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Stochastic Analysis of Dynamic Soil Liquefaction

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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 mostly occurs during the earthquake and it can be assessed in pseudo-static or dynamic loading types. However, in each type, the inherent variability of the soil parameters dictates that the problem is of a probabilistic nature rather than being deterministic. In this research, a stochastic analysis is used for reliability assessment of liquefaction potential based on dynamic loading. The Monte Carlo simulations were used for that purpose .The selected stochastic parameters are soil parameters such as shear modulus, Poisson ratio, unit weight, and friction angle. The thickness of soil layers, the initial water table position and time history record are regarded as constant parameters. This analysis shows that, for the considered case, the Poisson ratio and unit weight are the most subtle Parameters in order to define the liquefaction probability.

Keywords: analysis, Monte Carlo simulation, Reliability assessment, Dynamic soil liquefaction

1. INTRODUCTION

Soil liquefaction is the extreme manifestation of the pore pressure increase when saturated sand soil deposits are subjected to earthquake loading. 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 term liquefaction, originally coined by Mogami and Kubo [2], has historically been used in conjunction with a variety of phenomena that involve soil deformations caused by monotonic, transient or repeated disturbance of saturated cohesionless soils under undrained conditions [3].

Assessment of liquefaction potential has received considerable attention in the past few years. Casagrande [4] was the first researcher who attention to the desire of reduces volume of saturated loose sand under periodic loading in drainage conditions and increase pore water pressure in undrained conditions. Seed and Idress [5] presented an equivalent linear method based on empirical relationships in which the shear modulus and soil damping ratio depends on the level of strain in the soil for dynamic analysis of liquefaction. Martin et al [6] provide an effective stress analysis, which was capable of modeling the effects of pore pressure on the shear stiffness of the soil. This model was modified by Byrne [7]. Fully coupled effective stress approaches that consider shear-induced pore pressures at each time step have been developed by many researchers including Dafalias [8], Beaty and Byrne [9], Elgamal et al [10]. Taibat et al [11] conducted a study to investigate the changes of pore pressure during liquefaction using two, densities and two surface critical state models for saturated sand. The inherent variability of the soil parameters which affect liquefaction potential dictates that the problem is of a probabilistic nature rather than being deterministic. A recent research has been made to apply stochastic analysis to liquefaction potential assessment dynamic loading [12].

In this paper, a stochastic analysis is used for reliability assessment of liquefaction potential based on dynamic loading. For this purpose, two-dimensional area was modeled using the Flac2D software. The Monte Carlo simulations were used as reliability assessment approaches.