Response of Open-Ended Piles in Sand to Simulated Earthquake and Seaquake

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ABSTRACT

During a simulated earthquake, horizontal motion caused about 20% permanent reductions in both the total axial compressive pile resistance and the plug resistance in an open-ended model steel pipe pile. The loss of capacity was primarily caused by a reduction of bearing capacity at the pile toe. But vertical motion resulted in no loss of pile or plug resistance. Plug failure was not observed in any horizontal or vertical shaking test. During a simulated seaquake, due to the induced excess pore water pressure and pressure gradients in the soil, the capacity of short (≤ 27 m) open-ended single pipe piles installed in a simulated seadepth of greater than 220 m was reduced severely and the soil plugging resistance was degraded by more than 80%. The soil plug failed because of the upward seepage forces that developed in the soil plug due to excess pore water pressure produced in the bottom of the soil plug during the seaquake. The compressive capacity of short open-ended single piles in a simulated seadepth of less than 220 m was reduced only by about 10%, and the soil plug resistance was degraded by less than 5%. But the compressive capacity of an open-ended pipe pile with greater penetration (≥ 27 m) was not degraded, even in sea deeper than 220 m, and the soil plug within the open-ended pile installed in a simulated deep sea was stable after seaquake motion. In the case of the 2-pile or 4-pile groups, the compressive capacity after seaquake motion was not degraded at all regardless of pile penetration depth beneath the seabed, seawater depth or seaquake frequency.

EXPERIMENTAL ARRANGEMENT

The earthquake excitation testing system (Fig. 1a) consisted of a pressure chamber, the model pile, a cantilevered spring-mass system for maintenance of constant biased load on the pile head with a dynamic superposition that represented low-frequency seismic excitations.