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BSI Bridge Software Institute NEWSLETTER

In this issue, we discuss recently developed features in FB-MultiPier v5.1. The main item of discussion showcases how to make use of the Pile Cap Force Plot feature, as part of the streamlined UI output post-processing capabilities.

The articles Technical Corner and Discussions are open for input from all readers. If you have a topic that you think should be discussed, let us know. Did you create a great model with features that you want to share? Everyone is welcome to submit articles for possible inclusion in subsequent issues.

Please contact BSI at **BSI@ce.ufl.edu** with your ideas.

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What's New at BSI

We are pleased to announce the release of FB-MultiPier v5.1. This program and other structural analysis software are available for download from **BSI** website. The new version of FB-MultiPier contains fixes to the latest reported errors and also includes a number of new features.

Technical Corner

Pile Cap Forces

This simple example serves primarily to demonstrate the feature allowing for the integration of pile cap finite element stresses resulting in the computation of total shear and moment forces used for cap design. A partial development of the model is also shown.

To begin, we'll highlight portions of the model development that have been made convenient through the FB-MultiPier user interface (UI). For a 'Pile and Cap' model, on the Edit side of the program, consider the upper right window (the 'Pile Edit') window. This window displays a basic plan view of a pile cap that has been generated using specialized shell elements, with 4 spaces at 48 inches in the Xp direction and 12 spaces at 96 inches in the Yp direction (16 ft wide by 96 ft long).

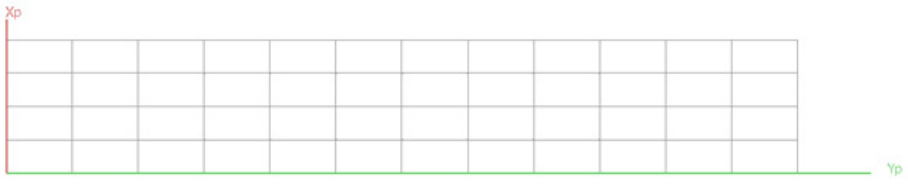

Figure 1. Plan view of Pile cap shell element grid

Next, a swath of piles can be quickly and conveniently added to the model, by making use of the 'Pile Edit' context menu (**Fig. 2**). To access this menu, right-click within the 'Pile Edit' window. After pulling up the menu, the 'Add Piles (Drag Box)' option is selected. Then, using the 'Add Piles (Drag Box)' option, a window can be drawn over any gridline intersections that are to be fitted with a pile. In this example, five piles are added to the left extent of the model (**Fig. 3**). Note that all five piles are added simultaneously, rather than having to individually add/define each pile location.

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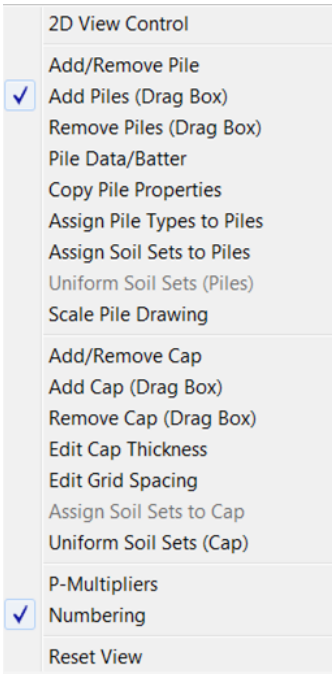

Figure 2. Context menu for the 'Pile Edit' window

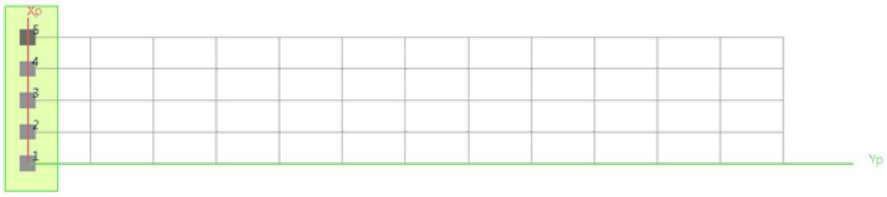

Figure 3. Addition of five piles to left extent of pile cap using the 'Add Pile (Drag Box)' option

Focusing on the upper left window of the screen (the 'Model Data' window), and navigating to the 'Analysis' page, the general analysis options can be reviewed. Of relevance to this example is the 'Include Soil in Analysis' option within the 'Soil Behavior' panel. For simplicity in this example, soil modeling is disabled. Accordingly, the 'Include Soil in Analysis' checkbox is unchecked. As a result, all pile tips are automatically restrained across the six available degrees of freedom. In other words, all pile tips are fixed for this example.

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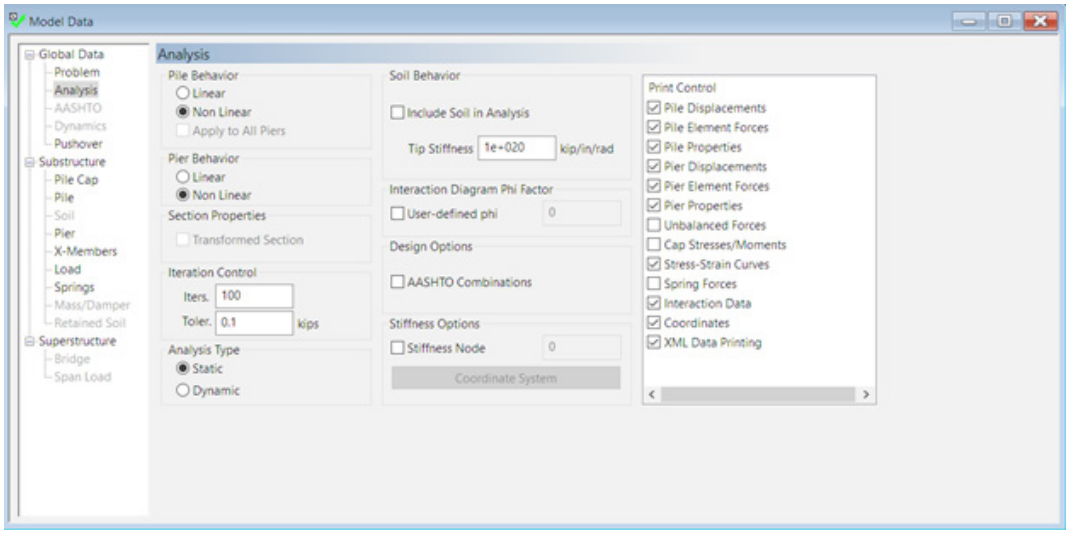

Figure 4. Screenshot of 'Analysis' page within the 'Model Data' window

Next, the 'Pile' page is accessed (**Fig. 4**). From within the 'Pile' page, we select 'Fixed' option within the 'Pile to Cap Connection' panel. Consequently, the pile heads are all capable of transmitting axial, shear, and moment internal forces during analysis. This ensures numerical stability for the example model.

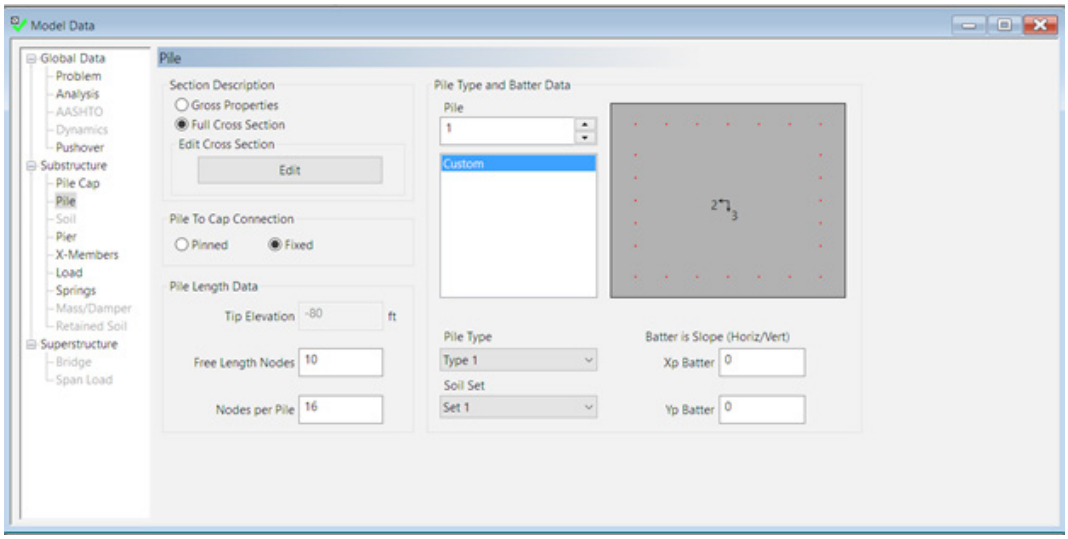

Figure 5. Screenshot of 'Pile' page within the 'Model Data' window

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Returning focus to model visualization, consider the finite element model and rendered (or 'thick view') depictions shown in **Fig. 6**. Note the presence of a family of springs at each of the pile tips, indicating that the pile tips are fully restrained during analysis.

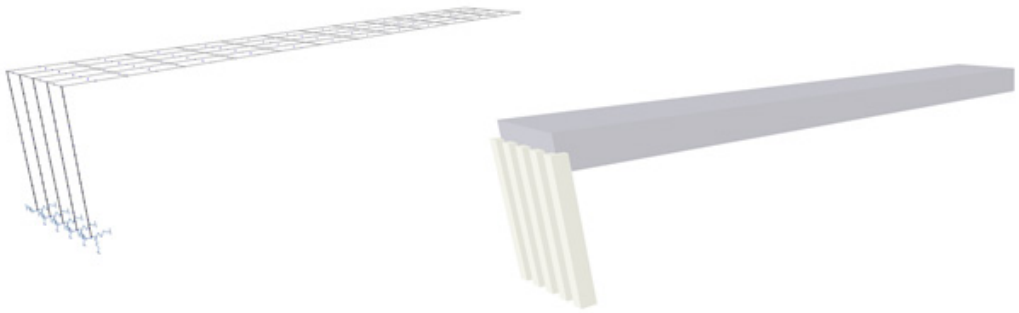

Figure 6. Finite element model and rendered (or 'thick view') depiction of example Pile and Cap system

Now that the model geometry and configuration have been defined within the FB-MultiPier UI, we will focus on applying a carefully crafted set of loads. The intention in this example is to bring about computed responses that facilitate verification with respect to quick 'back of the envelope' manual calculations. Further, we will showcase a load application convenience feature, referred to as the 'Distributed Load' option.

Recalling the 'Model Data' window in the upper left portion of the screen, navigate to the 'Load' page. From within the Load page options, select the 'Distributed Load' button. Then, within the '3D View' window, graphically select the first and last nodes along the Xp-direction right extent of the Pile and Cap system. For this example, these nodes correspond to a 'Starting Node' of 6 and an 'Ending Node' of 10. Then, supply a uniform load of 1 kip/ft across the set of selected nodes.

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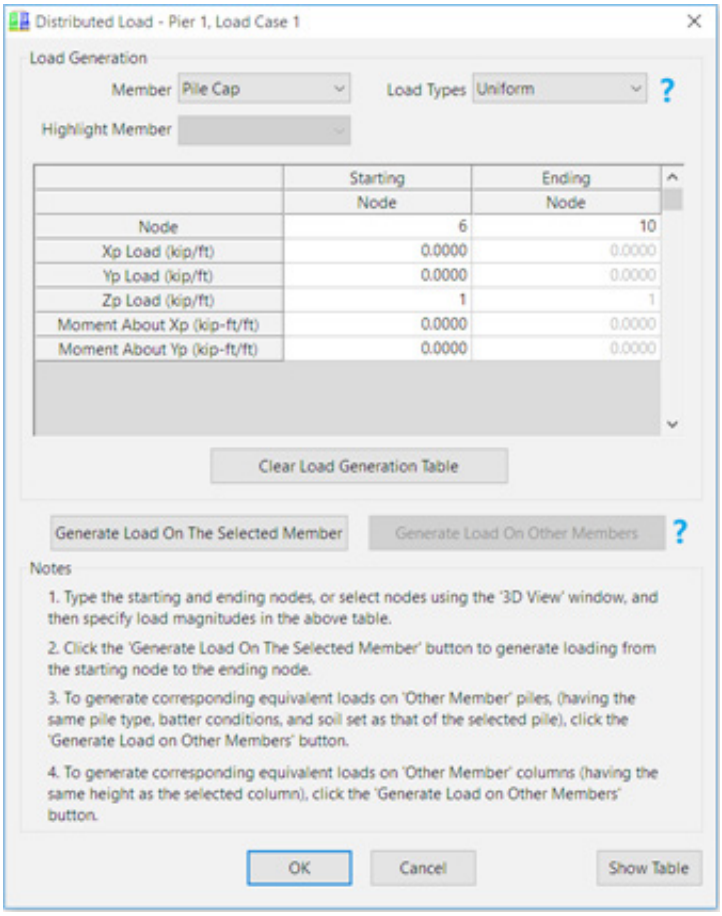

Figure 7. Partial screenshot of the 'Distributed Load' dialog

Shown in **Fig. 8** is the state of the finite element model, subsequent to application of the distributed (uniform) loads to the right extent of the Pile and Cap system. Again, the FB-MultiPier UI automatically performs the calculations to impose a uniform load Zp load of 1 kip/ft along the cap right edge, for a total downward-pointing loading of 16 kips.

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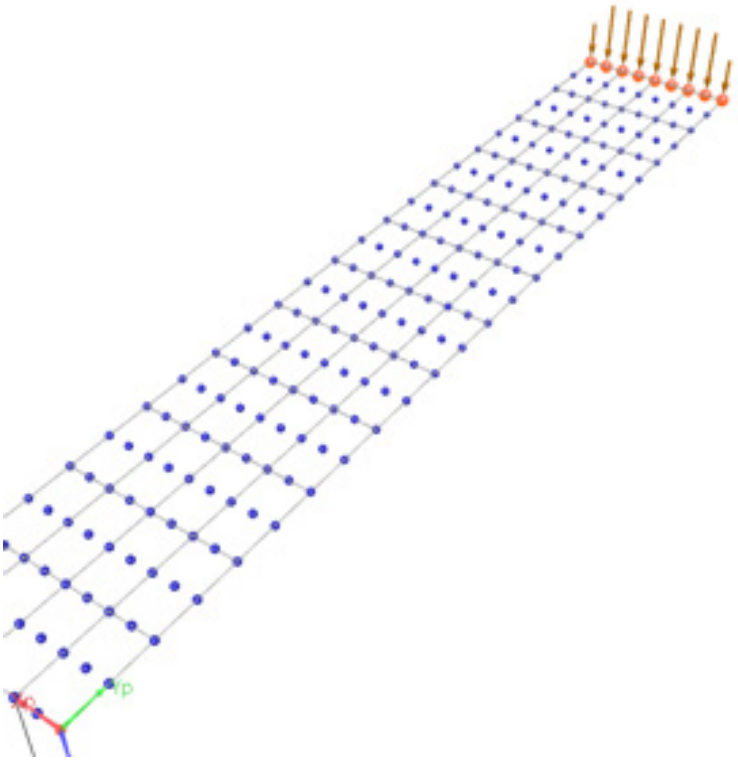

Figure 8. Partial screenshot of '3D View' window after application of uniform load to right extent of cap

Now, run the analysis by clicking the lighting bolt (**Fig. 9**). Then, navigate to the 3D results side of the program, by clicking the '3D Results' button (**Fig. 10**). Select "Pile Cap Force Plot" found in the menu seen below by right clicking the 3-D view window.

Figure 9. File and mode toolbar buttons in FB-MultiPier, with highlight of 'Analysis' button

Figure 10. File and mode toolbar buttons in FB-MultiPier, with highlight of '3D Results' button

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After the '3D Results' windows appear, right-click within the '3D Results' window to open the associated context menu (**Fig. 11**).

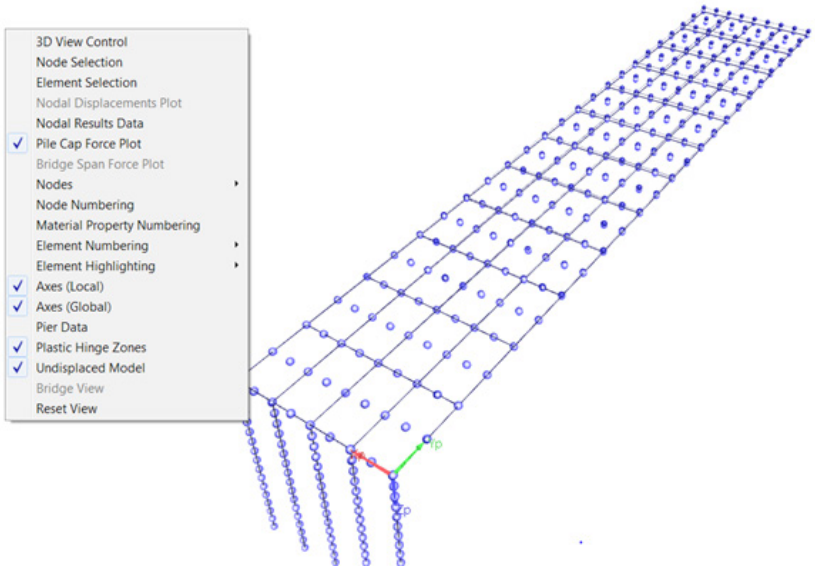

Figure 11. Context menu available within the '3D Results' window

From within the context menu, select the 'Pile Cap Force Plot' option. As a result, the 'Pile Cap Forces' dialog will appear (**Fig. 12**). From here, the process of integrating pile cap shell element stress and resolving the stresses into shear and moment forces has been streamlined by the FB-MultiPier UI.

Now we will select a line of nodes that are of interest for showcasing the streamlined pile cap force calculation process. Prior to selecting the line of nodes, and as shown in **Fig. 12**, make sure that the 'End Point Nodal Selection' checkbox is checked.

Then, within the '3D Results' window, graphically select node 46 and node 50. Upon selection of node 50, the Node list within the 'Pile Cap Forces' dialog will become populated with nodes 46, 50 and all nodes that lie in between, along the pile cap gridline.

After selecting the subset of nodes, the shear and moments about either the Xp or Yp directions can be determined and reviewed by simply clicking the 'Generate' button. Note that for this example, the max shear is 16.12 kips and the moment at this section is 1016 kip-ft. A quick, manual calculation gives 16 kips, and 1024 kip-ft (16 kips multiplied by the 8 ft lever arm). Dividing the integrated moment by the width of 4 elements (at 48 inches per element) leads to a distributed moment of 5.33 kip-ft / inch. These manual calculations show excellent agreement with the program results.

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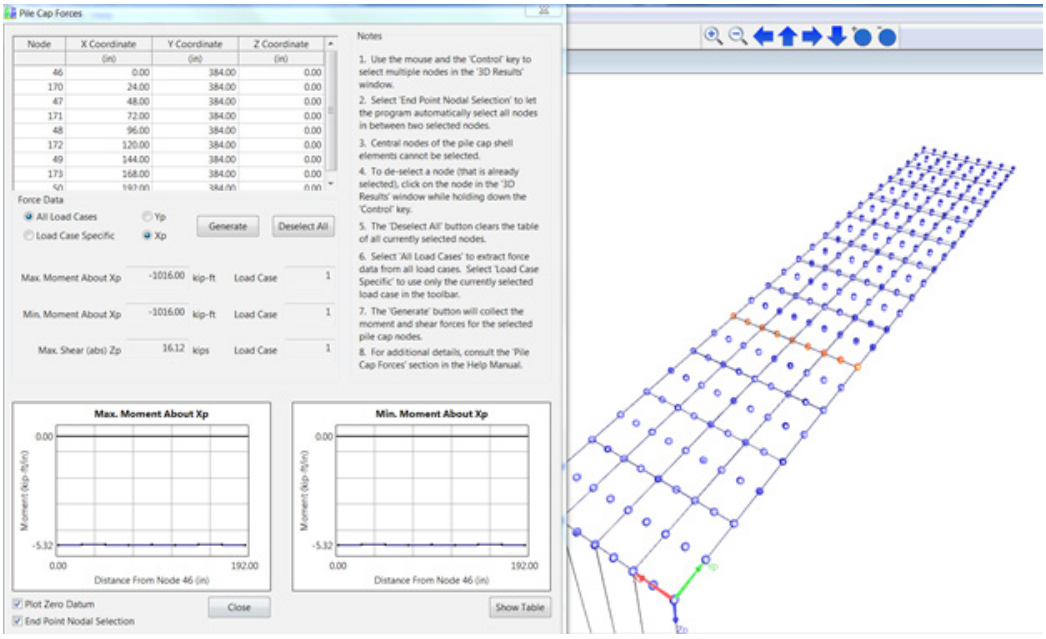

Figure 12. Pile Cap Force Plot feature, available in the '3D Results' window

Program Enhancements

Max/Min Strains and Stresses for Piles

In addition to displaying the maximum and minimum strains in piles, the corresponding stresses are now also shown. These are particularly helpful when checking AASHTO Code service stresses in concrete piles. Note that the program prints output for each constituent material type in the cross section, as exemplified for concrete in **Fig. 13**.

```
-----------------------------------------------------------------
- Concrete                                                      -
-----------------------------------------------------------------

 Pile No.                          =          7
 Element No.                       =        189
 Maximum Strain                    =  0.6090E-03
 Corresponding Stress              =  0.2376E+00

 Pile No.                          =          3
 Element No.                       =         89
 Minimum Strain                    = -0.9889E-03
 Corresponding Stress              = -0.3430E+01

 WARNING : The Concrete in this section has cracked
```

Figure 13. Screenshot of text output file showing prints of Max/Min Strains and Stresses for piles

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Confinement with Casing Options

For cross sections modeled with confinement, the following option has been added: 'Shear Reinforcement and Casing' (**Fig. 14**). This option incorporates the shear reinforcement and the casing for strength, confinement, and stiffness.

The pre-existing option for 'Shear Reinf. and Confine-Only Casing' allowed for the casing to serve only for confinement (but not for strength or stiffness).

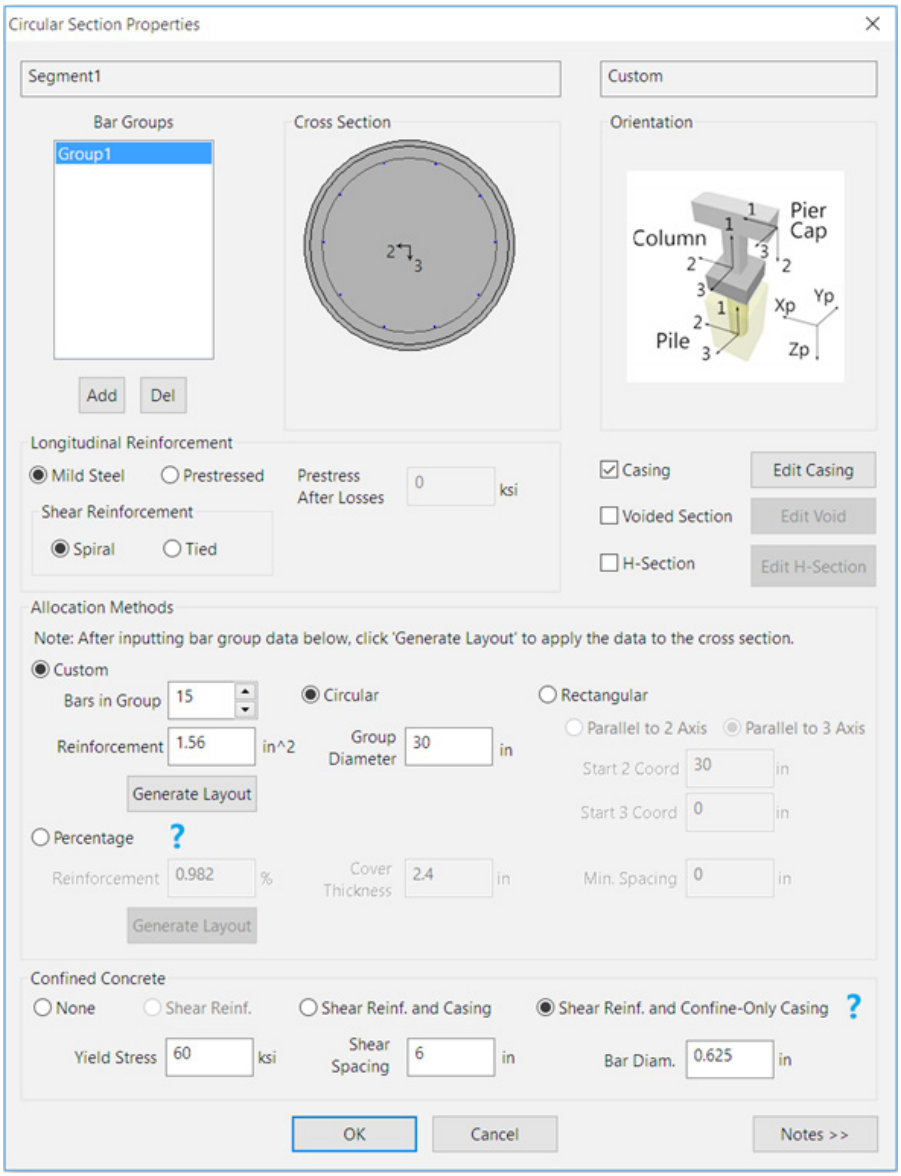

Figure 14. Screenshot of 'Circular Section Properties' dialog with new confinement options

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Equivalent Stiffness Option - User Coordinate System

The FB-MultiPier 'Equivalent Stiffness' option captures a 'snapshot' of a system equilibrium state, and facilitates the representation of foundation systems in external software. In order to facilitate transfer of the FB-MultiPier stiffness matrix as input to external software, engineers can now define a transformation matrix that rotates the equivalents stiffness AWAY from the FB-MultiPier coordinate system, and INTO the desired coordinate system.

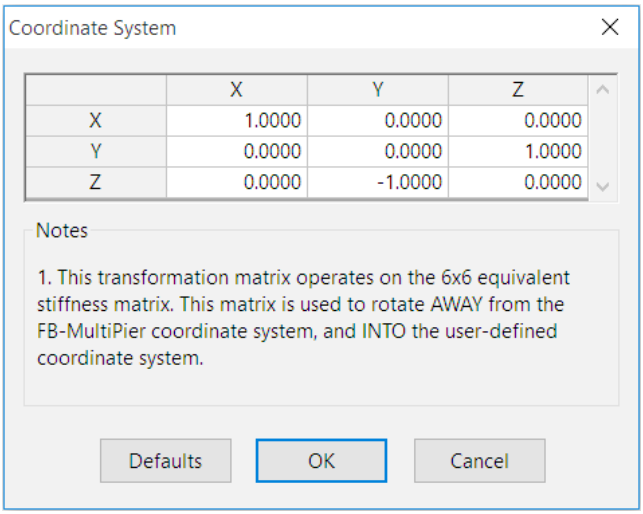

Figure 15. Screenshot of 'Coordinate System' dialog for use with the 'Equivalent Stiffness' option

RSA - CQC3 Option

The CQC3 method, based on random vibration theories, has been added within the FB-MultiPier modal analysis options. When applicable, this method can be superior to the square root of the sum of the squares (SRSS) method for combining modal response data. Namely, this method was developed to ensure calculation of maximum response quantities for the following conditions: 1) Input spectra are supplied in each of the X, Y, and Z directions; and, 2) The X and Y component scale factors are not equal.

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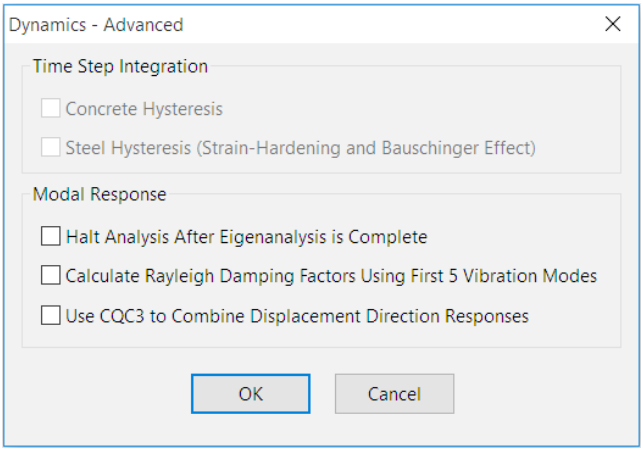

Figure 16. Screenshot of 'Dynamics - Advanced' dialog, which contains the new CQC3 option

For Technical Support

Cary Peterson
Technical Support, Bridge Software Institute

Technical support questions. When requesting technical support for any BSI software, it is recommended to email the input file (.in file for FB-MultiPier and Atlas or .spc file for FB-Deep) to the BSI address bsi@ce.ufl.edu along with a brief explanation and any supporting documentation of the issue. This will allow the support staff to provide the users prompt technical support.

Identifying the program version. It is important that users have the current most up-to-date version of the BSI software. Thus we recommend that users regularly visit the home page of the **BSI** website. To identify the current version of program installed on your computer, open the program and go to Help > About to see the program version number.

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BSI Program Status

FB-MultiPier V5.1 Download a FREE demo today!

Released: February 10, 2017 - Continuing Development - Technical Support Available

FB-MultiPier allows for the modeling of a bridge that consists of multiple piers that are connected with bridge spans. In addition to the multiple load cases and the AASHTO coefficients that are available in FB-MultiPier, the program is also capable of performing dynamic analysis for the bridge. For more information about FB-MultiPier, click here.

FB-Deep V2.04 Download a FREE demo today!

Released: May 28, 2012 - Continuing Development - Technical Support Available

The FB-Deep computer program is a Windows based program used to estimate the static axial capacity of drilled shafts and driven piles. The methodology is based upon Federal Highway Administration (FHWA) reports. FB-Deep guides the user through pile and shaft materials data, shape and dimensional inputs, soil properties, and boring log info. FB-Deep presents the data analysis in both clear graphical and text form. For more information about FB-Deep, click here.

Atlas V6.04

Released: December 8, 2011 - Limited Web Support Available

Atlas is a finite element analysis program that is used for the design/analysis of cable supported traffic signal systems. The Atlas program models dual cable supported systems including single-point or two-point attachments and suspended box systems. For more information about Atlas, click here.

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