



PROHITECH – WP3 (Leader A. IBEN BRAHIM)

A short Note on the Seismic Hazard in Israel

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Documented evidence of earthquake activity in the Israel and adjacent areas is available over a period of 4000 years (e.g., Ben Menahem 1991). This evidence, when correctly interpreted, can lead to reliable estimates of the earthquake hazard in the country.

Since instrumented data has become available only from the beginning of the 20th century, hazard information of earlier earthquakes is given in terms of seismic intensities, which are not easily convertible to useful engineering parameters, such as response spectral values. Yet, the available catalogues (e.g. Ben Menahem 1979, Amiran et al 1994,), with the inferred estimates of the earthquakes magnitudes and hypocentral locations, the available instrumental data (Geophysical Institute of Israel on-line earthquake catalogue 1900-present), magnitude-recurrence relations and appropriate attenuation model, can be used, by applying well known probabilistic seismic hazard analysis procedures, to obtain seismic hazard maps. Such procedures were used by the Geophysical Institute of Israel (Shapira 2002) to prepare the horizontal PGA (Peak Ground Acceleration) map of the Israeli seismic code SI 413 (1995, the 2004 amendment) shown in Fig. 1.

This map, developed for rock sites, using the Boore, Joyner & Fumal (1994) attenuation relation for (soft) rock (shear wave velocity on the order of 750m/sec), shows that the PGA varies appreciably throughout the country, with peak values close to 0.3g in the northern part of the Dead Sea fault. The hazard is based on 10% probability of exceedance in 50 years (10/50), or a return period of circa 475 years. This hazard is mainly contributed by magnitude 6.0 - 6.5 earthquakes. Evidently, larger earthquakes ($M > 7$) may occur in the region, once in 1000 to 6000 years on the average (Shapira et al 2004), depending on the seismogenic zone, posing much higher hazard. Hence, for design of critical facilities lower exceedance probabilities are required. Also, for performance based design more frequent events have to

be designed for (serviceability limit states). It is expected that such maps would soon be published by the Geophysical Institute of Israel.

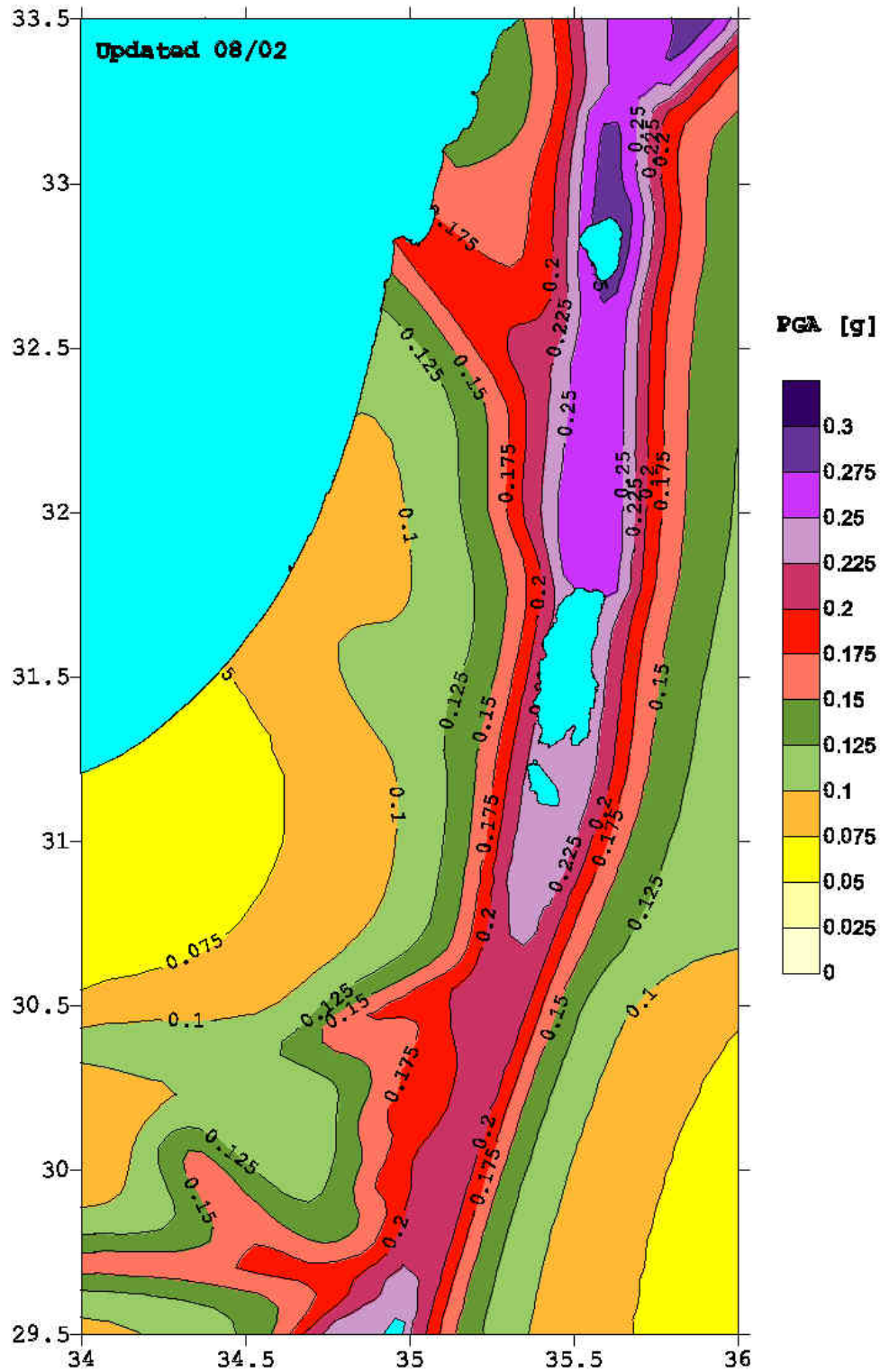


Fig. 1. PGA map of the Israeli seismic code SI 413 (1995, the 2004 amendment)

However, the characterization of the seismic hazard only begins with PGA maps. The frequency distribution of the seismic demand has also to be estimated. However, the instrumental data required for spectral characterization is not likely to become available in the foreseeable future in a country of moderate seismicity as Israel. So, it was not surprising the shapes of the response spectra in SI 413, shown in Fig. 2, are borrowed from an older foreign seismic code. It can be seen that the spectra for the equivalent lateral force (ELF) procedure (Fig. 2a) and for modal analysis (Fig. 2b) differ only in the level of the low period plateau: for the ELF it is 2.75x PGA, whereas for modal analysis it is 2.5xPGA.

Whereas the rock spectra in SI 413 are most probably reasonable in view of their similarity to design spectra in leading modern seismic codes, and the paucity of local instrumental data, the spectral shapes for different soil conditions, or the site coefficients, are obviously outdated, and are in urgent need of updating. This is evident from the appreciably higher site coefficients in the International Building Code (IBC, 2003), and the results of a very extensive parameter study published very recently by Ambraseys et al (2005). Similar observations have repeatedly been made by Zaslavsky et al (e.g. 2004). A very brief summary of the approach used in their studies is given in the Appendix.

Finally, more reliable prediction of the seismic hazard can be obtained by modelling the earthquake sources and propagation paths, as realistically as possible. The need for faithful modelling applies equally to the structure itself, namely by considering its actual post elastic response. In a country with very little strong motion data time-histories can either be taken from tectonically and geologically similar regions or be artificially produced, as those producing the spectra in Fig.3. Note, however, that the present version of SI 413 does not include specific provisions in this direction, although it does not preclude such analyses.

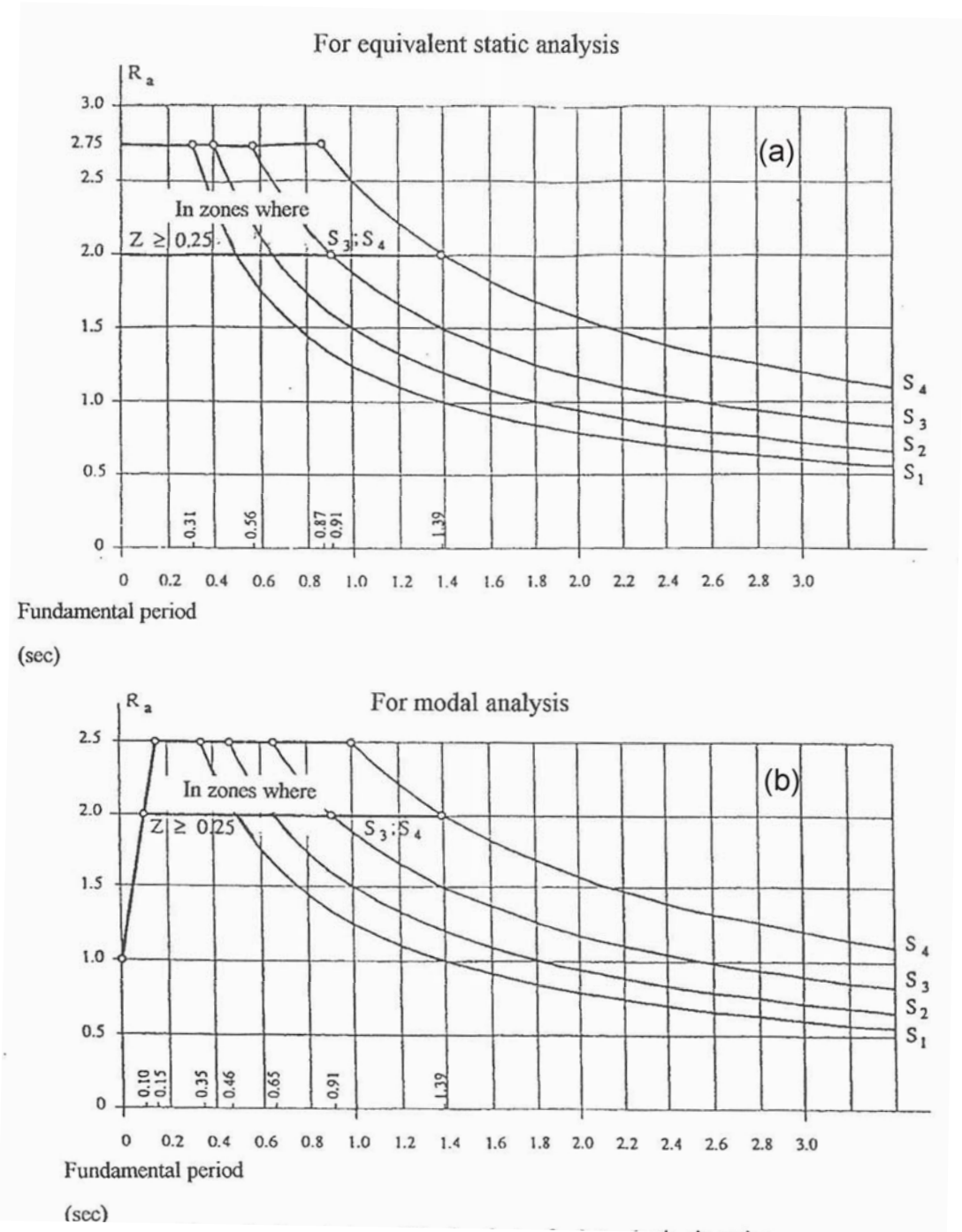


Fig. 2. Spectral amplification factor for lateral seismic action:
(a) for ELF, (b) for modal analysis

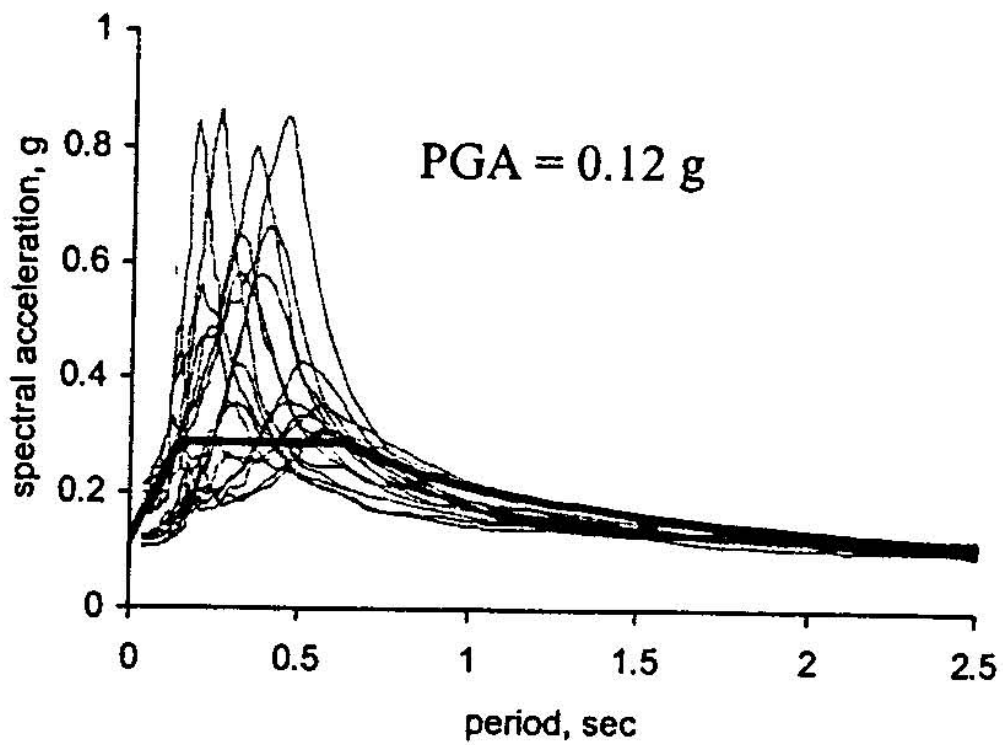
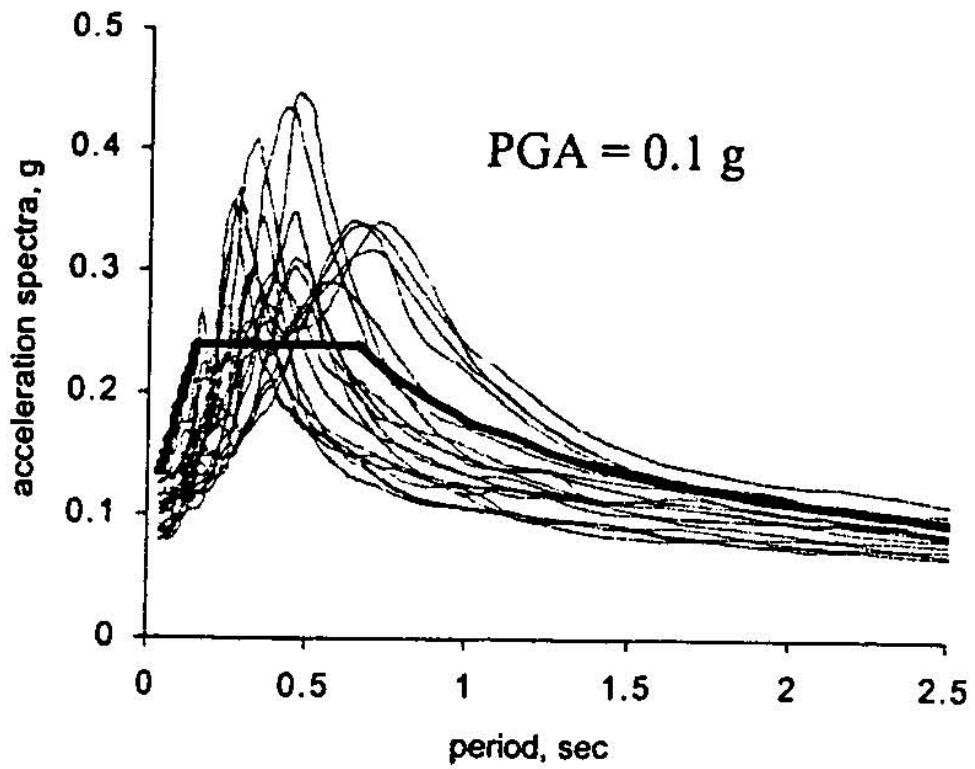


Fig. 3. Comparison of 5% damped site specific acceleration spectra obtained by SEEH with the SI 413 design spectra for two coastal plain zones with different PGAs

Appendix

In a series of studies, Zaslavsky and his co-workers applied the Stochastic Evaluation of Earthquake Hazard (SEEH) procedure (Shapira & van Eck 1993) for the standard 10% in 50 years probability. SEEH simulates the seismicity expected to occur within a very long period. These simulations are based on the empirical relationship between the frequency of occurrence of earthquakes in the surrounding seismogenic zones. From each of the earthquakes in the simulated catalogue, the procedure generates synthetic ground motions for the site. The ground motions are obtained by the stochastic method (e.g., Boore 1983), and by allowing the synthetic seismic accelerations to propagate through the stratified soil layers underlying the site. By means of Monte Carlo statistics, the procedure is repeated several times in order to account for the uncertainty associated with the many parameters involved in the computations. Thus, the SEEH procedure provides numerous synthetic site specific acceleration response spectra, from which uniform hazard spectral accelerations can be determined.

The parameters and their uncertainty used in the SEEH procedure to simulate the seismicity and to synthesize seismic motions are derived from local observations and studies, and include assessments of the frequency-magnitude relationship in each seismogenic zone, apparent attenuation with distance of low frequency ground displacements, stress drop, Q values, seismic-moment – magnitude relations, etc. The subsurface model at the site are deduced from available geological, geophysical and bore-hole data and from on site investigation of the H/V spectral ratios using seismological recordings of ambient noise, low amplitude S-waves and strong motion signals, if available. The computations in SEEH currently do not account for the uncertainty in the parameters of the subsurface model. The computations were restricted to linear behaviour of the soils. Nonlinear effects can be considered provided appropriate soil parameters are given.

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