P-y Curves of Piles in Saturated Degradation Sands with Residual Pore Water Pressures

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ABSTRACT

To improve our understanding of the lateral load behavior of piles in the saturated degradation sands resulted from seismic loads, a series of lateral load model tests were performed. The goal of the research was to develop a method to determine p-y curves of saturated degradation sands. The backpressure method was first developed to simulate residual pore water pressure in saturated sands due to seismic loads and was used to conduct model tests corresponding to five specific residual pore water pressure ratios for saturated sands with relative densities of 30% and 50%. Following conclusions were obtained based on test results. The lateral resistance of the stratum rapidly decreased with an increase of the residual pore water pressure ratio when the ratio was greater than 0.25 and approached to the lateral resistance of the liquefied stratum when the ratio reached 0.75 for looser saturated sands. The lateral resistance gradually decreased with an increase of the residual pore water pressure ratio and was obviously greater than that of the liquefied sands even through the ratio reached 0.75 for denser saturated sands. The ultimate lateral resistance of degradation strata could be determined based on the strength of degradation strata. Degradation p-y curves could be also expressed using three segment curves suggested by Reese. The relationships describing the subgrade reaction modulus coefficient, the ultimate lateral deflection and the diameter of piles were further established to quantitatively determine *p-y* curves of degradation strata. Finally, a method was developed to determine *p-y* curves of degradation strata based on these relationships.

KEY WORDS: lateral bearing capacity of piles, piles in liquefied sands, pile-soil interaction, model tests, lateral load behavior of piles.

INTRODUCTION

It is very important for the design of offshore platform foundations to evaluate lateral bearing capacity of piles under seismic loads. Previous researches more concentrated how to evaluate the lateral bearing capacity of piles in liquefied saturated sands. There are three methods to evaluate the bearing capacity at present. (1) Non-strength method. The lateral resistance is assumed zero for liquefied saturated sands. It is more conservative because the residual lateral resistance of liquefied strata is not considered. (2) Residual strength method (Wang and Reese 1998). The *p-y* curve of liquefied sands is determined using the method to determine the p-y curves of soft clays based on the undrained residual strength of liquefied sands (Matlock 1970). Because it was difficult to determine the residual strength describing the in-situ liquefied stratum using the laboratory method, Wang and Reese suggested that residual strengths of in-situ strata were estimated using the relationship between STP results and the strength developed by Seed and Harder (Seed 1987, Seed and Harder 1990, Wang and Reese 1998). But estimated results were frequently scattered because scattered SPT results. (3) P-multiplier method. A simple scale p-multiplier that was less than 1.0 and depended on the relative density of strata was applied to static *p-y* curves to account for the effects of liquefaction. It was ever researched how to reasonably determine the p-multiplier and different conclusions were obtained (Liu and Dobry 1995, Wilson 2000, Tokimatsu 1999, Wang and Feng 2004, 2005). In-situ model test results showed that the lateral bearing capacity was overestimated for less lateral deflections of piles and underestimated for larger lateral deflection of piles if the p-multiplier method was used to evaluate the lateral bearing capacity (Ashford and Rollins 2003, Gerber 2003, Weaver 2005). Therefore, it is necessary for us to improve the understanding of the lateral bearing capacity behavior of piles in liquefied saturated sands. It is noted that the liquefaction of saturated sands is the accumulative process with an increase of the cyclic accumulative pore water pressures. Lateral resistances of strata decreased due to an increase of the residual pore water pressure although strata do not liquefy under seismic loads, which is the degradation of saturated sands. It is difficult how to quantitatively determine *p-y* curves corresponding to degradation strata although some researchers studied the relationship between the *p-y* curve and the residual pore water pressure during liquefaction using model tests or theoretical analysis (Ashour 2000, Wang and Feng 2004, 2005).

On the basis of above analysis, the degradation of saturated sands with specific cyclic residual pore water pressures due to seismic loads were simulated by applying the back-pressure to saturated sands based on the effective stress principle. Lateral bearing capacity behavior of piles in different degradation strata was researched by pile-soil interaction model tests. The lateral resistance of strata and the lateral deflection of piles were determined for saturated degradation sands. A method to quantitatively determine degradation p-y curves was developed.