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Reliability Analysis of Static Soil Liquefaction Using Random Finite Element Method

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Abstract

Liquefaction of soils, defined as significant reduction in shear strength and stiffness due to increase in pore pressure. This phenomenon can be assessed in static or dynamic loading types. However, in each type, the inherent variability of the soil parameters dictates that this problem is of a probabilistic nature rather than being deterministic. In this research, a random finite element analysis is used for reliability assessment of static liquefaction potential of loose sand under monotonic loading. The Monte Carlo simulation was used for that purpose. The selected stochastic parameters are soil parameters such as unit weight, peak friction angle and initial plastic shear modulus. An elasto-plastic effective stress model is used that simulates the static liquefaction response of loose sands under monotonic loading. The modified Newton-Raphson method is used to consider the effect of changing material behavior in this research. Analysis process was performed in MATLAB code.

Keywords: Static soil liquefaction, Random Finite Element Method, Monte Carlo simulation, Monotonic loading

1. INTRODUCTION

Liquefaction under monotonic undrained loading, commonly called 'static liquefaction', is typically associated with loose and very loose saturated sands and sand-silt mixtures while in situ and under relatively low stress conditions, and may be defined as a large reduction of mean effective pressure induced by a persistent generation of pore pressures. It has been popularly recognized that the liquefaction induced ground failures caused severe damage in various forms such as sand boiling, ground settlement, lateral spreading, landslide, etc. [1].

The first study of static liquefaction was performed by Castro [2], who analyzed the effects of initial void ratio on un-drained behavior of sand. Castro shows that loose sand, which presents a compactive behavior in drained conditions, exhibits, in undrained conditions, an increase of pore pressure leading to a deterioration of effective stresses. Lade and Yamamuro [3], investigated the effect of fines content on the static liquefaction potential under monotonic loading. The results clearly show that the presence of fines can greatly increase the potential for static liquefaction of clean sand. Prisco and Silvia [4], evaluated the static liquefaction of a saturated loose sand stratum with one dimension finite difference numerical code using an elasto-viscoplastic constitutive model. Wanatowski and Chu [5], studied the static liquefaction behavior of sand under undrained plain-strain conditions and a unique relationship between the stress ratio of the instability line and the state parameter are established to enable the triaxial results to be used for plain-strain conditions. Della et al. [6], a study conducted for identification of the behavior of the Chlef sand to static liquefaction. They show that the initial confining pressure and the relative density affect considerably the resistance to liquefaction. Ibrahim et al. [7], studied the static liquefaction of fibre reinforced sand under monotonic loading.

In this paper, a computer program for evaluation static liquefaction potential of sandy soils, based on finite element method, also reliability assessment of safety factor against liquefaction was coded in MATLAB,