International Conferences on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics

1981 - First International Conference on Recent Advances in Geotechnical Earthquake Engineering & Soil Dynamics

01 May 1981, 9:00 am - 12:00 pm

Discussion on "Improvement of Characteristics of a Liquefiable Soil Deposit by Pile Driving Operations", by M. Iyengar

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Discussion by Miguel P. Romo, Research Professor, Instituto de Ingenieria, Universidad Nacional Autonoma de Mexico, on "Improvement of Characteristics of a Liquefiable Soil Deposit by Pile Driving Operations", by M. Iyengar.

The author has presented field data showing that the characteristics of a potentially liquefiable soil deposit can be improved on account of pile driving. Both cone and standard penetration - tests carried out before and after piling clearly indicate a significant increase in relative density. Furthermore, lateral load tests performed on piles driven within a pile group showed a better performance than tests carried out on isolated piles.

It is known that being other factors equal an increase in relative density decreases liquefaction potential of saturated, fine sands (Seed, Arango and Chan, 1975). However, pile driving being a destructive operation necessarily modifies the initial conditions of a sand deposit. Additionally, the free field shaking characteristics of a sand deposit can significantly be modified by the effects of the interaction that may be developed among soil, pile and structure. Since these two aspects affect directly the development of pore water pressure, they should be evaluated before it is accepted that an increase in sand relative density, due to pile driving - operations, restrain the generation of pore water pressures which could endanger the stability of the pile foundation or cause unacceptable foundation settlements.

Pile driving effects. When a pile is driven into a sandy deposit in addition to densifying the -- sand around the pile, two further effects are induced: 1) sand grain bonds are broken and 2) static shear and horizontal stresses are in- - creased.

From laboratory tests it has been established - that fresh sand samples are more susceptible to liquefaction than in situ samples due to aging effects (Seed, Arango and Chan, 1975). Thus, - being other factors equal pile driving increases liquefaction potential. On the other hand, when the ratio static shear stress/confining stress of the sandy soil is increased, which is the -- case when a pile is driven into a sandy deposit and then loaded with the structure, the liquefaction susceptibility of medium to dense sands decreases as has been shown from cyclic triaxial tests (Lee and Seed, 1967) and cyclic simple shear tests (Vaid and Finn, 1979).

Since these two effects are opposite, the result of their combined action (with regard to increasing or decreasing liquefaction potential) depends mainly on the variation of the ratio of static shear stress/confining stress with distance - - measured from the pile skin, and on the decrease in stiffness and strength of the sand mass due to sand grain bonds breakage.

Soil-pile-structure interaction effects. If the pile is flexible enough (the stiffness ratio, $\lambda = K\ D\ H^4/(4EI) \geq 4.5$, where K is the horizontal reaction modulus in kg/cm^3, EI is the pile stiffness in $kg\text{-}cm^2$, D is the pile diameter in cm, and H is the pile length or the thickness of the soil deposit in m) then, the pile follows - the ground movements during earthquake shaking and the interaction is negligible. Furthermore, if the structure has characteristics such that its presence does not modify the free field -- ground motion then, for this particular case, the cyclic shear stresses induced by the seismic -- event will be similar to those of the free field; henceforth, it may be safely said that if the final result of piling was to produce an increase in the resistance to liquefaction, the soil within the perimeter of the pile foundation will develop lower pore water pressures than the sand in free filed conditions, and thus, be more -- stable.

On the contrary, if dynamic interaction is de-- veloped, cyclic shear stresses along the interface pile-soil and underneath the mat foundation will be, in general, higher than those corres-- ponding to free filed conditions. In this case, development of high pore water pressures in these zones may endanger the stability of the pile -- foundation or cause undesirable settlements. In order to compute the amplitude and number of - shear stress cycles it is necesary to carry out a dynamic analysis of the soil-pile-structure - system. If the cyclic shear stresses are such that do not cause a significant reduction of the shear strength of the sand within the pile foundation then, the stability of the foundation will not be endangered. If the opposite situation -- occurs, the pile foundation will be unsafe regardless the intrinsic decrease on liquefaction susceptibility of the sand.

References

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