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Bridge Software Institute
University of Florida
PO Box 116580
Gainesville, FL 32611

Online: bsi.ce.ufl.edu
Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

BSI Bridge Software Institute NEWSLETTER

In this issue, we discuss the new modeling features, i.e., Coupled Vessel Impact Analysis (CVIA) and Extra Member Connectivity, of FB-MultiPier Version 5.0.

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 v5.0. This program and other structural analysis software are available for download from the **BSI** website. The new version of FB-MultiPier contains fixes to the latest reported bugs and also includes a number of new features.

Technical Corner - New Features

Coupled Vessel Impact Analysis (CVIA)

An example is used to demonstrate the Coupled Vessel Impact Analysis (CVIA) module and the One Pier Two Span (OPTS) modeling technique. A six-span portion of a bridge is modeled using structural bridge plans. Pier 59 from the bridge plans (i.e., Pier 3 of the FB-MultiPier bridge model) is the pier of interest (i.e., the impacted pier).

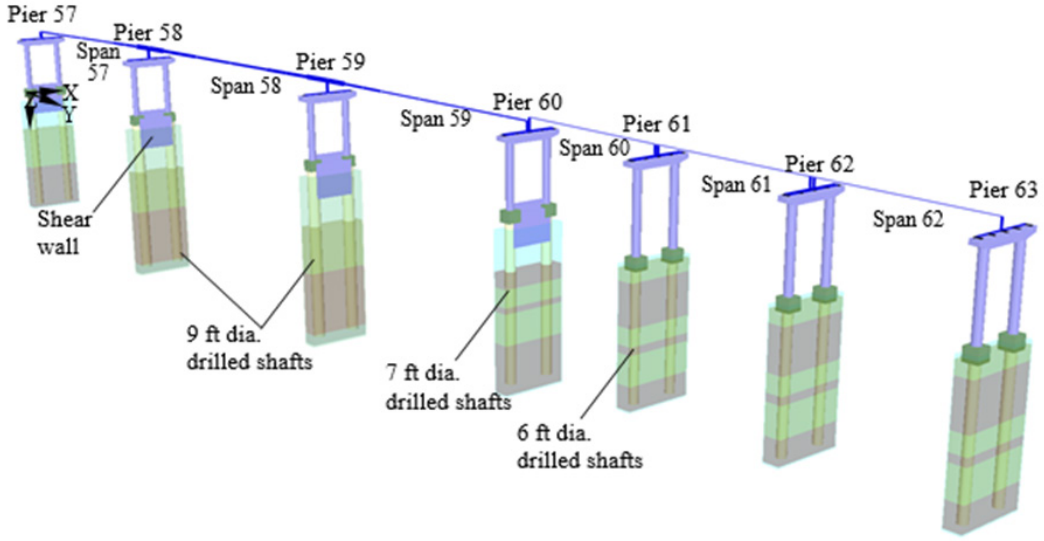

Figure 1 A sketch of FB-MultiPier v5.0 bridge model.

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The FB-MultiPier v5.0 finite element analysis (FEA) model of Pier 3 is shown in **Figure 2**. The following walkthrough explains how to use the CVIA module to facilitate streamlined vessel collision analysis of bridge-pier-soil systems (detailed information can be found in the Help Manual, Secs. 6.11, 6.12, and 6.15).

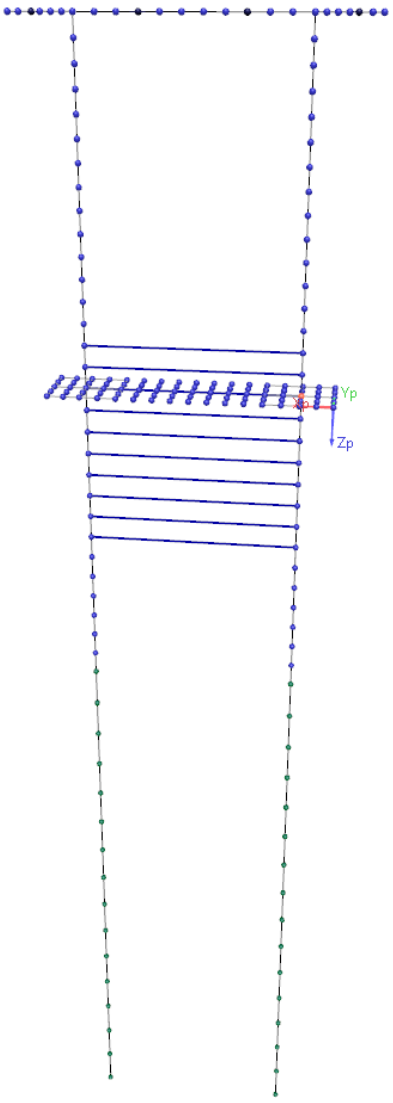

Figure 2 FB-MultiPier v5.0 FEA model of the impacted pier.

CVIA is performed by carrying out the following steps:

1. Select the "Dynamic" analysis option in the Analysis Type panel on the "Analysis" page (**Figure 3**).

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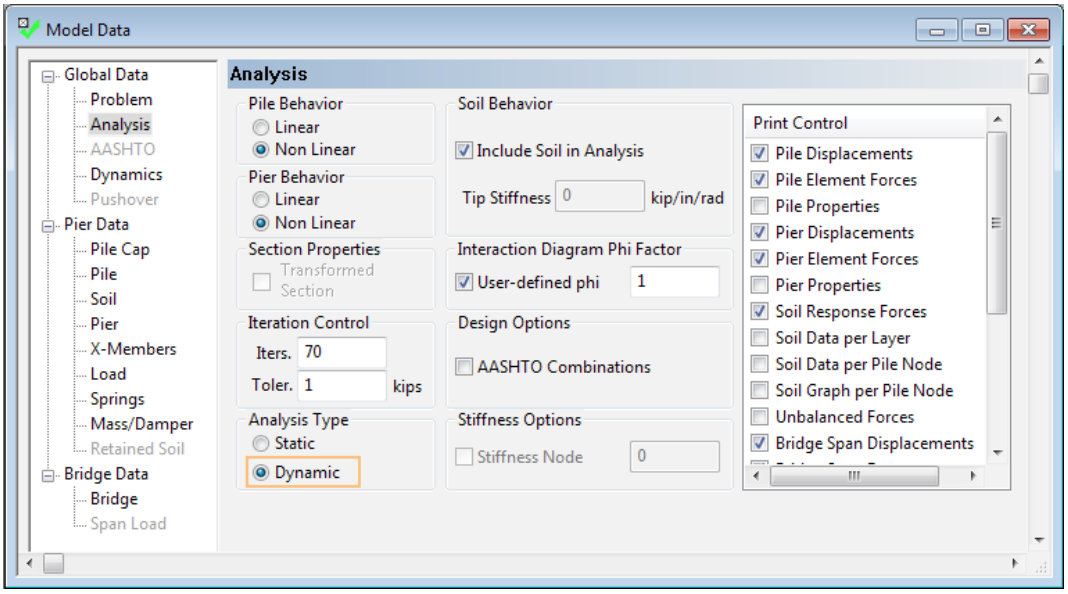

Figure 3 Select Analysis Type.

2. On the "Dynamics" page, select the "Vessel Collision" dynamic loading type. Enter the Time Step and number of Time Steps. Note that Rayleigh Damping Factors can be calculated by the engineer, or alternatively, FB-MultiPier can be used to generate and import the damping parameters (see Sec. 2.4 of the Help Manual).

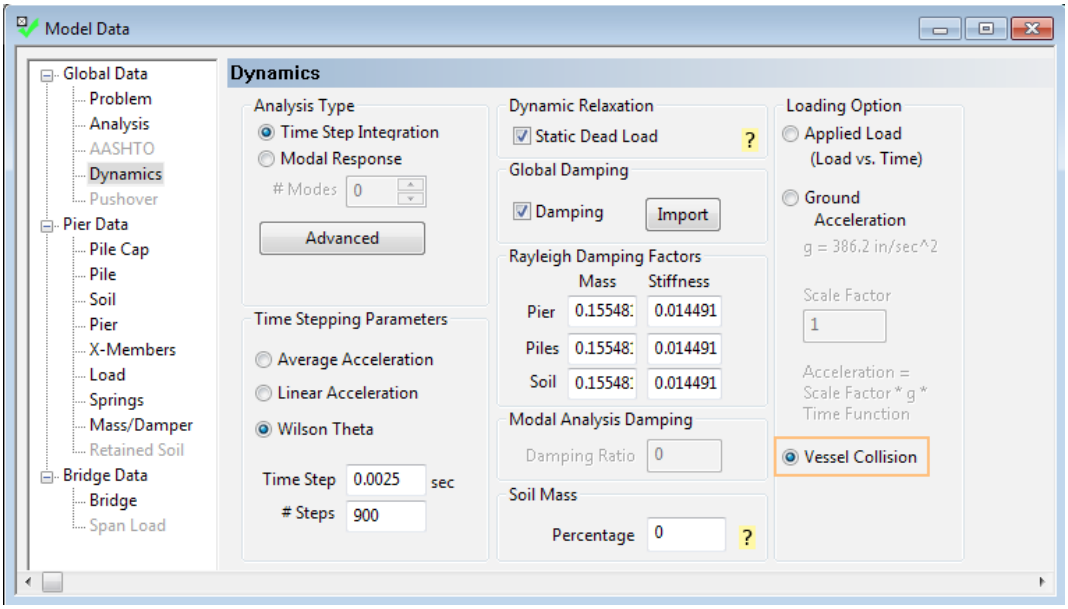

Figure 4 Select the Vessel Collision option on the "Dynamics" page.

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University of Florida
PO Box 116580
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3. Select "Pier #3" from the toolbar and navigate to the "Load" page (**Figure 5**) to apply the dynamic vessel collision load.

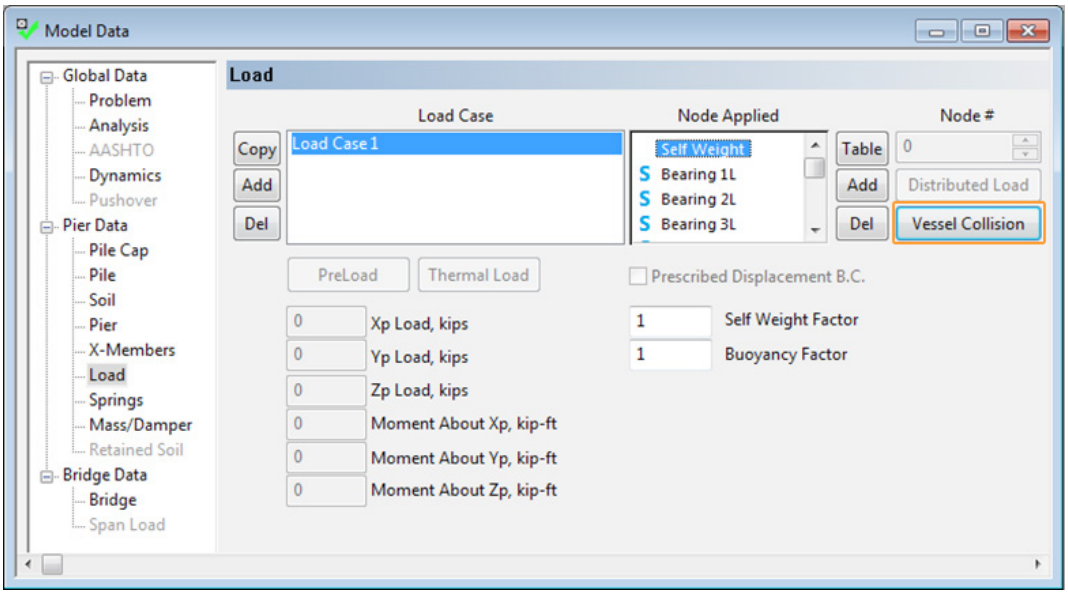

Figure 5 "Vessel Collision" button on the "Load" Page.

4. Open the "Vessel Collision" dialog by clicking on the "Vessel Collision" button.

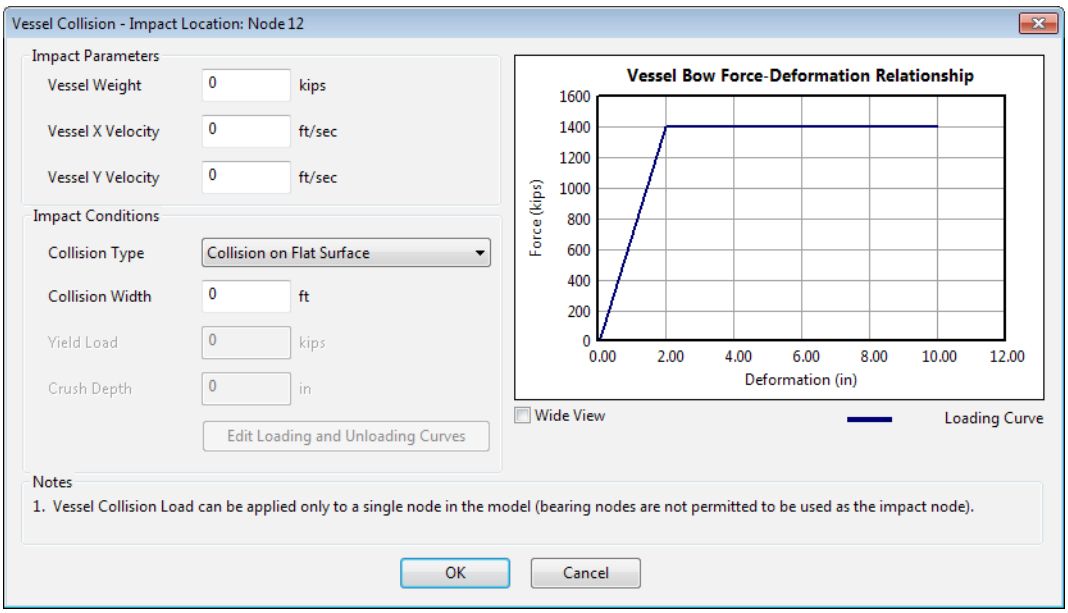

Figure 6 "Vessel Collision" dialog.

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PO Box 116580
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Online: bsi.ce.ufl.edu
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5. Enter the vessel weight, velocity, and collision type (**Figure 7**). To model the stiffness of the vessel bow, a force-deformation curve can be automatically created (or user-defined, if so desired).

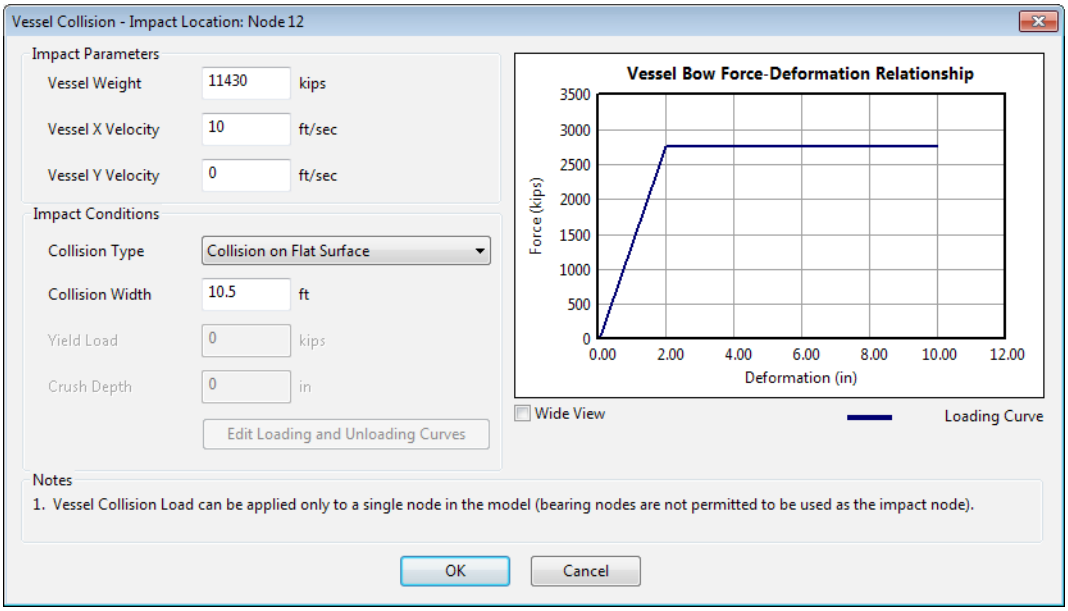

Figure 7 Definition of impact conditions.

Note that the barge bow force versus deformation curve is calculated in the "Vessel Collision" dialog, in accordance with **Figure 8**. Additionally, note that the vessel collision impact-load history is generated automatically during CVIA analysis. Alternatively stated, bridge response is calculated simultaneous to calculation of the impact-load history. In this way, computed pier response is coupled to loading, crushing, unloading, and reloading of the vessel bow. Please refer to Step 8 for instructions on accessing the computed impact-load history.

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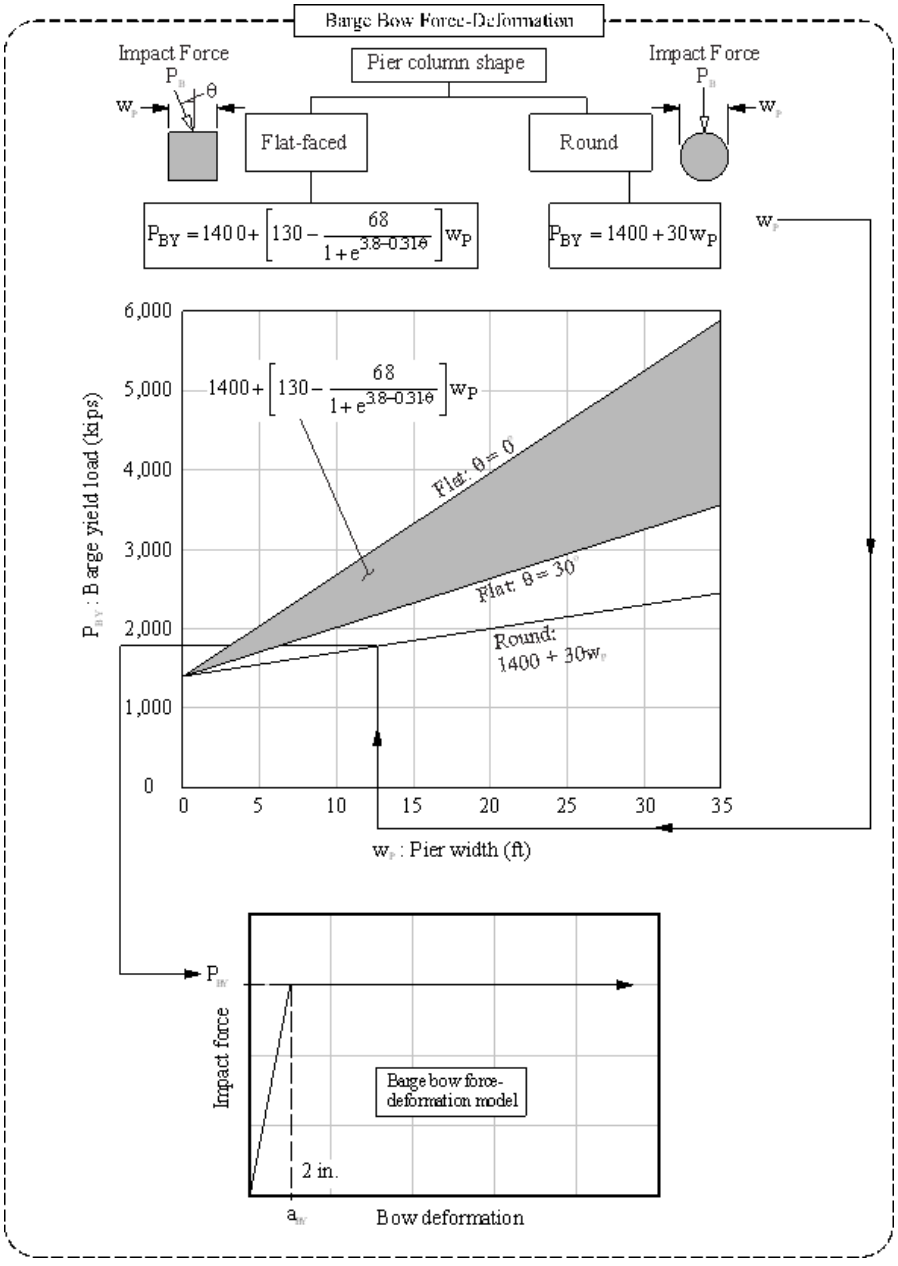

Figure 8 Flow chart with empirical equations for calculating barge bow force-deformation (after Getter and Consolazio 2011).

6. From the "Load" page, select the impact location (node 12) on Pier 3, using "3D View" and the "Load" page, and toggle the "S" to "D" to signify application of dynamic loading at node 12.

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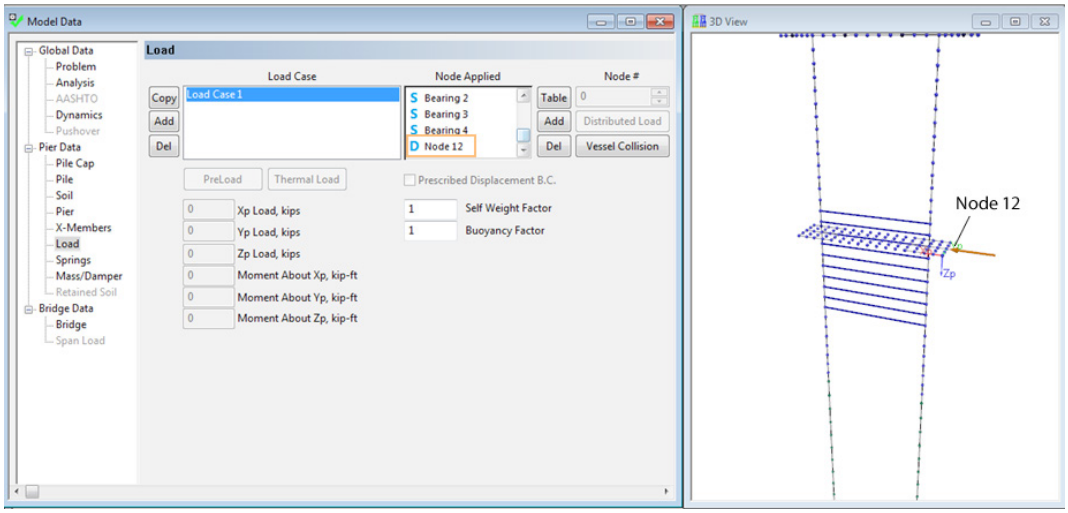

Figure 9 Application of vessel collision load at node 12.

7. The model input necessary to make use of the CVIA feature is now complete, and the dynamic vessel collision analysis is now ready to be carried out, by clicking the "Lightning Bolt" icon.

8. The vessel impact-load history is generated automatically by FB-MultiPier during the analysis and stored in the .VES file (**Figure 10**). This file (the .VES file) is saved in the same folder as the input file. The full impact-load history, excerpted from the .VES file generated as part of the current example, is shown in **Figure 11**.

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*           COUPLED VESSEL IMPACT ANALYSIS RESULTS                      *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

****************************************************************
*              IMPACTING VESSEL CHARACTERISTICS                *
****************************************************************

 Vessel Weight = 11430.0000 kips
 X-Velocity    =    10.0000 ft/sec
 Y-Velocity    =     0.0000 ft/sec

****************************************************************
*                     IMPACT FORCE-HISTORY                     *
****************************************************************

          TIME    IMPACT FORCE     CRUSH DEPTH
           sec            kips              in
 0.2500000E-02  0.4105445E+03  0.2986457E+00
 0.5000000E-02  0.8195913E+03  0.5962017E+00
 0.7500000E-02  0.1225229E+04  0.8912778E+00
 0.1000000E-01  0.1626717E+04  0.1183335E+01
 0.1250000E-01  0.2023399E+04  0.1471896E+01
 0.1500000E-01  0.2414660E+04  0.1756514E+01
```

Figure 10 First twenty four lines of .VES file.

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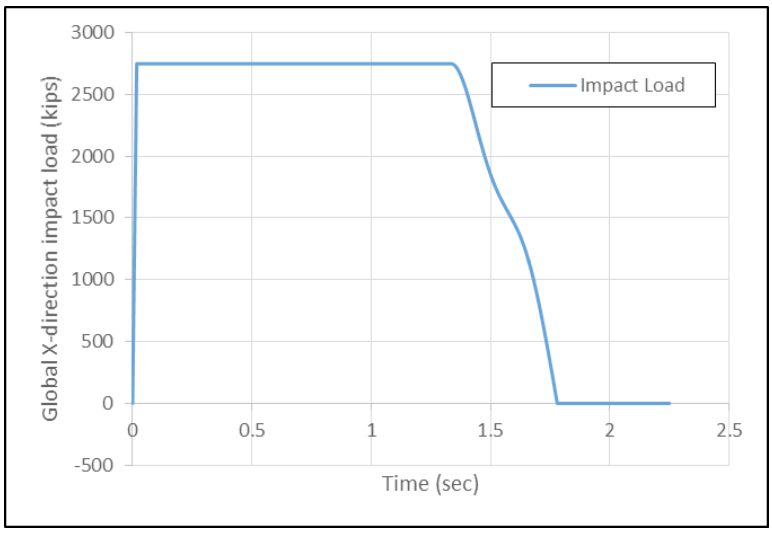

Figure 11 Vessel collision impact-load history.

The impacted pier considered above, pier 3 is now used to create an OPTS model (One Pier Two Span model). The OPTS modeling technique increases computational efficiency by transforming the bridge model (multiple-pier, multiple-span model) to an equivalent model with one pier and two spans. Concentrated spring stiffnesses and masses, connected at the ends of the two retained spans, are used to represent the stiffness and inertial resistance of the multiple-pier, multiple-span bridge model. The OPTS modeling technique substantially decreases computational time while still producing accurate results. A detailed example for an OPTS model can be found in the Help Manual Secs. 6.13, 6.14, and 6.15.

1. Open the full bridge model in FB-MultiPier and navigate to the "Problem" page (**Figure 12**).

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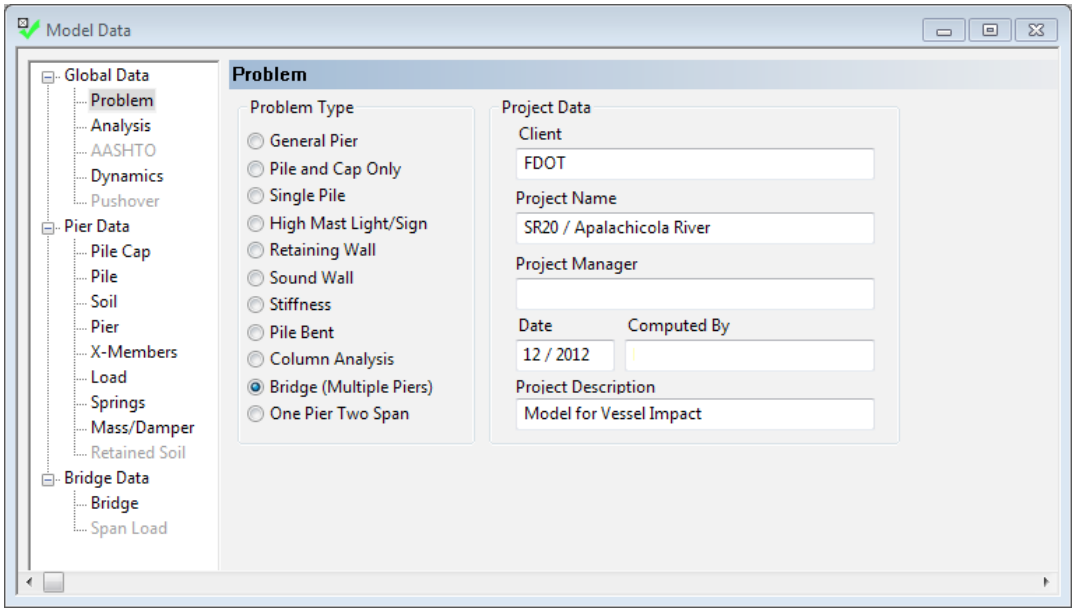

Figure 12 Problem Type Page.

2. On the "Problem" page, click on the "One Pier Two Span" problem type (**Figure 13**).

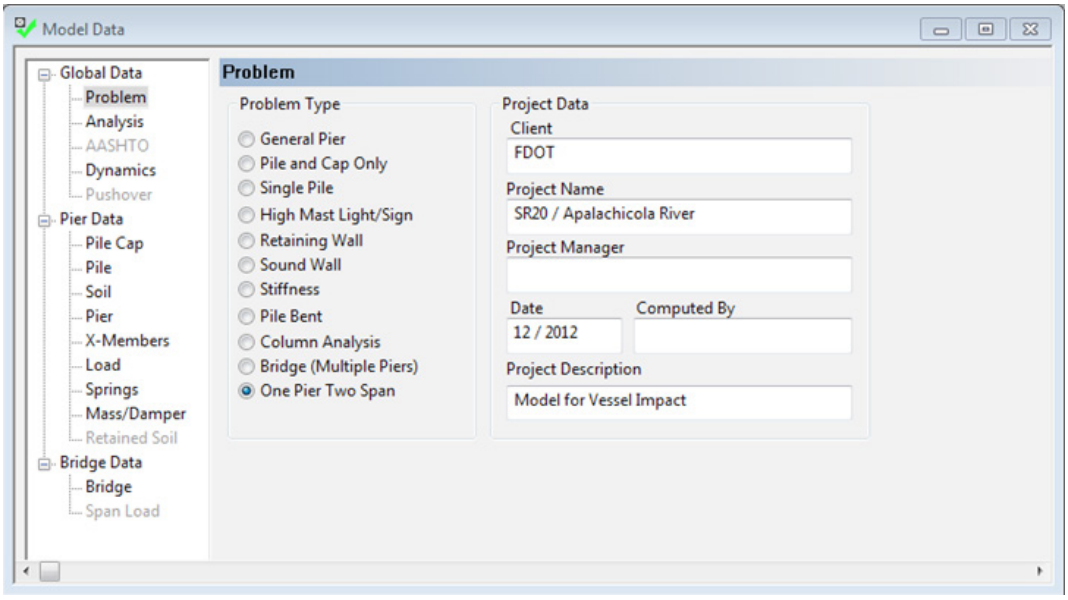

Figure 13 Select the "One Pier Two Span" (OPTS) Problem Type.

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3. When the "OPTS Conversion" dialog opens, select Pier 3 and click the "OK" button (**Figure 14**).

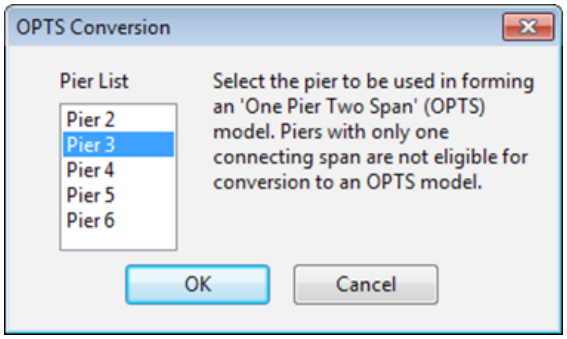

Figure 14 OPTS Conversion dialog.

4. As part of the OPTS model formation, a special analysis is automatically carried out to calculate the span end concentrated stiffness and mass values. The resulting OPTS model is shown in **Figure 15**.

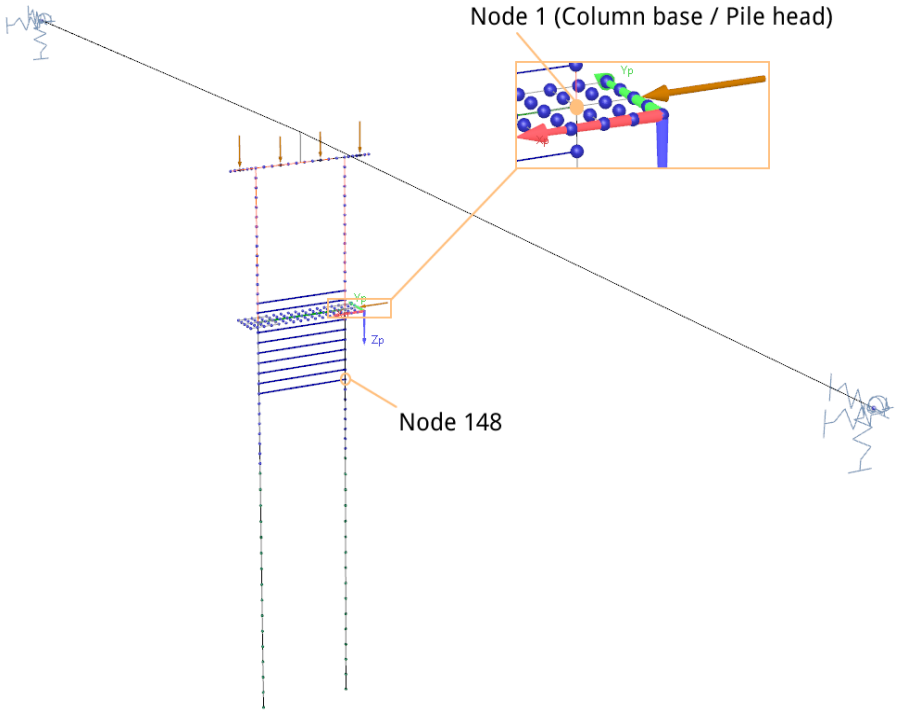

Figure 15 Automatic generation of an OPTS model (from the FB-MultiPier bridge model).

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5. For the OPTS model, the "Bridge" page has an additional option where engineers can modify the stiffness and mass data at the model extents, if so desired. Such modifications are made by navigating to the "Bridge" page, and then clicking the "Edit" button to open the "OPTS Data" dialog. For more information on how to calculate the spring stiffnesses and mass values please refer to Help Manual Sec. 6.14.

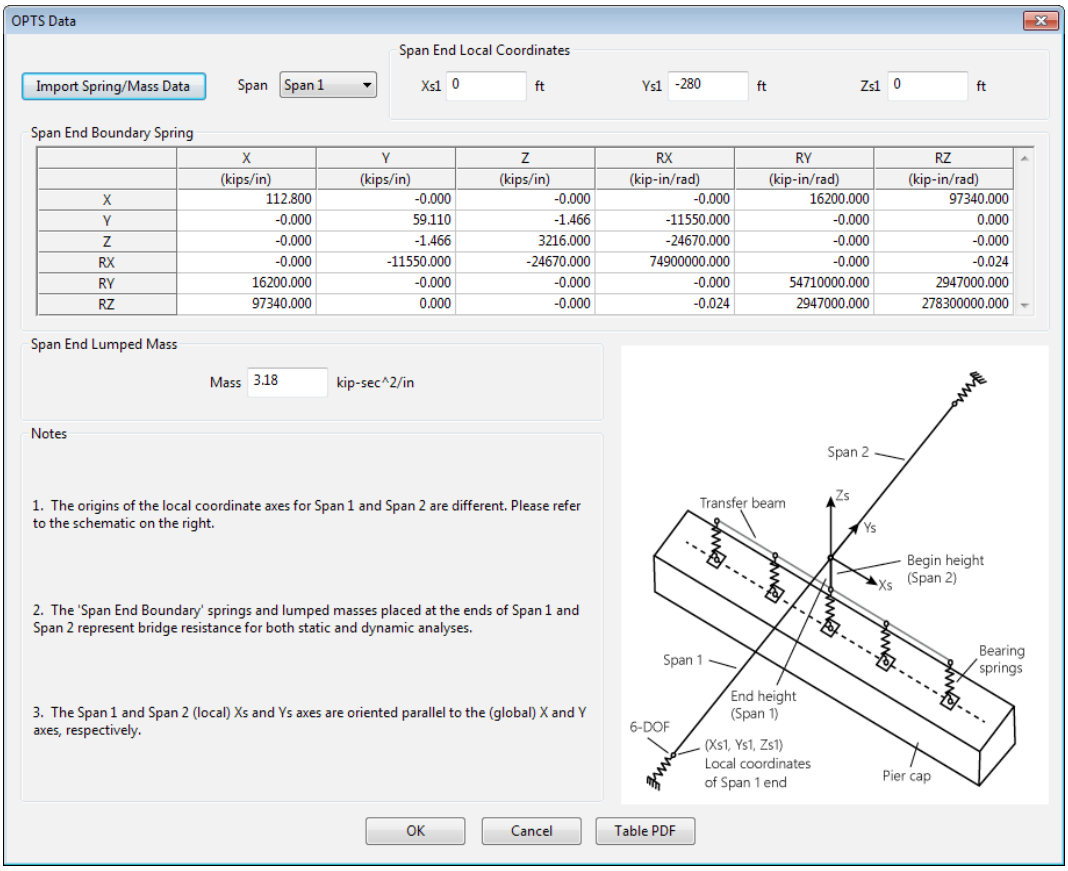

Figure 16 "OPTS Data" dialog.

6. The OPTS model is now fully prepared for analysis.

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PO Box 116580
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Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

Computational Robustness of the OPTS Modeling Approach

On an ordinary desktop PC*, the computational time required for carrying out CVIA using the full bridge model is 40 min. In contrast, when using the same ordinary desktop PC* to analyze the CVIA-OPTS model, only 30 sec. are required. **Figure 17** shows the resultant shear force in global X-direction at the base (Node 1 in **Figure 15**) of the impacted column. The vessel collision impact-load history (**Figure 11**) shows two slightly different stiffnesses during unloading from 1.34 sec. to 1.78 sec. Similar behavior can be seen for resultant shear force at Node 1 in global X-direction (**Figure 17**).

* The analysis was performed using Windows 7© desktop PC with specification of 16 GB of RAM and use of an Intel® Core™ i7 3.4 GHz processor.

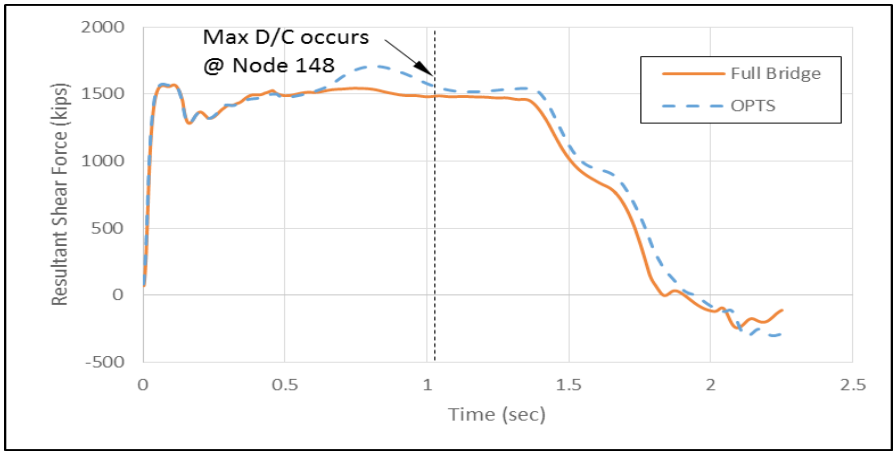

Figure 17 Resultant shear force in global X-direction at the base of the impacted column (Node 1).

The maximum Demand/Capacity (D/C) ratio occurs at Node 148 (refer to **Figure 15**). In **Figs. 18** to **21**, displacements and forces at Node 148 are compared between the full- bridge and OPTS models. While the displacements are generally conservative among the OPTS model results, computed time-histories of axial force, shear force, and moment show good agreement between both models.

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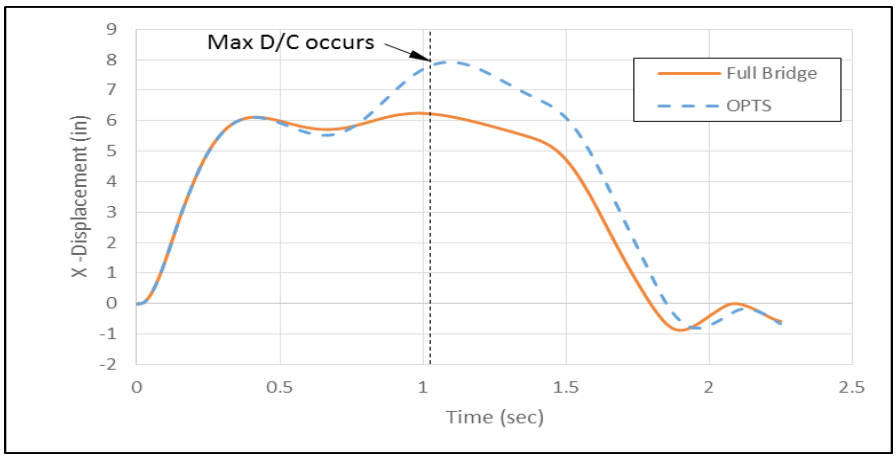

Figure 18 Global X-Displacement at Node 148.

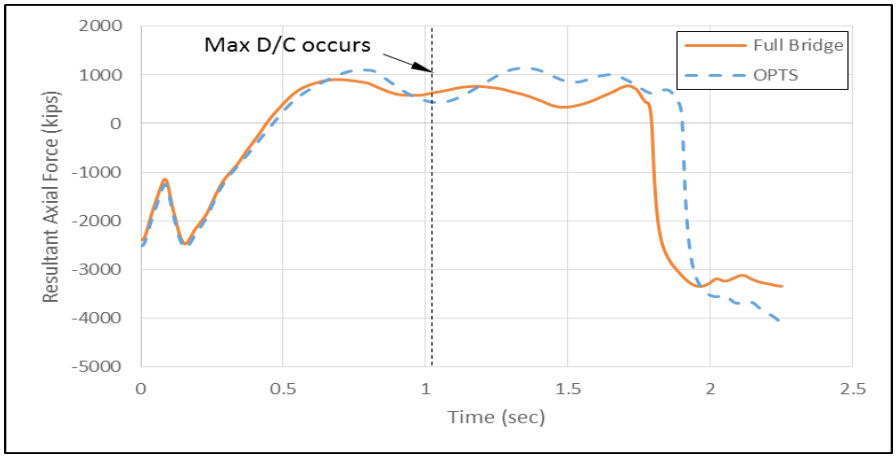

Figure 19 Resultant axial force at Node 148.

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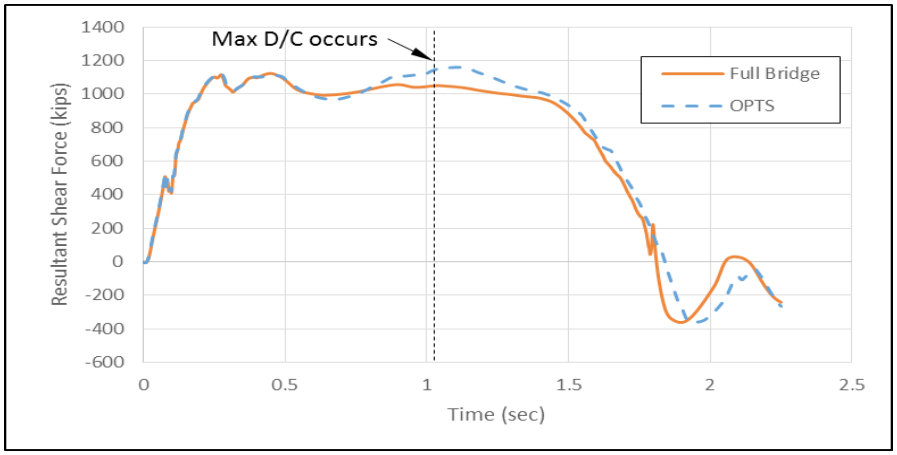

Figure 20 Resultant shear force in global X-direction at Node 148.

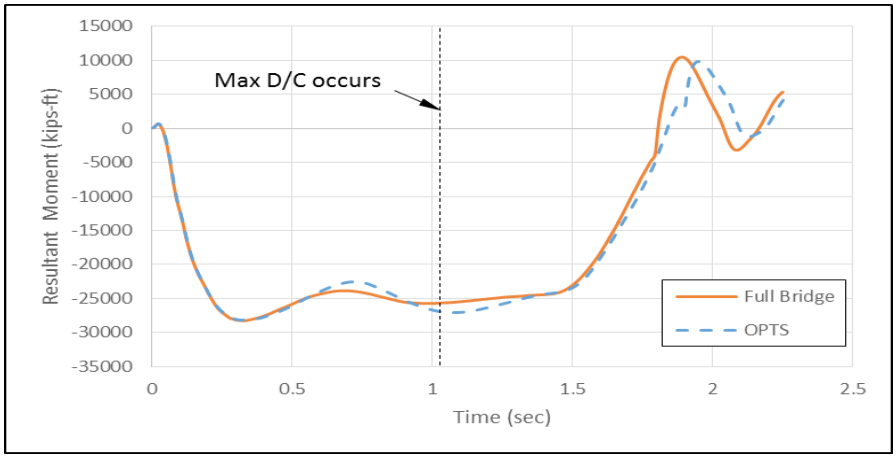

Figure 21 Resultant moment about global Y-direction at Node 148.

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PO Box 116580
Gainesville, FL 32611

Online: bsi.ce.ufl.edu
Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

Extra Member Connectivity

Element end conditions for extra members have been enhanced in FB-MultiPier v5.0 such that end-fixity can be specified by the engineer. This enhancement allows for either end or both ends of a given extra member to be "pinned" (no moment transfer) or "fixed". For example, consider the extra member element modeled as a strut between column nodes 86 and 105 (**Figure 22**). From the "Extra Members" page (**Figure 23**) in the FB-MultiPier user interface (UI), an "End Condition" drop-down menu allows for the assignment of any one of several end-fixity conditions.

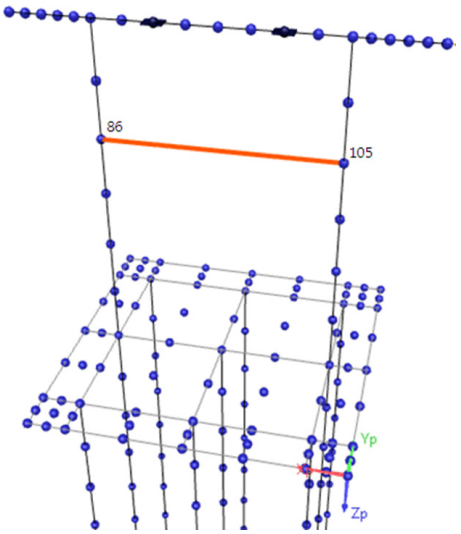

Figure 22 General Pier model with Extra Member (highlighted).

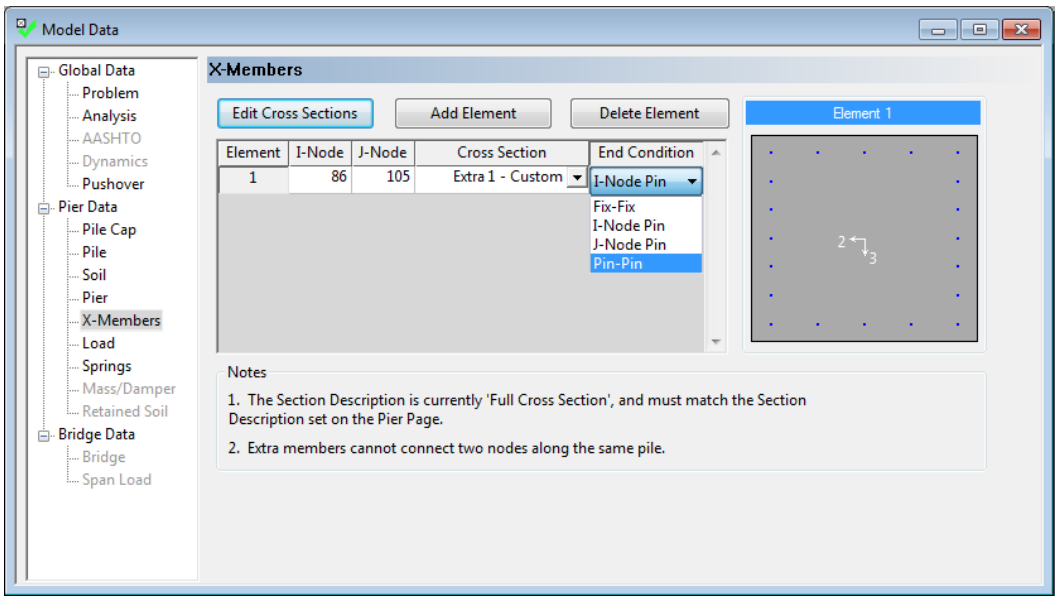

Figure 23 Selection of "End Condition" on the "Extra Members" page.

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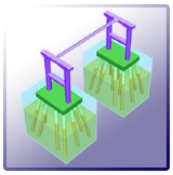
Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

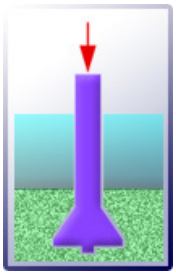
BSI Program Status



FB-MultiPier V5.0 Download a FREE demo today!

Released: March 31, 2016 - 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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University of Florida
PO Box 116580
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Online: bsi.ce.ufl.edu
Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

For Technical Support

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.

Contact BSI

If you need to contact BSI for any reason you can use any of the methods below:

Cary Peterson
Online: **bsi.ce.ufl.edu**
Email: bsi@ce.ufl.edu
Fax: (352) 392-3697

Mailing Address:

Bridge Software Institute
University of Florida
PO Box 116580
Gainesville, FL 32611