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COMPARATIVE STUDY OF SEISMIC HAZARD EVALUATION AND DEVELOPMENT OF COMPUTER PROGRAM

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SUMMARY

The purpose of this research is to develop a computer program which calculates the regional distributions of maximum earthquake motion by only assigning the area data and to make consideration on seismic hazard evaluation from various angles such as seismicity, seismic gap, active fault and others. The regional distribution of maximum earthquake motion such as maximum acceleration and maximum particle velocity were obtained for Algeria and Ethiopia and on the basis of the distribution, the seismic hazard zoning map, which is very useful for aseismic design, were obtained for Algeria and Ethiopia areas.

INTRODUCTION

In order to mitigate earthquake disasters, the following researches are indispensable : (i) earthquake prediction, (ii) estimation of earthquake motions and amount of damages and (iii) counterplans against the earthquake disasters. The above second reseach subject, estimation of earthquake motions and amount of damages, may be divided into three parts : (i) estimation of earthquake motion on the base rock or on the ground, (ii) eatimation of behavior of buildings and civil engineering structures, and forecast of the damages and casualties caused by the earthquake motions and (iii) eatimation of loss due to the above damages and casualties.

The ways of estimating earthquake motions are compared in Fig. 1 in which the evaluation of earthquake disasters and the countermeasure are also considered. The ways of estimating of earthquake motions are classified into two kinds :(1) Statistical method and (2) Deterministic method. In this research, the statistical method is mainly used, in which the maximum earthquake motions for some return periods are obtained by utilizing seismic data of the past, attenuation models and statistics of extremes (Ref. 1,2).

DEVELOPMENT OF COMPUTER PROGRAM AND ITS RESULTS

It is desirable to develop computer program for getting easily regional distribution of maximum earthquake motion for arbitrary areas by using up-to-date data and by only giving range of longitude and latitude of the area concerned as input data. And it is more advisable that the computer program gives also some relevant fundamental data such as magnitude frequency distribution, epicentral distribution and so forth.

Quality and Quantity of Seismic Data A general idea of temporal variation of quality and quantity of seismic data is shown in Fig. 2, where the ordinate means the scale of earthquake such as magnitude and/or intensity, and the abscissa indicates time in arbitrary scale, respectively. The seismic data in the period (A) are not based on instrumental observation. The magnitude, intensity and epicenter, in these data have been estimated on the basis of descripsions of historical documents, when the accuracy of estimation and the lower limit of scale of earthquakes vary furiously from time to time. In general, the quality and quantity of seismic data will become more superior and plentiful with progress of age.

The part with oblique line in Fig.2 (a) means earthquakes which occurred in the period without instrumental observation and the thick real line shows that the quantity of this kind of data varies with age and the thick dotted line means that this kind of data increase with time in general inclination.

The quantity of seismic data increased at begining of instrumental observation suddenly and the quality was improved very much. Thereafter, these have been much stepped up due to advance of instrument. The seismic data due to instrumental observation (Period B) is shown by the line B in Fig. 2 (b). The part Bdi means seismic data which would be lost because of low ability of instrument. The earthquakes which would be occurred in the period without instrumental observation are shown by the line A, which is made due to shifting the line B by taking account of the length of periods A and B. Ad and Adi mean the existing data and the lost data, respectively. When we make analyses on seismic hazard by using the seismic data in the periods A and B, considerations must be taken on the data Adi and Bdi (Ref.3).

Attenuation model A good number of attenuation models have been proposed till now. In this paper, Kanai's model and Oliveira-McGuire's model are used. Through earthquake observations under the ground, Kanai recognized that the velocity spectra of earthquake motions on the base rock were flat in certain period range. Further, he led an attenuation model for the maximum particle velocity on the base rock. Oliveira gave an attenuation model for the maximum acceleration on the ground and McGuire also suggested a models which were similar to one of Oliveira. It is reasonable that the maximum earthquake motions on the ground are to be calculated taking account of the ground characteristics of each site and the input on the base rock. But the seismic macrozoning map expressed by the maximum acceleration on the ground without the ground characterristics, are also useful in earthquake engneering. A new attenuation model which gives a mean value of Oliveira and McGuire models is used in this research.

Way of Analyses Fig.3 shows the outline of general procedure of analyses. Permanent seismic data, which should be overall and worldwide, are memorized as a dataset. The data should be in volume as much as possible and in period as long as possible. In this research, in principle, ISC (International Seismological Center) seismic data are used for making the permanent data, but many modification have been made for the areas of Japan, China and so forth.

The ranges of longitude and latitude of a specific area are given as input data. Temporary seismic data which are used for calculating the maximum earthquake motions for the area concerned are picked up from the permanent seismic data. On the basis of the temporary seismic data, magnitude frequency distribution, epicentral distribution and so forth are made and plotted.

Fig. 4 shows the outline of getting expectancy of maximum earthquake motion at one specific site. The maximum earthquake motions due to all earthquakes in and around the site for a unit period (for example one year) are calculated by the temporary seismic data and attenuation models. The biggest one among these values is taken as the maxmium earthquake motion in the year. The same step is repeated for each year of the whole period, that is, for n years. As the result, n maximum earthquake motions are obtained for the site.

By applying the Gumbel's third asymptotic distribution to these values, the expectancy of maximum earthquake motion for arbitrary return period for the site are obtained. Fig. 5 shows an example of analyses for a specific site. The abscissa means the return period and the ordinate corresponds to the maximum values mentiond above.

For all points of every half degree of longitude and latitude in the area, the procedures mentioned above are repeated and the expectancies are obtained. These values are memorized in a dataset and on the basis of these values, contour maps on regional distribution of maximum earthquake motions for some return periods are drawn.

Examples of Analyses Algeria was damaged by El Asnam earthquake of Oct. 10, 1980. The casualties due to the earthquake were 5,000 killed and more than 9,000 wounded. They suffered also a great deal of damages by earthquake of Sep. 9, 1951 (Ref. 4, 5, 6). Therefore, Algeria has made a lot of efforts for mitigations of earthquake disasters. Ethiopia is located on the north-eastern part of African plate which come contact with Arabian plate and the East Africa Rift Valley run through the central part of its territory (Ref. 7, 8). In consequence, Ethiopia has been ardent and interested in earthquake disaters and its prevention and has made a trial of making seismic zoning map. Therefore, making regional distributions of maximum earthquake motion and seismic hazard maps are very important for these areas. Fig. 6 shows the contour maps of maximum acceleration and Fig. 7 are seismic hazard maps for Algeria and Ethiopia.

CONCLUSIONS

The point of this report is that by only giving the latitude and longitude of the area concerned as input data, we can get fundamental informations on seismicity and regional distributions of maximum earthquake motion for the area. These results will prepare a basic and preliminary information for aseismic design code, countermeasures against disasters and so forth.

It is necessary to improve quality and quantity of the seismic data and to develop the method of analysis in which not only seismicity but also other factors related to earthquake phenomena are taken into considerations.

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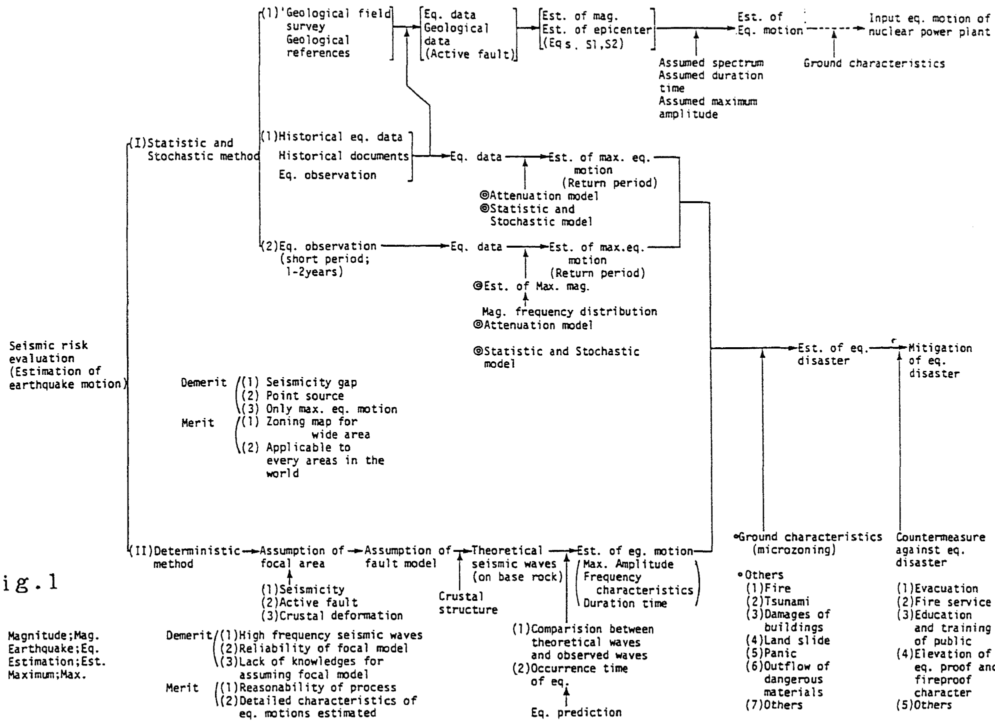

Fig.1

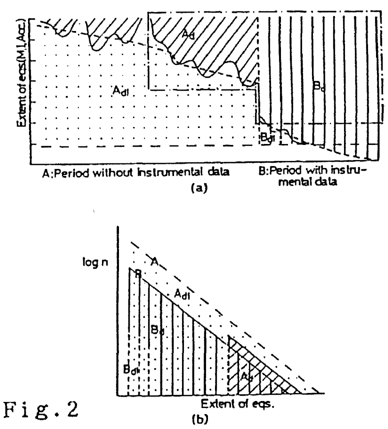

Fig.2

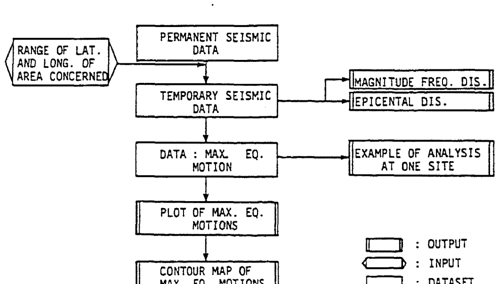

Fig.3

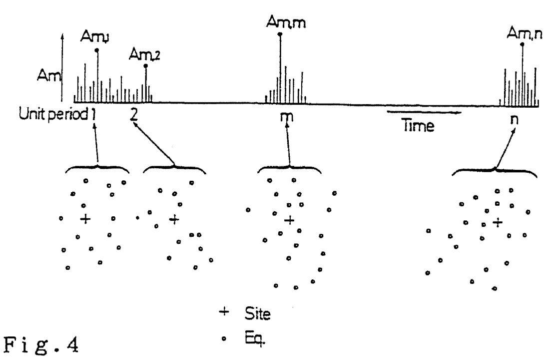

Fig.4

Fig.1 Comparison of ways of seismic hazard evaluation.

Fig.2 Change of quality and quantity of seismic data with the age.

Fig.3 General procedure of analyses.

Fig.4 Outline of getting expectancy of maximum earthquake motion at one specific site.

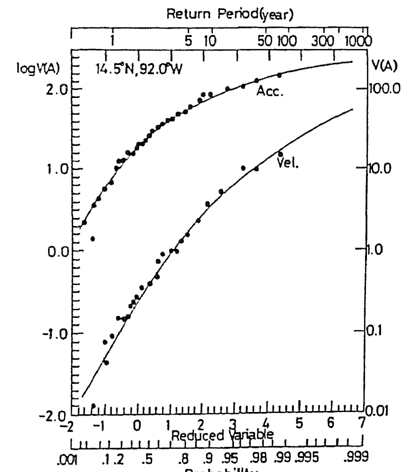

Fig.5

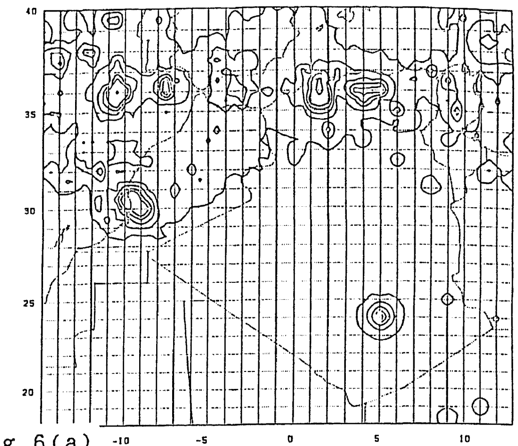

Fig.6(a)

MAXIMUM ACCELERATION(GAL). RETURN PERIOD: 100YEAR
CONT. INT.: 10. 20. 30. 40. 50. 100. 150. 200. 250. 300. 400. ....

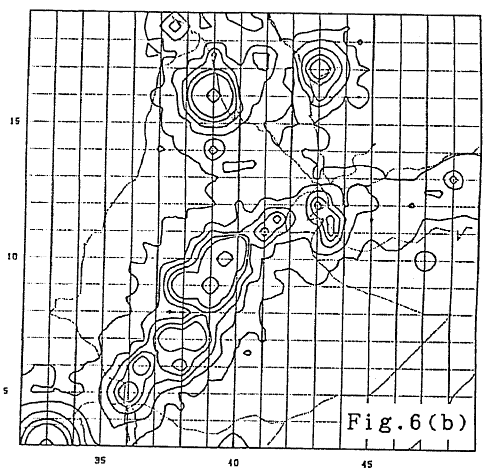

Fig.6(b)

MAXIMUM ACCELERATION(GAL). RETURN PERIOD: 100YEAR
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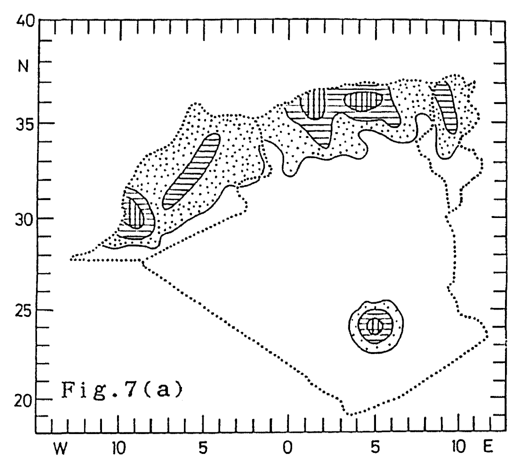

Fig.7(a)

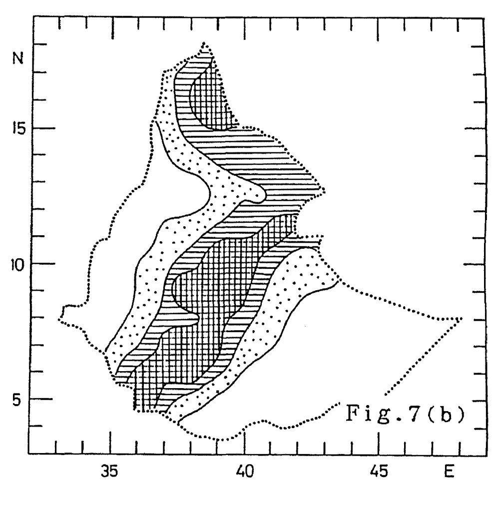

Fig.7(b)

Fig.5 An example of analyses for one specific site.

Fig.6 Regional distribution of maximum earthquake motion (a) Algeria. (b) Ethiopia.

Fig.7 Seismic hazard zoing map (seismic regional coefficient)
(a) Algeria
(b) Ethiopia