Centrifuge Analysis of Coupled Soil-pile-structure Interaction

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Introduction

Knowledge of the main parameters that affect the seismic soil-pile-structure interaction (SSPSI) is of utmost importance to evaluate the performance of pile foundations during earthquakes leading to a safe design. In this paper, a series of centrifuge testes are carried out to identify the fundamental frequencies that dominate the response of (SSPSI) system. The examined system comprises of an end bearing pile supporting single (one mass) or double (two mass) degree of freedom structures founded on a homogeneous dense sand layer over rigid rock as shown in figure 1. The role of the frequency content of the input motion on the development of pile bending moment is also studied.

Centrifuge Tests

Experiments were carried out using a geotechnical centrifuge at DPRI-KU under the centrifugal acceleration of 40g. The tested model (pile, column, masses) was made from steel. After fixing the pile at the base of the soil container, dry silica sand #7 was rained in 1g field using a hopper fixed at a specific height. The sand deposit was then consolidated in 40 g centrifugal acceleration field for 5 min in model scale. A total of 4 cases (free field, pile only, pile + 1 mass, and pile + 2 mass) were carried out. In each case, 12 sinusoidal waves as input base accelerations with constant amplitude of 1.5 m/s^2 and different frequencies (1 to 12 Hz) were applied.

Results and Analysis

Figure 2 shows the fundamental frequencies that dominate pile head response. These frequencies includes the effective natural frequency (f_{SSI}) where the structure response U_{m1} (displacement of m1) and U_{m2} (displacement of m2) are maximized relative to the free-field displacement (U_{ff}), and the *pseudo*-natural frequency (f_{pSSI}) where U_{m1} and U_{m2} are maximized relative to the pile-head motion (U_p). It is observed that pile-head motion is substantially amplified at f_{SSI} and de-amplification at f_{pSSI}. These results confirm the result reported in the literature through 3D finite element analyses and extend the applicability of their finding from single to double degree of freedom structures.

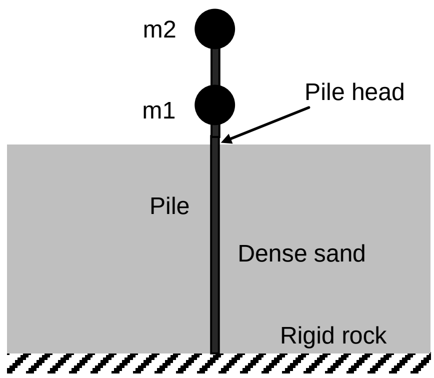

Figure 1. A schematic view of the system under investigation.

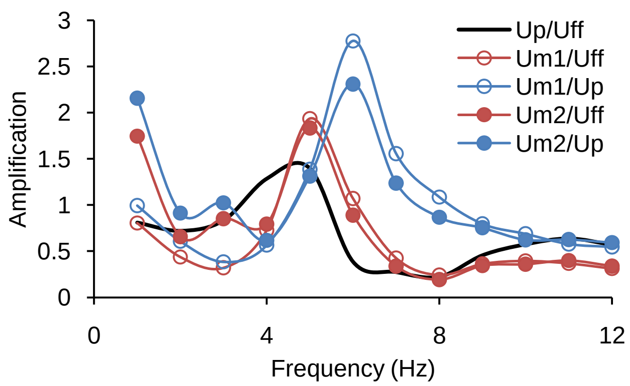

Figure 2. Amplification ratio versus input motion frequencies.