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Risks of Solely Relying on V_{S30} in Ground Motion Response Studies

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Abstract

The average shear wave velocity of the uppermost 30 m of earth (Vs30) is widely used in seismic geotechnical engineering and soil-structure interaction studies. In this regard, any given subsurface profile is assigned to a specific site class according to its average shear wave velocity. However, in a real-world scenario, entirely different velocity models could be considered in the same class type due to their identical average velocities. The objective of the present study is to underline some of the risks associated with solely using Vs30 as a classification tool. To do so, three imaginary soil profiles that are quite different in nature, but all with the same average Vs were considered and were subjected to the same earthquake excitation. Seismic records acquired at the ground surface demonstrated that the three sites have different ground motion amplifications. Then, the different ground responses were used to excite a five-story structure. Results confirmed that even sites from the same class can indeed exhibit different responses under identical seismic excitations. Our results demonstrated that caution should be practiced when large-contrast velocity models are involved as such profiles are prone to pronounced ground motion amplification. This study, which serves as link between soil dynamics and structural dynamics, warns practitioners about the risks associated with oversimplifying the subsurface profile. Such oversimplifications can potentially undermine the safety of existing or future structures.

Keywords: V_{s30}; Shear-Wave Velocity; Seismic Site Class; Soil-Structure Interaction.

1. Introduction

Stiffness properties of near-surface earthen materials have proven to have a great influence on seismic wave propagation. Specifically, the nature of ground motions at a given site is heavily influenced by the shallowest parts of the subsurface [1-2]. This is the underlying reason that explains why most of the geotechnical and environmental engineering applications focus on the shallowest 30 meters of subsurface [3] and therefore, a proper characterization of the near-surface is critically important. In this regard, shear-wave velocity (V_s) is among the parameters that is widely used as a proxy to soil stiffness. The vertical V_s profile for a given site can be estimated using a variety of different methods including conventional geotechnical subsurface investigations. Examples of geotechnical testing methods that have been used for such application are standard penetration testing (SPT) or cone penetration testing (CPT). Typically, results from the geotechnical tests are correlated to shear-wave velocity by using empirical relations available in the literature [4-6]. However, it has been shown that such indirect calculations are vulnerable to a large degree of uncertainty [7]. Therefore, one method to overcome the uncertainties associated with geotechnical testing techniques is to perform geophysical testing methods such as borehole seismic testing [8, 9], surface wave testing [10-12], and seismic refraction and reflection [13, 14].

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