Elasto-Plastic Soil-Structure Interaction

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Abstract

Success of continuum approaches such as the finite element method in providing accurate and reliable predictions for soil-structure interaction behavior critically hinges on the accuracy and capability of the constitutive models employed for the different types of soil in the foundation. In this presentation, applications of elasto-plastic finite element methods for modeling the soil-structure interaction behavior under static and dynamic loading are presented. In the static case, a real-world problem, where the construction of a landfill near a pile-supported bridge at a rate too fast caused severe damage to the bridge, is simulated by an elasto-plastic finite element method. Analysis of this problem by conventional analysis methods requires numerous assumptions to be made, most of which cannot be verified. Use of an elasto-plastic method provides a means for not only developing an understanding of the deformation and failure mechanisms that led to the observed failure, but also to make realistic and informed assumptions for simplified analyses (which may prove to be efficient for parametric studies). Of course, the finite element analysis provides complete information concerning the soil-pile behavior, including the shear and normal stresses in the piles, which may then be used to investigate the possibility of the failure of piles. However, repeating elasto-plastic finite element analyses in a parametric exercise is computationally infeasible at times. Accuracy of elasto-plastic finite element analyses also depends on whether or not various nonlinearities and other aspects of the physics are properly simulated; for example, fully-coupled formulation to simulate simultaneous deformation and pore water dissipation, interface elements to simulate the pile-soil interface slip/separation, etc. All of these issues are discussed in this presentation. In this type of modeling approach, moving from static simulations to dynamic simulations are conceptually straight forward, provided the constitutive models have the capability to simulate the soil behavior under cyclic conditions (simulating, in some cases, the liquefaction behavior of saturated sands). Examples involving sands and clays in the foundation soil, and static and dynamic loading will be presented.