

Characteristics of strong ground motion records obtained in Europe and adjacent countries

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This short communication was devoted to the current status of the data base of strong-motion earthquake records obtained in Europe and adjacent areas. The records have been identified, and some preliminary interpretations have been carried out as part of the tripartite project - a collaborative effort amongst CEA (Commissariat à l'Énergie Atomique) in Paris, ENEA (Ente Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative) and ENEL (Ente Nazionale per l'Energia Elettrica) in Rome, and ICSTM (Imperial College of Science, Technology, and Medicine) in London. The objectives of this cooperation are to analyze and define the cri-

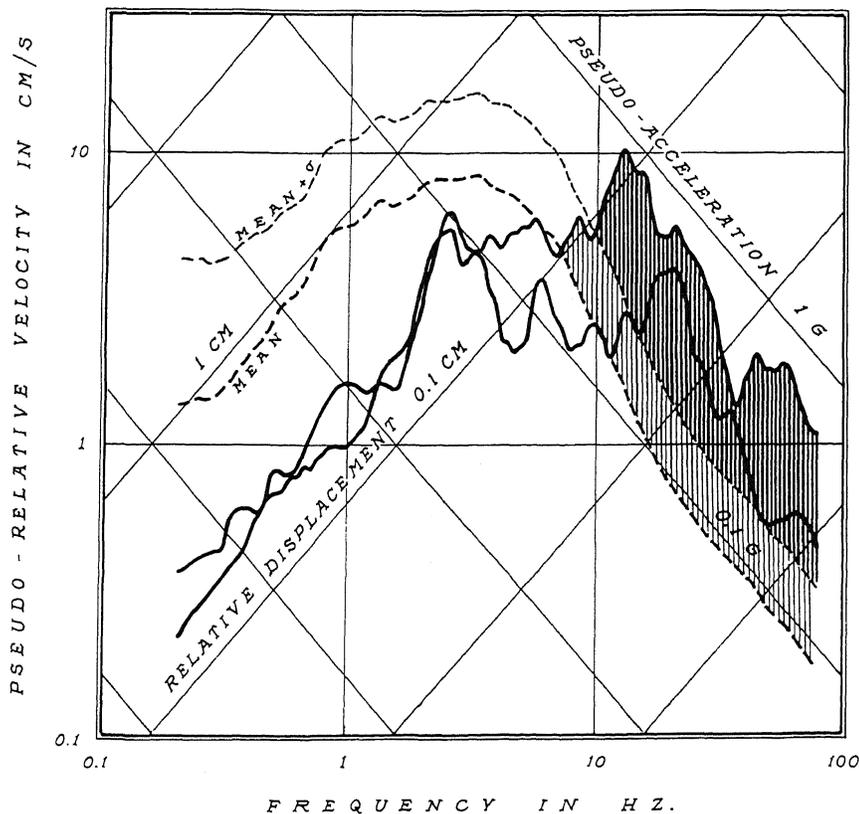


Figure 1. A comparison of spectra recorded for the 1982 New Hampshire earthquake (solid lines) and synthetic spectra (mean and mean plus one standard deviation) computed with coefficients for intensity class VI-VII, horizontal component (dashed lines).

teria for the establishment and management of accelerometric networks, to assess and define the characteristics of the recorded data in a homogeneous manner then collect these in a data base of standard format, and finally, to develop methodologies for the prediction of strong ground motion in a given site to be used in the antiseismic design of structures. The preliminary results of this collaborative research program were published in *European Earthquake Engineering* (Vol. IV, No. 2, in 1990, and Vol. V, No. 2, in 1991).

One of the immediate potential applications of this research program is exemplified by the comparison between the prediction of vibratory ground motion based on statistical analyses derived from California data and the results of similar analyses based on other data retrieved from sectors where a different seismotectonic environment prevails, notably around the mediterranean and in the eastern United States. A significant difference in frequency content has been revealed. A rather striking illustration of this difference is afforded by the response spectrum (5% damping) in Figure 1, depicting the magnitude 4.7, 1982 New Hampshire earthquake recorded at Franklin Falls Dam, 11 km from the source as compared with corresponding predicted spectra (mean and mean plus one standard deviation) computed from a selection of California data. This difference is not to be ascribed to geographical factors, but rather to dynamic parameters at the source.

In order to compare prediction results from California data with those from a European-type seismotectonic context, we undertook to calculate correlation coefficients from Italian data recorded from 1972 through 1984. A regression analysis was performed from 288 horizontal components corresponding to 49 events with magnitudes from 3.0 to 6.5, recorded at distances ranging from 6 to 186 km. Again, the comparison, for a given magnitude/distance couple, of the two predictions (Figure 2) demonstrates a significant translation of the spectrum towards higher frequencies for the latter set. In order to substantiate such observations, a theoretical basis should be sought with reference to classical methods in seismology.

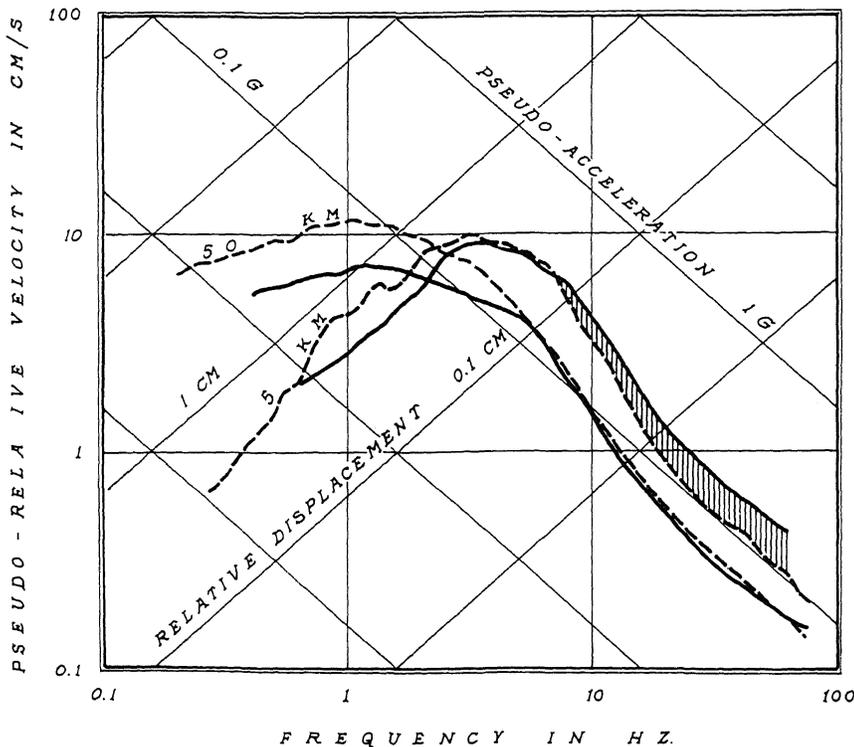


Figure 2. A comparison between the synthetic spectra computed with coefficients from Italian (solid lines) and California data, intensity class VI-VII (dashed lines) for two magnitude/distance couples: $M = 4.0, R = 5$ km and $M = 6.2, R = 50$ km.

In Brune's simple source model, the Fourier spectrum of acceleration, $S(f)$, is given by:

$$S(f) = (4 \pi f^2 M_0) / [1 + (f/f_c)^2] \quad (1)$$

where M_0 is the seismic moment and f_c is the corner frequency. This latter is related to the length of rupture, L , and to the rupture velocity, V_r , approximately by:

$$f_c = V_r / L = \frac{V_r \times \Delta \sigma^{1/3}}{2 \times M_0^{1/3}} \quad (2)$$

where $\Delta \sigma$ is the stress drop. In the case of moderate earthquakes (Kanamori & Anderson, 1975), one can write:

$$f_{c(A)} / f_{c(E)} = \frac{\Delta \sigma_{(A)}^{1/3} \times M_{0(A)}^{1/3}}{\Delta \sigma_{(E)}^{1/3} \times M_{0(E)}^{1/3}}$$

where the subscript A 's and E 's correspond to what we are referring to, for the sake of convenience, as *intraplate* and *interplate* contexts, respectively. Average stress drop for mid-plate earthquakes is believed to be higher than for interplate ones. If the hypothesis is retained whereby $\Delta \sigma_{(E)} = 30$ bars and $\Delta \sigma_{(A)} = 100$ bars, we obtain:

$$\Delta \sigma_{(A)} / \Delta \sigma_{(E)} = 100 / 30 \quad (3)$$

Then seismic wave energy, E_0 , is given by:

$$E_0 = (M_0 \Delta \sigma) / 2 \mu \quad (4)$$

where μ is the rigidity. For an equivalent amount of seismic energy, the corner frequency ratio is:

$$f_{c(A)} / f_{c(E)} = 2.23 \quad (5)$$

and the ratio, R , for intraplate/interplate source spectra is given by:

$$R = \frac{0.3 [1 + (f/f_{c(E)})^2]}{1 + [f / 2.23 f_{c(E)}]^2} \quad (6)$$

Values of R have been computed for different frequencies and with seven values of f_c as parameters (see Figure 3); for earthquakes with a high stress drop, a reduction of low frequencies is observed, as well as an increase in high frequencies.

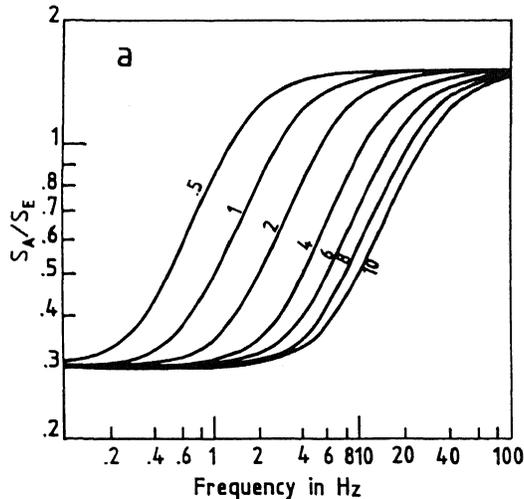


Figure 3. Spectral ordinate ratios (intraplate/interplate) plotted versus frequency, for different corner-frequency values, for moderate-magnitude earthquakes.

Seeing that a large majority of strong motion data has been obtained in interplate regions, seismic reference motion called for in various building codes to be applied in anti-seismic design is doubtless strongly influenced. It should be mentioned that the terms *interplate* and *intraplate* are not scrupulously precise in that in California, for instance, high stress drop earthquakes can also occur (as with Whittier Narrows, among others). We may accordingly infer that the tendency revealed when comparing results for California and for Italy is most probably to be ascribed to differences in stress environment in most parts of the two regions, though no direct measurements of this quantity are to be had. This difference in spectral content might also conceivably affect earthquake magnitude determinations and their relationship to teleseismic motion.