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Numerical evaluation of the effect of soil non-horizontal layering on seismic response of semi-sin alternating hills

M. Amelsakhi[1*], A. Sohrabi-bidar[2], A. Hrati[۳]

Abstract

Topographical and geological characteristics have a significant impact on seismic response of structures. Some topography exists intermittently in nature. Topographic alternation can be one of the reasons for the significant intensification of earth's seismic motion. However, most studies have focused on the amplification caused by a single topography. Limited research has been conducted on intermittent topography and side by side. In this paper, the intensification of seismic motion of the earth in heterogeneous hills (in terms of materials) in the form of semi-sin and alternating materials with layers of angles of 15 to 75 degrees relative to the horizon are investigated. At all angles of layering, with increasing the number of hills, the amount of displacement intensification also increases, for example, for the ridge, at an angle of 45 degrees, with the increase in the number of hills to three numbers, the maximum amplification increases to 2 percent. At smaller angles, the increase in the resonance of three-layer hills is more noticeable than the two-layer hills, and the larger the interlayer angle, the closer the resonance of the two and three-layer hills to each other. Therefore, each of the parameters of changing the angle of materials of the layers in the hill, as well as the increase in the number of layers in the hill, have an impact on the amount of seismic amplifications and each of these parameters should be considered in seismic designs.

Keywords: *Topography, Soil layering, Topographic effects, Semi-Sine Hills*

[1] Assistant Professor, Department of Civil Engineering, Qom University of Technology, Qom, Iran
[2] Associate Professor, College of the Sciences, University of Tehran, Tehran, Iran
[3] M.Sc. Student, Department of Civil Engineering, Qom University of Technology, Qom, Iran
*** Corresponding Author**

Extended Abstract:

1. Introduction

Assessment of destructive earthquakes shows that local conditions such as topography (slopes, bumps and valleys) and geology (alluvialities, fractures and faults) have significant effects on the characteristics of earth movement and seismic intensity. Sometimes, there are differences between field observations and numerical predictions of amplification; recorded ground movements are often larger than numerical predictions.

Since 1974, when Trifunac began theoretical studies on the two-dimensional response of a semi-circular valley stimulated by the harmonic SH wave, many research has been conducted to investigate the site's effects on earth's strong motion. In 2008, Kamalian et al. conducted a numerical parametric study on the seismic behavior of two-dimensional homogeneous hills under progressive vertical SV waves. However, the study of technical literature shows that the main emphasis was generally on the homogeneous environments of single hills and rarely simple horizontal layers.

2. Materials and methods

FLAC^{2D} software is a finite difference program of itasca software that is used for continuous environments. The first step in implementing a model is to build its geometry. Meshing in this software is done at the same time with geometry. Optimization of zone dimensions has a significant effect on model solving time and accuracy of the obtained solutions. Finally, the mesh size of the models is 2×2 meters.

In order to investigate the effect of topographical complications in terms of number and change of layering angle of hill materials on the amplification of the studied site (topography in the surroundings of the study site), three geometric models including one to three topographical complications in the form of semi-sin and shape ratio equal to 1 have been drawn. The height of each of the model hills, 20 meters and the layering angle of the materials of the complication varies between 15, 30, 45, 60 and 75 degrees. Increasing the number of layers in topography at a height of 20 meters for each of the model hills and the layering angle of the complication materials between 15, 30, 45, 60 and 75 degrees has been investigated. The distance between both complications is 10 meters.

Material behavior here is assumed like most previous studies that considered the behavioral model of materials as linear elastic model. The studied topography is under the publication of the actual record of earthquake in vertical direction. This record is related to the acceleration of bedding. In the dynamic analysis section of this study, the ratio of damping 5% and central frequency in each model is equal to the natural frequency of the site.

3. Results

At all layering angles, the greater the number of topography, the greater the exacerbation of displacement; For example, for the ridge, at an angle of 45 degrees, the maximum amplification increases by up to 2% with an increase in the number of hills to three. In heterogeneous environments, wave beams are curved by reflection and failure and concentrate at one point. The concentration of waves has increased each time with the increase in the number of hills, which can justify the increase in magnification. At all angles, with the increase in the number of layers, the amplification of topographies of the single hills and alternating changes.

4. Conclusion

Considering that a wide area of Iran has high seismicity, the effects of seismic intensification of seismic movements should be considered in the design of structures. The most important results of this study are as follows:

• At all layering angles, the topographic number increases, the greater the exacerbation of displacement.

• At all angles, with the increase in the number of layers, the magnification of topographies of the single hills and alternating changes.

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