ACCELEROGRAM, INTENSITY, DAMAGE-A NEW CORRELATION FOR USE IN EARTHQUAKE ENGINEERING DESIGN

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SUMMARY

This research presents a new unifying concept or invariant for the accelerogram, one of the basic records of an earthquake. The model is based upon a rigorous mathematical and physical argument and has been checked against different earthquakes in various parts of the earth. In addition a new damage criterion based upon the parameters of the invariant will be described.

THE ACCELEROGRAM INVARIANT

In developing the accelerogram invariant, an envelope is formed of the positive portion of the accelerogram between the time t=o (the initiation of the earthquake record) and t=t_f, the end of the earthquake record. It is assumed that t_f and $\Sigma(a\Delta t)$ are the fundamental parameters of this record. $\Sigma(a\Delta t)$ is the area under the envelope between t=o and any time t=t. Then, proceeding as in Borg, 1974, we obtain finally, the relation

$$\frac{\Sigma(a\Delta t)}{\Sigma(a\Delta t)_f} = e^{K\left[1-\left(\frac{t_f}{t}\right)^n\right]} \qquad (1)$$

in which K and n are constants to be determined from a study of actual accelerograms. Accelerograms from the Tolmezzo (1976), Taft (1952), Lima (1966), San Fernando (1971) and Bucharest (1977) earthquakes were analyzed and the single equation -the invariant- which applies to all is

$$\frac{\Sigma(a\Delta t)}{\Sigma(a\Delta t)_f} = e^{0.12\left[1-\left(\frac{t_f}{t}\right)^{1.8}\right]} \qquad (2)$$

The fundamental -the global- parameters for these earthquakes are as follows:

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Earthquake	t_f, seconds	$\Sigma(a\Delta t)_f$, "g" seconds
Tolmezzo	20	0.98
Taft	20	0.96
Lima	20	1.84
San Fernando	48	1.06
Bucharest	14	0.72

TABLE 1

In a tentative uniqueness-existence hypothesis developed in connection with Eq. 1, K and n are ultimately related to

1) the soil or geological conditions at the point where the accelerogram is obtained. This influences t_f
2) $(a\Delta t)_f$ is the parameter influenced by total surface horizontal energy per unit ground area at the site where the accelerogram is obtained.

This implies that t_f and $\Sigma(a\Delta t)_f$ vary depending on the above factors. Further studies are in progress to clarify and check this hypothesis.

A related, though different analysis leads to a parallel equation to Eq. 1. This leads to an expression for the surface horizontal energy per unit time supplied by the earthquake at the site where the accelerogram is recorded. For the K and n values given, we find that this quantity varies inversely as the $t^{2.8}$ -a prediction which should be capable of checking.

Note- if the accelerogram is too complicated to be represented by the simple Eq. 1, then it is conceivable that the record is due to a series of closely spaced shocks and a superposition of several Eq. 1, with time lags may represent the event. This -if verified- would introduce an entirely new procedure for studying the strengths and properties of earthquakes. Studies are also being pursued in this direction.

THE DAMAGE CONTOUR MAP

t_f and $(a\Delta t)_f$ are assumed to be the fundamental parameters of the accelerogram invariant. Furthermore, on physical grounds it seems reasonable to assume that the damage inflicted in a structure at a given location is related to the acceleration of the ground at that location.

Based upon the foregoing and utilizing available records concerning damage (or intensity) at the locations of the accelerograms considered, a "Damage Contour Chart" may be constructed, with t_f and $\Sigma(a\Delta t)_f$ as the coordinates and curves separating regions of approximately equal intensity.

Studies are underway in an attempt to alter the chart to account, in

some simple reasonable fashion, for the variation of frequencies, since these probably have an influence on the damage.

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REFERENCE

S.F.Borg - Similarity Solutions in the Engineering, Physical-Chemical, Biological-Medical and Social Sciences, Proceedings of Symposium "Symmetry, Similarity and Group Theoretic Methods in Mechanics", Ed. P.G. Glockner and M.E. Singh, Univ. of Calgary, Aug. 1974, pp. 263-282.

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