# ANALYSIS OF ISOLATION OF STRUCTURES SUBJECTED TO SEISMIC EXCITATION USING TRENCHES

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## ABSTRACT

One of the important and commonly studied problems in geotechnical earthquake engineering is the evaluation of responses of structures founded on soil medium. To better understand this phenomenon, several simple models have been proposed. May and Bolt [1] employed the FEM in the time domain, which allowed plots to be made of the complex propagating wave fronts to evaluate the effect of open air trenches in reducing seismic motion for a plane strain idealization. Banerjee, Ahmad and Chen [2] solved the wave screening by barriers using BEM. They considered the soil as layered, isotropic, linear elastic and visco-elastic medium. This paper deals with the evaluation of seismic soil structure interaction (SSI). The soil has been modeled as linear, elastic, homogeneous material and FEM has been used for the analysis. Both, Plane strain and 3D analysis have been carried out. Also effectiveness of vertical trenches for the isolation of structure from the seismic load has been investigated. The effects of various parameters of trench i.e. number of trenches and their location have been studied. Examples have been analyzed for the El-Centro (18 May 1940, California) earthquake and Bhuj (26 Jan 2001, India) earthquake. Also the later earthquake has been analyzed using unequal time steps. A load dependent Lanczos transformation technique has been used to reduce the time of computation and effort. The effect of number of Lanczos vectors on mode shapes and relative error norm of forces and displacements have been investigated. Direct method for dynamic SSI has been adopted for the analysis and a large model has been used to reduce the effect of the area of interest. Boundary absorbers have been included in the FEM model to reduce the effect of reflection of Rayleigh wave energy back to the area of interest. Resulting Finite element equations have been solved using Newmark's β method.

Ground acceleration has been used as base acceleration and variation of acceleration with respect to the depth has been neglected. Results are presented here for the horizontal vibration, because base acceleration in vertical direction is so small than in horizontal direction (about 50 % of that). In this paper, displacement means, horizontal displacement (Y-direction in 3D problem) and amplitude ratio means, horizontal amplitude ratio (Y-direction in 3D problem), unless otherwise specified in other directions. Results have been discussed in terms of geometric parameters of trench normalized with respect to length of Rayleigh wave (Lr) of trenches as follows.

Normalized length of trench = $L / L_r$
Normalized depth of trench = $D / L_r$
where L = length of trench, D = depth of trench,

A non-dimensional parameter, which is called amplitude ratio at any point of time, expressed as the ratio of amplitude of the ground surface/structure with trench to that of the system without trench has been used to express the isolation efficiency. Amplitude ratio of maximum displacement is that ratio which corresponds to maximum displacement with trench to that of the case without trench at same instant of time and it is a measure of reduction in maximum response.

SUMMARY

A complete framework for both plane strain as well as for 3 D seismic soil structure interaction using finite element method has been presented in this paper. This study also is aimed at investigating the effectiveness of trenches as barriers to reduce the seismic soil-structure interaction response. It has been found that multiple trenches (preferably two) are better to reduce the seismic response due to base motion. However effectiveness of trenches depends on various parameters such as their location, size and number of trenches. Depth of trench appeared as the most important parameter. Load dependent Lanczos vectors which also take the convex boundary conditions into consideration have been used to reduce the time of computation and effort. Efficient error monitoring technique has been used to assess the accuracy of transformation. Increasing the number of Lanczos vectors can reduce error in computation. It has also been found that required number of Lanczos vectors increases slightly with increase in degrees of freedom.

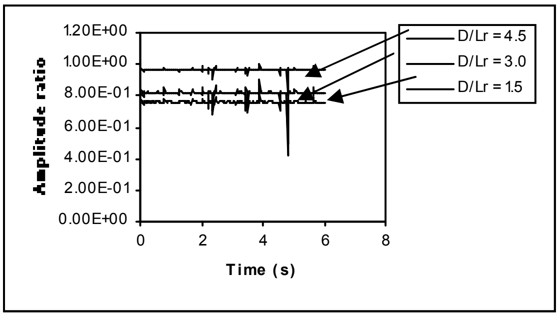


Fig 1. Amplitude Ratio vs Time (Lst/Lr =2 &Ltt/Lr = 12)

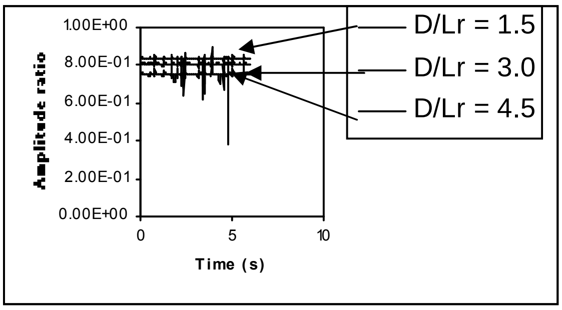


FIg 2. Amplitude Ratio vs Time (Lst/Lr =3 &Ltt/Lr =10)

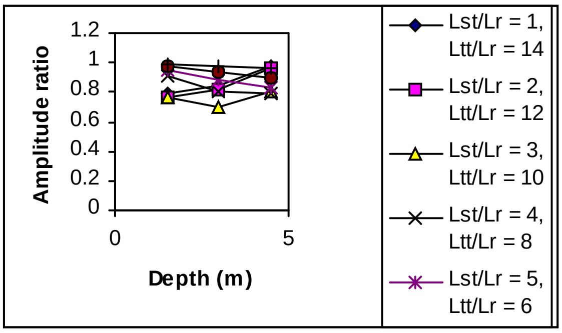


Fig. 3. Effect of location of trench on Amplitude ratio

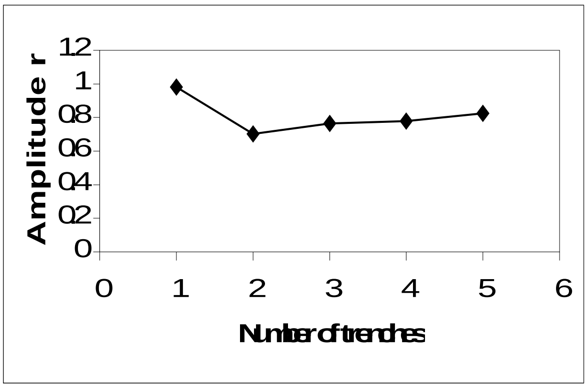


Fig. 4. Effect of number of trenches

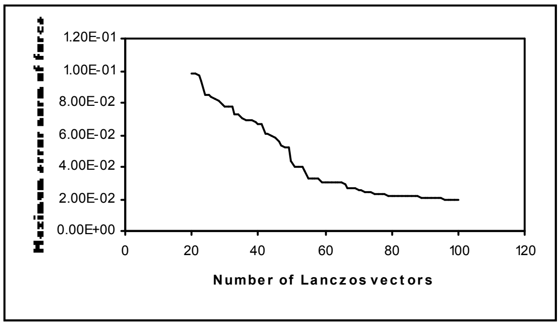


Fig.5. Maximum Error norm of force

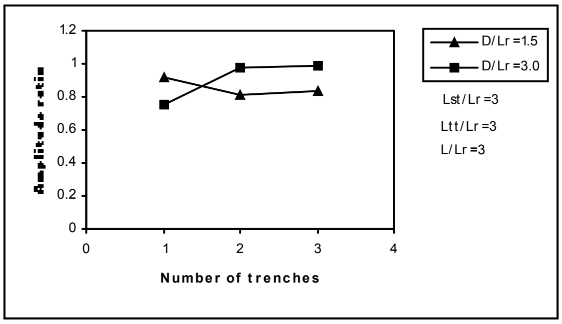


Fig. 6. Amplitude ratio vs Number of trenches