One Dimensional Stochastic Analysis of Site Amplification Potential Using Jointly Distributed Random Variables Method

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Abstract

The amplitudes of seismic wave might amplify significantly as it propagates through the soil layers near the ground surface during an earthquake. Analysis of site amplification potential is strongly influenced by the uncertainty associated to the definition of soil thickness and their properties. In this paper, the jointly distributed random variables method for stochastic analysis of site amplification is used. The selected stochastic parameters are shear wave velocity and the soil thickness. The circular frequency is regarded as a constant parameter. The base is considered as a rigid rock and no damping is assumed for soil layer. The results are compared with those of Monte Carlo simulation. Comparison of the results indicates good performance of the proposed approach for stochastic analysis of site amplification potential. Sensitivity and parametric analyses are conducted to verify the results.

Keywords: Site amplification, Jointly distributed random variables method, Stochastic analysis, Monte Carlo simulation

1. INTRODUCTION

One of the most important problems in geotechnical earthquake engineering is the evaluation of soil layer response to ground surface motion for designing of structures. A soil layer response would determine how the earthquake motions are influenced by the soils that lie above the bedrock [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. 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. 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. [3–5]). M. Rota et al. [6] 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 UNDAMPED SOIL ON RIGID ROCK

The horizontal displacement uniform undamped layer of isotropic, linear elastic soil overlying rigid bedrock can be express as:

$$U(z,t) = Ae^{i(\omega t + kz)} + Be^{i(\omega t - kz)} \quad (1)$$