EAEE Working Group on Strong Motion Records and Data Analysis WG2

During the period 1993 - 1996, WG2 concentrated on the retrieval, processing and analysis of strong motion records from the European region. The work was carried out with the support of CEC at Imperial College (UK), the participation of Italy (Dr.Rinaldis, ENEL & Dr.Berardi, ENEA), France (Dr.Mohammadioun, IPSN) and with the cooperation of Greece (Dr.Stavrakakis, NOA), Iceland (Prof.Sigbjörnsson, ERlUl), Switzerland (Dr.Smit, ETH), Turkey (Prof.Sucuoðlu, METU).

The purpose for the retrieval of such data from the European area was the derivation of reliable attenuation laws for use in EUROCODE-8. Predictive attenuation relationships for peak and spectral ordinates for ground accelerations, must be based on reliable observational data, they must be relatively simple and must involve design variables that can be assessed by the engineer with some confidence.

Earthquakes in Europe and in the Middle East since 1967 have generated a substantial number of analogue strong-motion records, estimated in excess of 2,500 triaxial sets. However, the growth of our bank of strong motion data was very slow. This was mainly because acquisition of this kind of information depended entirely on contributions from owners of strong-motion stations. We have been able to identify and accessed over 1,000 analogue triaxial free-field records produced by about 800 shallow earthquakes of all magnitudes, mainly from Italy, former Yugoslavia, Greece, Iran, as well as from the former USSR, Turkey, Algeria, Iceland, Germany and Romania, which were uniformly corrected and processed.

The seismological parameters associated with these events, such as location, depth, surface-wave magnitude, and seismic moment were re-assessed uniformly and station positions and local foundation conditions were re-evaluated.

Using these data we have derived predictive formulae for the attenuation of peak and spectral accelerations with source distance, magnitude, source depth and foundation conditions for both horizontal and vertical motions. Also we have examined the near-field behaviour of the zero-period and spectral acceleration ratio with distance and source mechanism. Some of the results obtained so far have been published by Ambraseys,N., Simpson,K., Bommer,J.(1996) "Prediction of horizontal response spectra in Europe", Journal of Earthquake Engineering & Structural Dynamics Vol.25, pp.371-400, and by Ambraseys,N., Simpson,K.(l996) "Prediction of vertical response spectra in Europe", Journal of Earthquake Engineering & Structural Dynamics, Vol.25, pp.401-412.

I find that one important observation that can be made regarding all attenuation laws that we have tested is that their standard error is large and varies for different laws between I.5 and 2.3. For the European data this error is about 1.7 for zero-period and greater for spectral response. This relatively large variability does not seem to improve much by increasing the size of the input dataset beyond a certain limit without increasing the number of variables. This level of scatter is smaller than in many other attenuation laws derived for the USA and Japan but it is large enough to mask likely differences

that exist amongst the various geologic regions, source mechanisms and, to some extent, amongst different local soil profiles.

Another general observation concerns the reliability of an attenuation law. It is, obvious that the lack of a common measure of the size of an earthquake (Mw, Ms, ML, mB), of its distance from a site, and of the soil classification makes it very difficult, if not impossible, to compare predictions derived by different authors and attribute their similarities or differences to particular regional or local effects. A too restricted selection or indiscriminate use of data may lead to gross differences in predictions. Also the use of different models can lead to large differences in predicted ground accelerations, particularly when the distribution of input data is limited or biased in magnitude and distance. In such cases over-parametrisation is not an improvement of an attenuation model. Some authors seem to have paid little attention to this, and their over-estimation of the importance of using too many free parameters has led to a widespread belief that their laws are verified to a degree that their input data do not in the least warrant.

I find that for site classification there seems to be an apparent advantage in the use of the average site velocity Vs as an actual measured value. This obviates the use of subjective two- or three category site classification systems and introduces a measure of the amplification factor needed in the definition of the seismic coefficient in building codes.

I find no saturation of acceleration with magnitude near the source and no evidence that our data fit better a magnitude-dependent shape of the attenuation model.

Also I find that the spectral shape and periods at which the maximum values occur are different for vertical and horizontal motions, and that on average vertical spectral values decay more slowly with period. Also very near the source of large thrust earthquakes the average value of the ratio of vertical to horizontal acceleration may exceed one but falls off rapidly with distance. For strike-slip faults the available data suggest that this ratio reaches only for moderate size events, decreasing for larger earthquakes, and that distance variations in the near-field have little effect on its value. These differences in vertical acceleration are large enough to warrant consideration in the definition of design spectra for EUROCODE-8.

In the derivation of many local or regional European attenuation laws, use is often made of all available data, regardless of their quality, homogeneity and range of variables, with the result that little confidence can be placed on the resulting predictive relationships, particularly of relationships of a "national" character. This uncritical use of limited, enhanced or arbitrarily pruned datasets contributes to the proliferation of local "national" attenuation laws of ephemeral validity which confuses the uninitiated engineer or gives him a wide choice for the selection of convenient design ground motions.

The data used in our study are considered to be suitable in both quality and quantity. An attenuation equation should be accepted if the input data, attenuation model and method of analysis used are suitable, and if the parameters characterising the earthquake, path and site are reliable.

The growing number of strong-motion accelerograms now available world-wide, particularly digital, along with supporting data from seismology, geophysics, geology, and soil mechanics we are increasingly becoming aware of the fact that strong-motion records are much more complicated and

different from one another than had previously been supposed. Our studies clearly show that the process in the near field is much more complex than we had at one time hoped and that the number of basic parameters must increase if we wish to deal effectively with the rather large dispersion of the predicted values. This in turn implies that we need more high quality input data, both in terms of strong-motion records and geophysical and soil parameters.

Regarding future work for WC2 = TG2, I find that there is at the moment an imbalance in strong motion research. I feel that much effort has been diverted to solving statistical problems based on limited datasets and that more field data and observations are now needed. Regional collections of a limited number of unprocessed records without reliable supporting seismological and geological information do exist in CD-ROMs, often creating more problems than they solve since the indiscriminate use of these relatively easily obtainable datasets has the danger that the resulting estimates of ground motion may be subject to so much uncertainty as to be worthless.

One of the causes for concern is that although earthquakes in Europe have generated more than 2,000 records, full use of this larger body of data remains unexploited, hampered by problems of access. No European strong-motion centre exists and no regional organisation has been, or is likely to be able to collect, process and disseminate in the public domain the complete set of analogue and digital recordings that are available. Even within the same country, given the diverse groups operating strong motion instruments and the lack of cooperation by some of the responsible individuals, it is unlikely that such a dissemination centre can be established and service effectively end-user.

Our attempt to put together a data bank for European records has been successful but our effort to provide end-users with readily available data has been disappointing. We are not the owner of the accelerogram data we acquire and this fact implies that WG2 = TG2 must observe the restrictions imposed by contributors of strong-motion data, that is, that some of the data are openly available, much require the owner's approval of the data transfer, and some are not available for dissemination.

WG2 has now been re-cast as TG2. Let us hope for a better collaboration.

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