3D FINITE ELEMENT ANALYSIS OF LATERALLY LOADED PILE GROUPS USING OPENSEESPL

PEER Transportation Systems Research Program

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Abstract

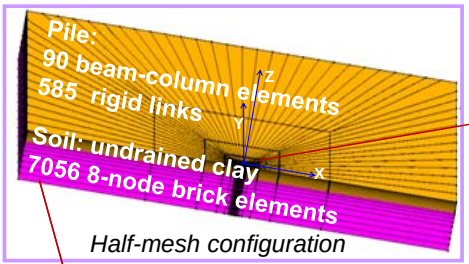
Practice shows that the seismic analysis of laterally loaded pile foundations is critically important. For years, numerous experimental, theoretical and numerical investigations have been conducted to predict the behavior of laterally loaded piles. With the development in material modeling techniques and high-speed efficient computers, linear and nonlinear three-dimensional (3D) finite-element (FE) methods are becoming a promising technique for understanding the involved SSI mechanisms. In this poster, we are describing a computational study to investigate large pile-ground system under lateral load based on 3 dimensional (3D) OpenSees finite element models. For soil model, the influence of an imposed no-tension strength cutoff is also assessed. A robust and versatile framework (OpenSeesPL) for computational analysis of pile-ground systems is employed to facilitate the pre- and post-processing phases. The numerical simulation results provide insights for lateral pile group efficiency and load distribution within the pile group.

Computational Platform

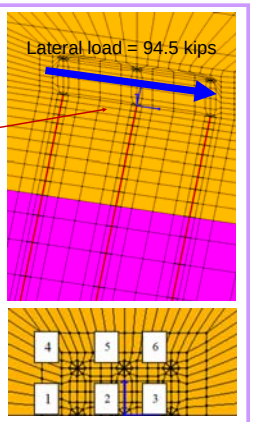
OpenSees: An open-source computational platform developed for simulation of structural and geotechnical systems subjected to seismic load

OpenSeesPL: A window –based graphical user interface to facilitate the pre- and post-processing efforts for 3D pile-ground system analysis

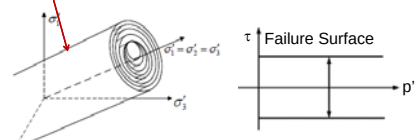
Finite Element Model



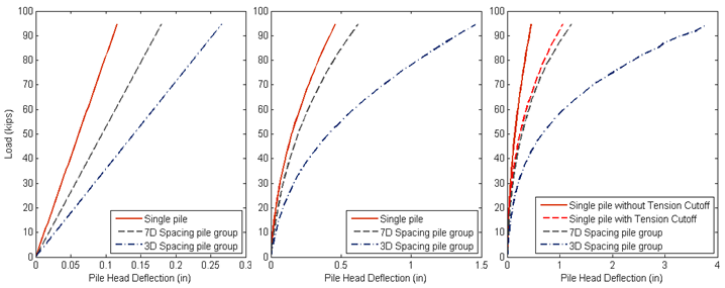
Half-mesh configuration



Close-up Plane view



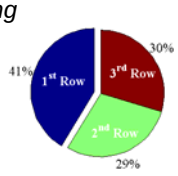
pressure-independent J_2 plasticity



3 ×3 pile group @ 3D and 7D spacing

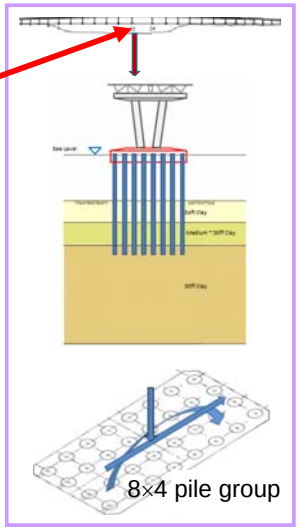
Displacement efficiency (u_s/u_g)			
	Linear	Nonlinear	Tension Cutoff
7D	0.646	0.737	0.864
3D	0.435	0.314	0.279

32%

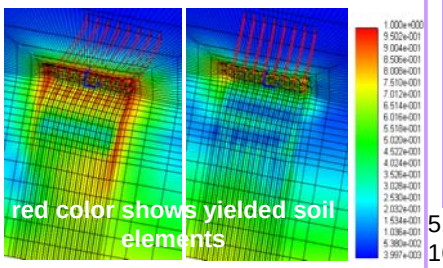


Force distribution

Application for Large Pile Group



stress ratio contour



Loading & unloading

512 beam-column-elements
1664 rigid links
23,040 8-node brick elements

Summary

- ☑ Shear strength fully mobilized within the immediate vicinity of the pile group in nonlinear case ➔ displacement efficiency of nonlinear soil case was lower than that of linear counterpart for close spacing
- ☑ Linear and nonlinear soil cases ➔ the front and back piles show similar load distribution
  Nonlinear with tension cut-off case ➔ the front pile shoulders a higher portion of the load
- ☑ Group effects significantly reduced lateral resistance for pile group relative to single pile
- ☑ Group interaction effects become less significant as the spacing between piles increases ➔ a more uniform loading sharing pattern
- ☑ Gap formation is one of the major factors that influence the laterally loaded pile response

References:
Brown, D. A., Reese, L. C., and Oneill, M. W. (1987). "Cyclic Lateral Loading of a Large-Scale Pile Group." *Journal of Geotechnical Engineering*, 113(11), 1326-1343.
Elgamal, A., and Lu, J. (2009) "A Framework for 3D Finite Element Analysis of Lateral Pile System Response." Proceedings of the 2009 International Foundation Congress and Equipment Expo, Contemporary Topics in In Situ Testing, Analysis, and Reliability of Foundations, ASCE GSP 186, Orlando, Florida, March 15–19, pp. 616-623.
Lu, J., Elgamal, A., Yan, L., Law, K., and Conte, J. (2011). "Large scale numerical modeling in geotechnical earthquake engineering." International Journal of Geomechanics, Special Issue on Material and Computer Modeling, 490–503

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