BSI NEWSLETTER

Bridge Software Institute

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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

In this issue, we discuss recently developed features for FB-MultiPier v5.5.

Engineers making use of software produced by the Bridge Software Institute (BSI) are encouraged to communicate suggestions for new features and program improvements to BSI. These suggestions may be general or very specific to project needs. We firmly believe that you are in the best position to know what those needs are!

In this release of FB-MultiPier, the enhancements listed below were largely a result of YOUR suggestions:

a) Option to rigidize pile top portions
b) American Railway Engineering and Maintenance-of-Way Association (AREMA) load combinations for rail bridges
c) Customized Design Table output
d) Directionality of lateral soil resistance (p-y) springs
e) Multiple-support excitation for nonlinear dynamic seismic analysis

The FB-MultiPier v5.5 enhancements are highlighted below.

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FB-MultiPier v5.5
FB-Deep v2.05
Atlas v7.1

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Option to Rigidize Pile Top Portions

A feature for which BSI has received numerous requests is the ability to “rigidize” pile or shaft portions that fall within the physical thickness of the pile cap. Accordingly, the newly introduced pile rigidization feature allows engineers to specify a length over which the pile or shaft is assumed to act as rigid, and then the program automatically amplifies (by a factor of 10,000) the material properties of the pile (or shaft) portions that fall within the rigidized length. In tandem with the rigidization feature, engineers may also choose for the program to not apply soil resistance forces to pile (or shaft) portions within the rigidized length (e.g., for the case of buried or partially buried pier foundations).

The following single span bridge model is used to demonstrate the rigidization feature. For this demonstration case, 25 prestressed piles (24-inch square) are pin-connected to an 8-ft thick pile cap, (Fig. 1). Longitudinal loads of magnitude 550 kips, acting in the positive-Xp direction, are applied to the pier caps of each pier. Further, and only for the second pier (Pier 2), a 4-ft long rigidized length is specified in the Rigidized Length input on the Pile page (Fig. 2), which results in the top 4 ft of each pile being treated as rigid. Alternatively stated, this input causes the effective connection of the piles at Pier 2 to coincide with the physical bottom surface of the 8-ft thick pile cap. It is important to note that the program requires at least one pile segment (i.e., set of cross section properties) to be defined such that the pile segment bottom elevation aligns with the Rigidized Length.

Displaced shapes of the pier foundations, obtained from analysis of the demonstration case under the loading described above, are shown in Fig. 3. Note the distinct difference in the displaced shape just beneath the pile cap of Pier 1 as opposed to the effectively rigid response in the topmost 4 ft of the piles from within Pier 2. The effect of rigidizing the pile top portions in Pier 2 (as opposed to that of Pier 1) is obvious, demonstrating the utility of this feature for instances where rigidization of pile top portions is warranted.

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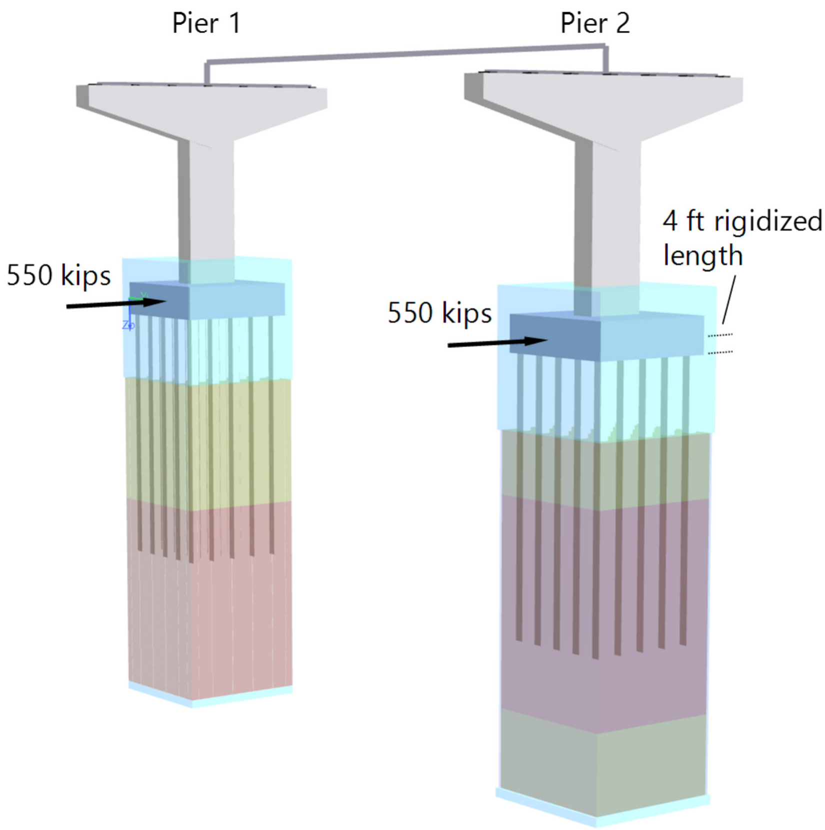

Figure 1. 3D View of two-pier demonstration case for rigidization of piles

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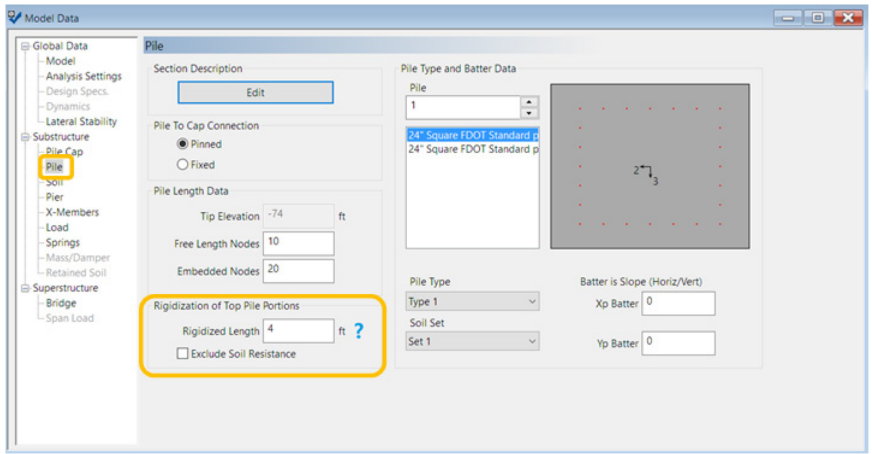

Figure 2. Model Data window with Pile page and Rigidization of Top Pile Portions panel

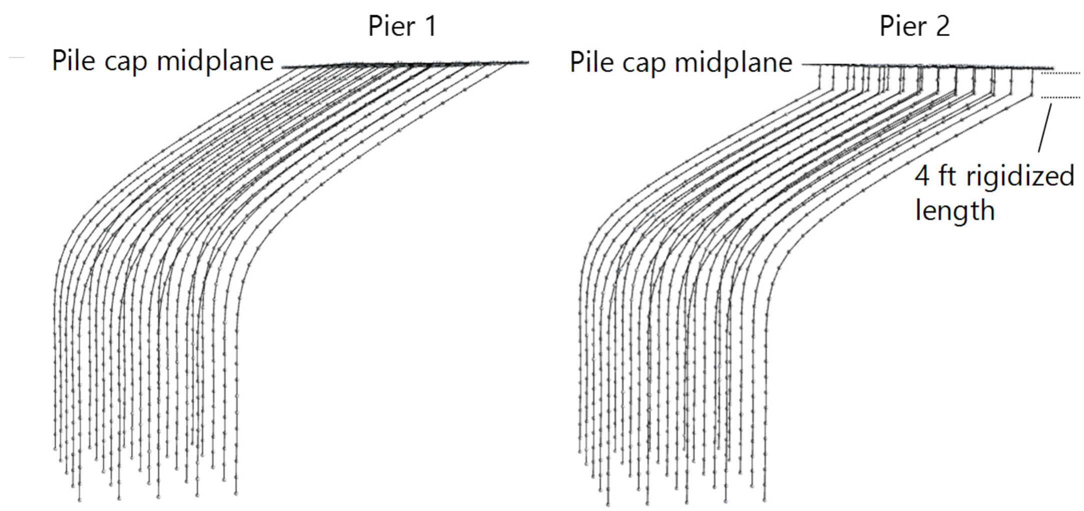

Figure 3. Pier foundation displaced shapes under 550 kip lateral loading: a) Pier 1, without pile rigidization; 2) Pier 2, with pile rigidization

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AREMA Load Combinations for Rail Bridges

In addition to the feature set for automated load combination generation based on AASHTO LRFD, FB-MultiPier is now equipped with the ability to generate load combinations for railway bridges (Fig. 4). Accordingly, the "AASHTO" page has been renamed the "Design Specifications" (or, "Design Specs.") page. In addition, the Load Factor Design (LFD) and Service Load Design (SLD) load combinations and load factors listed in the AREMA Manual for Railway Engineering (2018), with example display given in Fig. 5, can be accessed from within the Design Specs. page. By making use of this feature set, engineers can save considerable time in building up AREMA load combinations.

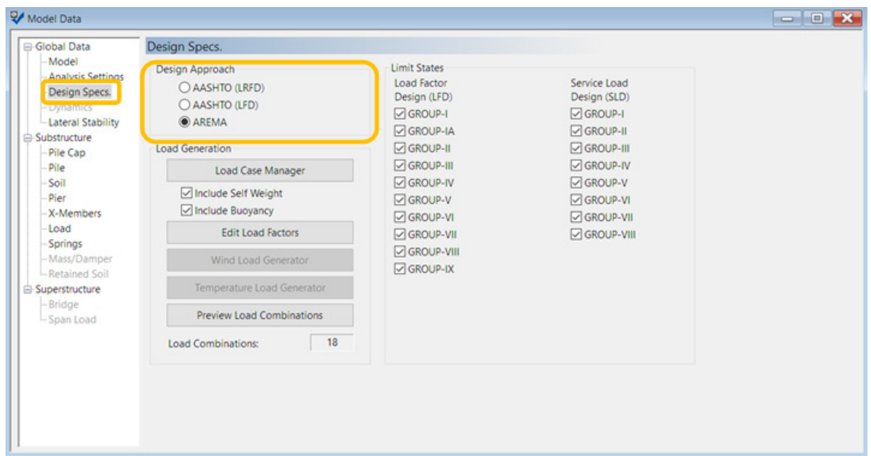

Figure 4. Model Data window with Design Specs. (previously AASHTO) page and Design Approach panel

		D	L1	I1	CF1	E	B	W1	WL1	LF1	F	EQ	SF	ICE	OF
LFD-GROUP-I	Comb. 1	1.40	2.34	2.34	1.40	1.40	1.40	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00
LFD-GROUP-IA	Comb. 2	1.80	1.80	1.80	1.80	1.80	1.80	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00
LFD-GROUP-II	Comb. 3	1.40	0.00	0.00	0.00	1.40	1.40	1.40	0.00	0.00	0.00	0.00	1.40	0.00	0.00
LFD-GROUP-III	Comb. 4	1.40	1.40	1.40	1.40	1.40	1.40	0.70	1.40	1.40	1.40	0.00	1.40	0.00	0.00
LFD-GROUP-IV	Comb. 5	1.40	1.40	1.40	1.40	1.40	1.40	0.00	0.00	0.00	0.00	0.00	1.40	0.00	1.40
LFD-GROUP-V	Comb. 6	1.40	0.00	0.00	0.00	1.40	1.40	1.40	0.00	0.00	0.00	0.00	1.40	0.00	1.40
LFD-GROUP-VI	Comb. 7	1.40	1.40	1.40	1.40	1.40	1.40	0.70	1.40	1.40	1.40	0.00	1.40	0.00	1.40
LFD-GROUP-VII	Comb. 8	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
LFD-GROUP-VIII	Comb. 9	1.40	1.40	1.40	0.00	1.40	1.40	0.00	0.00	0.00	0.00	0.00	1.40	1.40	0.00
LFD-GROUP-IX	Comb. 10	1.20	0.00	0.00	0.00	1.20	1.20	1.20	0.00	0.00	0.00	0.00	1.20	1.20	0.00
SLD-GROUP-I	Comb. 11	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
SLD-GROUP-II	Comb. 12	1.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
SLD-GROUP-III	Comb. 13	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	0.00	1.00	0.00	0.00
SLD-GROUP-IV	Comb. 14	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
SLD-GROUP-V	Comb. 15	1.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
SLD-GROUP-VI	Comb. 16	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	0.00	1.00	0.00	1.00
SLD-GROUP-VII	Comb. 17	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00
SLD-GROUP-VIII	Comb. 18	1.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00

Fig 5. Load Combination Preview dialog with example display of AREMA load combinations

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Online: bsi.ce.ufl.edu
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Customized Design Table Output

The Design Tables feature in FB-MultiPier can be accessed (Fig. 6) for most model types after analysis has been carried out. This feature was originally implemented (in FB-MultiPier v4.19) to streamline post-processing efforts for applications involving relatively more complex structural configurations or relatively large numbers of load cases (combinations). In FB-MultiPier v5.5, the Design Tables feature (Fig. 7) is enhanced to provide engineers with increased control regarding the selection of load cases (or combinations) of interest.

Figure 6. FB-MultiPier toolbar with Design Tables button

An example means of accessing this new component of the overall Design Tables feature set is given for an AASHTO LRFD model. After conducting an AASHTO LRFD analysis, open the Design Table Generator dialog (click the button outlined in Fig. 6). Then, select the Custom Set of Load Combinations radio button from within the Load Combination Selection panel of the Design Table Generator dialog (Fig. 7). Next, click the Choose Load Cases (or Combinations) button to open the Choose Load Combinations dialog (Fig. 8). From within this dialog, any load combination of interest can be chosen (by inputting a value of '1' in the table). Note that all (or none) of the load combinations can be selected (or unselected) by clicking the "All | None" labels positioned beneath the table. After the combinations of interested have been set within this table, all subsequent reports generated using the Design Tables will only reflect results from those load combinations. This is particularly useful for scenarios where the controlling load combinations are known prior to conducting the analysis.

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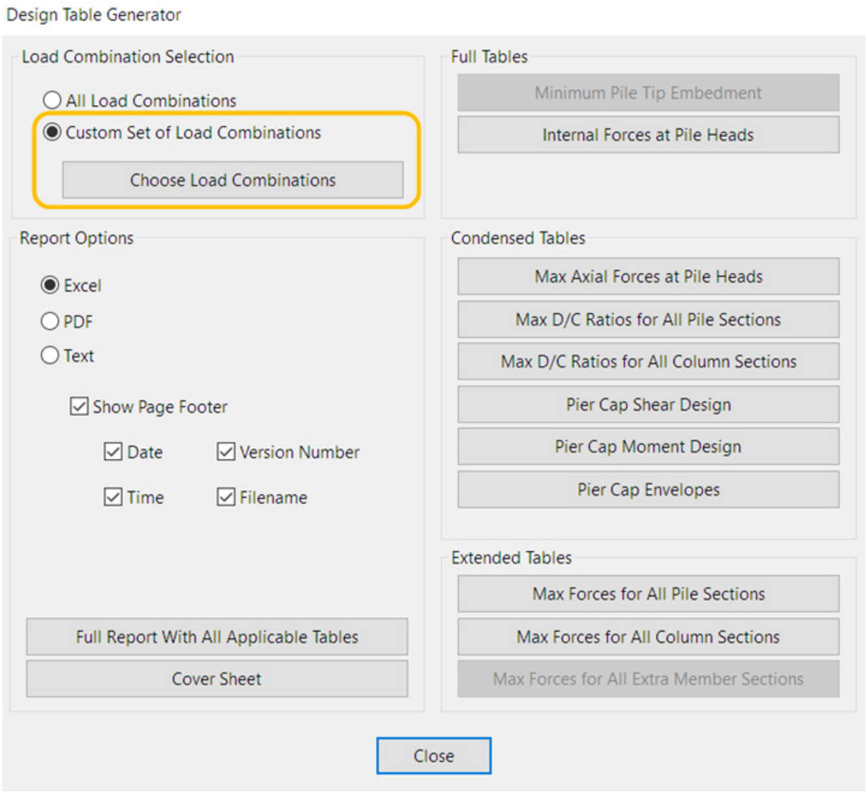

Figure 7. Design Table Generator dialog with Load Combination Selection panel

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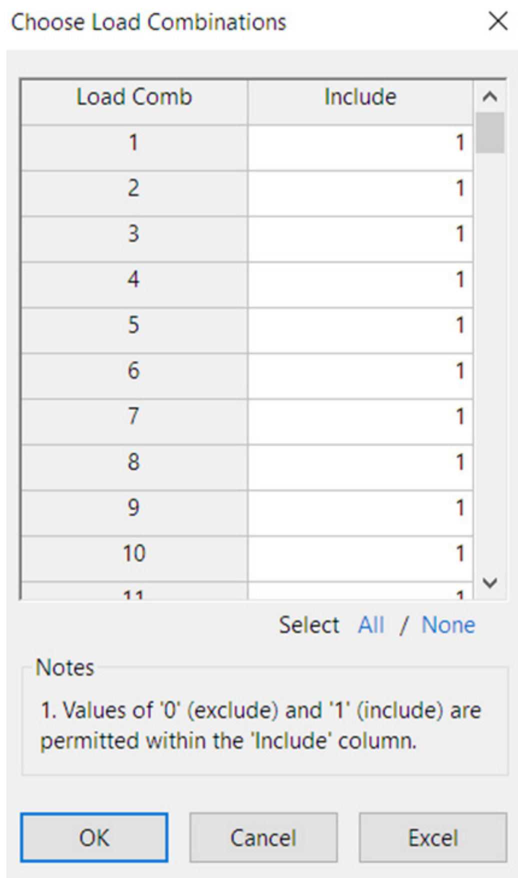

Figure 8. Choose Load Combinations dialog

Directionality of Lateral Soil Resistance (p-y) Springs

In FB-MultiPier v5.5, processing of soil lateral resistance (p-y) springs is enhanced such that the p-y spring at each embedded pile (or shaft) node is oriented in the nodal resultant horizontal direction of motion. Nonetheless, this enhancement is motivated by (for example) the expectation that, for a single pile subjected to static horizontal pile head loads, the resultant pile head displacement should remain constant regardless of the load direction. For scenarios where pronounced displacements occur with both X-direction and Y-direction components, this program enhancement may lead to changes in computed response relative to previous program versions.

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In the following, computed displacements of a single pile are shown to be invariant with respect to the direction of loading when analyzed using the enhanced p-y approach of FB-MultiPier v5.5. Shown in Fig. 9 is a single pile embedded in a clay layer and subjected to a 50-kip horizontal load. The load direction is varied from 0˚ to 90˚. Shown in Fig. 10 are the computed (resultant) horizontal displacement magnitudes for each loading considered, where the results are consistent with the expectation that the displacement magnitudes should be uniform despite the plan-view angle of the applied horizontal load.

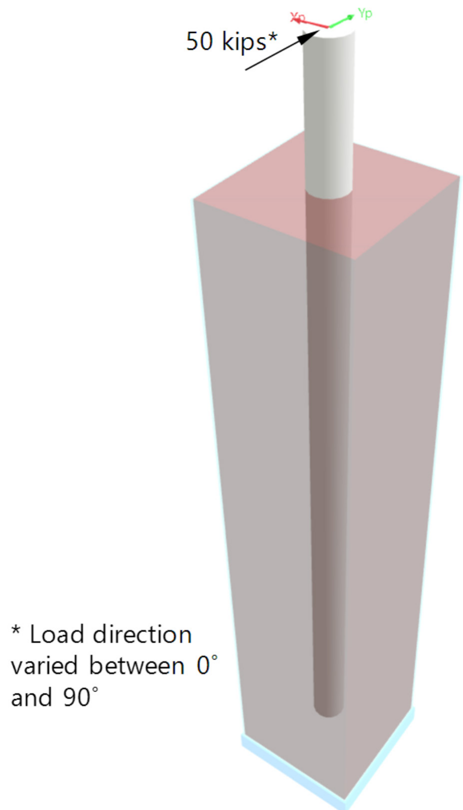

Figure 9. Single pile embedded in clay and subjected to horizontal pile head load

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

Online: bsi.ce.ufl.edu
Email: bsi@ce.ufl.edu

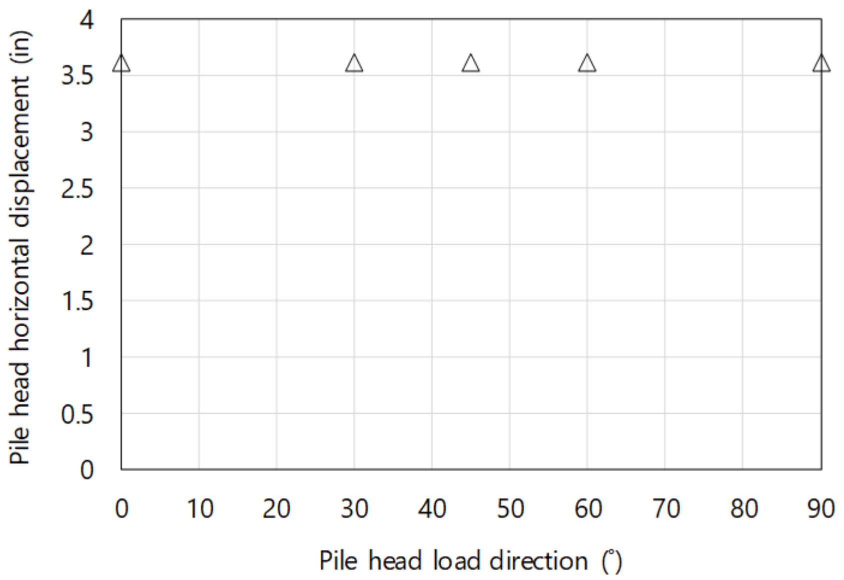

Figure 10. Computed pile head horizontal displacement magnitude versus load direction

Multiple-support Excitation for Nonlinear Dynamic Seismic Analysis

For seismic design applications, multiple-support excitation can be carried out using FB-MultiPier v5.5. This feature is activated from the Dynamics page, for models that make use of time-history analysis, by checking the Multi-Support Excitation checkbox (Fig. 11). Consistent with previously implemented program capabilities, profiles of prescribed accelerations can then be input for all embedded pile (or shaft) nodes, as shown in Fig. 12. However, for multi-support excitation, these accelerations are used to induce motions in the soil (base, anchor) nodes of the p-y spring supports for embedded piles, and thereby considerably expand the range of scenarios that may be analyzed as part of seismic design applications.

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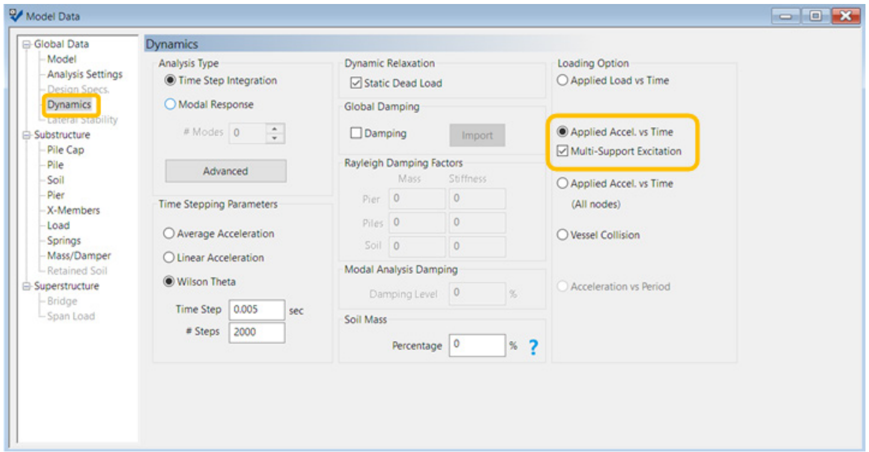

Figure 11. Model Data window with Dynamics page and Multi-Support Excitation checkbox

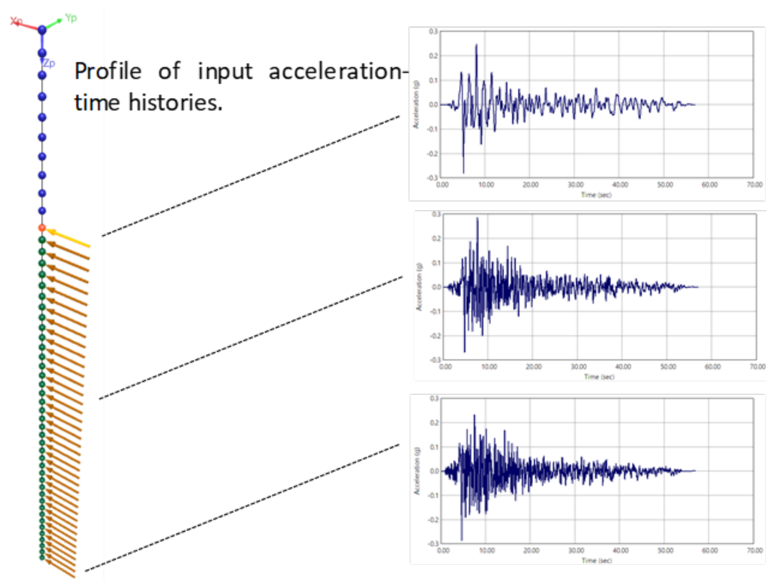

Figure 12. Example pile with profile of input acceleration time-histories

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University of Florida
PO Box 116580
Gainesville, FL 32611

Online: bsi.ce.ufl.edu
Email: bsi@ce.ufl.edu

License Updates

When updating your FB-MultiPier license you can now use copy and paste buttons to retrieve and paste license unlocking codes. Clicking the Copy Codes to Clipboard (Fig. 13) puts the Session Code and Machine ID on the clipboard. You can then email bsi@ce.ufl.edu with these codes. In response, BSI will email the unlocking codes. Copy all of the codes at once and then click the Paste Codes from Clipboard to paste the unlocking codes into the License Configuration Wizard. Click Next to complete your license update.

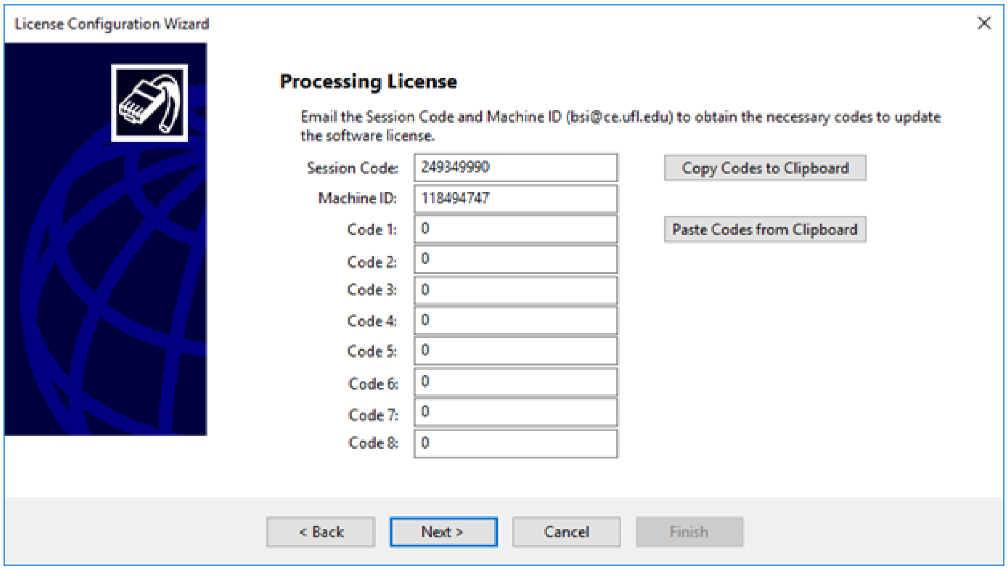

Figure 13. License Configuration Wizard dialog

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BSI Program Status

FB-MultiPier v5.5 Download a FREE demo today!

Released June 2019 - Continuing Development - Technical Support Available

FB-MultiPier allows for the modeling of bridges, bridge piers, pile bents, and other foundation structures. In addition to allowing for multiple load cases and AASHTO load combinations, FB-MultiPier is also capable of performing dynamic analysis (time-history and RSA). For more information about FB-MultiPier, click here.

FB-Deep v2.05 Download a FREE demo today!

Released January 2018 - Continuing Development - Technical Support Available

FB-Deep is 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. For more information about FB-Deep, click here.

Atlas v7.1

Released June 2019 - 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, and two-point attachments systems. For more information about Atlas, click here.

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Contact BSI

If you need to contact BSI for any reason you can use any of the methods below:
Online: **bsi.ce.ufl.edu**
Email: bsi@ce.ufl.edu

Mailing Address:

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