Preparation of a Catalogue of European Earthquakes and of an Atlas of European Seismic Maps

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Abstract

The paper summarizes the work presently on the way in the Commission of the European Communities in the field of protection of nuclear power plants against seismic effects. In fact, this is the continuation of the so-called "Ahorner Report"(report EUR 8371) that principally treated the seismic ground motion characteristics and their relationships with displacement, velocity and acceleration transmitted to a structure by the soil particles.

As a consequence of the shortcomings of the previously mentioned report, prime priority was given to a General European Earthquake Catalogue and an Atlas of seismic maps accompanied by an explanatory textbook.

1. Introduction

In order to improve the safety of nuclear installations the Commission of the European Communities established Working Group No. 1 to harmonize methodologies, criteria, codes and standards applied in European countries.

In the frame of this Working Group a special sub-group was devoted to the "Protection of Nuclear Power Plants against Seismic Effects", which prepared a comprehensive report on the reference seismic ground motions.

A general consensus was achieved on two levels of reference ground motions, the deterministic and the probabilistic approach.

Nevertheless, this "Ahorner Report" shows some shortcomings:

1) soil and structural aspects are missing,
2) the general safety philosophy needs a better confrontation of the seismic outcome with the earthquake resistant design topics and
3) the lack of an harmonized seismic data bank.

As regards these points, a second mandate was given to the sub-group for completion of the above-mentioned report by Working Group No. 1.

2. The available Data Base

In the different member countries of the European Communities the data base for what concerns its distribution in time and space and the methods applied in the evaluation of the seismic parameters is not at all homogeneous.

The data base comprises two main parts: the historical data and the present day data.

2.1. The Historical Data

These data are confined in an heterogeneous set of national catalogues. Albeit the only way to go back in time as far as possible not one of the catalogues refers to the same time-period nor to the same intensity-scale.

Written documentation may appear sufficient but not necessary reliable. The scarcity and the disparity of historical data constitute the greatest shortcomings. After all, written documentation should be analyzed with the assistance of historians and linguists for a better understanding of their content and significance.

2.2. The Present Day Data

The period under consideration for these data starts at the beginning of the 20th century as it was at that moment that the greater part of the European stations were installed.

The present day data are to be split into two complementary groups:

1) the instrumental data, and
2) the macroseismic data, which are provided by
   a) the questionnaires, and
   b) the inquiries in situ.

Since the beginning of the present century, reliable instrumental data are available, but nevertheless macroseismic data may have a great advantage over the instrumental ones as regards the historical seismicity or in estimating the future activity of a given region.

The existing data base is stained by some shortcomings, but it can be improved as follows:

1) in collecting macroseismic data more systematically by using a unique "intensity-scale" and an identical "questionnaire" in accordance with the adopted scale;
2) by gathering data relevant to historical events and then confronting it among each other in order to eliminate misinterpretations, wrong evaluations, duplicates, a.s.o. ...;
3) by compilating comprehensive catalogues;
4) by upgrading the instrumental quality of national seismographic networks.

2.3. Intensity and Intensity Scales

Based on instrumental data only, the strength of an earthquake is expressed in terms of "Magnitude" while with macroseismic data the importance of a shaking is given in "Intensities". In order to evaluate the seismic risk, the most appropriate procedure for estimating the strength of earthquakes, over a time span as long as possible and on the basis of historical and modern data, consists in applying a unique intensity scale.

Presently the two scales used in most cases are the Modified Mercally Intensity scale and the MSK-64 scale. The two scales are compared in the paper and critically reviewed.

Unfortunately, all intensity-scales suffer from serious extrinsic limitations stemming principally from:

1) the methods of collecting the needed data;
2) the lack of systematic approach to evaluation, i.e. more complete statistics should be used;
3) the behaviour of new types of structures as multistory buildings;
4) the missing of transfer functions connecting the degree of damage with the degree of intensity;
5) the lack of relationships between intensity and soil conditions, between intensity and ground motion parameters;
6) the non-continuous calibration of the intensity-degree with new corrected values of acceleration, velocity and displacement;
7) the non-inspection of struck areas by engineers in case of damaging earthquakes.

2.4. The Macroseismic Data

2.4.1. The Questionnaire

Questionnaires for macroseismic data collection are different from one country to another and, generally, not in conformity with the used intensity-scale.

After having compared the questionnaires used in different countries, the following defects are found:

1) the geographical situation is insufficiently described;
2) the local soil conditions are not considered;
3) the time of occurrence is inaccurate;
4) nothing is mentioned about how the earthquake is felt: a single or a multiple shock;
5) no attention is paid to the sounds emitted during the earthquake;
6) the different types of constructions are not described in detail.

2.4.2. The Inquiries

When earthquakes strike dwelled regions their effects on people, immediate surroundings and vicinity, are gathered and classified.

An easy way to collect macroseismic data consists either in waiting for entering telephone calls from the stricken area or reading reports given by newspapers or noting the accounts emitted by other media.

The best procedure to perform an inquiry consists in disseminating questionnaires and to make, simultaneously, a traverse survey. When the damages are of greater importance this survey should be made by both a seismological and a civil engineer. The sooner this is done, the smaller will be the tendency for staining the truth by exaggeration.

All, of course, depends on:

1) the addressees of the questionnaire;
2) the means used to distribute the questionnaire: by mail, the printed and the spoken press;

3) the rapidity of replying;
4) the responsibility of the collecting authority.

However, the more abundant the gathered macroseismic material will be, the more precise the isoseismal charts will be mapped out.

2.5. The Microseismic or Instrumental Data

The greater part of the available seismic data is formed by macroseismic observations. But with the turning century these data were completed by instrumental data read out from seismograms. They are more objective and provide the following parameters:

- the time of occurrence: hours, minutes and seconds;
- the geographic coordinates;
- the epicentral radius;
- the hypocentral depth;
- the magnitudes: Mb, MS or ML;
- the seismic moment;
- the fault-plane solution.

All these parameters are very valuable quantities for site selection as they provide better knowledge on the geological features of the site-area.

However, they should be complemented by strong motion data generated by earthquakes. From such records response spectra can be deducted which are more suitable for design purposes.

3. The Catalogue of European Earthquakes

The elements to be put in the catalogue or the periods to be covered show some disparities which are to be overcome.

The analysis of the files reveals:

1) that the overall time-span considered should be subdivided in smaller periods;
2) that each of these smaller periods should be assigned to a lower limit of intensity.

Two main sections are, therefore, to be considered:

1) the period going back in time as far as possible providing only macroseismic data;
2) the period running from 1901 up to now, called instrumental period.

The first section, obviously, is to be divided in subsections according to some historical guiding principles.

Based on an argumentation described in the explanatory textbook, the following time divisions and the associated lower intensity-levels are proposed:

1) The period from BC up to the Vth century	-	Intensity I_0	VIII
2) from the Vth c. up to the XVIth "	-	"	VII
3) from the XVIth c. up to 1750 AD	-	"	VI
4) from 1751 up to 1900 AD	-	"	V
5) from 1901 up to the present	-	"	IV

The fundamental earthquake parameters needed in a comprehensive catalogue are:

- the date (year, month, day) and time (hours, minutes, seconds (up to 0,1 s));
- the geographical coordinates of the epicentre (to 0°, 01 near);
- the magnitude (MS, MB or ML);
- the maximum intensity observed I_o;
- the focal depth (in km);
- the radius of perceptibility (in km);
- the name of the main place in the pleistoseist zone;
- the macroseismic map number, if a map is available;
- the bibliographic references;
- the main parameters of the fault-plane solution (XXth c. only).

4. The Atlas of European Seismic Maps and Matters to be mapped out

There are presently three types of maps under preparation:

- national maps extending over one country and its neighbouring zones;
- regional maps spreading over several countries, constituting a seismic entity and
- general maps covering the entirety of the territories of the EC countries and the adjacent regions.

The envisaged atlas should provide information on a series of features to be expanded over either larger or smaller areas as to their importance respectively.

National and regional maps should be made up at larger scales. These maps should allow an easy read out and reveal delineations the significance of which may be of importance in siting problems.

5. Computational Procedures

In order to obtain an overall view of the epicentres in the area and to reveal the features of the regional tectonics it is necessary to plot out the content of the established catalogue.

As long as the number of epicentres is small the plotted events are easily checked, but when their number increases consequently a counting function should be deviced to control the identity of the two numbers, the listed and the plotted events.

This method consists in attributing to the plotted points a "Gaussian weight", the magnitude of which decreases from the central axis of the function up to the outer limit considered, function applied at the crosspoints of a grid.

The weighting function not only introduces a probability, but also the epicentral parameter.