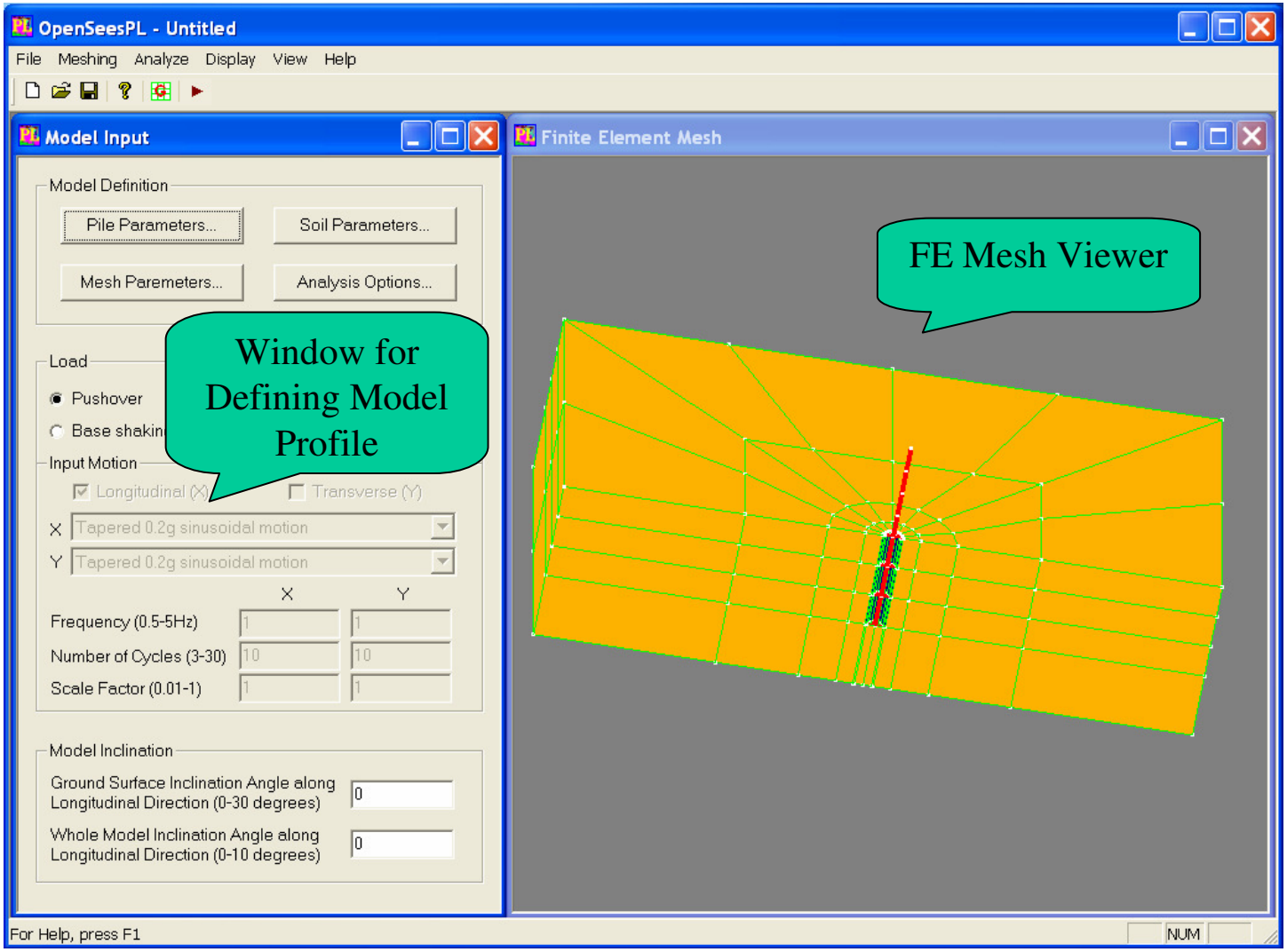
A User-Friendly Interface for Pile Analysis Using OpenSees

Jinchi Lu
University of California, San Diego

Zhaohui Yang
URS Corporation, Oakland Office

Ahmed Elgamal
University of California, San Diego

Single Pile in a Layered Half-Space

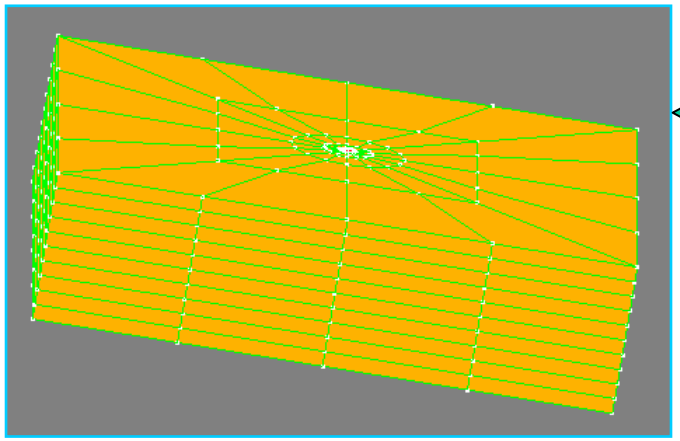


Circular pile in level ground: filled view of ½ mesh due to symmetry

Problems could be Studies by the GUI

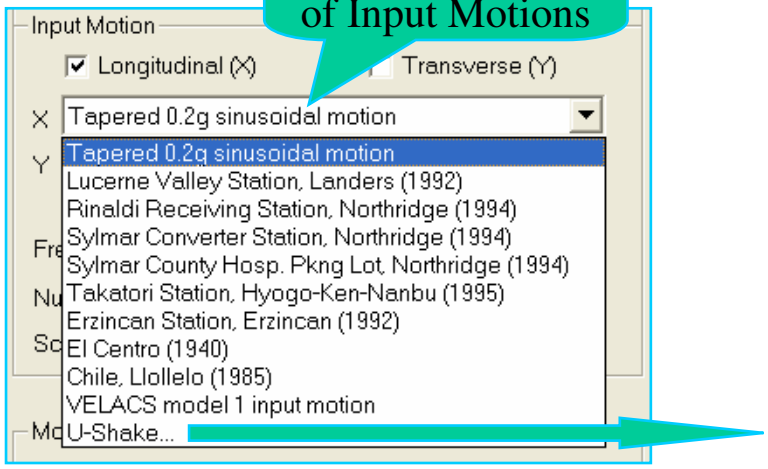
- **Seismic Excitation**: Linear and nonlinear (incremental plasticity based) 3D ground seismic response with capabilities for 3 dimensional excitation, and multi-layered soil strata.
- **Pushover Analysis**: Inclusion of a pile or shaft in the the 3D ground mesh (circular or square pile in a soil island).
- **Ground Modification**: Various ground modification scenarios may be studied by appropriate specification of the material within the pile zone.

Seismic Excitation

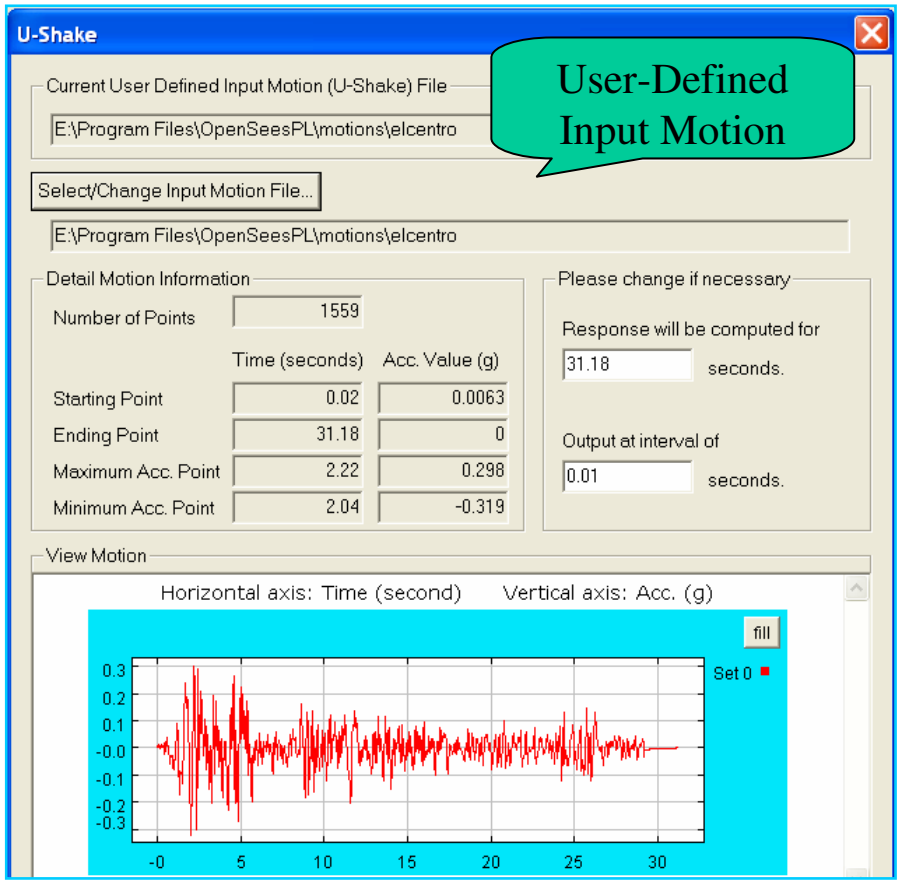


Full Mesh for 3D
Seismic Response

Build-in Library
of Input Motions

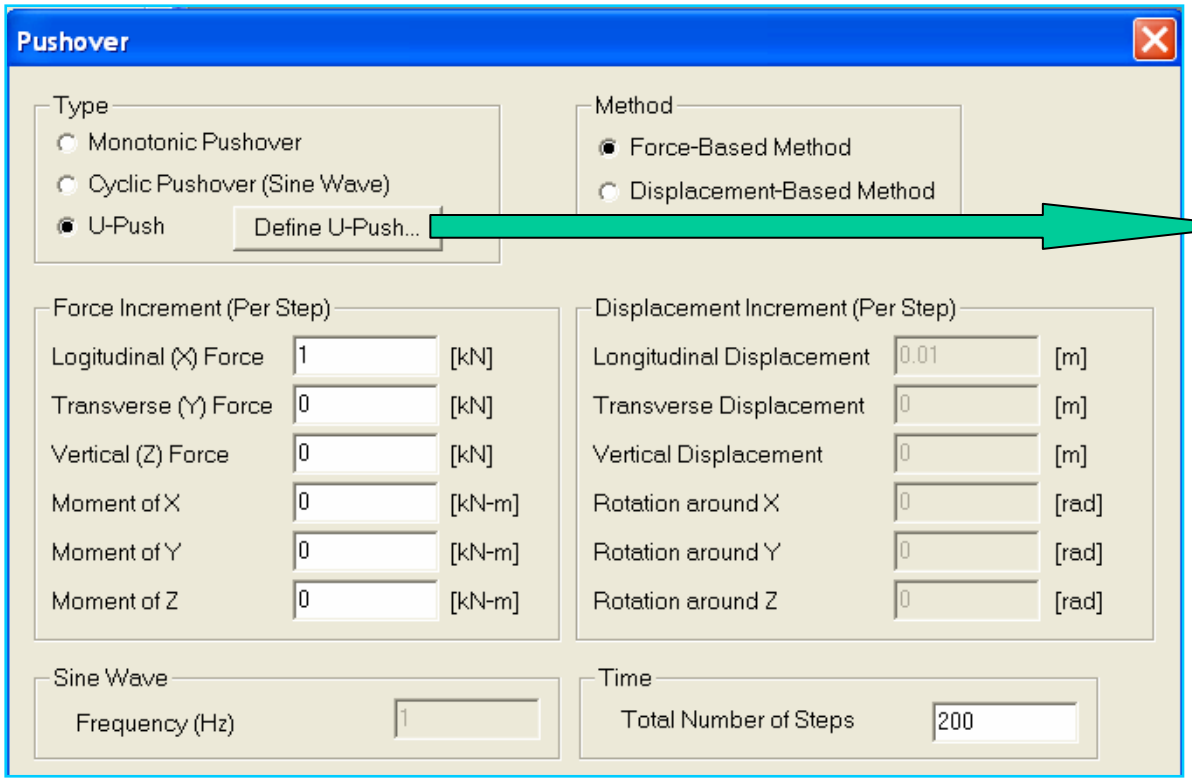


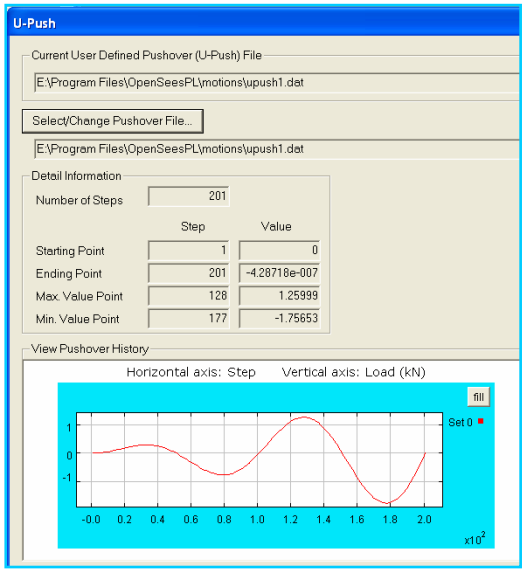
User-Defined
Input Motion



Pushover Analysis

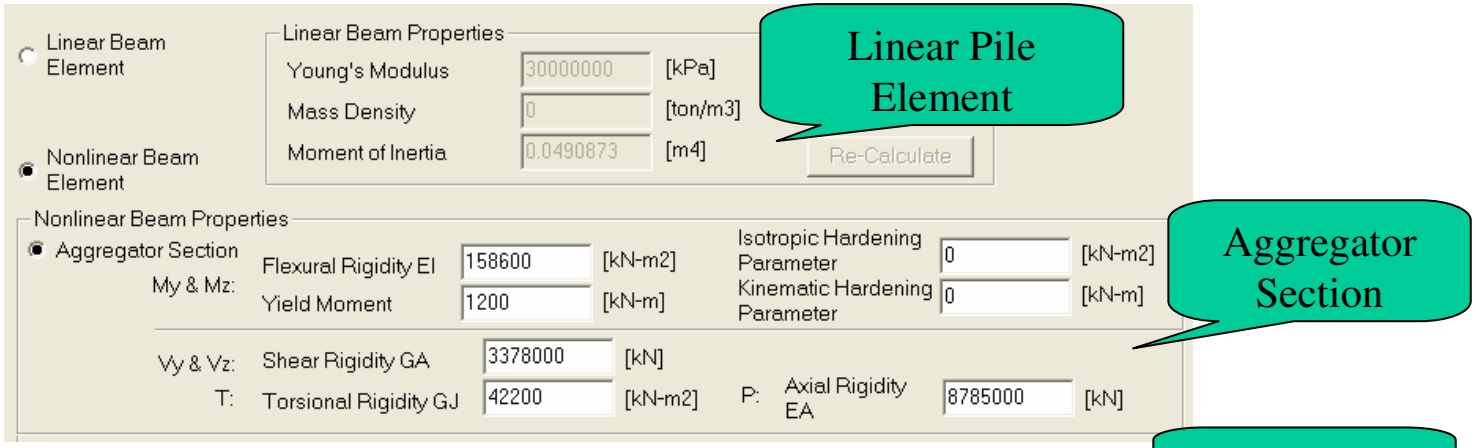
- Force Based or Displacement Based
- Monotonic or Cyclic

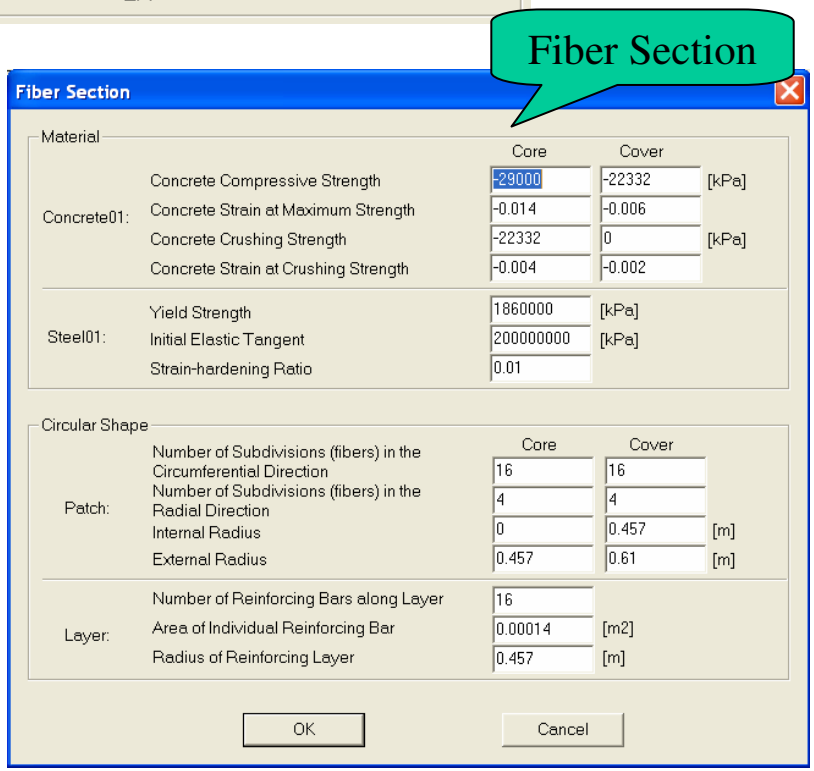




User-Defined Pushover

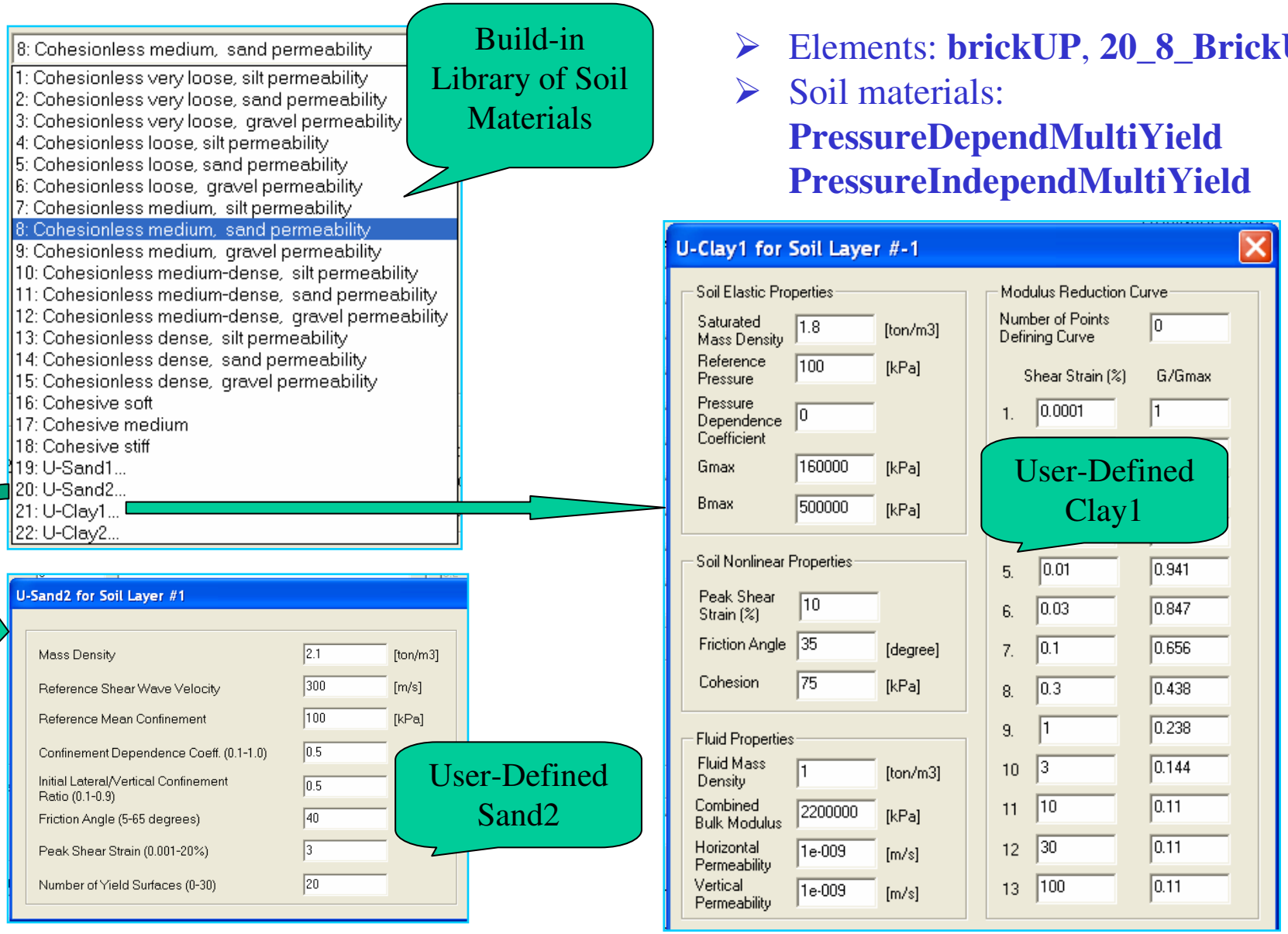
Pile Element Types





- Linear pile element (**elasticBeamColumn**)
- Nonlinear pile elements (**nonlinearBeamColumn**)
  - Aggregator section
  - Fiber section

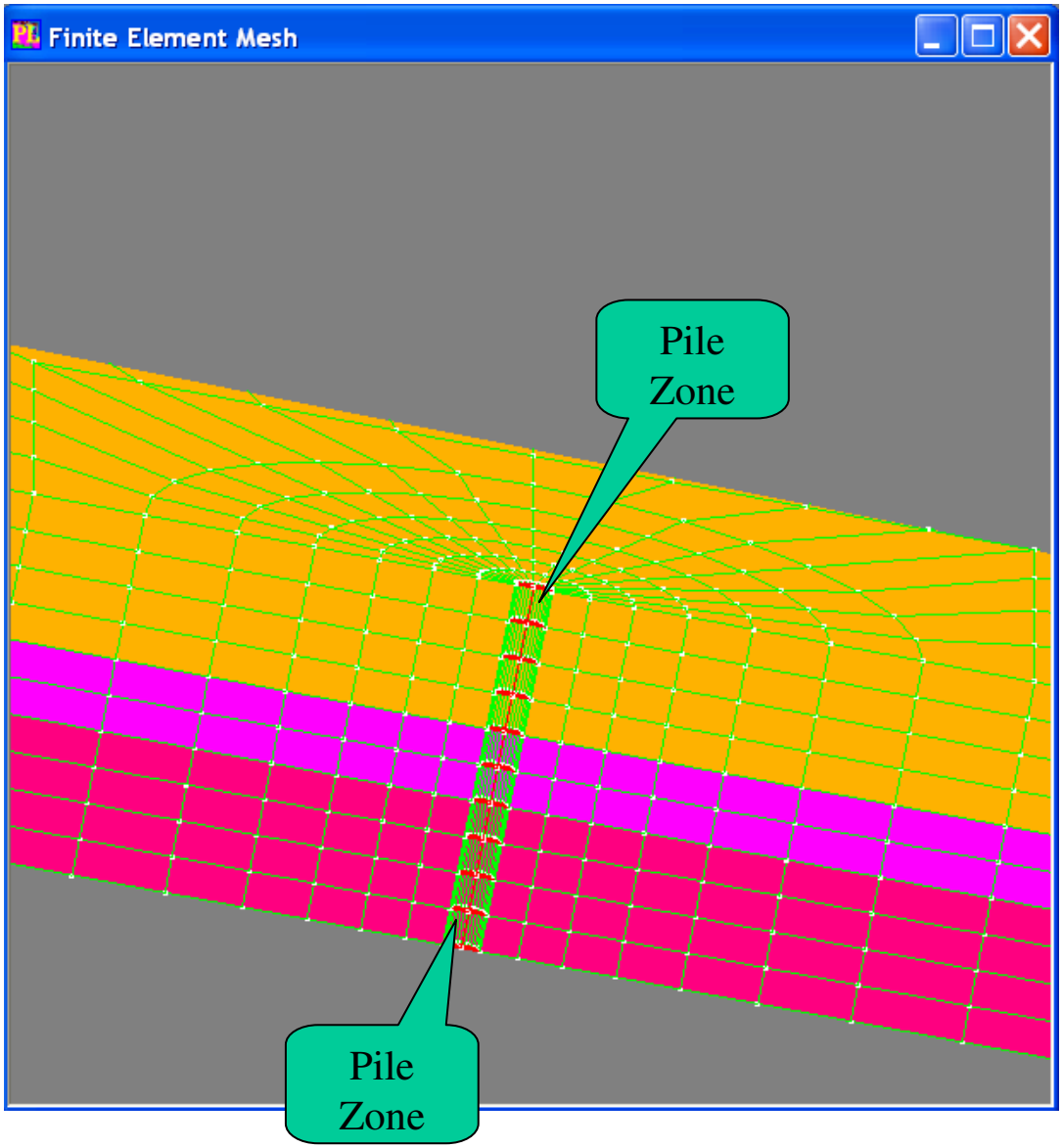
Soil Materials



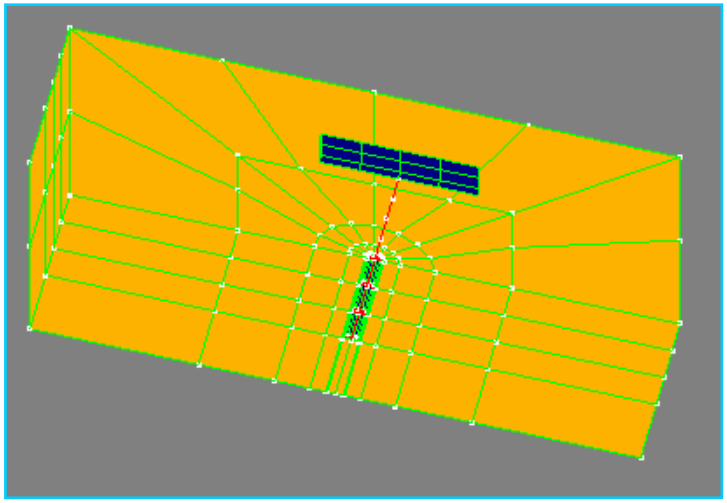
- Elements: **brickUP, 20_8_BrickUP**
- Soil materials:
  PressureDependMultiYield
  PressureIndependMultiYield

Ground Modification Scenarios

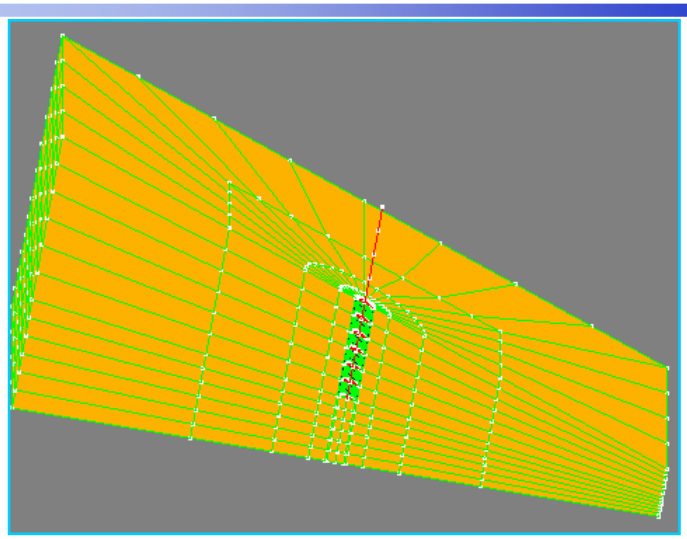
- Material within the pile zone (e.g., gravel permeability)
- Materials outside the pile zone (e.g., multi-layered soil strata with sand or silt permeability)



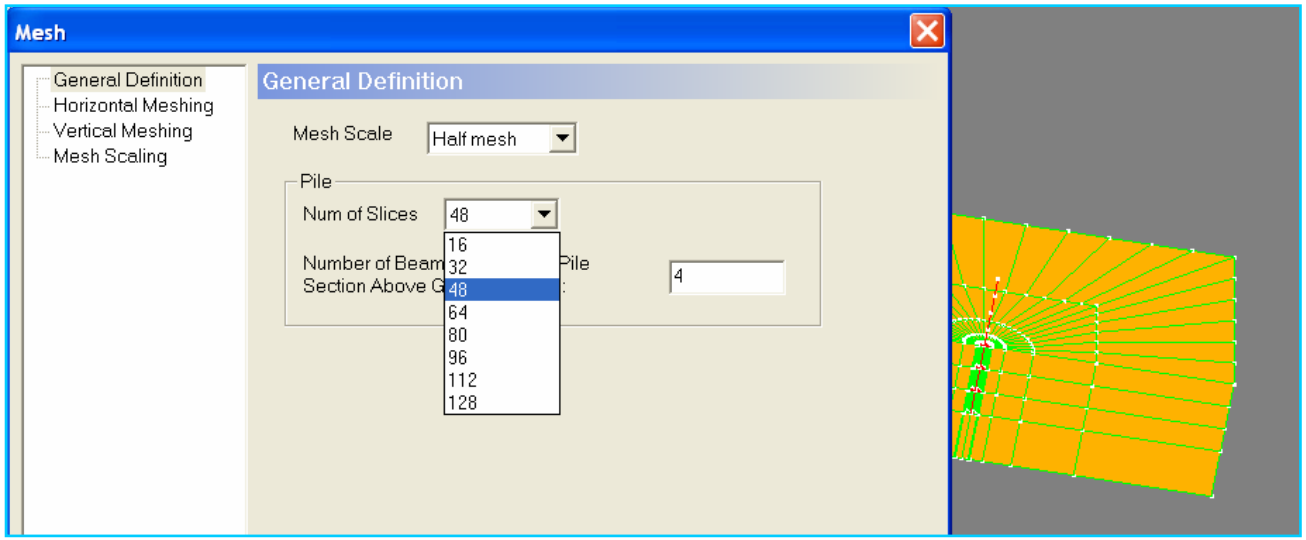
Other Features



Bridge Deck

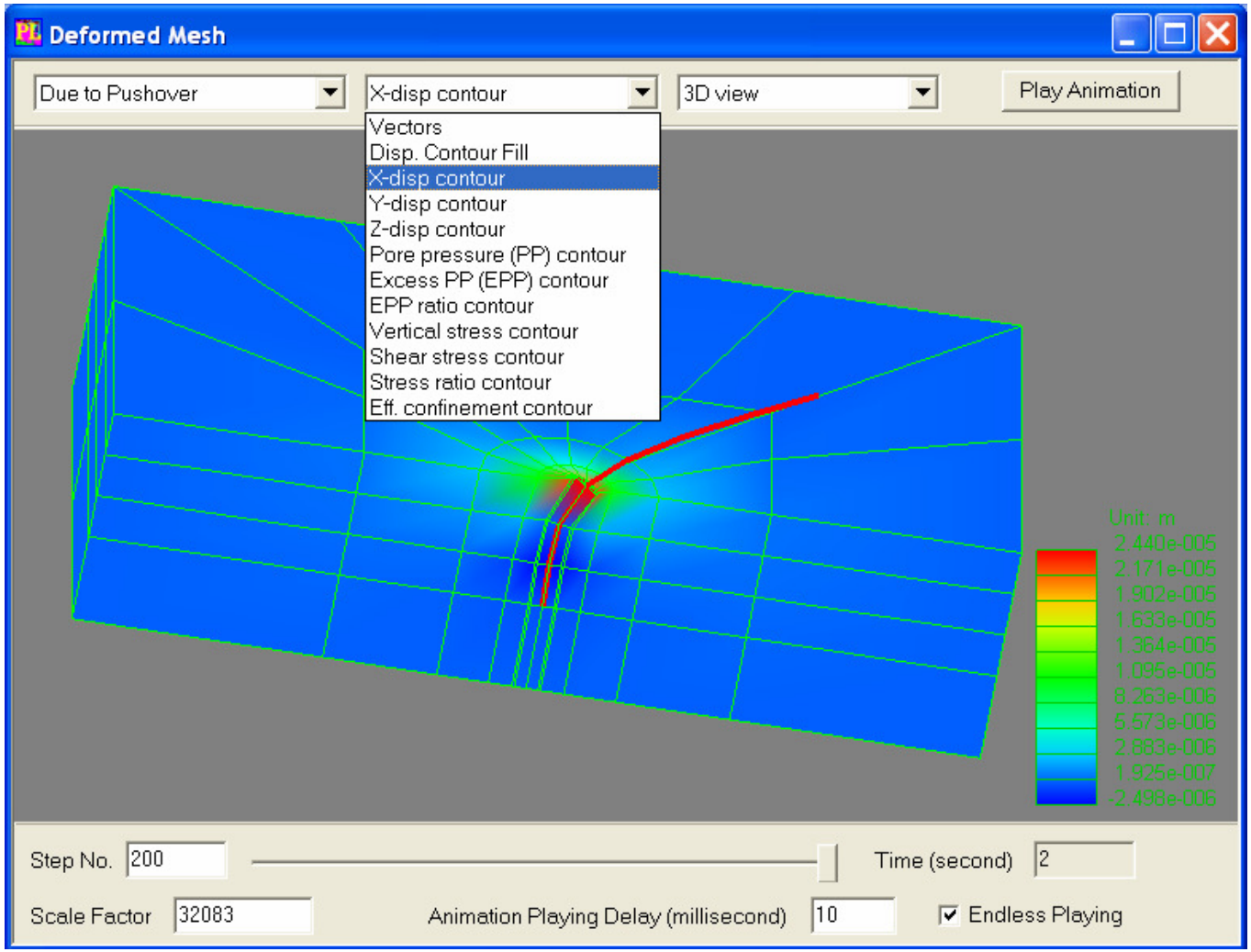


Pile in Sloping Ground

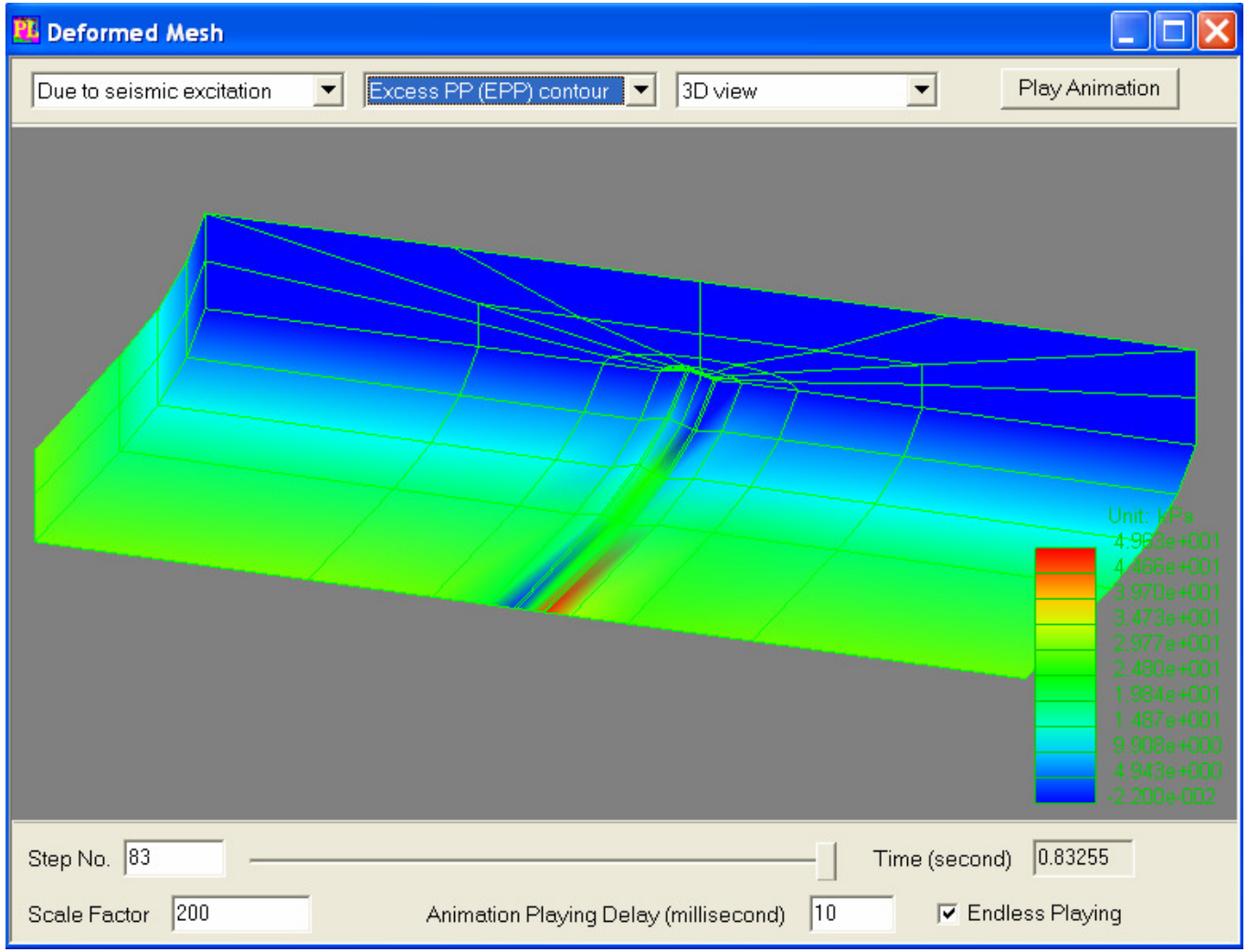


Straightforward and fast mesh definition/ refinement

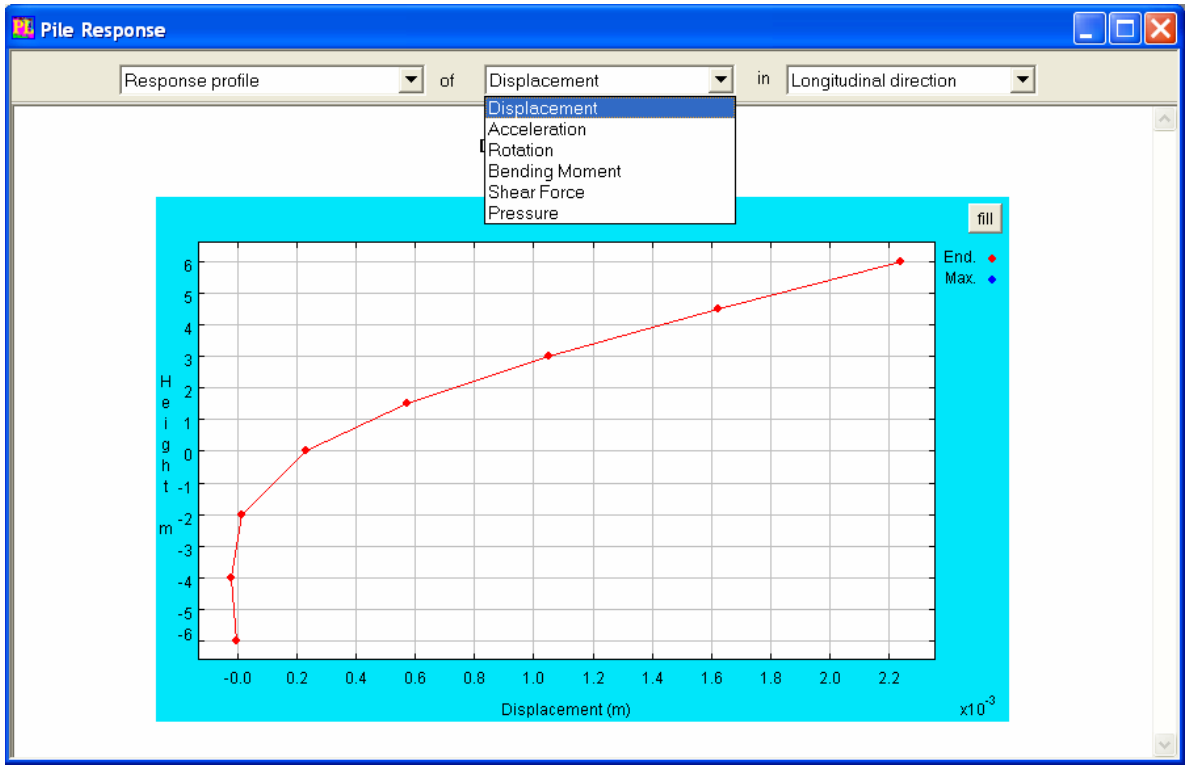
Output: Deformed Mesh



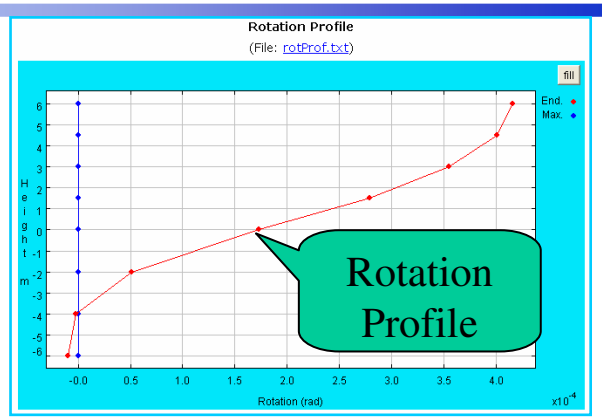
Output: Excess Pore Pressure Contour

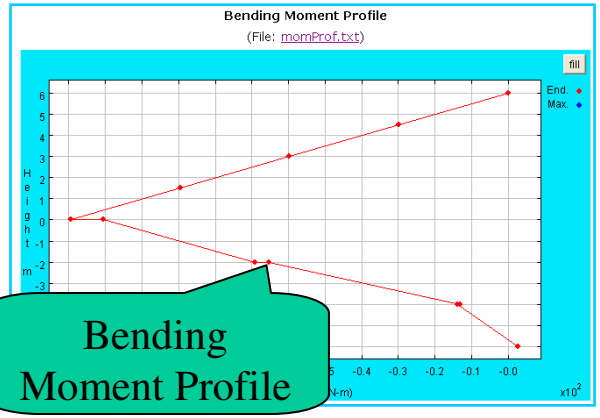


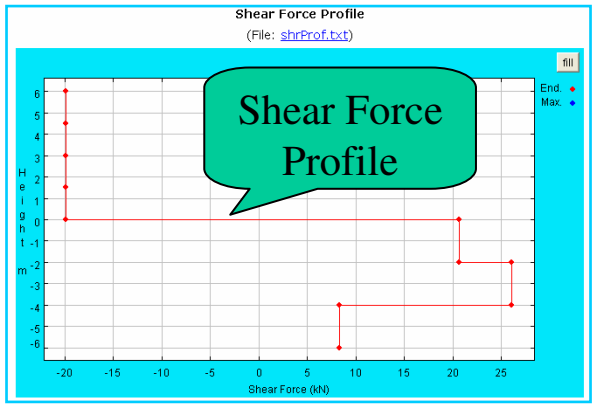
Output: Pile Response Profiles



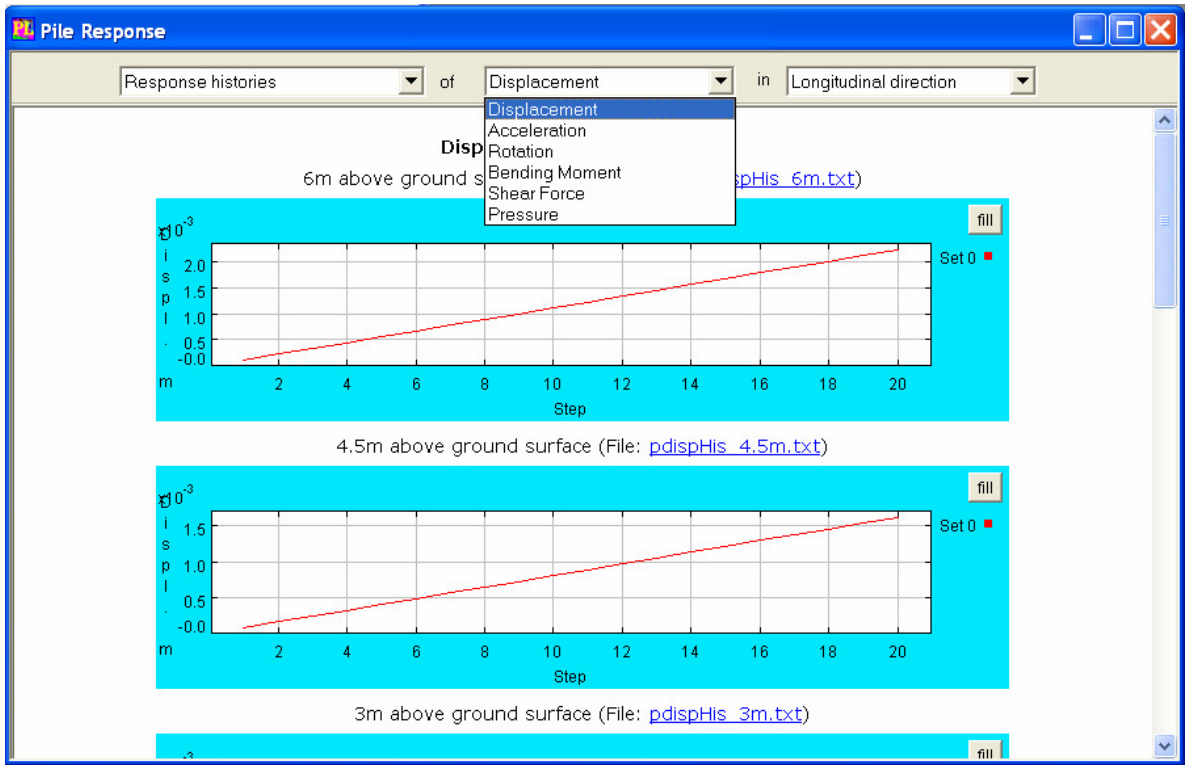
Displacement Profile



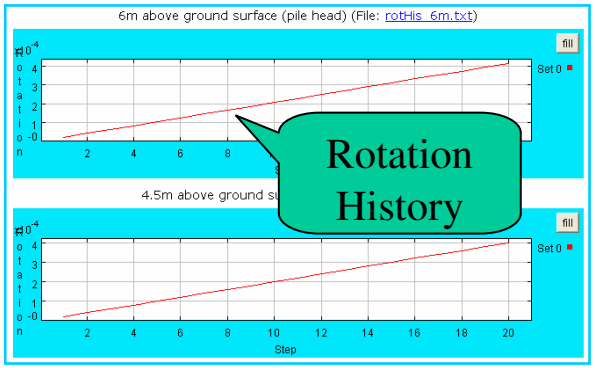




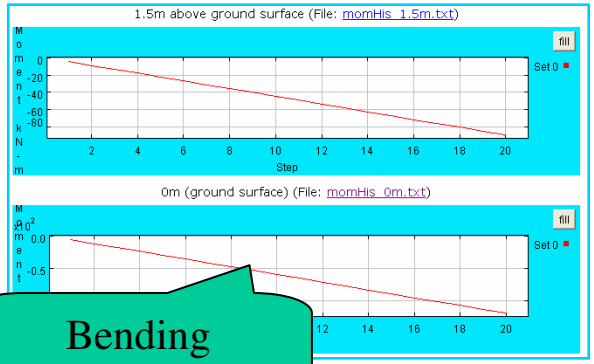
Output: Pile Response Histories



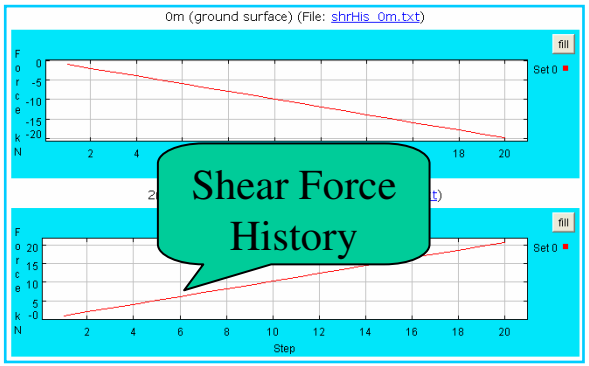
Displacement History



Rotation History

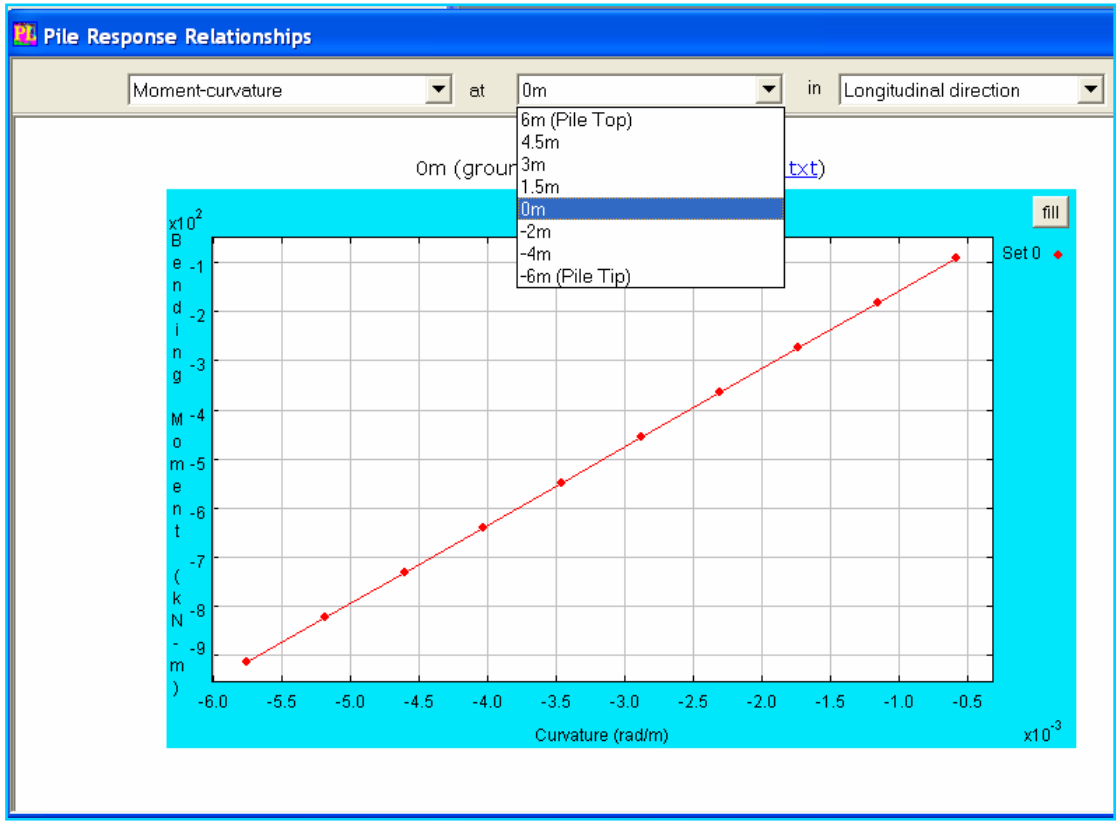


Bending Moment History

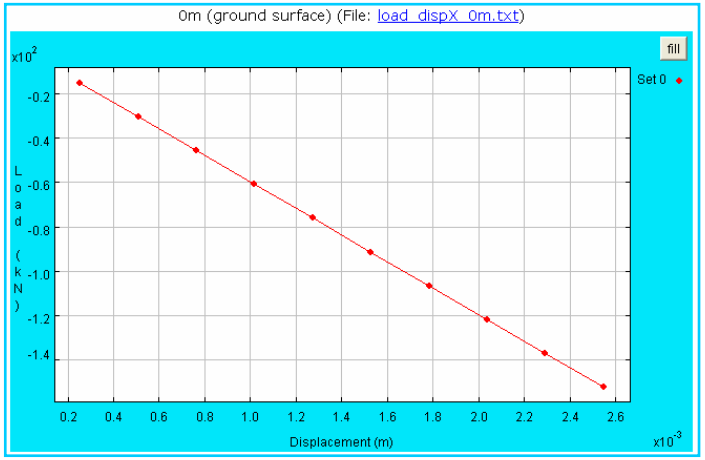


Shear Force History

Output: Pile Response Relationships

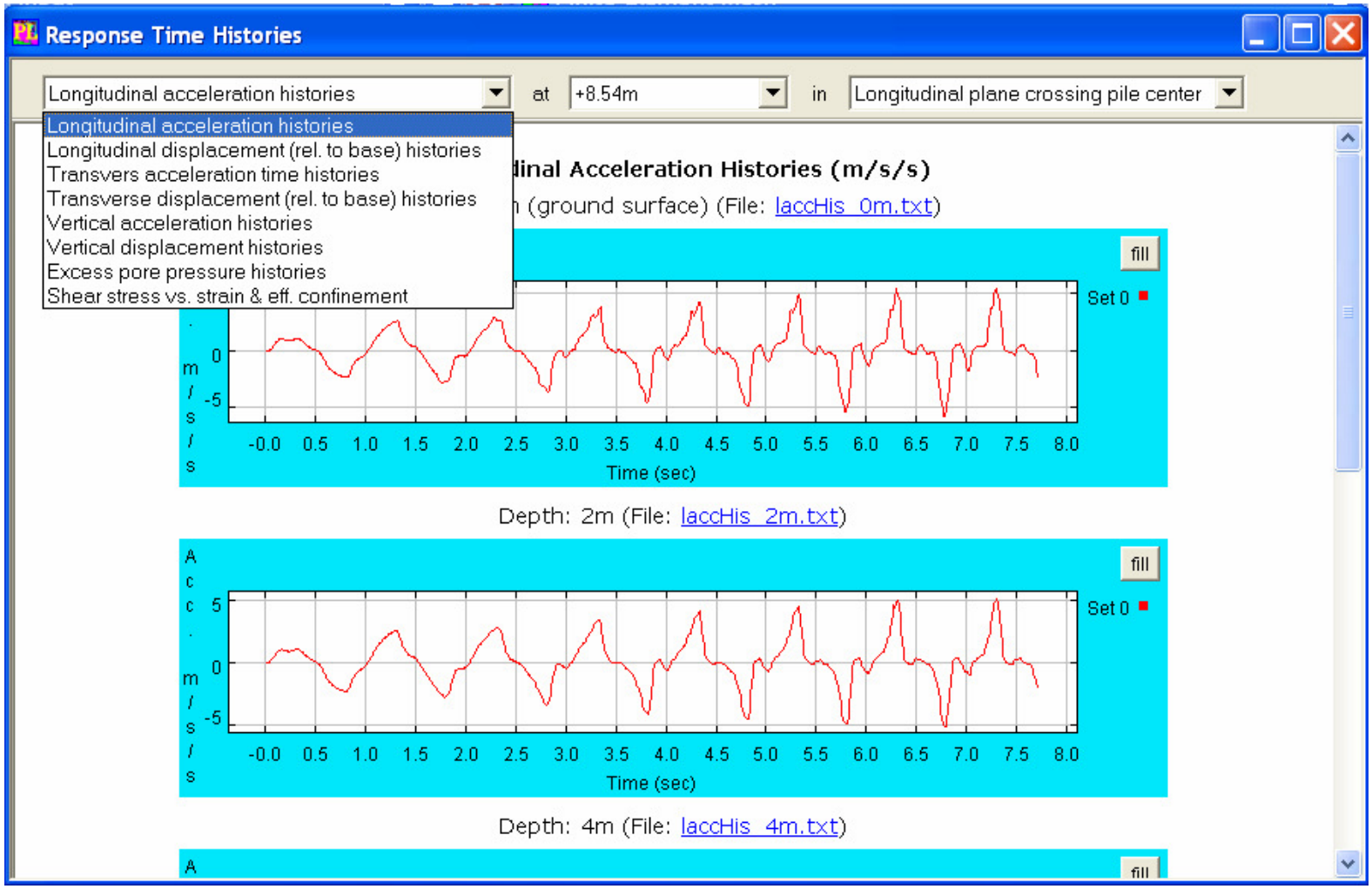


Moment-Curvature Relationship
(at Different Locations of Pile)

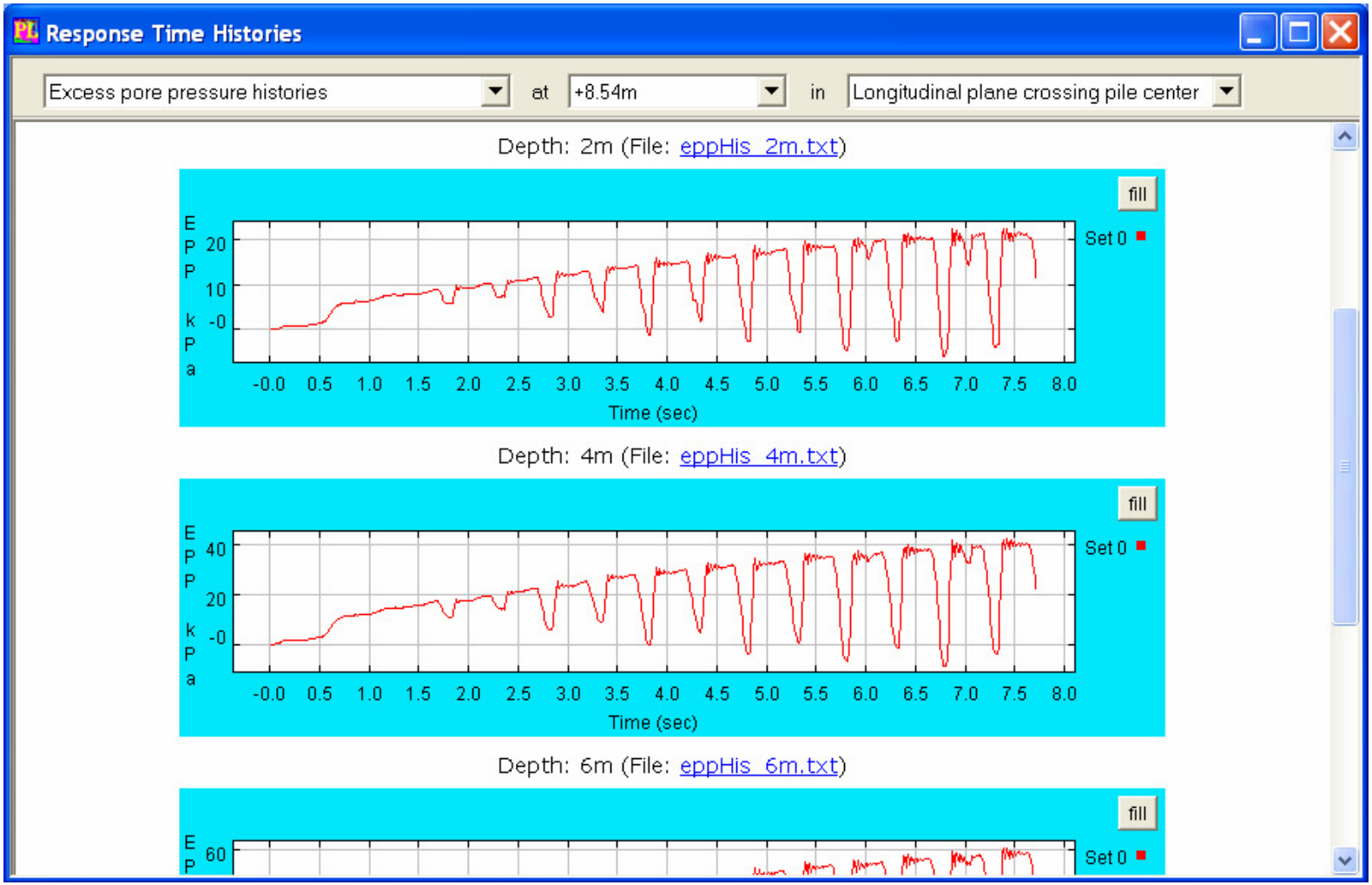


Load-Displacement
Relationship

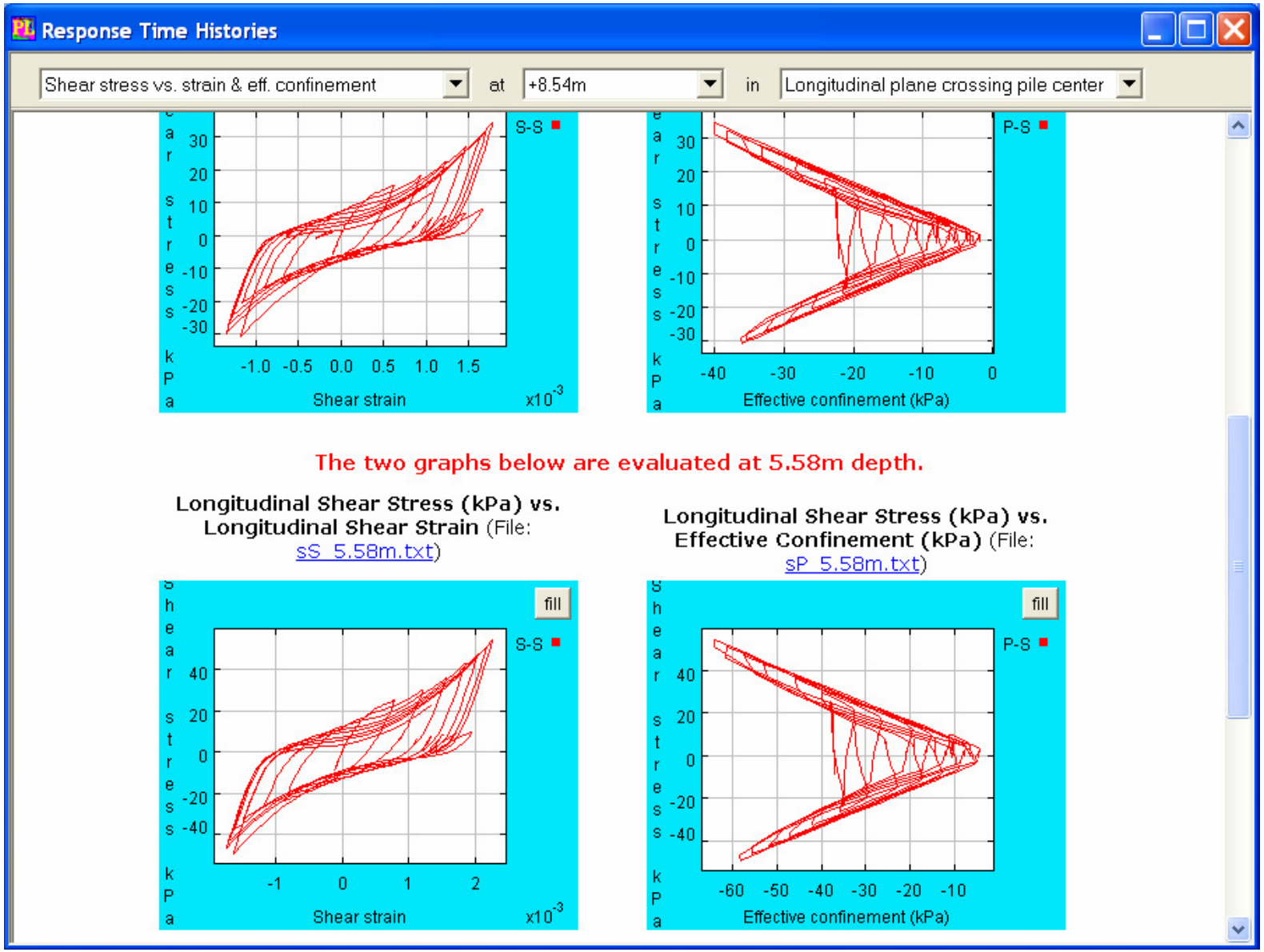
Output: Soil Acceleration Time Histories



Output: Excess Pore Pressure Time Histories



Output: Shear Stress vs. Strain & Effective Confinement

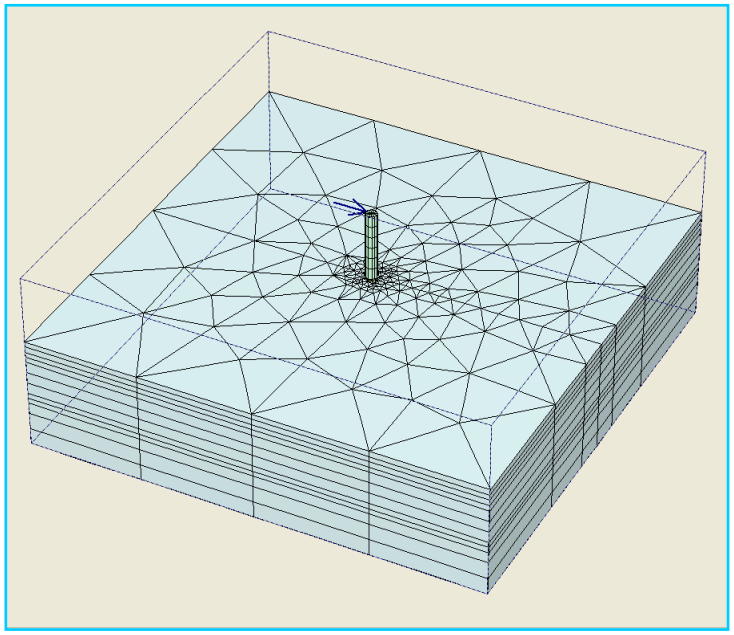


Comparison with PLAXIS

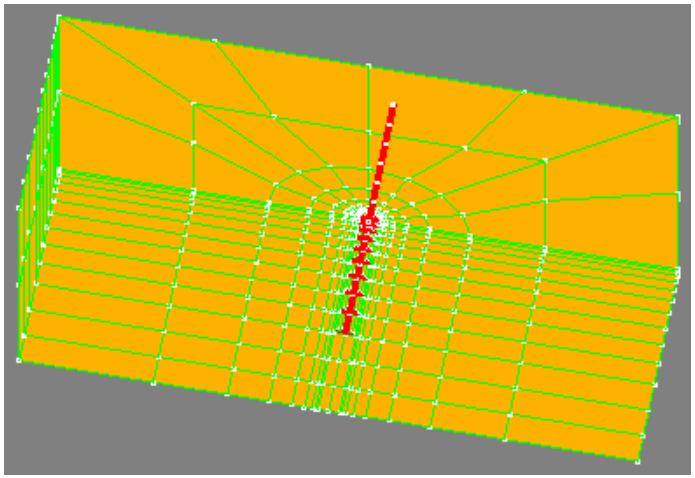
Soil, linear elastic	E	ν
	100 MPa	0.35 (K/G=3)

Compact elastic concrete pile	E	ν	Diameter	I
	20 GPa	0.25	1 m	0.049 m^4

The pile is 6m above terrain, 6m into soil. The soil layer is 10m thick. The load is 100kN at pile head.



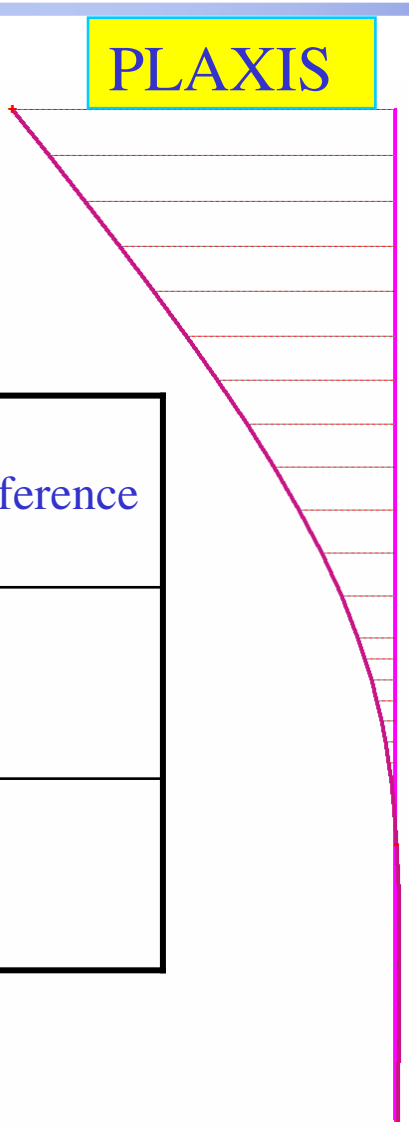
PLAXIS Mesh (S. Nordal, 2006)

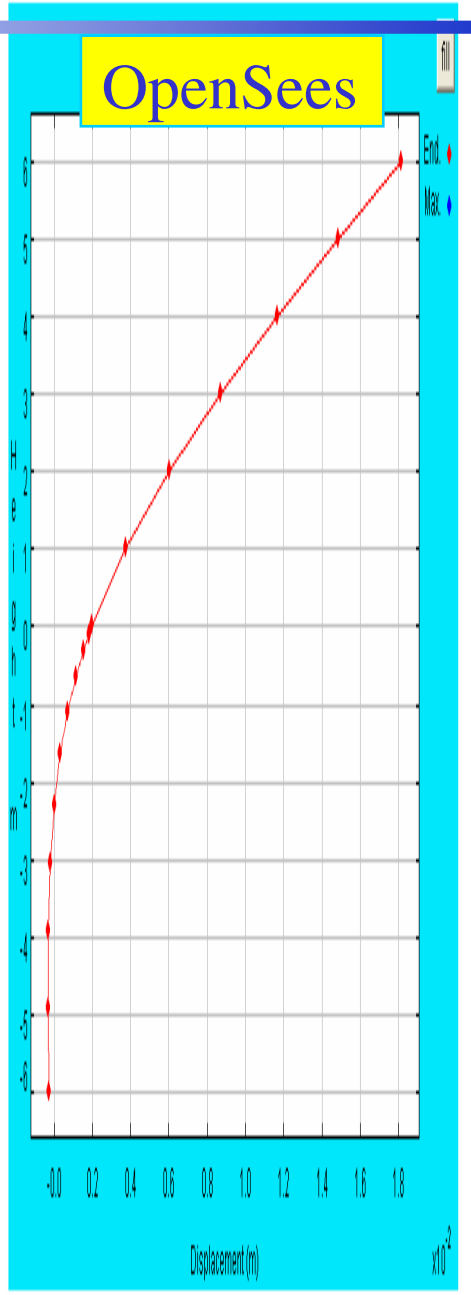


OpenSees Mesh

Deflection Comparison

Deflection (mm)	PLAXIS	OpenSees	Difference
Pile head	19.47	18.13	7%
Ground surface	1.99	1.97	1%

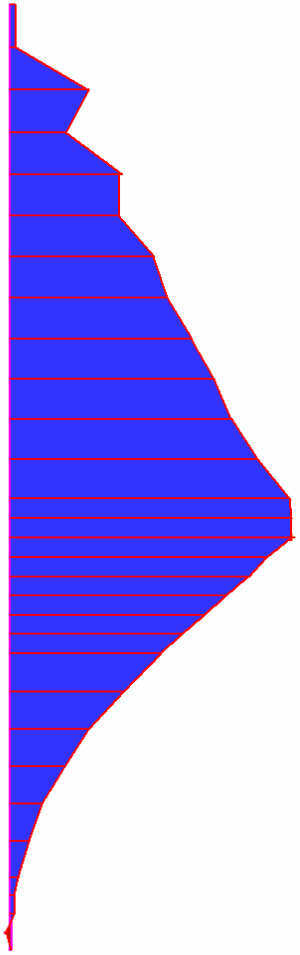




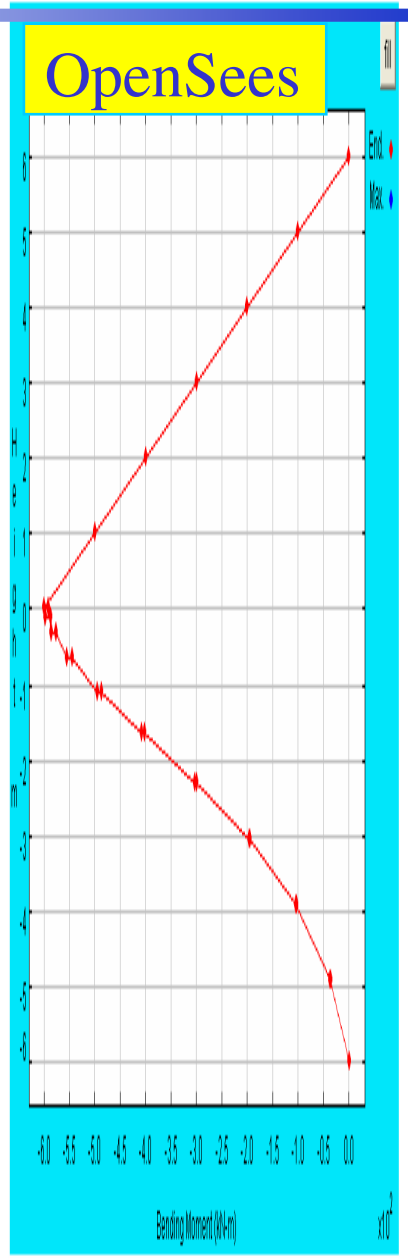
Bending Moment Comparison

	PLAXIS	OpenSees	Difference
Max. Moment (kN-m)	685	600	12%
Location for Max	0.5 m below surface	Near surface	

PLAXIS



OpenSees



Summary

- A user interface for pile analysis using OpenSees was developed.
- Analysis options available include seismic excitation, pushover analysis and ground modification.
- Features include automatic meshing of soil and pile configurations, available libraries of already calibrated soil models, and structural models for seismic response.
- Future work includes option for pile group.
- OpenSeesPL can be downloaded from:

  http://cyclic.ucsd.edu/OpenSeesPL/