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One-dimensional site response reliability assessment of damped soil: A comparative study

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Abstract

Ground motion time histories can be significantly affected by the local subsurface geology and morphology. To evaluate the reliability of the results, the estimation of uncertainties is essential. The uncertainties come from the input site parameters as well as from the numerical model. In this research, site parameters uncertainty is considered. For this purpose, a computer program was coded by MATLAB and the point estimate method is used for assessing reliability site response. The results are compared with the Monte Carlo simulation. Damped soil on rigid rock and elastic rock are selected as two different conditions for comparison. The selected stochastic parameters are damping, shear wave velocity, density and thickness of the soil layer for elastic bedrock condition. As well as damping, shear wave velocity and density of rock for rigid bed. The circular frequency is regarded as a constant parameter in each step of ground response analysis in the frequency domain. Comparison of the results indicates the soil layer on rigid rock has higher magnification on the input motion against the soil layer on elastic rock.

Keywords: Site response, Reliability, Monte Carlo simulation, Point estimate method, Ground motion, Stochastic

1. INTRODUCTION

Site response analysis is a critical component of geotechnical earthquake engineering. It facilitates the incorporation of the subsurface material properties as well as surface topography, among others, on the prediction of the amplitude, frequency content, and duration of surface ground motion resulting from a specific input "bedrock excitation." The phenomenon that a soft soil site might amplify the incoming seismic wave is well known. The amplitudes of seismic wave might increase significantly as it propagates through the soil layers near the ground surface. The amplification can be as high as several times the incoming wave amplitude depending on the incoming wave properties and site characteristics.

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 [1], with a random vibration method. After that, a Monte Carlo simulation has been used by several researchers to understand the sensitivity of a model to uncertain soil parameters (e.g. [2–4]). Rota et al. [5] used stochastic 1D site response analysis for considering uncertainty in soil modelling at a site in central Italy. Wang and Hao [6] used point estimate method to consider the effects of random variations of soil properties and ground water level on the random dynamic responses of the soil. Recent researches have been made to apply the jointly distributed random variables to analysis of site amplification potential with considered uncertainties for a layer on rigid rock [7,8]. This study presents the implications of uncertainties of soil properties and effects of rigid and elastic bedrock on the surface response spectra. The effects of the uncertainties of soil are included in the calculation by the point estimate method and the results were compared with Monte Carlo simulation.