EFFECT OF INITIAL BASE MOTION ON RESPONSE SPECTRA[b]

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The authors present an interesting attempt to explain a characteristic of some computed Pseudo Relative Velocity Spectra (PSV) in the long period range (say, $T > 2$ sec). This trend is that the PSV spectral amplitudes for $T \leq 15$ sec appear to approach a constant velocity asymptote rather than an asymptote

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[a] December, 1977, by Geoffrey John Turvey (Proc. Paper 13409).
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[b] April, 1978, by David A. Pecknold and Rafael Riddell (Proc. Paper 13649).
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determined by the peak ground displacement. They introduce the subject by stating that "certain low frequency distortions or anomalies can arise when accelerograms with initial conditions are used in structural response calculations." The explanation of low frequency systems (on p. 487) that follows appears a little unclear to the reader. In particular, some inconsistencies seem to occur in assuming: (1) That on physical ground the initial conditions on the oscillator, at the time at which the record of motion starts, are $x(0) = -d_o$, $\dot{x}(0) = -v_o$; and (2) deducing that the peak relative velocity $V = v_o$.

If t_s were the time at which the ground motion record begins and t_e the

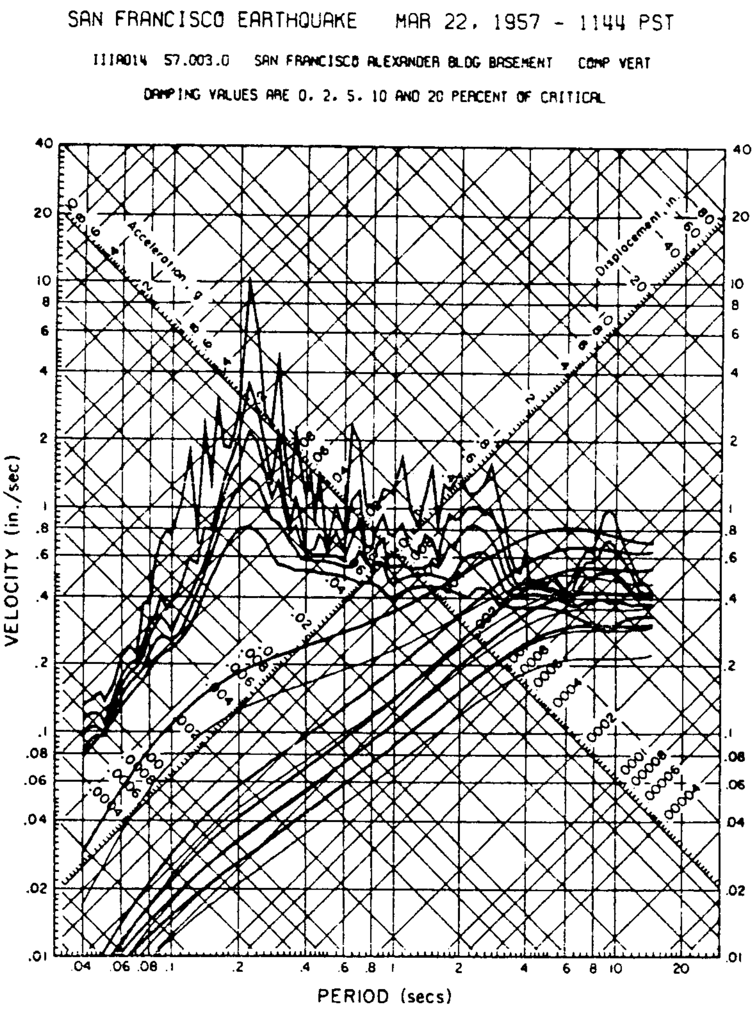

FIG. 3.—Response Spectrum

time beyond which ground motions are assumed to be negligible, the oscillator relative response, x, can be described, for all time, t, by

$$\ddot{x} + 2\omega_n\xi\dot{x} + \omega_n^2 x = -\ddot{z}(t) \quad \text{. . . . .} \quad (5)$$

with $x(0) = 0$, $\dot{x}(0) = 0$, $z(0) = 0$, $\dot{z}(0) = 0$, in which z is the absolute ground displacement. Taking Fourier transforms it can be seen that $X(\omega) = -Z(\omega)$ when $\omega_n/\omega \rightarrow \infty$. This yields $x(t) = -z(t)$ and $\dot{x}(t) = -\dot{z}(t)$ for all time. If it is assumed on physical grounds that at the start of the record $t = t_s$, $x(t_s) = -z(t_s)$, and $\dot{x}(t_s) = \dot{z}(t_s)$, thus implying $\omega_n/\omega \rightarrow \infty$, it would follow that $x(t) = -\dot{z}(t)$ and $\dot{x}(t) = -\dot{z}(t)$ for all time; the maximum relative velocity

$\dot{x}(t)$ would then be the maximum velocity of the ground motion. This maximum velocity could, in general, occur at any time; usually, it occurs neither in the initial unrecorded portion of ground shaking ($0 \leq t \leq t_s$) nor in the undigitized segment of the record ($t > t_s$).

Several studies have shown (7–10) that the contribution of the recording and processing noise to the amplitudes of computed response spectra (8,9) and Fourier amplitude spectra (7) can be considerable when earthquake sources are small or distant, or both, from the recording station. Detailed analysis of PSV spectra for 186 ground motion records plotted on the same scale with the spectra for digitization and processing noise (8) clearly suggests this. An example of such a comparison is shown in Fig. 3 for vertical acceleration recorded in the basement of the Alexander Building in San Francisco during the March 22, 1957 earthquake. In addition to five response spectrum curves for the fractions of critical damping ζ = 0.0, 0.02, 0.05, 0.10, and 0.20 computed from the recorded accelerations, this figure also shows the average (light lines) the average plus one standard deviation of PSV spectrum amplitudes (heavy lines) that would result from digitization and processing noise only. It is seen that for the periods $T \gtrsim 3$ sec, the amplitudes of spectra for recorded motions approach the amplitudes of spectra for digitization and processing noise, suggesting that the signal-to-noise ratio becomes small for this frequency range.

Appendix.—References

7. Trifunac, M. D., "Preliminary Empirical Model for Scaling Fourier Amplitude Spectra of Strong Ground Acceleration in Terms of Earthquake Magnitude, Source to Station Distance and Recording Site Conditions," *Bulletin of the Seismological Society of America*, Vol. 66, 1976, pp. 1343–1373.
8. Trifunac, M. D., "Uniformly Processed Strong Earthquake Ground Accelerations in the Western United States of America for the Period from 1933 to 1971: Pseudo Relative Velocity Spectra and Processing Noise," Department of Civil Engineering, *CE 77-04*, University of Southern California, Los Angeles, Calif., 1977.
9. Trifunac, M. D., and Anderson, J. G., "Preliminary Empirical Models for Scaling Absolute Acceleration Spectra," Department of Civil Engineering, *CE 77-03*, University of Southern California, Los Angeles, Calif., 1977.
10. Trifunac, M. D., Udwadia, F. E., and Brady, A. G., "Analysis of Errors in Digitized Strong Motion Accelerograms," *Bulletin of the Seismological Society of America*, Vol. 63, 1973, pp. 157–187.