

DURATION OF STRONG GROUND MOTION^I

Discussion by

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The duration given by Bolt is likely that measured from filtered records and in such a case the result is necessarily strongly influenced by a band-pass filter employed. In measuring "filtered duration", therefore, the frequency characteristics of the filter should be clearly defined, since otherwise some arbitrariness would be introduced.

If an accelerogram with uniformly distributed frequency components from 0.25 to 7 Hz (approximate frequency range for SMAC record)^{III} is passed through an Octave- or 1/2-Octave-band-pass filter, the output levels will be lower than the over-all level by the amount given in Table A.

The writer has studied some twenty SMAC records obtained in Japan and derived an empirical formula for duration "exceeding"^{IV} an arbitrary threshold acceleration α gals as

$$\log_{10} t_{\alpha} = -0.0088\alpha + 0.50M - 1.82 \text{ (sec)}$$

for

$$\log_{10} r \leq 0.51M - 1.57 \text{ (km)}$$

where M and r are the earthquake magnitude and hypocentral distance in km, respectively. (Fig.A)¹

According to the relation the durations for threshold values 0.05g and 0.10g are respectively given by

$$\log_{10} t_{50} = 0.50M - 2.26 \text{ (sec)} \text{ and } \log_{10} t_{100} = 0.50M - 2.70 \text{ (sec)}$$

Thus the durations at Hachinohe in the 1968 Tokachioki earthquake of M=7.8 would be

$$t_{50} = 43.65 \text{ (sec)} \quad \text{and} \quad t_{100} = 15.81 \text{ (sec)}$$

On the other hand the fluctuation of unfiltered horizontal accelerations at Hachinohe in the earthquake and the durations exceeding thresholds were as shown in Fig.B and C. From the figures

$$t_{50NS} = 63 \text{ (sec)}, \quad t_{100NS} = 27 \text{ (sec)}$$

$$t_{50EW} = 37 \text{ (sec)} \text{ and } t_{100EW} = 12 \text{ (sec)}$$

The values determined above for Hachinohe except t_{50EW} are appreciably higher than those plotted by Bolt ($D_{0.05} \approx 33$ sec and $D_{0.10} \approx 5$ sec in Fig.5). The differences are too great as to be attributable to the difference between "uniform" and "bracketed" durations and seem to be due to the effect of band-pass filtering as described above. In earthquake engineering the over-all acceleration (unfiltered acceleration) may be as well important as the filtered one according as each case involved and longer estimates referred to by the author (1) would not always be "over-assessing".

¹ Kobayashi, Y., Effects of Earthquakes on Ground (II), Journal of Physics of the Earth, Vol.19, No.3, pp 231/241, 1971

I Paper No.292 by B.A.Bolt

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III Strong Motion Accelerograph

IV "bracketed duration" of unfiltered acceleration

Table A - Difference in Levels(dB) Between Filtered and Unfiltered Noise of Uniformly Distributed Frequency Components(0.25 - 7 Hz)

Filter \ Freq.	1 Hz	2 Hz	4 Hz
Octave	- 9.8(0.33)	- 6.7(0.47)	-3.6(0.66)
1/2-Octave	-12.9(0.23)	- 9.8(0.33)	-6.7(0.47)

() denote amplitude ratios

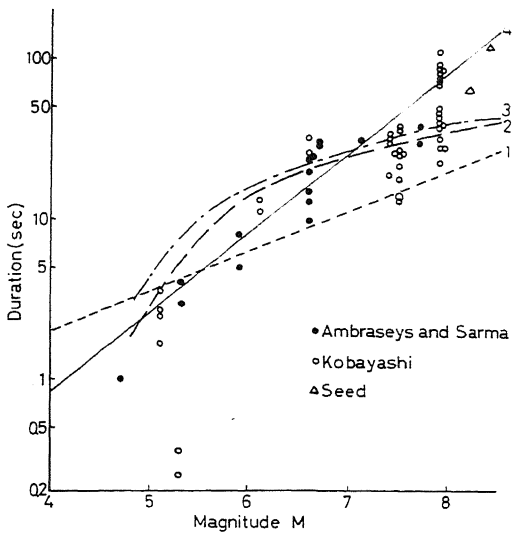


Fig. A Duration of strong shaking and the earthquake magnitude. 1. Gutenberg and Richter; $\log_{10} t_0 = 0.25 M - 0.7$, 2. Housner; $t_0 = 11M - 52$, 3. Ambraseys and Sarma; $t_0 = 11.5 M - 53.0$, 4. Kobayashi; $\log_{10} t_{30} = 0.50 M - 2.08$.

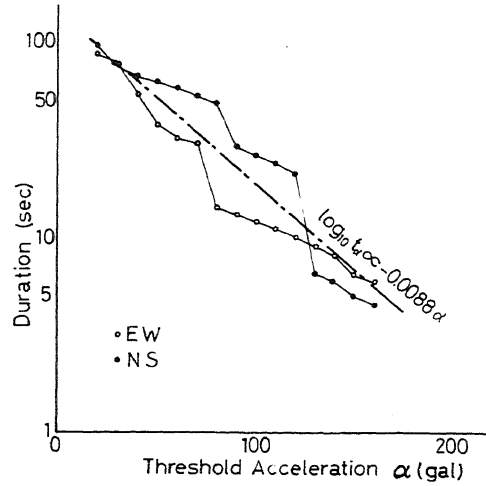


Fig. C Duration of ground motion exceeding arbitrary threshold values of acceleration; Tokachioki earthquake, May 16, 1968, $M=7.9$, recorded at Hachinohe harbor, $\Delta=180$ km.

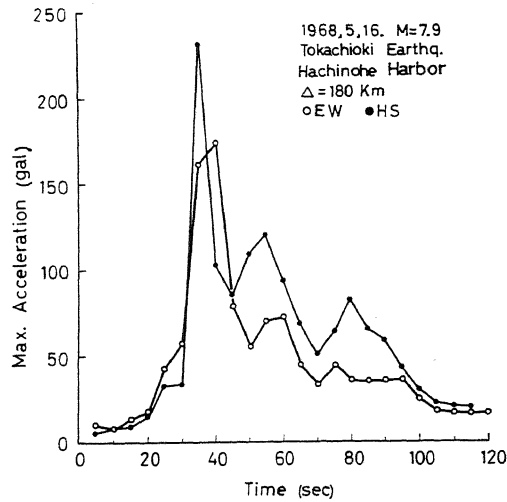


Fig. B Fluctuation of acceleration during an earthquake: Tokachioki earthquake, May 16, 1968, $M=7.9$, recorded at Hachinohe harbor, $\Delta=180$ km.

