[10]

Environmental
and Engineering
Geophysical Society
European section

Proccedings of the

IV Meeting of the Environmental and Engineering Geophysical Society (European Section)

Editor
ALBERT CASAS

September 14 - 17, 1998
Barcelona (Spain)

[10]

COMBINED GEOPHYSICAL METHODS FOR DETAILED MICROZONING STUDIES

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INTRODUCTION

The peak ground motion parameters, related to earthquake hazard at a given site, are strongly dependent on the source process, the ray path and the local geological conditions. The area of Thiva city, situated in Central Greece, is surrounded by seismogenetic zones characterized by high seismicity level (figure 1). The broad region of Thiva has sustained severe damage from earthquakes occurred in near and moderate distances.

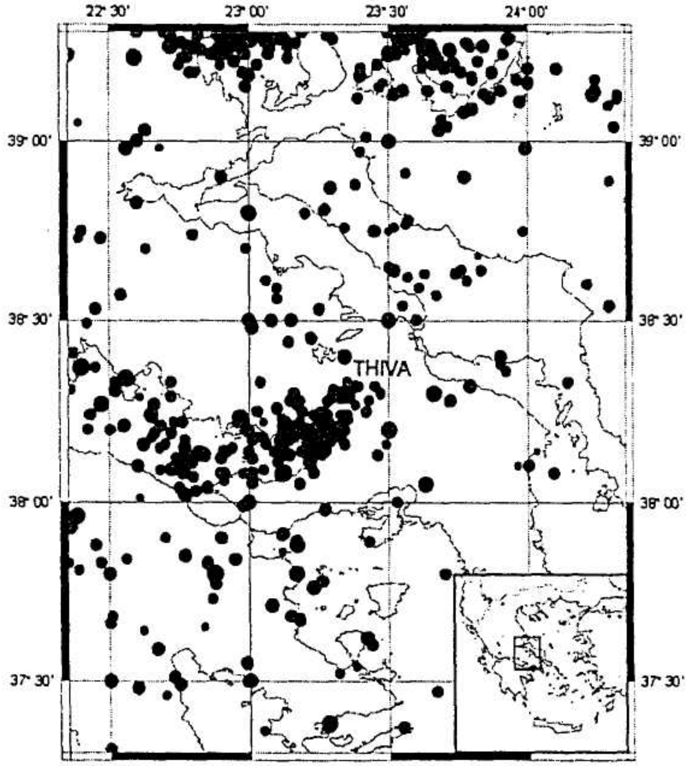

Figure 1. Seismicity in Thiva area during the period 1900-1992.

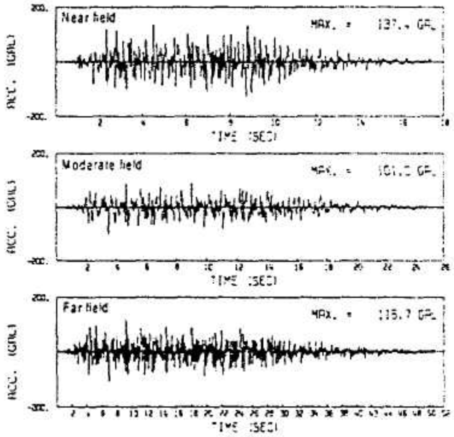

Figure 2. Synthesized strong ground motion for the near, moderate and far field design earthquakes.

Because of high seismicity and poor quality local soil conditions (post-alpine clay and sand sediments of variable thickness), the area has been chosen as a test site for a microzonation study, in order to elaborate on the local effects on the expected strong ground motion at the free-surface. To achieve this purpose a multidisciplinary project comprising of geophysical, seismotectonic, geotechnical and geological studies was carried out, providing valuable data for proposing a detailed microzonation map. The same procedure has also been applied in another area of Greece (Papadopoulos et al. 1997).

[10]

To compute expected ground motion at the free surface, synthetic accelerograms have been calculated based on the results of detailed seismic hazard analysis. Furthermore, the underground structure was investigated using seismic refraction techniques as well as cross-hole and well logging measurements at 5 borehole pairs. The simulated strong motion at the base rock level has been transferred to the free surface by considering the properties of the overlying formations by applying the methodology initially proposed by Schnabel et al (1972) and modified by M. Idriss and J. Sun (1992).

INPUT DATA

To investigate the effect of soil conditions on the frequency content of the expected strong ground motion different accelerograms have been synthesized at near, moderate and far distances (10, 40 and 100 km) with corresponding magnitudes of 6.5, 7.0 and 8.0 respectively (figure 2). The synthesis was based on the random vibration theory (Oshaki et al, 1980), incorporating phase angles of strong earthquakes, recorded at different seismotectonic regions of Greece (Stavrakakis et al, 1997).

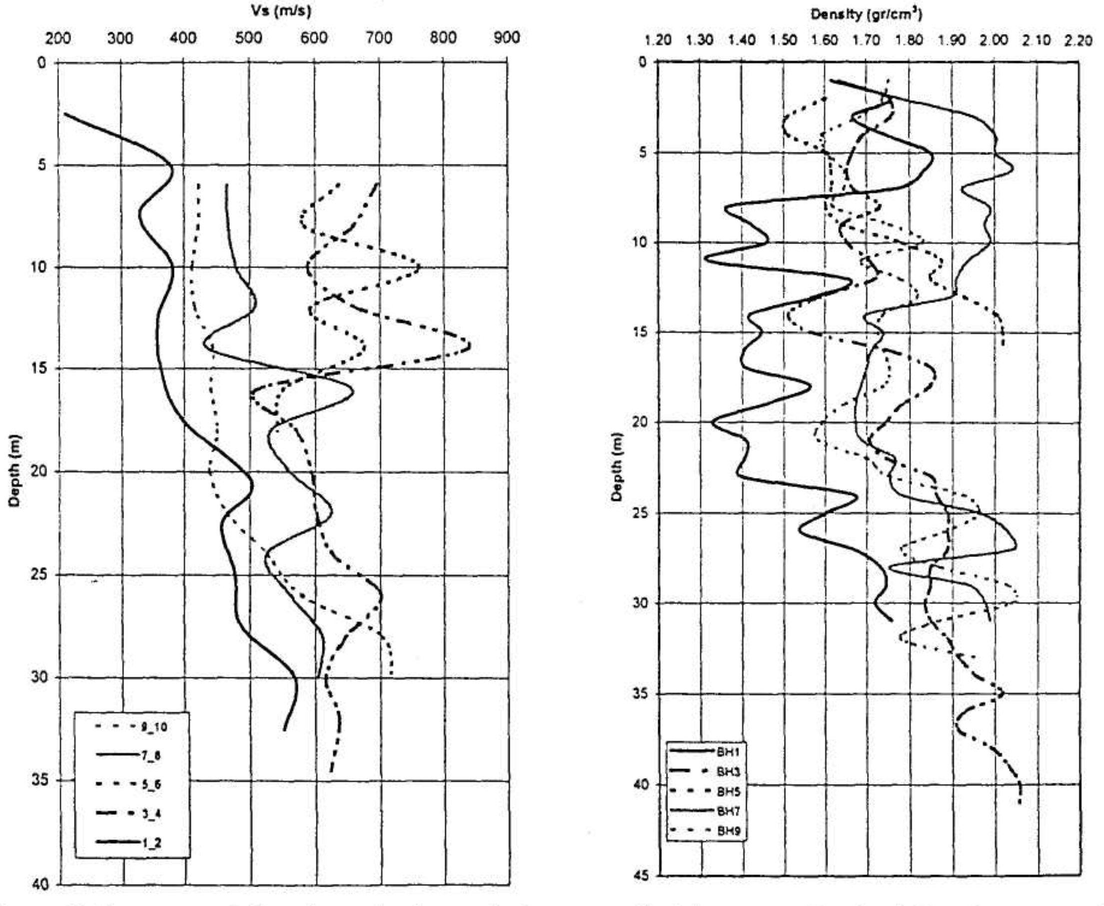

Figure 3. S-wave and density velocity variation compiled from geophysical data interpretation recorded in different borehole pairs.

Cross-hole measurements, conducted at 5 different borehole pairs along a profile with depths varying from 15 to 30 meters, provided a detailed representation of S-wave velocity variation with depth down to the seismic base rock level and well logging measurements in the same boreholes the corresponding density variations (figure 3). Soil characterization, based on the geotechnical tests carried out on the samples obtained, revealed that the sediments overlying

[10]

the seismic basement are clays, silts and sands, with varying plasticity. Based on these observations, a soil profile from the surface to the seismic basement was defined for each borehole pair. The discrete layers of each soil profile were parameterized by assigning a corresponding soil type, S-wave velocity and density value.

GROUND MOTION AT THE SURFACE

Following the above procedure, the spectral acceleration at the ground surface has been computed using data from each pair of boreholes and for different design earthquakes. The obtained results for near and far field design earthquakes are illustrated in figure 4. In this figure the variation of the predominant period of the motion for each pair of boreholes, is evident, strongly depending upon the soil profile and varying from 0.1 to 0.35 seconds for the near and 0.1 to 0.45 seconds for the far field.

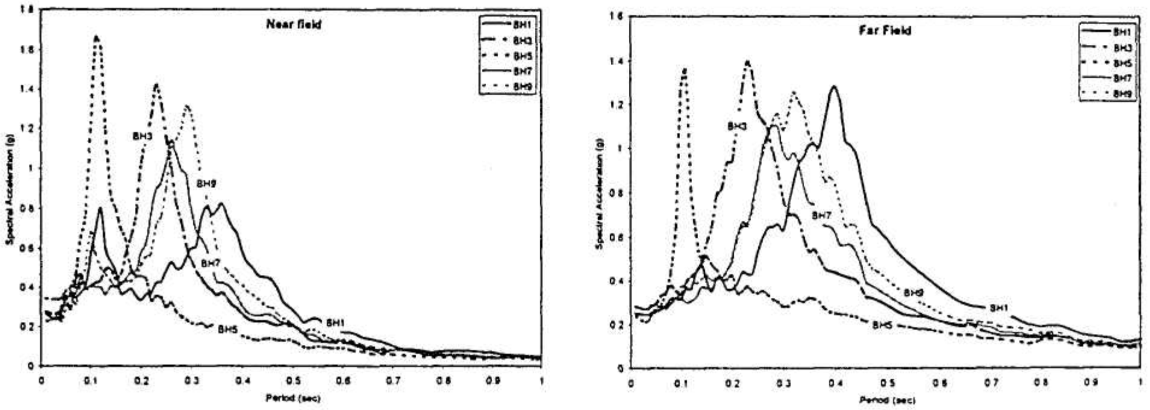

Figure 4. Computed acceleration spectra for the near and far field design earthquakes.

Moreover, according to the near field case results high spectral acceleration at a period of 0.12 sec is expected at the site of borehole 5, characterized by relatively shallow base rock depth. On the contrary, computed spectral acceleration at the vicinity of borehole 1 is remarkably lower displaying twin peaks at periods of 0.12 and 0.35 sec. Hence, in this case of greater basement depth and less consolidated materials, seismic energy of the near field event is distributed over a wider spectrum band. In the case of the far field event the level of computed spectral acceleration for the different borehole pairs is similar while the width of many part of the spectrum varies according to the soil profile. Finally, it should be mentioned that in order

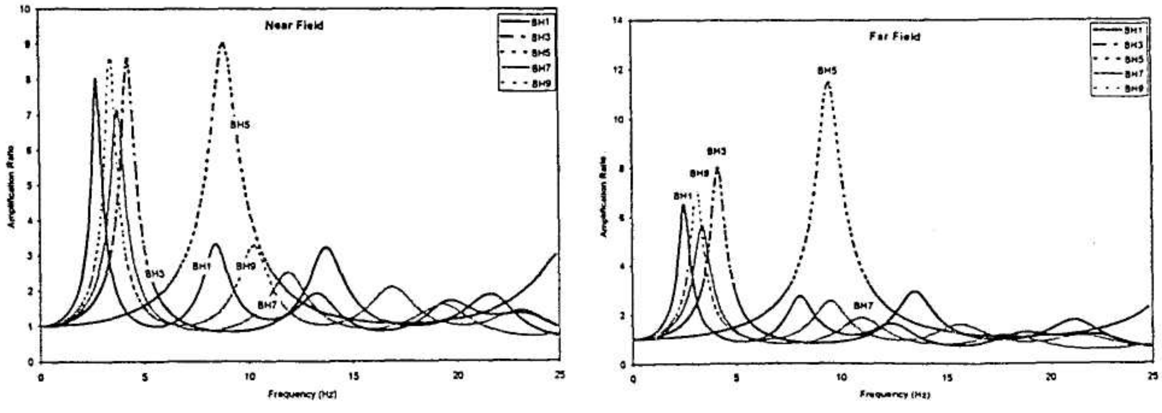

Figure 5. Computed amplification ratios for the near and far field design earthquakes.

to interpret variations observed between the corresponding spectra obtained from far and near field design earthquakes the different characteristics (frequency content and duration of the motion) of the input motion, must also be taken into account.

Similar observations can also be made from the amplification ratio diagrams in figure 5, which indicate that high amplification in the case of shallow base rock depth is expected at frequencies around 10 Hz, while in most cases high amplification is limited at frequencies lower than 5 Hz.

The above results will be considered in order to delineate the final microzonation map for the city of Thiva and define the design parameters for each microzone.

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