

Measuring Earthquake Intensity in Pounds Per Square Foot

A suggested deduction based on a controlling maximum ground velocity for all periods in a given disturbance

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CONVENTIONAL measure of the intensity of an earthquake is the ratio, α , of the greatest horizontal acceleration of the ground to the acceleration due to gravity. When seismograms are interpreted as sets of sine and cosine waves with different periods, superimposed on one another, it appears that the greatest values of the intensity α are identified with small waves with short periods, while waves with greater amplitudes and longer periods correspond to smaller intensities. The effects of an earthquake on a structure depend to a great extent on the relations of its periods of free vibrations to the periods of the vibrations of the ground. Therefore, if the safety of a structure against earthquakes is examined with due consideration of the different possible periods of vibration, it does not seem rational to assume a single constant value of the intensity ratio, independent of the periods. When the ratio is not a constant it loses its usefulness as a measure of the intensity of the earthquake, although of course it may be kept as a quantity occurring in the computations.

Consider the motion defined by the equation

$$x = \alpha g \left(\frac{T}{2\pi} \right)^2 \cos \frac{2\pi t}{T} \quad (1)$$

in which x = the displacement of the ground in a horizontal direction, T = the period, and t = time. The maximum acceleration is seen to be αg . The maximum velocity becomes

$$v = \alpha g \frac{T}{2\pi} \quad (2)$$

If α is to decrease when T increases, then perhaps it is plausible to assume

α inversely proportional to T within some range of values of T . Then v becomes a constant. For this reason it is suggested that consideration be given to the following possibility: The anticipation of earthquakes in a given region is expressed not in terms of a greatest acceleration αg , but in terms of a greatest velocity v . The examination of the safety of a structure against earthquakes resolves itself, then, into a study of its vibrations due to the most unfavorable possible combinations of seismic waves, these combinations being subject to the restriction that the greatest velocity of the ground shall be v .

In case of simple harmonic motions, if in some region the ratio $\alpha = 0.05$ is likely to occur when $T = 1$ sec., then

to $T = 0.1$ sec. would correspond $\alpha = 0.5$. The corresponding maximum velocity would be $v = 0.256$ ft.-sec.⁻¹.

Anticipating a particular maximum velocity of the ground is equivalent to anticipating a particular maximum kinetic energy of the ground per unit of volume. If w is the weight of the bedrock per unit of volume, then this kinetic energy becomes

$$k = \frac{1}{2} \frac{w}{g} v^2 \quad (3)$$

This energy is measurable in ft.-lb. per cu.ft. or in lb. per sq.ft.

During an earthquake, waves of kinetic energy are transmitted through the bedrock. It seems reasonable that the intensity of this action should be measured by its energy. The suggestion is submitted that the energy k might serve as a measure of the intensity of earthquakes.

A numerical example will indicate the orders of magnitude of the various quantities. Assume $k = 1$ lb.ft.⁻², $w = 170$ lb.ft.⁻³; then eq. (3) gives $v = 0.615$ ft.sec.⁻¹. If the motion is simple harmonic, eq. (2) gives $\alpha T = 0.12$ sec., which permits the combination $\alpha = 0.1$, $T = 1.2$ sec., $x_{\max} = 0.118$ ft.

Letters to the Editor

Trends in Engineering Education

Sir—I am quite in agreement with the analysis of the future trends of engineering education made by Dean H. S. Rogers in your issue of April 6, 1933, p. 438. The tendencies that he outlines have been growing steadily for the past quarter of a century. In the nature of things any marked technological progress can come only through more highly trained men, for as progress is made in any line of thought the difficulties become increasingly greater, and the pioneer days of engineering are past. There is sure to be a demand for a limited number of highly trained men in all fields of engineering and a decreasing demand for engineers of ordinary ability and qualifications. I agree,

also, with Dean R. A. Seaton that no revolutionary changes are necessary and that all educational thought is and should be always in flux to meet changing industrial conditions.

I am sure that Dean Rogers is quite right, also, in his opinion that there will be an increasing demand for engineers with administrative ability and sound training in business fundamentals. Industry in all of its phases has been growing more and more scientific, and in time there will be little or no place in industry for the executive of the old empirical type. An engineering course supplemented by courses in English, economics, corporation finance, cost-finding, etc., will probably offer the best training possible for the prospective industrial executive.