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Liquefaction Analysis using Shear Wave Velocity

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Abstract

The Andrus and Stokoe curves developed based on shear wave velocity case history databases, are the most widely used in the context of the Seed and Idriss simplified procedure as a deterministic model. Theses curves were developed from the database according to the calculate Cyclic Stress Ratio (CSR) proposed by Seed and Idriss in 1971 with the assumption that the dynamic cyclic shear stress (τ_d) is always less than the simplified cyclic shear stress (τ_r) deduced by Seed and Idriss based on their simplifying hypotheses ($r_d = \tau_d / \tau_r < 1$). Filali and Sbartai in 2017, showed that rd can in many cases be greater than 1, and they have proposed a correction for the CSR in the range where $r_d > 1$. In this paper, we will present a probabilistic study based on the Bayesian method for the evaluation of the liquefaction potential of a soil deposit using a case history database based on shear wave velocity measurement. The result of this analysis shows that by using the corrected version of the simplified method, the boundary curve is moved to a new position. Then, the objective of this study is to present an adjusted mathematical model which characterizes the new position of the boundary curve (CRR) and a new formulation for computing the probability of liquefaction based on the probabilistic shape of the CRR curves using the corrected and the original version of the simplified method.

Keywords: Earthquakes; Probabilistic Hazard Analysis; Site Effects/Liquefaction; Probability; Random Variable; Wave Propagation.

1. Introduction

After the earthquakes of Alaska (1964) and Niigata in Japan (1964), Seed and Idriss [1] developed a simplified procedure based on in-situ tests to evaluate the liquefaction potential which is defined by a safety factor calculated by the ratio between the Cyclic Resistance Ratio and the Cyclic Stress Ratio (CRR/CSR). Thereafter, this procedure was modified and improved, in particular by Seed [2], Seed and Idriss [3], Seed et al. [4]. Youd et al. [5, 6] in their contribution have modified the expression of the stress reduction factor (rd) to extend it whatever the depth of the soil deposit, Akhila et al. [7] have used an artificial intelligence techniques to predict the cyclic resistance ratio for clean sands. The contribution of Kuo et al. [8] in the improvement of this method were summarized in a proposed empirical simplified method to evaluate the liquefaction potential, Guoxing et al. [9] have developed from a liquefaction case history database a new mathematical model to predict the CRR curves. This procedure is based on simplifying hypothesis by considering the soil column as a rigid body with the assumption that the actual peak shear stress (τ_d) induced at depth, h, is always less than that predicted by the simplified procedure (τ_r) of Seed and Idriss ($r_d = \tau_d / \tau_r < 1$). Thus, Filali and Sbartai [10], in their study, showed that the dynamic cyclic shear stress (CSRD) can in many cases be greater than the Simplified Shear Stress (CSR) according to the used earthquake. This result ($r_d > 1$) was found in the study conducted by Farrokhzad [11] for many sites at significant depth and in the work presented by Sun et al. [12] at shallow depth for a few sites. Therefore, r_d, can be greater than 1 ($r_d > 1$), in this case, this procedure cannot be

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