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Experimental and FE Analysis of Seismic Soil-Pile-Superstructure Interaction in Sand

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Introduction

In this paper, a two-dimensional finite element analysis based on a multi-shear mechanism constitutive relationship, **FLIP** (**F**inite element analysis program for **LI**quefaction **P**rocess) is used to analyze the results of a series of dynamic centrifuge tests of a soil-pile-superstructure model. The soil-pile interaction in three-dimensions is idealized in the two-dimensional type using soil-pile interaction springs with a hysteretic nonlinear load displacement relationship. The system under investigation comprises of a single pile supporting a two degree of freedom structure founded on a homogeneous dense sand layer over rigid rock.

Centrifuge Tests

The model tests were performed using the geotechnical centrifuge at the Disaster Prevention Research Institute Kyoto University (DPRI-KU). The tested model (pile, pile cap, and superstructure) was made from steel. After fixing the pile at the base of the soil container, dry silica sand # 7 was rained in 1 g field using a hopper fixed at a specific high. The sand deposit was then consolidated in 40 g centrifugal acceleration field for 5 min in model scale. The model was shaken in the centrifugal acceleration field of 40 g with and without the superstructure using sinusoidal waves as input accelerations with different amplitudes and different frequencies. Figure 1 shows the bending moment profiles of the pile obtained at the maximum absolute pile cap displacement with and without the superstructure at different frequency contents of the input motion. The figure shows how the dynamic bending moment of the pile affected by the superstructure and the frequency content of the input motion.

Finite Elements

The applicability of the two-dimensional finite element model to model the complex soil-pile-superstructure interaction was checked first as shown in Fig. 2. Then the two-dimensional finite element model was used to carry out a parametric study in the frequency domain, focusing on the dynamic characteristics of the superstructure, as affected by typical foundation properties such as pile slenderness and soil-pile relative stiffness.

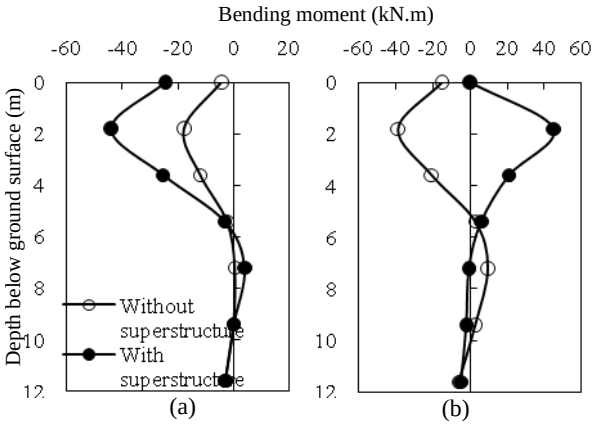

Figure 1. Bending moment profiles at maximum pile cap displacements: (a) 20 Hz; (b) 80 Hz

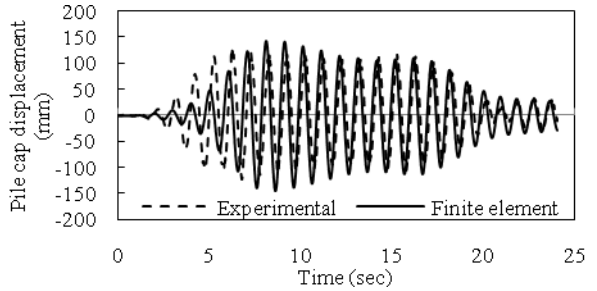

Figure 2. Computed and measured time history of pile cap displacement at 40 Hz input motion.