SEISMIC RESPONSE OF 2D AND 3D SEMI-SINE SHAPED HILLS AND VALLEYS SUBJECTED TO SIMPLE INCIDENT PULSES

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This research presents the preliminary results of a numerical parametric study on seismic response of two-dimensional and three-dimensional symmetrical semi-sine shaped hills and valleys to earthquake incident waves. All analyses are performed in the time-domain using the finite difference method by Flac 3D software. The medium was assumed to have an elasto-plastic constitutive behavior, while the hystertic behavior of soil is considered using *Finn* model. All models have been subjected to propagating incident waves of the Ricker type. Topographic effects could be defined by the spectral amplification of seismic signals recorded along the topography with those corresponding to the free field motion far away from the topography; thus in this research, maximum horizontal spectral and displacement amplification pattern of the models are presented. The influence of geometry characteristics and type of soil as the key independent parameters governing hill and valley amplification behavior are considered. Different aspect shape ratios (height per radius) and soil parameres (especially reference strain in *Hardin-Drnevich* damping model that can change affect on soil shear modulus and damping ratios) are taken into account.

It was shown that the ground motion was amplified along the hill. At the edges of the hill the ground motion was slightly attenuated. Except for valleys, the attenuation of ground motion in most part of topography model was observed; while there was slightly amplified motion at the edges. According to the results, three-dimensionality has a strong effect on the seismic responses of the hill but has little effect on the valley models. The three-dimensional hill models generally have greater maximum amplification potential compare to 2D models. The 3D valleys have greater maximum attenuation potential along the models and difference of results between 2D and 3D valley models are negligible. Also the amplification potential of models can be affected by the shape ratio and soil type or soil parameters. A sample of results are shown in Figure 1. Maximum horizontal spectral amplification pattern of 2D and 3D hill and valley models with shape ratio (SR) equal to 0.4 and sandy soil with reference strain (γ_r) equal to 0.03 are shown in this figure (x = distance from center of the models and b = radius of the models). The peak value of displacement at the center of the hill generally increased with the shape ratio, i.e., the center of the higher hill experienced a higher peak value of displacement. But the peak value of displacement at the center of the valley generally decreased with the shape ratio, that means the center of deeper valley experienced a lower peak value of displacement. The horizontal spectral amplification potential on three-dimensional models is shown in Figure 2. Generally, the amplification or attenuation potential increased for both hill and valley models as the shape ratio increased. Reference strain is one of the most important parameters in soil dynamic behavior that can change affect on soil normalized shear modulus (G/G_0) and damping ratio (D) curves. Figure 3 demonstrates the influence of reference strain in horizontal spectral amplification potential on two-dimensional models. As can be seen, the amplification potential of hill models and attenuation potential of valley models decreased as the reference strain increased.

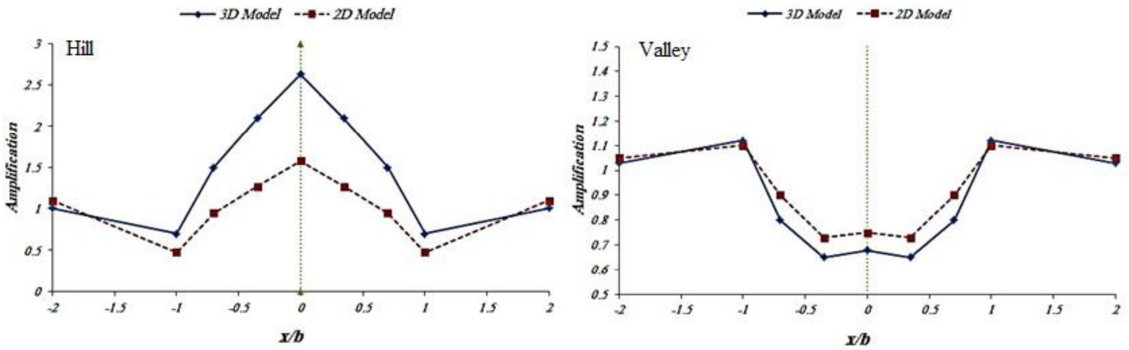

Figure 1. Maximum horizontal spectral amplification patterns of hill and valley models, (SR= 0.4, γ_r = 0.03)

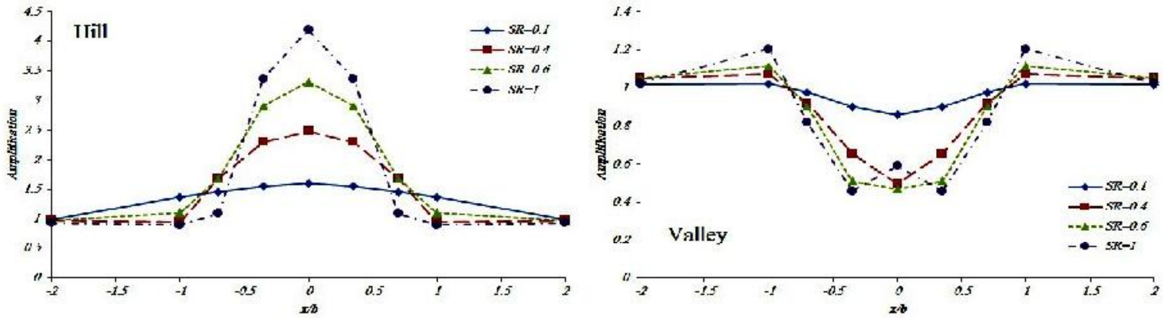

Figure 2. Horizontal amplification potential on the 3D hill and valley models with different shape ratios, (γ_r = 0.03)

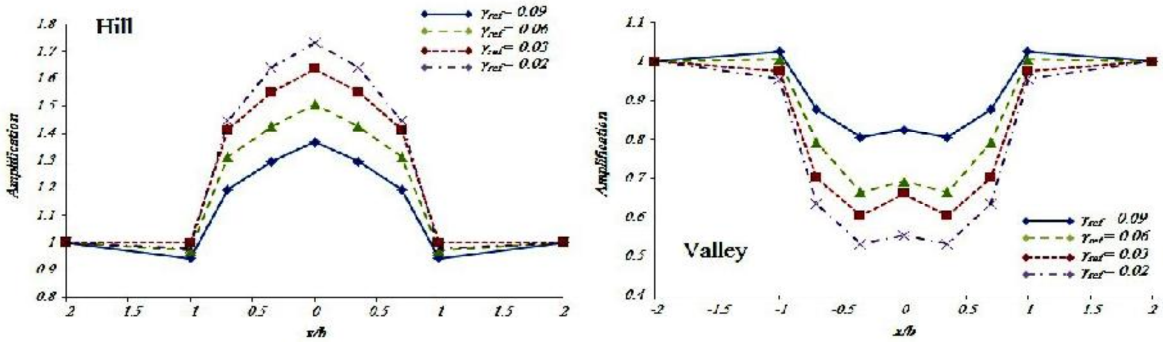

Figure 3. Horizontal amplification potential on the 2D hill and valley models with different reference strain, (SR= 0.4)

REFERENCES

Bouchon M, Schultz, CA and Toksos MN (1996) Effect of Three-Dimensional Topography on Seismic Motion, *Journal of Geophysical Research*, 101 (B3): 5835-5846

Geli L, Bard PV and Julien B (1988) The Effect of Topography on Earthquake Ground Motion: A Review and New Results, *Bull. Seism. Soc. Am*., 78: 42-63

Kamalian M, Sohrabi-Bidar A, Razmkhah A, Taghavi A and Rahmani I (2008) Considerations on seismic microzonation in areas with two-dimensional hills, *Journal Earth Syst. Sci.*,117 (S2): 783–796

Sanchez-Sesma FJ, Bravo MA and Herrera I (1985) Surface motion of topographical irregularities for incident P, SV, and Rayleigh waves, *Bull. Seism. Soc. Am*., 75: 263-269

Sohrabi Bidar A, Kamalian M and Jafari MK (2010) Seismic Response of 3D Gaussian Shaped Valleys to Vertically Propagating Incident Waves, *Geophysical Journal International*, 183 (3): 1429-1442

Sohrabi Bidar A and Kamalian M (2013) Effects of three-dimensionality on seismic response of Gaussian-shaped hills for simple incident pulses, *Soil Dynamics and Earthquake Engineering*, 52: 1-12