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THE PORT HUENEME EARTHQUAKE OF MARCH 18, 1957

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ABSTRACT

The Port Hueneme earthquake of March 18, 1957, was the first recorded strong-motion earthquake for which the ground motion consisted essentially of a single pulse. Since all the energy of the earthquake was concentrated in one pulse, the ground accelerations and the response spectrum values were considerably larger than for more typical Pacific Coast earthquakes of equivalent magnitude. These abnormally high values are reflected in damage reports, which indicated an unusual amount of damage for a shock of magnitude 4.7.

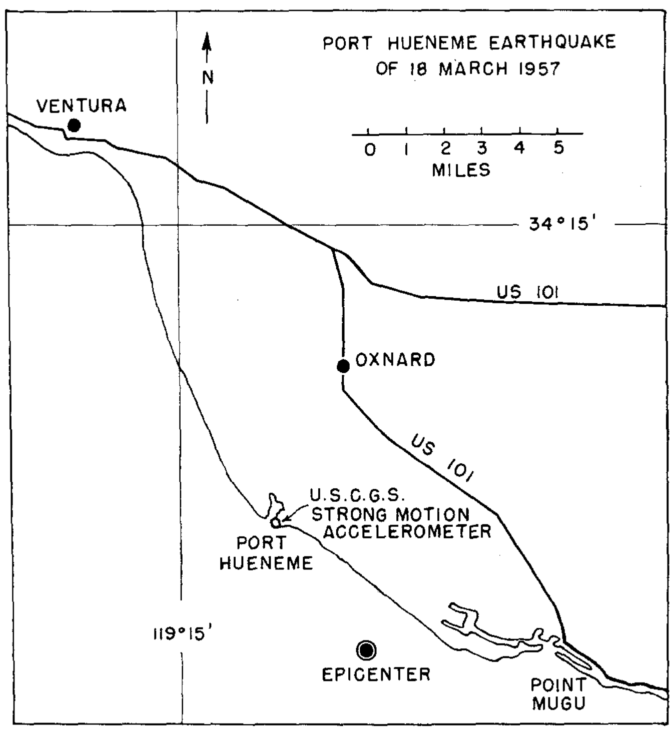

Fig. 1. Location of epicenter and strong-motion accelerometer.

The earthquake at Port Hueneme, California, on March 18, 1957, had certain unusual features that are of interest to engineers concerned with earthquake-resistant construction. According to Professor C. F. Richter of the Seismological Laboratory of the California Institute of Technology, in Pasadena, the shock was rated at magnitude 4.7 and the epicenter was located at 34° 06′ N, 119° 10′ W, with probable accuracy of five miles. A United States Coast and Geodetic Survey strong-motion accelerometer was approximately five miles northwest of the point just mentioned, as is shown in figure 1. The maximum recorded ground acceleration was 18 per cent g, which was exceptionally large for an earthquake of magnitude 4.7, and this was reflected in the damage reports, which were relatively numerous for a shock of this magnitude. The smallest earthquakes for which strong-motion records

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of interest to structural engineers had previously been obtained were of magnitude 5.3.

In figures 2 and 3 are shown the recorded ground accelerations and the integrated ground velocities and ground displacements. The initial acceleration pulse in the east–west direction was poorly defined on the accelerogram and its amplitude was therefore determined by the requirement that the velocity and displacement should go to zero at the end of the shock. It is shown in figures 2 and 3 that the strong

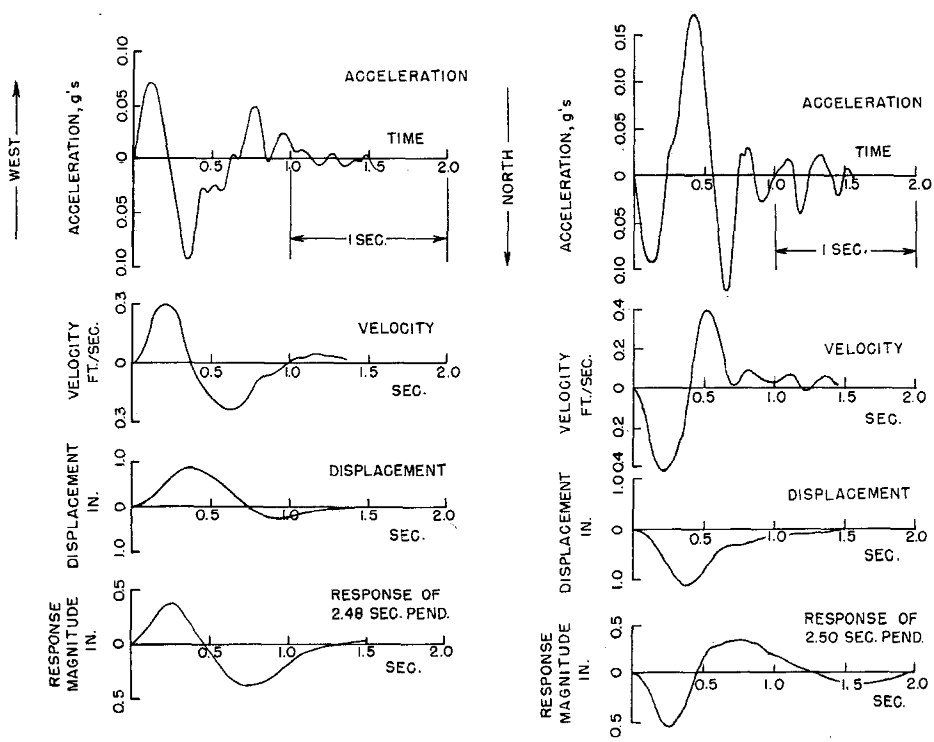

Fig. 2 (left). East–west components of ground motion.

Fig. 3 (right). North–south components of ground motion.

ground motion consisted essentially of a single displacement pulse with its corresponding accelerations. The traces of the combined horizontal ground motions are shown in figure 4, where it is seen that the ground displacement consisted of an almost straight throw in the northwest direction followed by a slightly curved path back to the original position. The ground motion was thus surprisingly simple, for the usual strong-motion records show a much more complicated motion. The strong motion of the Port Hueneme shock lasted approximately one second and consisted of three acceleration peaks. This may be compared with a more typical record such as the Golden Gate Park accelerogram of the March 22, 1957, San Francisco earthquake. This earthquake had a magnitude of 5.3 and its epicenter was 6 miles from the accelerometer. The strong motion lasted for 3 to 4 seconds and there were twenty acceleration peaks with a maximum acceleration of 12 percent g. This San Francisco earthquake was itself of unusually short duration, as compared with the

15 to 20 seconds duration of many Pacific Coast strong-motion earthquakes. Its record has been selected for comparison since of all the available strong-motion records this one most nearly matches in magnitude and distance the Port Hueneme earthquake.

Recorded along with the strong-motion accelerometer traces were the responses of two pendulums having periods of approximately 2½ seconds. The records produced by these instruments are shown in figures 2 and 3. It should be noted that the scale for these 2½ second pendulum responses differs by a factor of 2 from that used for the integrated displacement curves. Comparing the recorded responses of the 2½ second pendulums with the integrated velocity and displacement curves of

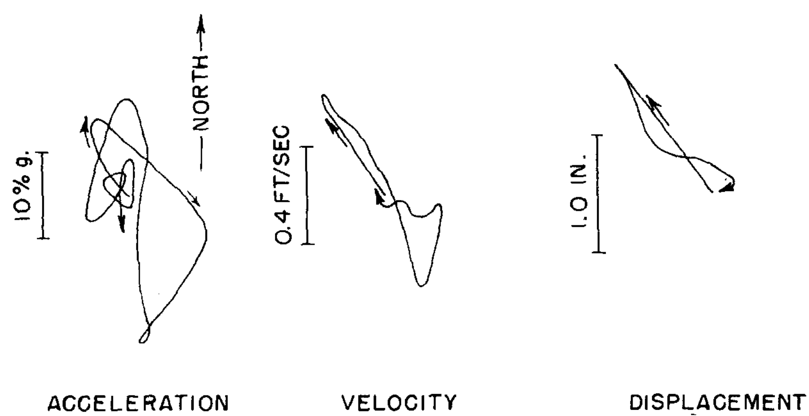

Fig. 4. Combined horizontal ground motions.

figures 2 and 3, it will be noted that the 2½ second instrument measures something in between the velocity and the displacement. It can thus be concluded that the pendulum period of 2½ seconds is not sufficiently large as compared with the periods involved in the present ground motion for the instrument to serve as a displacement meter.

Judging from the ground displacement shown in figure 4, the slip took place along a fault oriented N 37°.5 W. Assuming that the present earthquake is associated with typical large-scale ground motions in the California region, which are known to involve a slow drift of the western section of the state in a northwesterly direction, it would seem that the accelerometer must have been southwest of the fault line. Since the accelerometer was close to the shore line, the motion it recorded originated at the fault and traveled out under the ocean, whereas the motion that produced damage inland originated on the other side of the fault and was not recorded.

As a further means of comparing the present earthquake with past Pacific Coast strong-motion earthquakes, response spectrum curves for the two components have been calculated.[1] Figures 5 and 6 show the relative velocity response spectrum curves, and figures 7 and 8 give the acceleration spectrum curves.

[1] D. E. Hudson, "Response Spectrum Techniques in Engineering Seismology," *Proc. World Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, San Francisco, 1956; G. W. Housner, R. R. Martel, and J. L. Alford, "Spectrum Analysis of Strong-Motion Earthquakes," *Bull. Seism. Soc. Am.*, Vol. 43, No. 2 (April, 1953).

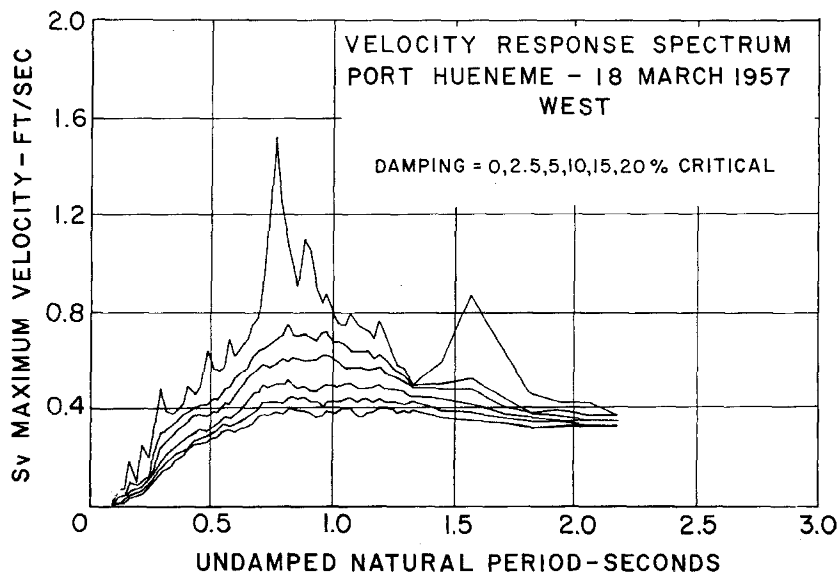

Fig. 5. East–west component. Maximum relative velocity response spectrum.

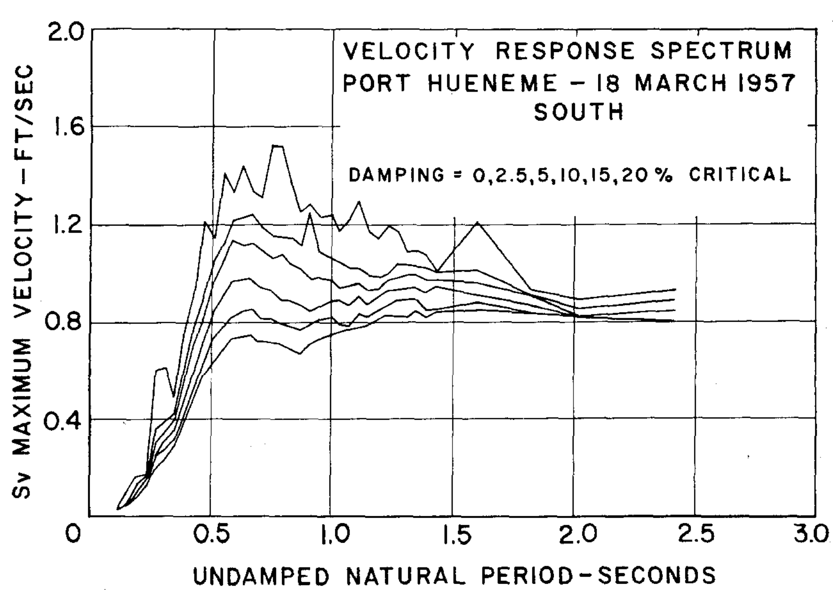

Fig. 6. North–south component. Maximum relative velocity response spectrum.

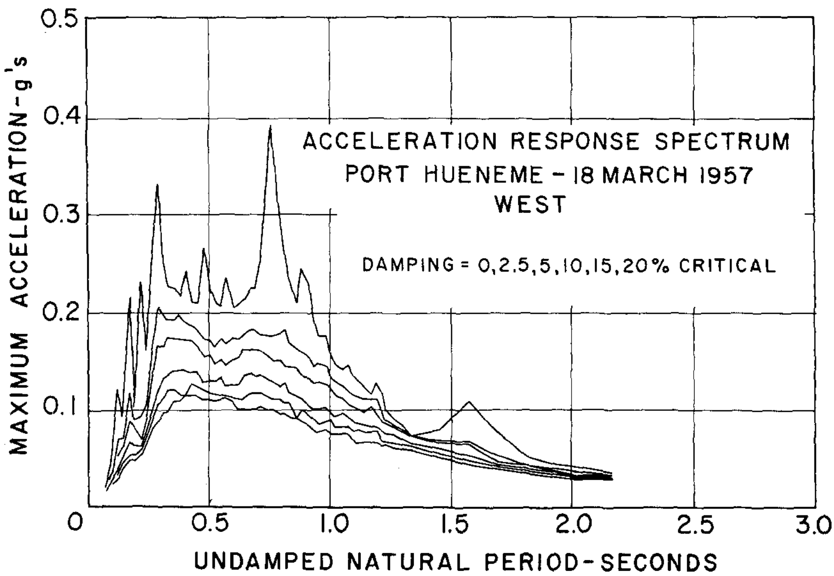

Fig. 7. East–west component. Maximum absolute acceleration response spectrum.

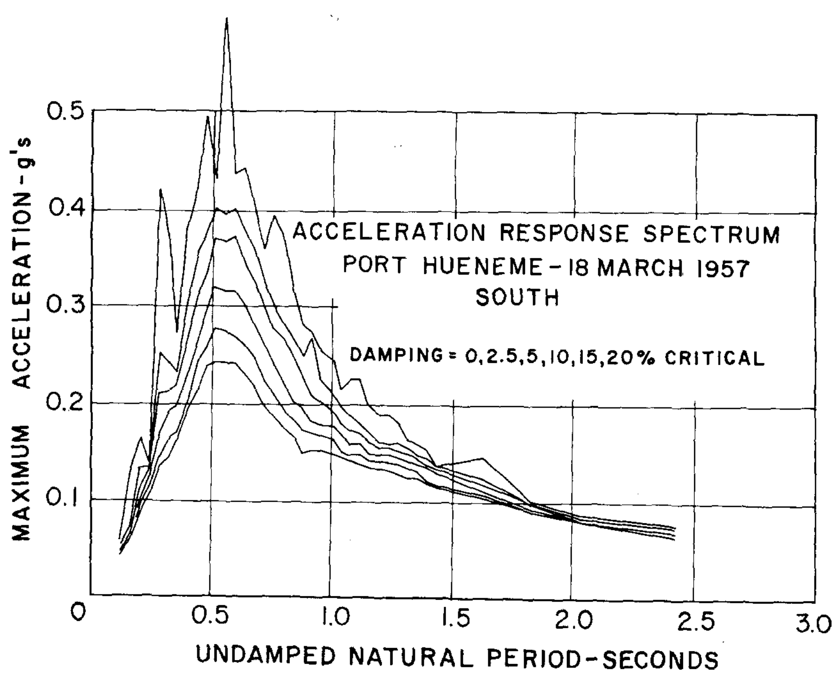

Fig. 8. North–south component. Maximum absolute acceleration response spectrum.

The shapes of the spectrum curves do not differ markedly from those of more typical earthquakes, but the ordinates are suprisingly large for a shock of 4.7 magnitude. For example, the ordinate of the 20 per cent damping curve is approximately 0.8 for the north–south component and 0.4 for the east–west component. These are compared in the following table with spectra of the San Francisco earthquake of March 22, 1957.

	Magnitude	Epicentral distance	20 per cent S_v
		(miles)	(ft./sec.)
Port Hueneme	4.7	5±	0.8; 0.4
Golden Gate Park	5.3	6.1	0.25; 0.18
State Building	5.3	8.4	0.30; 0.22
Alexander Building	5.3	9.6	0.15; 0.12

These figures show that if the energy released by an earthquake is concentrated in a single displacement pulse the effect on structures will be much more severe than if the character of the ground motion is like that of the San Francisco shock of March 22, 1957.

Single-pulse earthquakes have been recorded by seismologists before this, but these were shocks of small magnitude. The Port Hueneme accelerogram is the first strong-motion recording of a single-pulse shock. It is thus now known that such exceptional strong ground motions can occur, at least for shocks up to 4.7 magnitude. This raises the question whether it is possible that shocks of larger magnitude could be of this type, for if a shock of magnitude 6 or greater could be of the single-pulse type, it would require a revision of engineering thinking with respect to possible intensities of ground motions. On the basis of past experience it would appear that the probability of a strong single-pulse shock is relatively small, and hence engineers should continue to be guided by typical earthquake ground motions. The possibility of strong single-pulse shocks must, however, be kept in mind.

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