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P-y Model Describing Interactions of Piles and Saturated Degradation Sands

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Abstract

Saturated strata will degrade if residual pore water pressures in strata are less than the overburden pressures of strata under seismic loads. Because it is not better understood how to describe the p-y relationships of strata with residual pore water pressures so far, interactions of laterally loaded piles and degradation strata were researched in this paper. Saturated degradation strata were simulated by applying backpressures to strata that overburden pressures were acted on. Fifteen model tests were conducted to research effects of relative densities and residual pore water pressures on p-y relationships of saturated degradation sands. Results showed that lateral resistances of strata gradually decreased with the increase of residual pore water pressures and ultimate lateral resistances decreased by 80-90% for post-liquefaction strata. The method determining the ultimate lateral resistances was developed by defining the equivalent strength of saturated degradation strata and the reduced factor of residual pore water pressure of saturated degradation strata. Subgrade reaction modulus coefficients of saturated degradation strata were analyzed based on model test results, which showed that they also decreased with the increase of residual pore water pressures. Effects of pile-diameter on coefficients were further analyzed using the method of combined the 3D finite element and the Winkler foundation beam. Results showed that coefficients increased with increase of pile-diameter when the diameter was less than 0.4m and approached to constant results suggested in API Code when the diameter was greater than 0.4m. The formula determining coefficients of saturated degradation strata using the equivalent strength was developed. A method determining hyperbola p-y curves of saturated degradation strata was finally developed.

Introduction

It is an important content for offshore platform foundation design to evaluate the seismic resistance of pile foundations. The residual pore water pressure will exist in saturated sands under seismic loads. If the pressure approaches to the overburden pressure of the stratum, it will liquefy. If the pressure is less the pressure, the stratum will degraded due to residual pore water pressures [1], which means that the strength of strata with residual pore water pressures will decrease and lateral resistance acted on piles will also decrease. So it is very important for the design of ocean platform pile foundations to objectively evaluate lateral resistances of saturated strata with residual pore water pressures under seismic loads.

The p-y model based on the nonlinear Winkler foundation beam theory is widely used to evaluate the pile-soil interaction under lateral loads. The hyperbola p-y curve can be used to describe the pile-soil interaction for saturated strata without residual pore water pressures [2-3]. But, it is not better understood how to determine p-y curves of saturated degradation strata so far. Therefore, p-y curves without considering the effect of residual pore water pressures are used to describe p-y relationships of saturated strata with residual pore water pressures for designing ocean platform pile foundations at present, which may be incorrect.

In order to understand the p-y relationship of saturated sand strata with residual pore water pressures, Wang used the p-multiplier method to research variations of p-y curves during strata liquefaction by back analyzing shake table model test results [4-5]. To quantitatively analyzed interactions of piles and saturated degradation strata, Wang further developed a method simulating saturated degradation strata with different residual pore water pressures by applying the backpressure to saturated strata that the overburden pressure was acted on [6-7]. The method can be used to quantitatively research variations of p-y curves by model tests of pile-soil interaction under keeping constant residual pore water pressure in strata.

The silty fine sand and the fine sand were selected and above method were used to prepare saturated degradation strata with different residual pore water pressures. P-y relationships of saturated degradation strata were studied by model tests. Variations of the ultimate lateral resistance and the subgrade reaction modulus coefficient with the