EVALUATING THE INTERACTION BETWEEN MULTIPLE IRREGULAR TOPOGRAPHIES DURING EARTHQUAKES

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Soil layers and topographic irregularities can lead to amplification or attenuation of seismic waves. Such phenomena have been theoretically explained and investigated in many researches by means of ground response analysis (e.g. Hasal and Iyisan, 2014). Ground response analyses can properly satisfy the needs for realistic and precise seismic excitation in analysis of structures or in soil-structure interaction. Available methods of the seismic ground response analysis can be categorized in terms of their dimension of calculation. Based on this aspect, numerical studies are categorized into 1D, 2D and 3D analyses. Analyses by these methods can be carried either in time or frequency domain.

In present study, 2D Finite Element Method (FEM) is applied to evaluate the ground response of multiple topographic irregularities and estimation of their interaction effects using time domain approach. Calculation of parameters for a system affected by a dynamic load in a finite element approach in multidimensional analysis is based on the equation of motion, which can be derived as (Kramer, 1996):

$$[M]\{\ddot{u}\}+[C]\{\dot{u}\}+[K]\{u\}=\{f\} \tag{1}$$

where [*M*], [*C*], and [*K*] are mass, damping, and stiffness matrices, respectively. Besides $\{\ddot{u}\}$, $\{\dot{u}\}$, $\{u\}$ and $\{f\}$ are acceleration, velocity, displacement and force vectors, respectively, which vary with time.

Fifteen-node elements were used to model the soil medium because they provide more accurate results since they benefit a better interpolation scheme (Figure 1). These elements have two degrees of freedom defined at every node and have 12 Gaussian points.

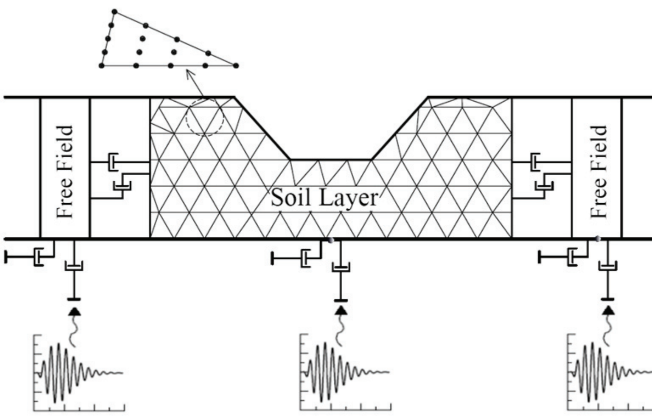

Figure 1. Schematic image of the single topographic irregularity and fifteen-node element.

To investigate the effect of multiple topographic irregularities and site effect parameters on seismic ground response, canyon environment was adopted (Figures 1 and 2). Soil layer was assumed overlain rigid bedrock and seismic excitation adopted were acceleration time histories, which induced to bedrock. Responses were obtained at the ground level at various points.

To illustrate the method, numerical model of seismic wave propagation across a series of canyons were carried out and compared to the case of a single canyon as well as free field condition. The results are presented using amplification factors of different parameters as well as response spectral of acceleration and Fourier amplitude through the canyons span and their surrounding area.

As seen in Figure 2, each canyon considered in this study was symmetric whose maximum depth is h while d refers to center to the center distances of the canyons. L and l are respectively half of the top and bottom span of canyon.

The results showed a much stronger amplification of seismic waves due to the interaction of multiple topographies compared with single one. Comparison of the results indicated the variations of frequency content seen inside the canyon and around it. It was concluded that the locus of maximum and minimum of amplification or attenuation depends not only on the geometric characteristics of the site but also on the frequency content of the incident wave. It was shown that different sites with the same geometric characteristics might require different seismic ground response and special consideration according to seismic zone of the site.

It should be noted that displacement variation on ground surface due to topographical effects is an important parameter to select the site location or design of important structures especially those with linear behavior.

This study highlights the fact that, when evaluating topographic site effects, the interaction of surrounding topographies must be taken into account in addition to effect of local topography and soil layers.

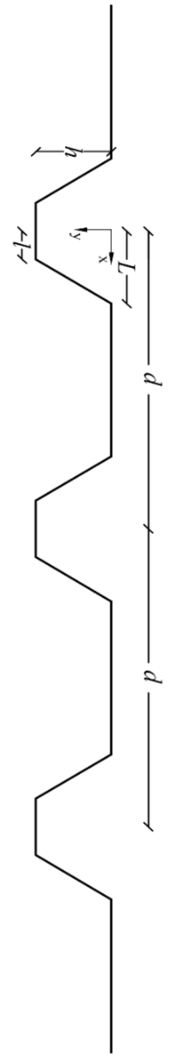

Figure 2. Configuration of adopted multiple canyons.

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