NUMERICAL SIMULATION OF GROUND RESPONSE INDUCED BY EARTHQUAKES

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ABSTRACT

In order to investigate the earthquake induced ground motion in various locations, two-dimensional wave propagation is simulated using the FLAC model with a rigid base. A potential drawback of a rigid base is that the motion at the base of the model is completely prescribed. Hence, the base acts as if it were a fixed displacement boundary reflecting downward propagating waves back into the model.

Therefore, this study investigates by expanding boundaries to minimize this effect of reflecting downward propagating waves back into the model.

Finally, this study compares resultant response spectrum of model 1 with that of model 2. The comparison indicates that the maximum ground acceleration of the model 2 in which the extended boundaries are used is decreased by ten times of the peak ground acceleration of model 1.

Keywords: Earthquake Catalogue, PGA, SA, attenuation

1. INTRODUCTION

In order to investigate the earthquake induced ground motions in various location, two-dimensional wave propagation is simulated using the FLAC model. FLAC is a two-dimensional finite difference program for engineering mechanics computation and FLAC's analysis capability to a wide range of dynamic problems in disciplines such as earthquake engineering, seismology and mine rock bursts. The explicit, Lagrangian calculation scheme and the mixed-discretization zoning technique used in FLAC. Because no matrices are formed, large two-dimensional calculations can be made without excessive memory requirements. The drawbacks of the explicit formulation (i.e., small time step limitation and the question of required damping) are overcome to some extent by automatic inertia scaling and automatic damping that do not influence the mode of failure [1], [4], [5].

However, it is important to note that an acceleration-time history is specified for grid points along the rigid base of the mesh. While simple to use, a potential drawback of a rigid base is that the motion at the base of the model is completely prescribed. Hence, the base acts as if it were a fixed displacement boundary reflecting downward propagating waves back into the model. Thus, a rigid base is not an appropriate boundary for general application unless a large dynamic impedance contrast is meant to be simulated at the base (e.g. low velocity sediments over high velocity bedrock).

Therefore, this study investigates by expanding boundaries to minimize the effect of reflecting downward propagating waves back into the model. For this purpose two flac models are developed as Model 1 which has no extended boundaries and Model 2 which has extended boundaries. Finally, this study compares results of the two FLAC models .

2. DEVELOPMENT OF A FLAC MODEL

At the beginning, a simple FLAC model (Model 1) of 2 km long and 1 km deep ground profile is developed and simulated for an earthquake. Figure 1 shows Model 1 with the approximate grid size of 50mx50m. It must be noted that the model is developed by the quadratic elements avoiding the use of triangular elements to get rid of numerical difficulties.

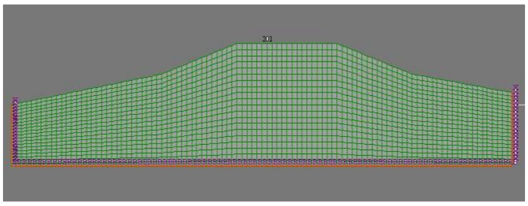

Figure 1- 2D FLAC Model 1

Figure 2 shows the FLAC model (Model 2) with the extended boundary. The three boundaries are extended by 2 km on each side.

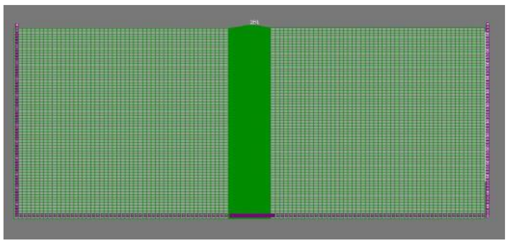

Figure 2- 2D FLAC model with extended boundaries-Model 2

However, for *FLAC* analyses, seismic input must be applied at the base of the model rather than at the ground surface as illustrated in Figure 1. The question then arises: 'what input motion should be applied at the base of the *FLAC* model in order to properly simulate the design motion?'
The appropriate input motion at depth can be computed through a 'deconvolution' analysis using a 1-D wave propagation code such as the equivalentlinear program SHAKE. This seemingly simple analysis is often the subject of considerable confusion resulting in improper ground motion input for *FLAC* models [2], [3].
Numerical model is presented illustrating the typical case that a rigid base, where an acceleration-time history is specified at the base of the *FLAC* mesh.

3. SEISMIC INPUT TO FLAC

Input of an earthquake motion into *FLAC* is typically done using either a 'rigid base' or a 'compliant base'. However, it is important to note that an acceleration-time history is specified for grid points along the rigid base of the mesh. Figure 2, 3 and 4 illustrate the acceleration-time history applied at the base of the model, the response spectrum and the Fourier spectrum of the input ground motion, respectively.

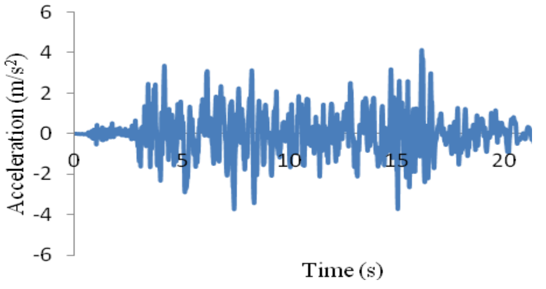

Figure 2 - Acceleration time history applied at base

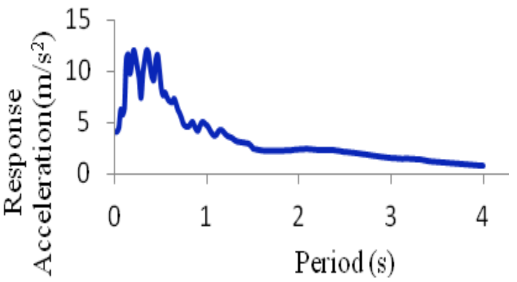

Figure 3 - Response spectrum

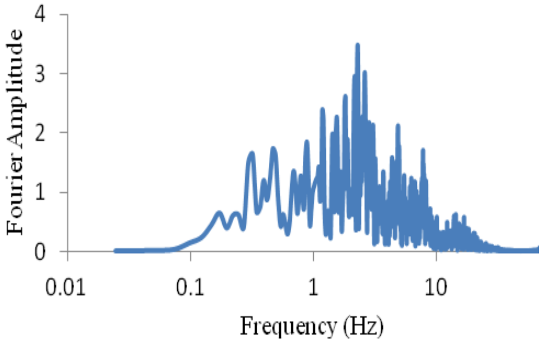

Figure 4 - Fourier transformation spectrum

For accurate representation of wave propagation through the model, element size must be smaller than approximately one-tenth to one-eight of the wave length of the input motion. The wave length is associated with the highest frequency component, which contains appreciable energy, can be identified in the Fourier spectrum shown in Figure 4 as 10 Hz.

4. RESULTS FROM FLAC MODEL

Figure 5 and 6 illustrate the acceleration-time history extracted at the top free surface of Model 1 and the corresponding response spectra at the top free surface of the two models. By the comparison of input spectrum with output response spectrum of model 1, twenty times amplification of the output response of can be observed. However, such a high amplification at the free surface can be observed due to trapping of waves inside the model as a consequence of reflection of waves at the rigid boundary. However, by the comparison of input spectrum with output response spectrum of model 2, ten times amplification of the output response can be observed.

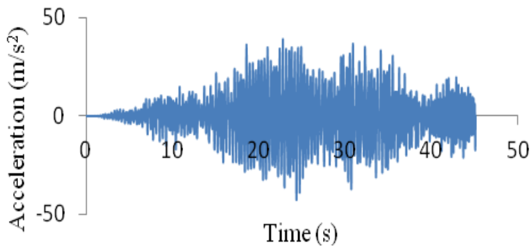

Figure 5- Output acceleration-time history at top free surface.

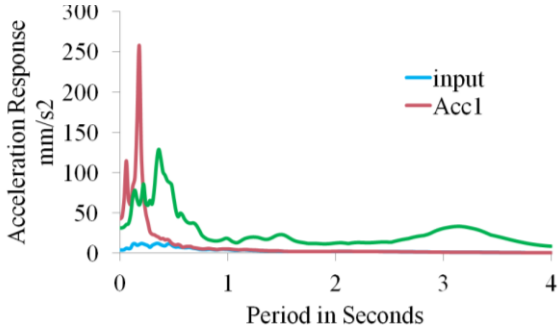

Figure 6- Response Spectrum.

5. CONCLUSIONS

By comparison of input spectrum with the output response spectra of the two models, The following conclusion can be made.

By extending the boundaries significantly, the effect of reflecting downward propagating waves back into the mode to the response of the free surface can reduced drastically.

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