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Numerical Modeling of Soil-Pile-Interaction with Near and Far Field Earthquake's Effects

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Abstract

This paper studies Near and Far Field effects of the response of a column-pile to earthquakes considering Dynamic-Soil-Structure-Interaction (DSSI) effects in soft clay (Vs<180 m/s) and stiff clay (180<Vs<375 m/s). Opensees software that can simulate the dynamic time history analysis is used. Both kinematic and inertial interactions are considered and Finite Element Method (FEM) is used to solve DSSI. The direct method applies to 3D modeling of the layered soil and column-pile. A Pressure Independ Multi Yield Surface Plasticity Model is used to simulate different kinds of clay behavior. Time history seismic analyses provide for the mass and stiffness matrices to evaluate dynamic structural response with and without directivity effects for Near and Far Field earthquakes. Results show that the Multi-Yield-Surface-Kinematic-Plasticity-Model can be used instead of bilinear springs between piles and clay soil, for both Near Field and Far Field earthquakes. In addition, comparing Near and Far Field analyses, acceleration response spectrum at the top of the structure in the Far Field increases with the softness of the soil more than that in the Near field.

Keywords: Dynamic Soil-Structure-Interaction; Multi Surface (Von Mises) Plasticity Model; Opensees; Near Field and Far Field Earthquake; Soft and Stiff clay.

1. Introduction

To understand the behavior of pile-column in a nonlinear modeling of soil considering soil-pile-structure-interaction, considering Near and Far Field is designated for earthquakes. Based on the previous studies, Near Field ground motions can make ground motion features naturally different from those in the Far Field due to forward rupture directivity, fling step effects, vertical seismic component, velocity pulse, hanging wall and footwall and vertical earthquake ground motion [1, 2]. The effect of forward directivity pulse (forward directivity pulse happens when the front rupture spreads toward the site, and the fault slip direction is aligned with the site [3]) and fling step play a crucial role in the Near Field earthquake because of the large energy that can cause considerable structural damage during an earthquake. Figure 1 shows that the velocity and displacement of near fault ground motion and displacements follow directions that are dominated by the fault geometry such as strike and fault rupture propagation.

Winkler foundation, Finite Element, and Boundary Element methods have been used in the soil-structure-pile-interaction analysis. Paying attention to the elastic modulus of the structure, interface of the pile-soil systems and structure material is significant for resonant amplitude and natural frequency [4].

We should consider that the plastic hinge in the pile is not allowed by code rules and specifications owing [5] to three main reasons: (i) plastic hinge locations are not accessible to repair after the strong ground motions which can

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