THE INFLUENCE OF LOCAL GEOLOGY ON SEISMIC GROUND MOTION PREDICTION IN VOLVI VALLEY TEST AREA, (GREECE).

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INTRODUCTION

The importance of the influence of local geology on the seismic ground motion and their correlation with the damage distribution is widely recognized in earthquake engineering. The geometry of the subsoil structure, the variation of soil properties with depth, the lateral discontinuities and the surface topography increases locally the amplitude and duration of the ground motion created by a seismic event.

Especially, it is difficult to evaluate seismic site effects from experimental observations in zones with low to moderate seismicity, although a significant seismic risk can be present. Geological and geotechnical research offers information about the parameters of the near-surface subsoil structure that allow the estimation of these site effects by means of numerical modelling techniques to improve the seismic hazard assessment.

With this aim, within the framework of the European Community projects, the following projects have been conducted: Euroseistest (EV.5V-Ct.93-0281); Euroseismod (ENV4-CT96-0255); Euroseisrisk (EVG1-CT-2001-00040).

These projects selected the Volvi basin (northern Greece) as European test site to allow experimental and theoretical site effect studies in one of the more active areas in Europe. The site is located in the epicentral area of the 1978, Ms=6.5 earthquake which struck the town of Thessaloniki.

The basin was well instrumented and seismic records in soil and rock sites were obtained. A detailed knowledge of the geotechnical structure is available thanks to joining these observational data with the performed geotechnical and geophysical works in the area.

One of the main objectives in the projects concerning the site effects is to link the high quality earthquakes recordings in the valley with the obtained synthetical estimations using the available accurate knowledge of the subsoil structure and the theoretical methodologies.

For this purpose a Benchmark exercise was proposed to validate the application of several 1D and 2D numerical seismic wave propagation modelling methods in the Volvi Valley.

Real records obtained in soil sites have been used for their comparison with the synthetic ones obtained with the numerical modelling. From these comparisons important conclusions have been obtained relating the considerations of 1D or 2D methods, the linear or non linear behaviour of the soil and the selection of parameters to evaluate local effects (PGA, Arias Intensity, etc.).

Specifically, we present in this work the influence of taking into account different levels of detail in the definition of the geological and geotechnical local subsoil structure in the application of numerical modelling techniques to estimate local effects and the importance of the knowledge of the subsoil properties to estimate synthetically the local effects of local geology structures.

GEOLOGICAL SETTINGS OF THE VOLVI VALLEY

The area of Volvi is located in the Mygdonian graben (Figure 1), 30 km north-east of the town of Thessaloniki in the epicentral area of the 1978 earthquake. The region is characterized by an active fault system.

The Mygdonian basin is located in the Serbo-Macedonian massif which consists of a crystalline basement (gneiss) with intercalations of marble bands. The valley is on E-W graben divided by a ridge in the basement into the two basins of Langada and Volvi.

Accurate geophysical and geotechnical investigations have been performed in the valley (Euroseistest, 1995; Jongmans et al., 1998). These studies, including surface and borehole seismic surveys, electrical measurements, aeromagnetic campaigns, geotechnical in situ investigations, laboratory tests and a “big shot” experiment, have allowed constructing the geometry and estimating the physical properties of the area where the test site is located. Especifically, the thickness, stiffness, shear and compressional wave velocities and attenuation of soil materials are very important parameters for theoretical estimations of site effects.

The interpretation of the acquired data during the research has shown that the Volvi basin mainly consist of lacustrine and deltaic sediments filling a graben structure (Mygdonian graben). The crystalline basement is dislocated in blocks by at least four normal faults (Jongmans et al., 1988), and the resultant Valley, reaching a depth of 200m deep and 5.5 km wide in the test area, is filled with materials with heterogeneous granulometry. The superficial layers are mainly composed of clayey, silty and sand material with different compactation intensities. The water table is located in these layers. In the deeper parts of the graben, the weathered crystalline basement composed of micaceous gneisses and schists is overlaid by red clay beds and sandstone layers belonging to the Neogene succession of the Promygdonian system.

a)

b)

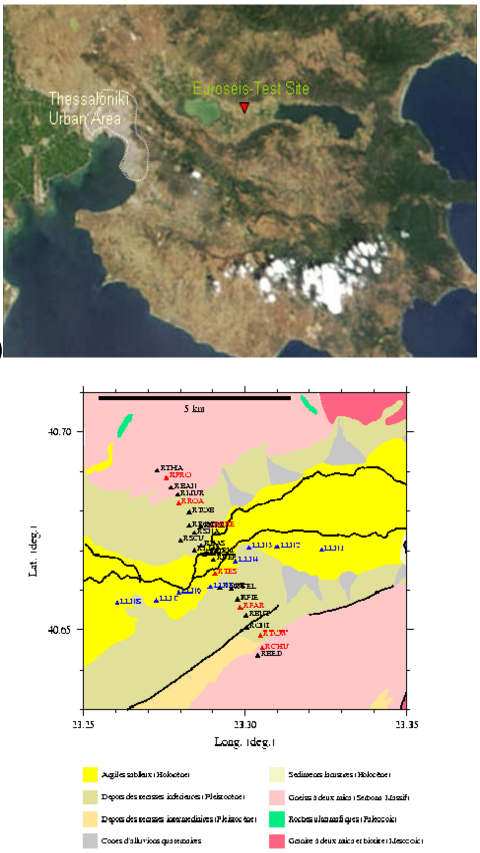

Figure 1 – a) Test Site location. b) Geological map of the Test Site with the seismological network installed by Aristotle University Thessaloniki – Geophysical Laboratory (AUTH-GL).

In Figure 2 is presented a reliable model of the geological structure across the valley obtained from the interpretation of available geophysical and geotechnical data. In the model construction, the attention is focussed on the definition of sediment-bedrock interface, the evaluation of possible lateral variations of the geology and the definition of the superficial formations (Makra et al., 2002).

NUMERICAL MODELLING

As mentioned in the introduction, with the purpose to calibrate different numerical seismic wave propagation modelling methods for the site effects analysis, a Benchmark ("blind" experiment) was proposed during the Euroseismod project.

The exercise consisted of the computation of the ground motion that could be observed with different input motions along the Volvi's Valley by the application of different 1D linear, 1D linear equivalent, 2D boundary element or finite differences numerical simulation methods (Cid et al., 1998; Chávez Garcia et al., 2000).

To perform the computations it was needed the geological definition of the valley structure. The geological and geotechnical structure model presented in figure 2 was simplified and two geotechnical models were proposed to be used in the modelling. One is the AUTH model that considers the free surface layer without topography, and the other, the LGIH model with also flat surface layer and with several sedimentary layers grouped considering similarities between their geology. These simplified models are presented in figure 3.

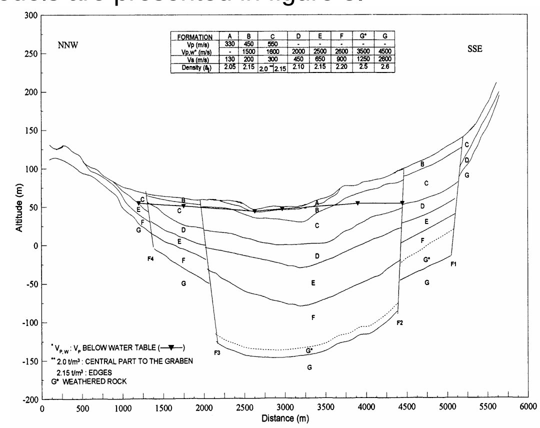

Figure 2 – NNW-SSE 2D geological structure interpretation of the valley obtained from geophysical studies (Makra et al. 2002).

As input motion, it is used actual records in rock site corresponding to different earthquakes occurred in the region. Actual records are also available in soil sites along the valley. This allows the later comparison between real observation and the modelled records.

Wavelet pulses were also used as input motions to make a sensitivity analysis of the considered numerical methods, although they don't allow linking the real behaviour with the synthetic results.

All this computations carried out by the several participants in the Benchmark exercise with the several definitions of geological structure and numerical methods have been processed. The processing of this data involves the computation of several parameters in time and frequency domain that have been chosen to perform the comparisons between the synthetic results and real observations.

The comparison with real records give important conclusions with reference to the use of 1D or 2D geometries in the numerical methods, the considerations of linear or non-linear soil behaviour, the considered attenuation model and which is the influence of the level of detail in the geological structrure definition.

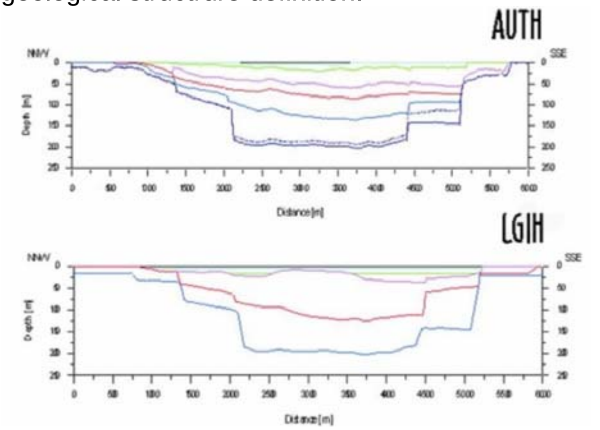

Figure 3 –Simplified models of the 2D Volvi structure, proposed for the Benchmark exercice.

As example, in the Figure 4, it is shown the transfer functions computed along the valley using the computations obtained with 2D numerical modelling method with the two different geological interpretation of the valley (Figure 3) and different attenuation models.

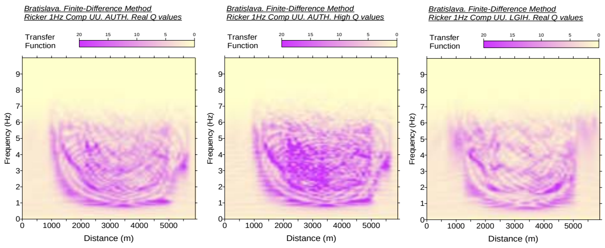

Figure 4 –Transfert functions along the Valley by 2D numerical simulation and different geological models.

As can be seen comparing first and third graphic in the Figure 4, the simplification in the geological definition of the structure model (AUTH vs. LGIH) have a great influence in the soil amplification along the Volvi valley. The response is different in each case. The attenuation model only affects the level of the amplitude of the response along the valley.

A complete analysis of these comparisons is reported in Tapia and Figueras, 2005 and Tapia and Figueras, 2006.

CONCLUSIONS

Local geology has a great impact in the seismic ground motion. These local effects must be taken into account in seismic risk studies.

Seismic areas with no observational data need the application of synthetic methodologies for this purpose. This implies that the knowledge of the geotechnical and geophysical properties is very important.

The mentioned European projects focused their efforts in the achievement of a detailed definition of the local geology of the Volvi valley as site test and the quality data collection in the area.

This research, among other goals, allowed us to validate 1D and 2D wave propagation modelling methods for using them as a reliable estimation of site effects in places where no experimental data are available to estimate the site effects.

In the process of validation of different techniques (Benchmark exercise) has been observed how important is the role of the geometry simplification and the smoothing of the geological properties of the local subsoil. This highlights the importance of carrying out geophysical and geotechnical research in local areas to improve the seismic risk studies.

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