Πρακτικά	4ου Συνέδριου	Μάϊος 1988	
Δελτ. Ελλην. Γεωλ. Εταιρ. / Bull. Geol. Soc. Greece	Τομ. XXIII/3 Vol.	σελ. 365-371 pag.	Αθήνα 1989 Athens

A FAULT RUPTURE MODEL FOR SEISMIC HAZARD ANALYSIS IN THE AREA OF MESSINIA, SOUTHWESTERN PELOPONNESUS

G. STAVRAKAKIS*, J. PAPOULIA**, J. DRAKOPOULOS***

ABSTRACT

A fault rupture model for seismic hazard analysis is applied to the area of Messinia, southwestern Peloponnesus, for the specification of the maximum expected ground acceleration over a given duration of time.

The analysis shows that the highest hazard values are originating, as would be expected, from the areas western of Messinia, along the Hellenic Arc.

The dependance of hazard on a certain number of parameters and physical relationships is finally investigated.

INTRODUCTION

The majority of seismic hazard studies for the area of Greece (Algermissen et al. 1976, Drakopoulos and Makropoulos 1983, Makropoulos and Burton 1985b) are based either on statistical or seismotectonic models referred as point source models , since they are formulated under the assumption that the total energy released during an earthquake is radiated from the focus of the earthquake.

In the present study, an attempt is made to assess the regional seismic hazard using the "fault rupture model". The model assumes that an earthquake originates on a fault, at random location, and the rupture front propagates in discrete series of slips in the rupture zone. The maximum of the ground motion at a site is then determined by the slip that is closest to the site (Douglas and Ryall 1975, Kiureghian and Ang 1977).

The most important advance of this model is the consideration of the length of fault rupture as a function of the earthquake magnitude in the probabilistic seismic hazard estimations.

Uncertainties in the location of the rupture on the fault, in the maximum possible magnitude, and in the expected ground motion are accounted for explicity.

All mathematical calculations are performed using the FRISK code (McGuire 1978).

---

* National Observatory of Athens, Seismological Institute

** Earthquake Planning and Protection Organization, Athens

*** University of Athens, Geophysical Laboratory

SEISMIC HAZARD MODEL

Under the assumption that the occurrence of earthquakes is a Poisson process, the probability of exceedance of a certain level of the ground motion parameter, α, at a site, in a period of one year, is given by

$$P(A>\alpha)_{1,year} = 1-\exp-\sum_{v=1}^{n} P(A>\alpha/E_i)\,v_i$$

$$\simeq \sum_{v=1}^{n} P(A>\alpha/E_i)\,v_i \qquad (1)$$

where A is a random ground motion parameter, E_i is the event that an earthquake with magnitude $m \geq m_o$ occurs in the source i, v_i is the average occurrence, and n is the number of active faults in the area of study.

The probability that the amplitude A exceeds a value α, given one event of random size, M, rupture length, L_r, and location, X, on a fault is given by the total probability theorem

$$P[A>\alpha]=\iiint P[A>\alpha/M,L_r,X]\,f_M(m)\,f_{Lr}(l_r)\,f_X(x)\,dm\,dl_r\,dx \quad (2)$$

where $f_M(m)$, $f_{Lr}(l_r)$, $f_X(x)$ are the density probability functions of M, L_r, and X, respectively.

In the calculation of (1) and (2) the following assumptions are made:

(i) The length of active fault is related to the magnitude.

(ii) The intensity of the ground motion parameter at a site is a function of earthquake magnitude and distance to the closest slip.

(iii) The log-frequency vs. magnitude relationship for earthquakes is shown through truncated Gutenberg-Richter' s formula.

(iv) The average focal depth is constant.

To calculate the expected number of exceedances, the above probability (eq. 2) is simply multiplied by the mean activity rate for the time of interest, while the total number of exceedances is estimated as the sum of the expected number for each fault.

INPUT PARAMETERS

The area of southwestern Peloponnesus is considered as one of the most seismically active zones of the Hellenic Arc. Figure (1) outlines the seismicity, and the proposed main seismogenetic faults of the region.

The seismicity in zone A (Southern Ionion) is associated with the NW-SE orientated faults of the Hellenic Arc (Papazachos et al. 1985). The most severe earthquake occured in the remote past (1886, August 27, M=7.5), while the strongest event of the present century is the M=7.0 earthquake of October 6, 1947.

The seismicity in zone B (Central Peloponnesus) has never been high, and the strongest event is the M=6.1 earthquake of April 5, 1965. The delineation of Fault B derives directly from the orientation of the main geological faults with neotectonic activity (Mariolakos et al. 1985).

The fault rupture model requires as input seismicity parameters the mean annual rate of occurrence of earthquakes, the slope of the frequency-magnitude relationship, and the minimum and maximum considered earthquake magnitudes with their associated probabilities.

The focal depth of earthquakes is considered constant.

Furthermore, the model requires as input the rupture length vs. magnitude relationship. In the present study the formula developed by Kiratzi et al. (1985) is adopted.

The physical relationship describing the attenuation of the seismic waves from the rupture zone to the site is also required as input. Such relationships are empirical, and derived from regressions of observed ground motions against earthquake magnitude and distance from the causative fault. In this application the average formula proposed by Makropoulos (1978) is used.

RESULTS AND CONCLUSIONS

The model described above was applied to the area of southwestern Peloponnesus in order to predict the maximum ground acceleration over the next 50, and 100 years. The results of the analysis, in terms of isoacceleration maps with 0.37 probability of exceedance, are presented in figures (2) and (3).

The sensitivity of the model to a certain number of parameters and physical relationships was finally investigated.

The maximum possible magnitude on each fault is a key parameter in the application of the model. It is remarkable to notice that a 0.5 increase in magnitude leads to large variances in the expected hazard values, especially at high magnitudes, as illustrated in figure (4). This emphasizes the need to develop more accurate methods for the estimation of maximum possible magnitude, based on both seismological and neotectonic information.

The exact position of the fault in the seismogenetic zone as a result of poor knowledge of the present tectonic movements involves a high degree of uncertainty. The model introduces a weighting factor to incorporate such uncertainties in the fault location. A change of this factor of about 20% yields a variation of about 10%, especially for the higher levels of ground motion.

Finally, the model is very sensitive to the physical relationship describing the attenuation of seismic waves from the rupture zone to the site. The use of three different attenuation formulas leads to large variances in the estimated ground motion parameter, as shown in figure (5), emphasizing the importance of use of local attenuation laws in seismic hazard assessment.

It is remarkable that the results obtained are significantly similar to those already known for southwestern Peloponnesus (Stavrakakis et al. 1987). Specifically, the absolute values are nevertheless the same, and only the shape of the isoacceleration maps is slightly different. This can be contributed to the hypothetical fault delineation, emphasizing the importance of source modelling in the assessment of seismic hazard.

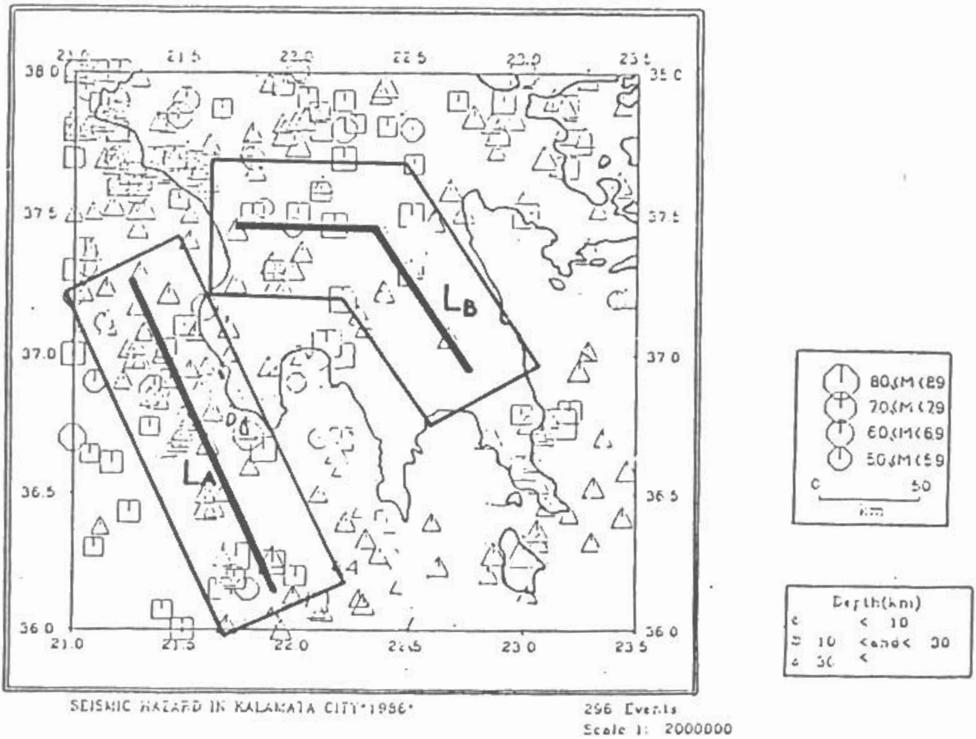

Figure 1. Seismicity and proposed seismogenetic faults in the area of Messinia, SW Peloponnesus.

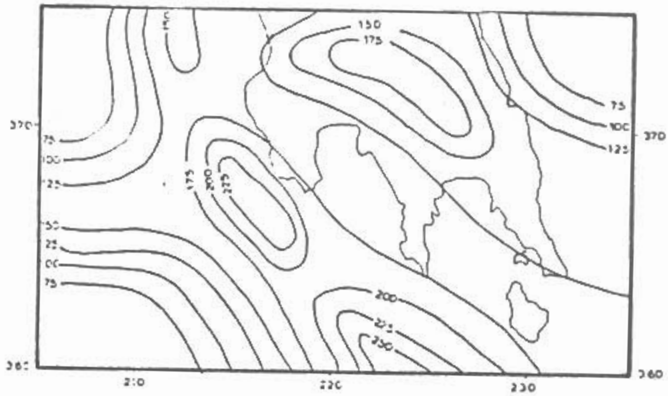

Figure 2. Maximum acceleration (in gals) with 0.37 probability of exceedance in 50 years.

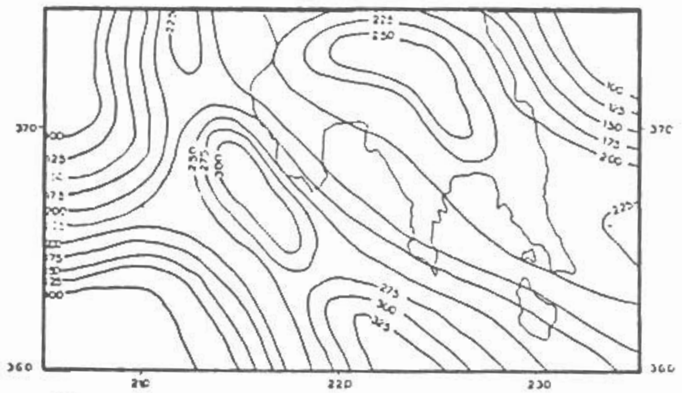

Figure 3

Figure 3. Maximum acceleration (in gals) with 0.37 probability of exceedance in 100 years.

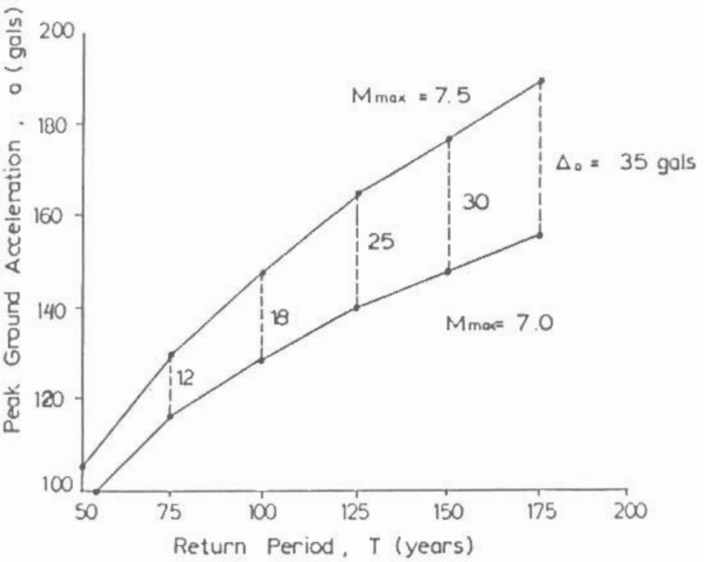

Figure 4. Maximum acceleration at a site using two upper bound magnitude values.

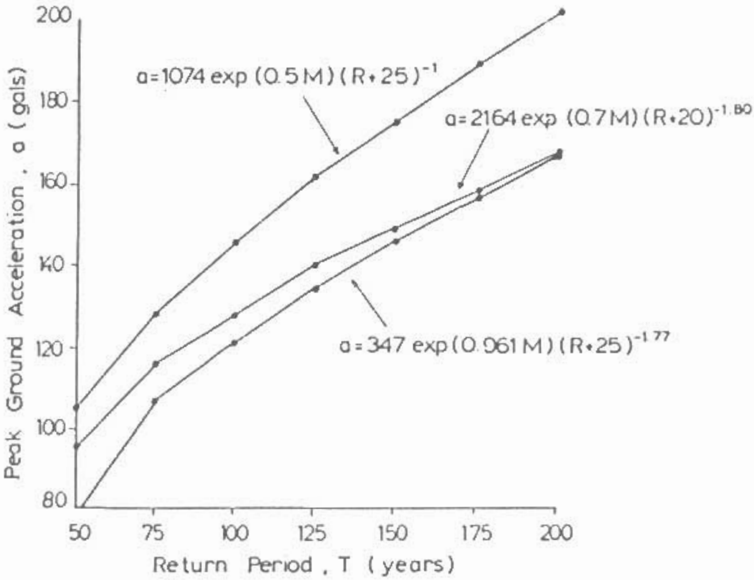

Figure 5. Maximum acceleration at a site using three different attenuation functions.

REFERENCES

Algermissen, S. T., Perkins, D. M., Isherwood, W., Gordon, D., Reagor, G., and Howard, G. (1976): Seismic risk evaluation of the Balkan region. Unesco, Survey of the Seismicity of the Balkan region.

Douglas, B. M., and Ryall, A. (1977): Seismic risk in linear source regions with application to the San Andreas Fault. Bull. Seism. Soc. Am., 67, 233 - 241.

Drakopoulos, J., and Makropoulos, K. (1983): Seismicity and hazard analysis studies in the area of Greece. Univ. of Athens, Seismological Laboratory, Publ. No. 1.

Kiratzi, A., Karakaisis, G. F., Papadimitriou, E. E., and Papazachos, B. G. (1985): Seismic source parameter relations for earthquakes in Greece. PAGEOPH 123, 27 - 41.

Kiureghian, A., and Ang, H. S. (1977): A fault rupture model for seismic risk analysis. Bull. Seism. Soc. Am., 67, 1173 - 1194.

Makropoulos, K. (1978): The statistics of large earthquake magnitude and evaluation of greek seismicity. Ph.D thesis, Edinburg Univ.

Makropoulos, K., and Burton, P. W. (1985b): Seismic hazard in Greece II. Ground acceleration. Tectonophysics, 117, 259 - 294.

Mariolakos, I., Papanikolaou, D., and Lagios, E. (1985): A neotectonic geodynamic model of Peloponnesus based on Morphotectonics, Repeated Gravity Measurements and Seismicity. Geol. Jb. 50, 3 - 17, Hannover.

McGuire, R. (1978): FRISK- computer program for seismic risk analysis using faults as earthquake sources. U.S. Geol. Surv. Open-File Report, 78 - 1107, 71 pp.

Papazachos, B. C., Hatzidimitriou P. M., Karacostas, B. G. (1985): Seismic fracture zones in Aegean and surrounding area. Publication of the Geophysical Laboratory, Univ. of Thessaloniki, 2, 1 - 10.

Stavrakakis, G., Drakopoulos, J., and Makropoulos, K. (1987): A model for seismic hazard assessment in SW Peloponnesus and synthesized ground motions for the city of Kalamata. Annales Geol. Pays Hell., 226 - 242.