ABSTRACT

Seo, Hoyoung. Ph.D., Purdue University, December, 2012. Load-Settlement Response of Axially Loaded Piles. Major Professor: Monica Prezzi.

Settlement controls the design of piles in most cases because, by the time a pile has failed in bearing capacity, it is very likely that serviceability will have already been compromised. This notwithstanding, pile foundations are often designed based on the calculations of ultimate resistances reduced by factors of safety. This is in part due to the lack of accessible realistic analysis tools for estimation of settlement, especially for piles installed in layered soil.

In this research, analytical and semi-analytical methods of analysis of axially loaded piles in multilayered soils are developed. First, the governing differential equations for an axially loaded pile in a multilayered, linear elastic soil are derived using the principle of minimum potential energy. The analytical solution to the governing differential equations is obtained by determining the unknown integration constants using the boundary conditions, Cramer's rule, and a recurrence formula. Then the governing differential equations are rederived with consideration of the spatial variation of the shear and bulk modulus in the soil surrounding the pile using a modified hyperbolic constitutive model. While the governing differential equation for the pile remains the same as that of the linear analysis, the governing differential equation for the soil changes, and its solution is obtained using the finite difference method.

The pile base load-settlement analysis is developed based on the analytical solution for a rigid, circular punch on the surface of an elastic half space. After each load increment, the values of the equivalent linear-elastic parameters reflecting the updated level of strain at every discretization node in the soil mass below the pile base are obtained using a modified hyperbolic model. Representative values of the shear and bulk moduli within the zone of influence below the pile base, which are used as input in the rigid punch solution, are then obtained using the distortional and volumetric energies as weighting factors.

Good agreement is obtained between results of the nonlinear analyses of a nondisplacement pile in sand with different relative densities and those from finite element analysis of the limit unit shaft resistance of nondisplacement piles using an advanced constitutive model available in the literature. In addition, results of the pile base load-settlement analysis are in good agreement with results of plate load tests performed in a calibration chamber and of finite element analyses available in the literature. The developed analyses provide useful insights on

the effect of soil layering and slenderness ratio on the load-settlement response of axially loaded piles and can be performed at only a small fraction of the time required for an equivalent three-dimensional finite element analysis.