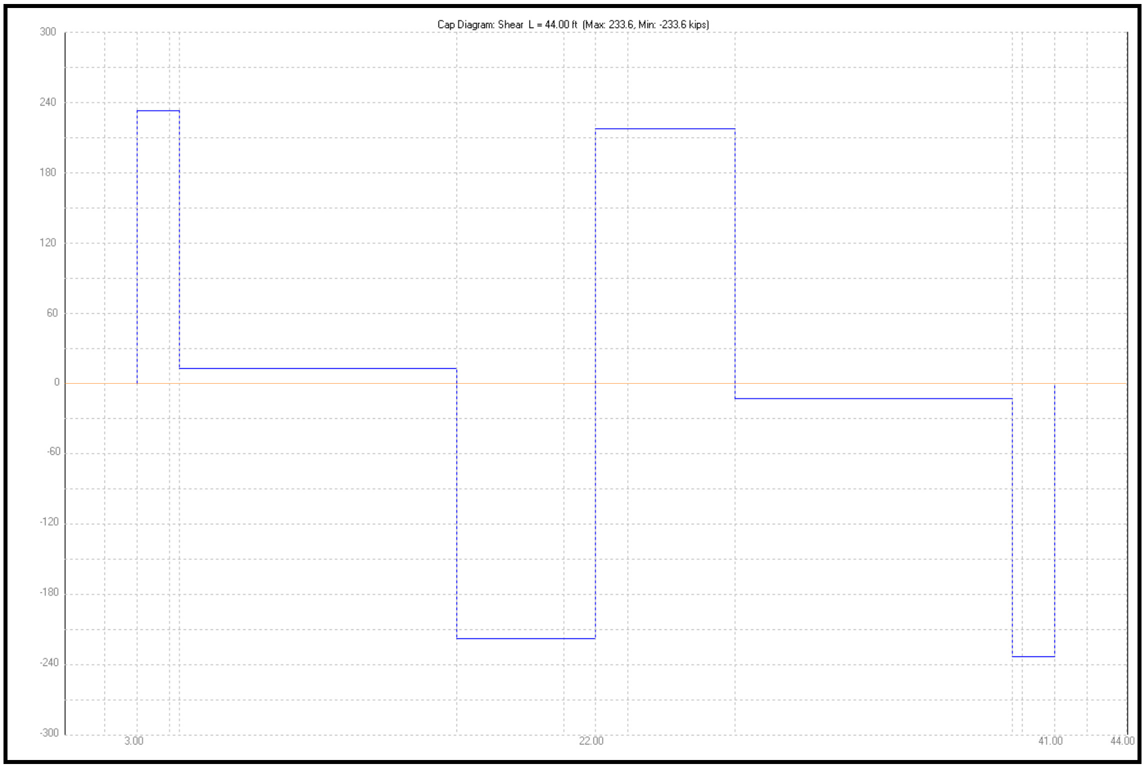
11. Lastly add the load groups/limit states to the Selected Groups window: *Strength Group I, Strength Group III, Strength Group V, Service Group I.*

Analysis

The *Analysis* tab allows you to perform an analysis and also specify various factors relating to the analysis and design.

➔ **Exercise: Perform Analysis**

1. From the **Analysis** tab in RCPIER select **A/D Parameters**. Review the LRFD Design and Analysis parameters. Select **OK** to accept any changes.
2. Select **Run Analysis…** .
3. Select the **Diagrams** tool to review shear and moment diagrams of the cap and columns.

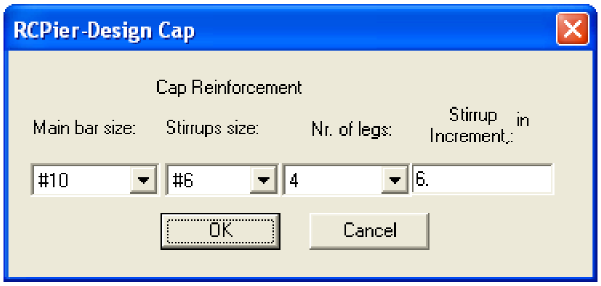


Cap Design

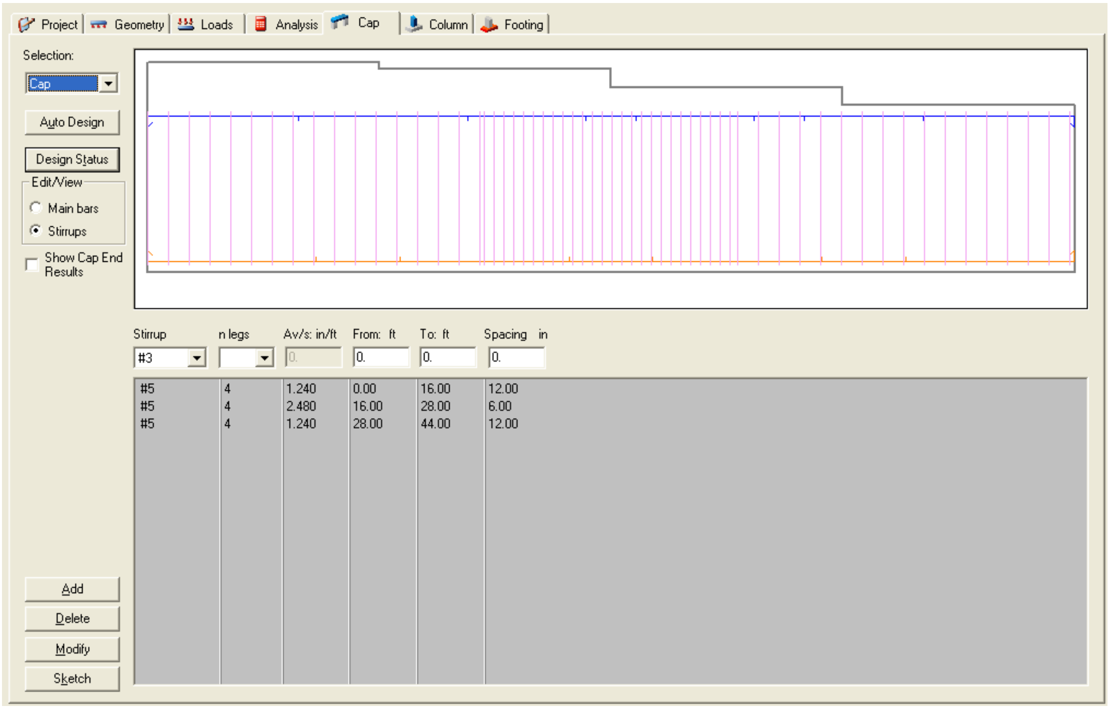
The *Cap* tab allows you to automatically design the cap by clicking the **Auto Design** button or manually enter the cap design. The following illustrates the auto design feature and the manual changes.

➔ **Exercise: Design the Cap using Auto Design Tool**

1. From the **Cap** tab in RCPIER select **Auto Design**. Populate the **RCPier-Design Cap** dialog as shown and select **OK**.



2. Review the Design Status output.
3. Modify the Stirrups as shown below.

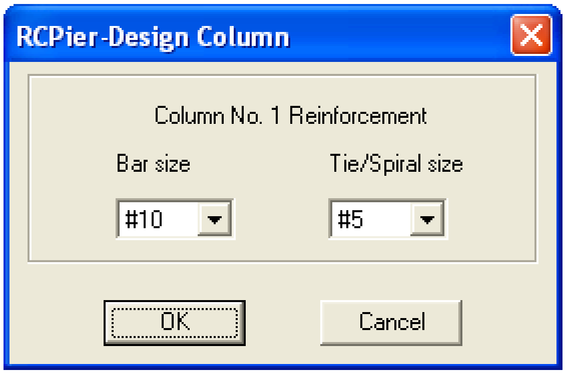


Column Design

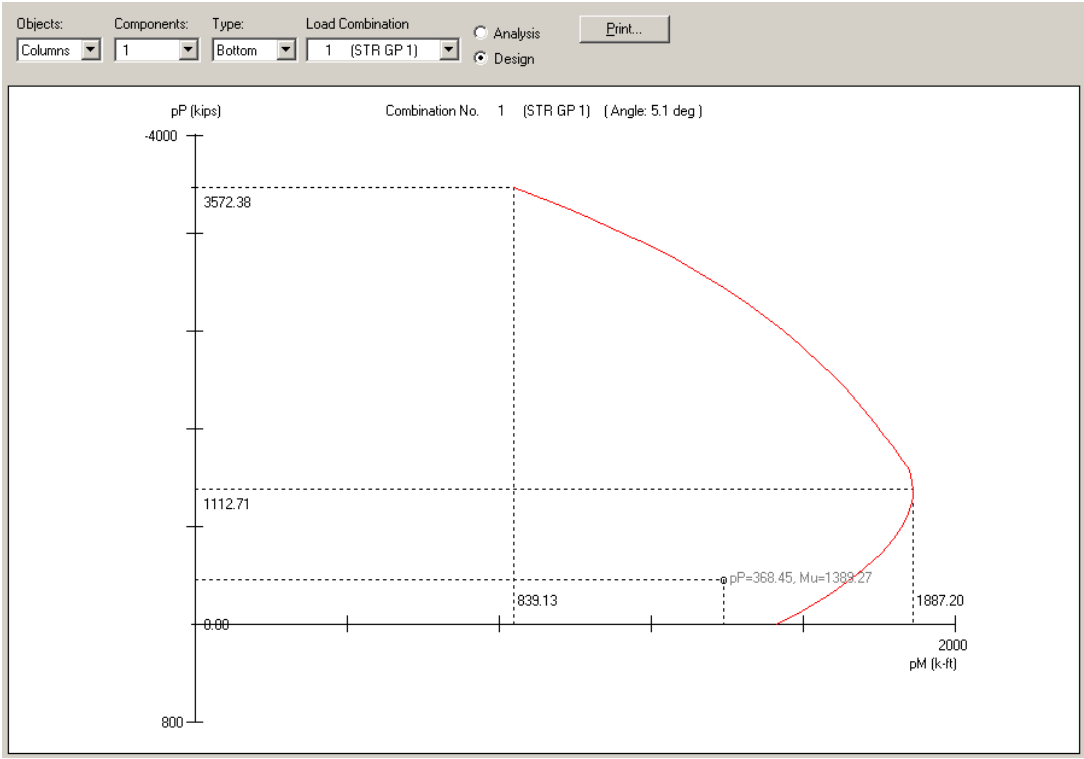
The *Column* tab allows you to choose to manually enter the column reinforcement or to allow the program to automatically design it. We will use the Unbraced moment magnification with specified values of K and Auto Design feature for this example.

➔ **Exercise: Design the Column using Auto Design Tool**

1. Select the **Column** tab in RCPIER.
2. Enable the **Auto Design All** toggle.
3. Select **Auto Design**. Populate the **RCPier-Design Column** dialog as shown and select **OK**.



4. Review the Design Results for the 3 columns.
5. After designing the column, RC-PIER allows you to view the column interaction diagram. Select the **Diagrams** command from the *Show* menu, or its respective icon on the toolbar. Then, select the column you want to view from the **Objects** drop-down list and select the **Design** option. The column interaction diagram will appear on the screen as shown in the following figure.



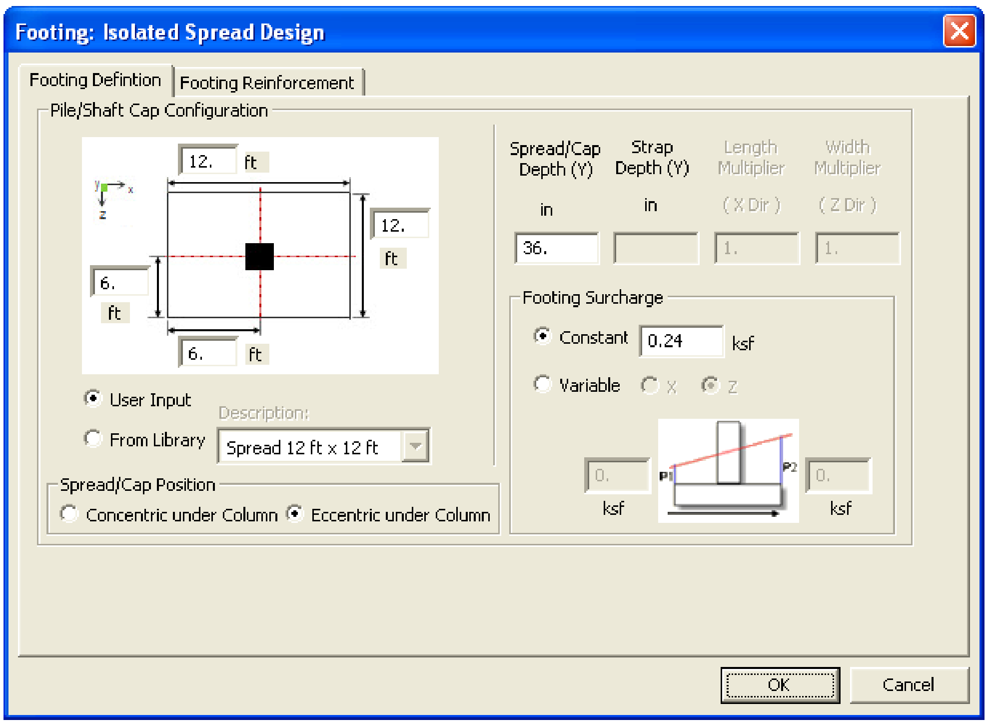
6. You can view different load combinations by making selections from the **Load Combination** drop-down list. Close the diagrams window when done reviewing the diagram.

Footing Design

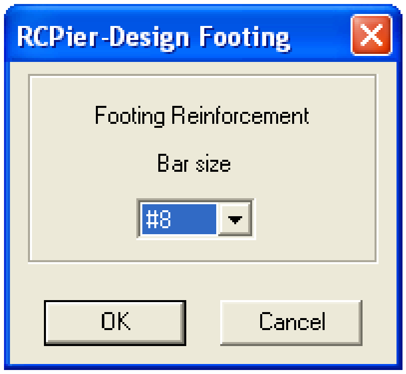
This is the final screen in the tab series and is a unique feature available only in RC-PIER. Here, you can design and analyze multiple footings or footing types for each column, to include single spread footing under all columns, isolated spread footings under each column, single pile/shaft cap under all columns, and isolated pile/ shaft cap under each column. You can also check overturning from this tab.

➔ Exercise: Design the Footings using Auto Design Tool

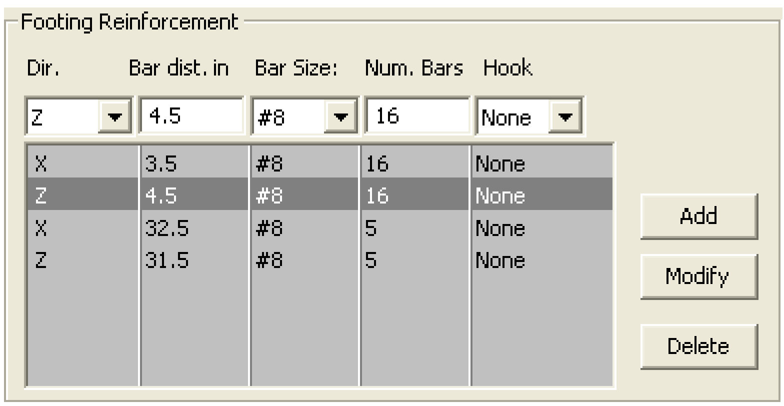
1. Select the **Footing** tab in RCPIER.
2. Select the footing associated to column 1.
3. Select **Design**. Change the Footing Surcharge to a **Constant** value of *0.24* ksf.



4. Select **Auto Design** from the Footing Reinforcement tab to design the reinforcement in the footing. Select **Close** when you are finished reviewing the resulting reinforcement design.



5. Modify the computed reinforcement such that there are 16 bars in each direction at the bottom of the footing.



6. Repeat steps 3-5 for the remaining footings.

7. Close RC-Pier. Select **Yes** when prompted to update the LEAP Bridge model. Select **No** when prompted to Generate Reports.