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Stability Analysis of Slopes during Pile Driving

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Abstract : In Geotechnical practice, there is no standard method recognized by the industry to account for the reduction of safety factor of a slope as an effect of soil displacement and pore pressure build-up during pile installation. Pile driving disturbs causes large strains and generates excess pore pressures in a zone that can extend many diameters from the installed pile, resulting in a decrease of the shear strength of the surrounding soil. This phenomenon may cause slope failure. Moreover, dissipation of excess pore pressure set-up may cause weakening of areas outside the volume of soil remoulded during installation. Because of complex interactions between changes in mean stress and shearing, it is challenging to predict installation induced pore pressure response. Furthermore, it is a complex task to follow the rate and path of pore pressure dissipation in order to analyze slope stability. In cohesive soils it is necessary to implement soil models that account for strain softening in the analysis. In the literature, several cases of slope failure due to pile driving activities have been reported, for instance, a landslide in Gothenburg that resulted in a slope failure destroying more than thirty houses and Rigaud landslide in Quebec which resulted in loss of life. Up to now, several methods have been suggested to predict the effect of pile driving on total and effective stress, pore pressure changes and their effect on soil strength. However, this is still not well understood or agreed upon. In Norway, general approaches applied by geotechnical engineers for this problem are based on old empirical methods with little accurate theoretical background. While the limitations of such methods are discussed, this paper attempts to capture the reduction in the factor of safety of a slope during pile driving, using coupled Finite Element analysis and cavity expansion method. This is demonstrated by analyzing a case of slope failure due to pile driving in Norway.

Keywords : cavity expansion method, excess pore pressure, pile driving, slope failure
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