AMPLIFICATION STUDIES OF THE PACOIMA DAM FROM AFTERSHOCKS OF THE SAN FERNANDO EARTHQUAKE

by

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SYNOPSIS

Eight aftershocks, recorded at the strong-motion site and at the crest of Pacoima Dam indicated amplification in both the frequency and time domain as compared to a free-field station. Average over-all amplification was 1.4 in the north-south direction, 1.65 east-west, and 0.85 vertical at the strong-motion station site. If this is representative of amplification in the time-frequency domain, the observed and corrected peak acceleration from the San Fernando earthquake are 1.25 to .89g north-south, 1.25 to .76g east-west, and 0.72 to 0.85g vertical.

INTRODUCTION

The strong-motion station at Pacoima Dam, which recorded 1.25g maximum horizontal motion, was near the south abutment of the dam on a narrow rocky ridge of gneissic granite-diorite which had many nearby surface fractures as a result of the earthquake. There was a small rock slide about five meters to the west of the strong-motion site, and numerous rock slides in the valley below the 113 meter high arch constant angle dam which was completed in 1929.

The primary objective of this study was to determine if amplification was present at the strong-motion seismograph site, i.e., to synthesize ground motion characteristics, maximum motions and response spectra which would have been recorded if the dam was not there and if the station was not influenced by the possible effects of the narrow rocky ridge.

Figure 1 shows the locations of the primary shock (star), Pacoima Dam (triangle), and the eight aftershocks (circles) used in this study. The aftershocks

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with date, time, location, depth, magnitude (M_L), and approximate distance and direction from the dam, are listed below:

Date	Time h m	Aftershocks Location	D^I km	M^{II} M_l	R^{III}
3-6-71	0553	34°23.8'N 118°26.5'W	7.4	3.3	8 km NW
3-7-71	0707	34°17.4'N 118°23.2'W	7.3	2.7	4.5 km S
3-7-71	0711	34°22.7'N 118°26.7'W	5.1	3.1	7 km NW
3-7-71	0752	34°24.3'N 118°24.6'W	11.4	3.2	8 km NNW
3-7-71	0810	34°22.9'N 118°24.4'W	6.4	2.8	5.5 km NNW
3-7-71	1126	34°21.7'N 118°29.4'W	1.4(?)	3.6	9 km WNW
3-8-71	0316	34°17.5'N 118°23.8'W	8.7	2.9	4.5 km S
4-18-71	2227	34°37.5'N 118°40.9'W	20	3.7	30 km NW

NOTE: The first seven earthquake data were provided by the U.S. Geological Survey, Menlo Park, California.

The April 18 earthquake was on the NOAA/ERL/ESL PDE card 35-71, June 9, 1971.

Three stations were installed to record aftershocks. The first Station, 24, was located down stream in the valley floor at a sufficient distance to assure that there would be no feedback from the dam which would be induced to vibrate in its own

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I D = Depth

II M = Magnitude

III R = Distance and direction

characteristic modes. Station 25A was on the center-crest of the dam next to the location of the seismoscope which had sufficient motion from the primary shock to dislodge the recording plate. Station 25B was near the south abutment adjacent to the strong-motion recording shelter.

PROCEDURE

Frequency domain amplification was derived using techniques developed by Murphy, et al[1]. Amplification as used here is defined as the increase in vibration levels at the strong-motion site and dam-crest station as compared to the "free field" station down stream in the valley floor.

Time domain amplifications were evaluated by: 1. Total time duration that particle velocity was above certain levels; 2. Number of occurrences or peaks contributing to the total duration; 3. Maximum motion for each of the 72 seismograms and the ratio of this motion; 4. Arias intensity[2]; and, 5. Ratios of the total cummulative summation of the particle velocity squared.

RESULTS

Figure 2 is an example of the response spectra ratios representing amplification. As would be expected, the amplification is frequency dependent and, in this particular example, ranges from a factor of 3 at 0.2 second period to less than one at longer periods.

The overall average ratios for all frequencies for the aftershocks are as follows:

Station		Ratios	
Combinations	North	East	Vertical
25B/24	1.40	1.65	0.85
25A/24	1.20	1.27	0.76
25B/25A	1.16	1.32	1.12

Figure 3 is a typical example of the time domain amplification showing that for aftershock Number 6, the crest station had overall larger vibrations in the east-west component, while the north-south component was larger at the strong-motion site. Overall average

ratios for all frequencies reduced the maximum motion from 1.25 to 0.9g. The acceleration resultant vector at the time of maximum motion on each of the three components was 1.1g acting in a S33°W direction and inclined at 20° from the horizontal.

Figure 4 shows the original psuedo-relative velocity response spectra (5% damping) and the modified spectra which would have resulted had the station been on hard rock in the valley floor away from the influence of the dam and narrow ridge.

SUMMARY

There was amplification in both the frequency and time domain for the strong-motion station site as compared to a free field station for eight aftershocks varying in magnitude M_L of 2.7 to 3.7 occurring at epicentral distances of 4.5 to 30 km from the dam. The average spectral ratios which could be considered amplification varied from 4.2 at 0.2 second period for 25B/24 north component, to 0.52 deamplification at 0.8 second period for 25A/24 vertical component.

The maximum motion ratio, time duration, number of occurrences, and Arias Intensity maximum ratios all in general indicate amplification of the horizontal motion for the strong-motion site as compared to the free field motions.

Extrapolation of true amplification data from aftershocks as low as earthquake magnitude 2.7 to the 6.6 magnitude of the primary shock is speculation at best. If linearity exists in scaling from the low to higher magnitudes, the amplification is real.

REFERENCES

1. Murphy, J.R., R.D. Lynch, and L.J. O'Brien, "Calculated San Fernando Earthquake Response Spectra," National Conference on Earthquake Engineering, Investigation of the San Fernando Earthquake, Los Angeles, California, February 7-9, 1972.

2. Husid, Raúl, Hermán Medina and Jorge Rios, "Analisis de Terremotos Norteamericanos y Japoneses," Vol. 8, No. 2, September 1969, Revista del Idiem.

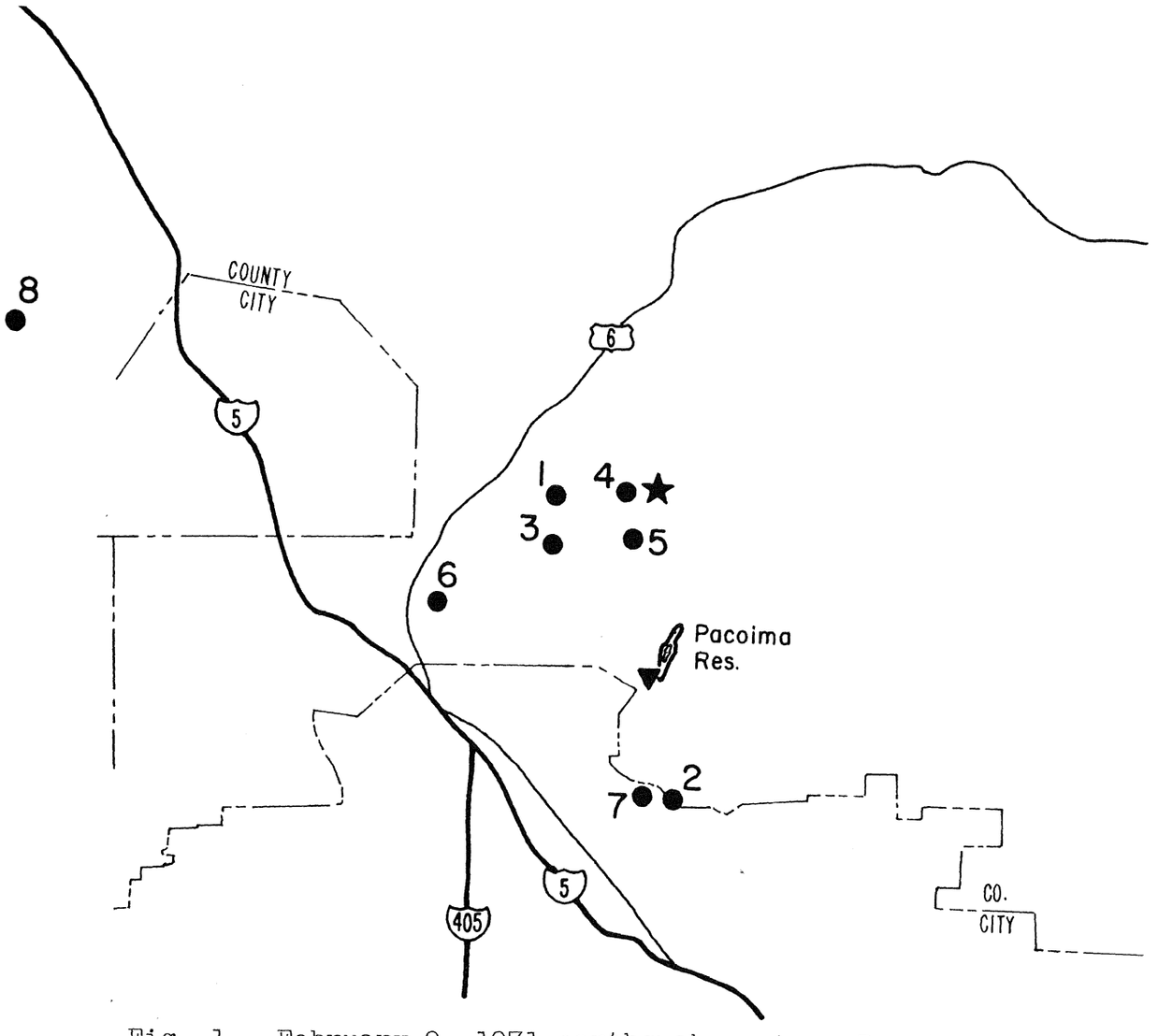

Fig. 1. February 9, 1971 earthquake, star; Pacoima Dam, triangle; and eight aftershocks numbered in order of occurrence, circle.

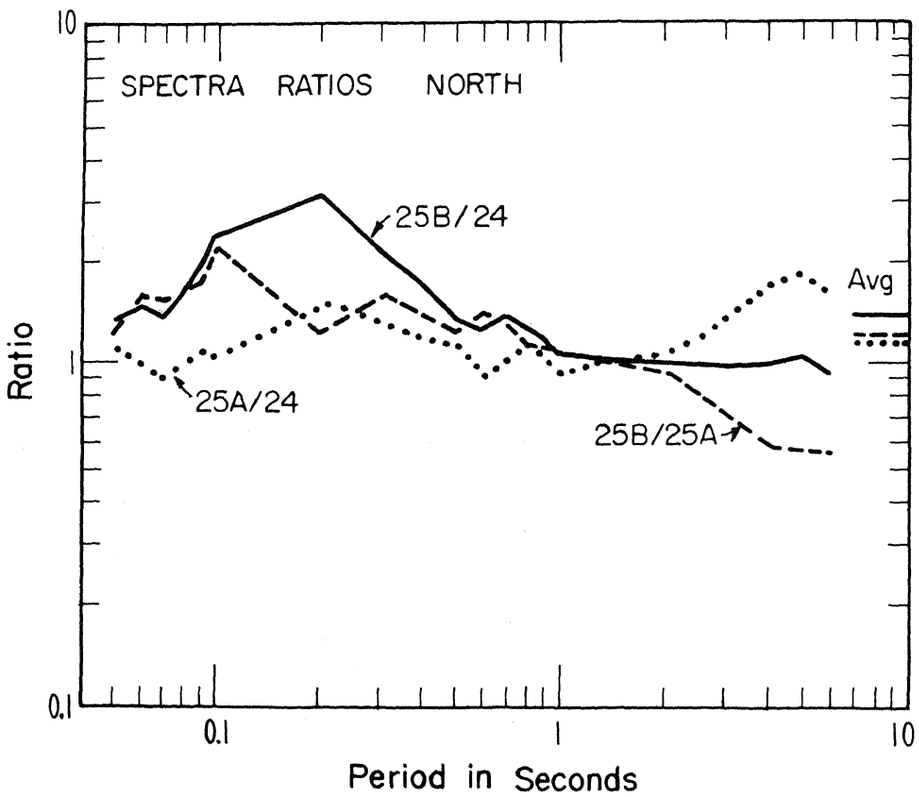

Fig. 2. Overall average response spectra ratios, strong-motion site to free field, strong-motion site to dam crest, and dam crest to free field for the eight aftershocks, north component.

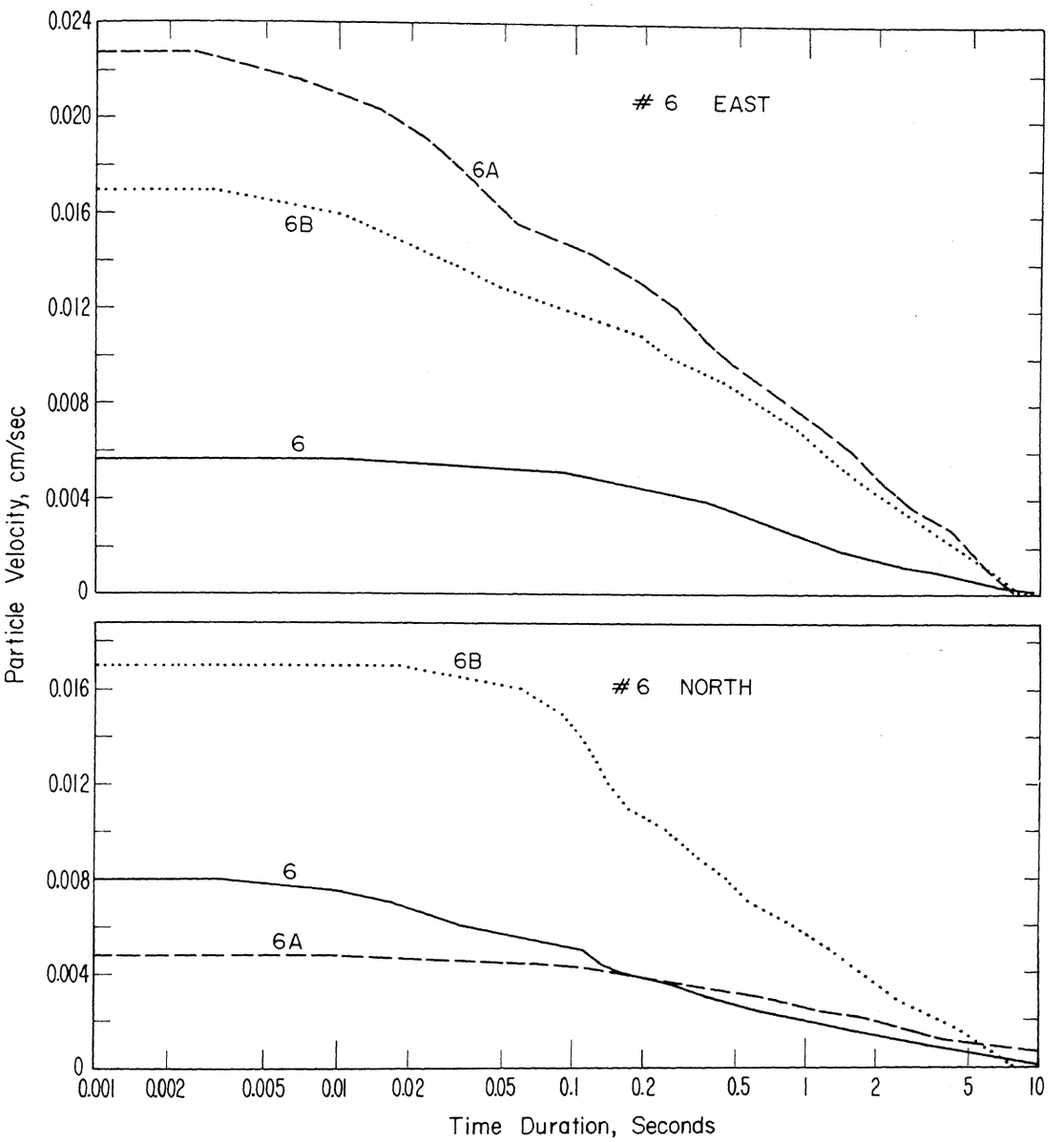

Fig. 3. Time duration for particle velocity on north and east components of stations 24, 25A, and 25B event 6.

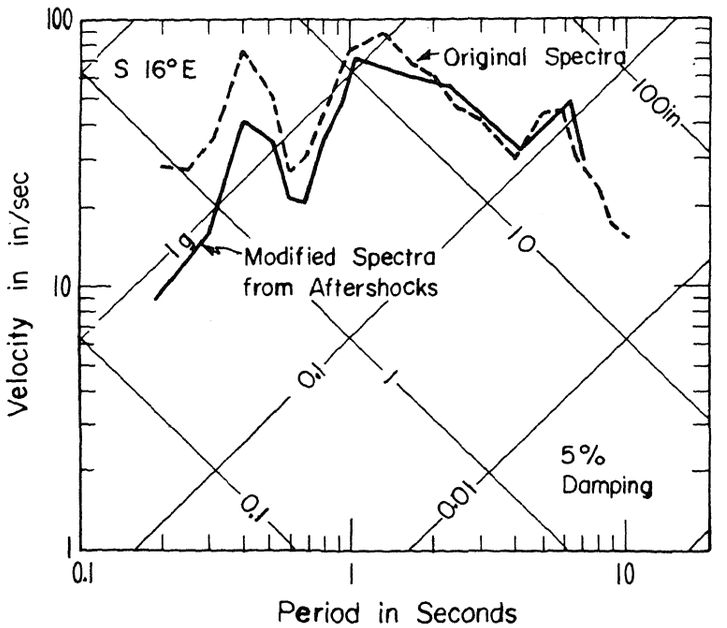

Fig. 4. Original response spectra (February 9, 1971) and modified spectra for north component.