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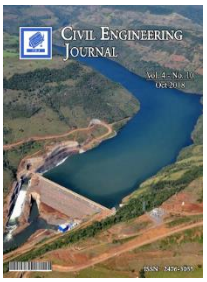

Application of Nor Sand Constitutive Model in a Highway Fill Embankment Slope Stability Failure Study

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Abstract

This paper presents a case study of a static load induced liquefaction in a simple roadway widening project constructed in north eastern part of Ohio in 2008. The widening required an embankment fill, which moved nearly 4 feet vertically and 1 foot laterally after two days of installation. The main objective of the work is to demonstrate how a simple Constitutive model, in this case Nor Sand model, can represent the static liquefaction in loose sand layers under specific conditions. A set of parameters is assumed based on the soil properties and an Excel Spreadsheet is used for simulations of triaxial compression of sand. It was considered that the situation which led to the failure, and the situation after the solution adopted. Moreover, slope stability analysis is provided for validation of the original results using a commercial software. It was found that the model can represent through stress strain curves and stress paths the behavior of the soil layer which led to the embankment fill movement. As the original work considered only slope stability analysis to explain this phenomenon, the present study shows a different approach for the case study, and this is the main contribution of this research.

Keywords: Static Liquefaction; Nor Sand; Slope Stability Analysis; Road Embankment Failure.

1. Introduction

In October 2008 a simple roadway widening constructed in northern Summit County, Ohio, had some issues during the construction. The situation is presented in [1]. It was a 25-foot wide and 15-foot high embankment. Right after the conclusion of fill placements activities, some shear cracking started in the embankment fill (Figure 1). After two days the placed fill had considerably moved (3.5 ft vertically and more than 1.0 ft horizontally) (Figure 2).

The two initial premises for the problem were vertical settlement and rotational slope failure. Four (4) soil borings were made utilizing both Standard Penetration Testing (SPT) and Cone Penetration Testing (CPT). After finishing the exploration program, an analysis was done to estimate the settlement, and it was concluded that this settlement could not be the cause of the failure. Therefore, a slope stability analysis was provided considering a typical section (Figure 3) and was able to simulate static liquefaction caused slope failure for this situation.

Two loading conditions were evaluated to simulate the static liquefaction in the sand layers: undrained condition (during failure) and drained condition (after installation of internal drainage). The undrained condition could be considered for this case because of the confining of loose sand layers between two clay layers (Figure 4). The factors of safety demonstrated that the undrained situation was not in a stable situation, and that a drained situation could change this. Therefore, the only required solution would be a way to change the condition of the loose sands from undrained to drained. The best solution presented in [1] was the installation of wick drains, therefore relieving the pore water pressure

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