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Analytical Reliability Assessment of Damped Soil on Rigid Rock Response

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Abstract

One of the most important problems in geotechnical earthquake engineering is the evaluation of ground response. Analysis of ground response is highly amenable to probabilistic treatment because of uncertainty associated to the soil properties. In this research, the jointly distributed random variables method is used as an analytical method for reliability assessment of a uniform damped soil on rigid rock response. The selected stochastic parameters are damping, shear wave velocity and thickness of soil layer. The angular frequency is regarded as a constant parameter. The base is considered as a rigid rock and. The results are compared with those of Monte Carlo simulation. Comparison of the results indicates good performance of the proposed method for reliability assessment of ground response. Sensitivity analyses are conducted to verify the results.

Keywords: Ground response, Jointly distributed random variables method, Reliability, Monte Carlo simulation

1. INTRODUCTION

The bedrock motion is significantly modified at the ground surface due to the presence of local soil layers above the bedrock beneath the site of interest. The estimation of the amplifications in ground response due to the local soil sites is a complex problem to the designers [1]. In practice, linear one- dimensional models are commonly utilized. In these models obtaining the Amplification Function (AF) is the most important stage for site amplification analysis. A deterministic analysis does not allow an assessment of the uncertainty of site amplification analysis, caused by the stochastic nature of geotechnical parameters. Several studies in the literature have dealt with the spatial variability of soil properties (e.g. [4,5]). One of the first works studying the feasibility of a stochastic approach to one-dimensional amplification analysis, using a hysteretic soil model, was developed by Faccioli [2], with a random vibration method. Even a series of parametric analyses may not be sufficient to fully address the problem of accounting for the uncertainty of model parameters [3] in site response analyses. Schevenels et al. [6] used stochastic finite elements applied to a hybrid thin layer, to study the influence of the (small scale) variations of the dynamic shear modulus on the Green's functions of a soil excited at the surface. After that, a Monte Carlo type of analysis has been used by several researchers to understand the sensitivity of a model to uncertain soil parameters (e.g. [7–9]). M. Rota et al. [10] used stochastic 1D site response analysis for considering uncertainty in soil modeling at a site in central Italy. In this research, the jointly distributed random variables method is used as an effective analytical method to assess the reliability of amplification function considering uncertainty in the values of the soil parameters.

2. UNIFORM DAMPED SOIL ON RIGID ROCK

The amplification function for the case of damped soil over rigid rock can be expressed as:

$$F(\omega) = \frac{1}{\cos k^* H} = \frac{1}{\cos(\omega H / v_s^*)} \quad (1)$$