AN ISOSEISMAL-ENERGY CORRELATION FOR USE IN EARTHQUAKE STRUCTURAL DESIGN

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SUMMARY

A fundamental invariant for the earthquake phenomenon is studied in this Report. The analysis presents a rational analytical representation for the isoseismal map, which is one of the key sets of data for an earthquake. Five separate earthquakes in different parts of the world, which occurred over the past 100 years, are used to check and correlate the data. The invariant obtained in this research is of basic importance in energy analyses of the earthquake event and may find use in studies of the earthquake mechanisms as well as in applications to the practical structural design. In addition, it introduces new parameters that may be of importance in earthquake studies.

THE ISOSEISMAL INVARIANT

An overall consideration involved in this research is an attempt to determine the significant parameters involved in one particular set of earthquake engineering data -the isoseismal map. In this map regions of equal intensity are bounded by curves. There is no doubt that the location of the regions of different intensity is somewhat arbitrary and subject to the data-taker's interpretation. However, it is an important, recognized set of earthquake engineering data. It would therefore be very desirable that some generalization or invariant or parameter or correlation be developed from this data and the present report addresses this problem.

On purely physical grounds, it would seem reasonable that a measure of the earthquake strength -or of its energy- is connected with the intensity number and the area over which this intensity number acts.

Thus -as a first step in the development of the model, it was assumed that the isoseismal curves may be represented by equivalent area circles. Admittedly, some of the isoseism representations are highly assymetric. These are probably due to linear surface or near-surface faults. Deep focus earthquakes probably generate more nearly circular isoseisms. In any case, an average circular representation can be taken as a first step and its validity checked against the realities of actual earthquakes-including the inevitable discrepancies and differences inherent in the determination of accurate isoseismals.

Having made the initial "circular assumption", it is then assumed that a basic parameter for the isoseismal analysis is the product of "intensity times average radius to the region of constant intensity". Physically, this is reasonable. The product (IS_{AV}) or simply (IS) is one measure of the localized energy generated by the earthquake. We shall call this term the Intensity Index.

The mathematical development of the invariant is also a reasonable one -on physical as well as mathematical grounds. It is based upon a development described in Borg, 1974 and leads finally to the equation

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$$\frac{\Sigma(IS)}{\Sigma(IS)_f} = e^{K\left[1-\left(\frac{S_f}{S}\right)^n\right]} \qquad (1)$$

in which

$\Sigma(IS)$ is the summation of this quantity from S=o (the epicenter) to the given Intensity region

$\Sigma(IS)_f$ is the total or final value from I_{MAX} to I=3, which is about the lowest Intensity reading possible

K and n are constants to be determined by studying actual earthquake isoseismal maps.

To test this invariant hypothesis, the published isoseismals of the following earthquakes were utilized: 1) San Fernando, Feb. 9, 1971, 2) Friuli, May 6, 1976, 3) Udine region, June 29, 1873, 4) Washington State, Dec. 14, 1872, 5) Imperial Valley, May 18, 1940. It was found that a good fit for all five earthquakes is given by

$$\frac{\Sigma(IS)}{\Sigma(IS)_f} = e^{2\left[1-\left(\frac{S_f}{S}\right)^{1/3}\right]} \qquad (2)$$

The two fundamental parameters are S_f and $\Sigma(IS)_f$ and an analysis based upon a tentative uniqueness-existence hypothesis leads to the conclusion that 1) S_f is influenced by soil or geological conditions 2) $\Sigma(IS)_f$ is influenced by the surface horizontal energy of the earthquake.

Finally, an extension of the mathematical analysis leads to the conclusion that the total surface horizontal energy per unit radius attenuates inversely as the $S^{1/3}$ power.

All of the above is covered in detail in the report mentioned in the Acknowledgement and further study is in progress in checking and attempting to verify the different predictions which follow from the theory.

ACKNOWLEDGEMENT

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REFERENCE

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