GEOLOGICAL SURVEY CIRCULAR 736-B

Seismic Engineering Program Report, April–June 1976

Prepared on behalf of the
National Science Foundation
Grant CA-114

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ILLUSTRATIÓNS

Table 1 - *Summary of accelerograph records: April - June 1976*

Event	Station location: Name	Station location: Coord	S-t time[1] (sec)	Comp	Max accl[2] (g)	Duration[3] (sec)
10 December 1975 0958 GMT Imperial Valley 32.95N, 115.50W Magnitude 3.8	Two minor records were obtained at El Centro: Sations 5 and 6.					
5 February 1976 0936 GMT Alaska 59.8N, 149.1W Magnitude 4.8	One small record obtained at Wesleyan Hospital in Seward, Alaska.					
22 February 1976 0722 GMT Alaska 51.2N, 177.0W Magnitude 5.4	Adak, Alaska, Vault	51.88N 176.58W	— — —	North Down West	.03 .01 .05	— — —
8 April 1976 1521 GMT So. California 34.36N, 118.66W Magnitude 4.7	Santa Felicia Dam, Crest	34.46N 118.75W	— — —	S78W Down S12E	.05 .03 .05	— — —
	Santa Felicia Dam, Right abutment	34.46N 118.75W	— — —	S78W Down S12E	.04 .03 .05	— — —
	Note: three minor records obtained at 8244 Orion street, ground, 4th and 8th floor levels.					

[1] S-wave minus trigger time.

[2] Unless otherwise noted, maximum acceleration recorded at ground or basement level. Data from the records are summarized only if the maximum acceleration is greater than 0.05 g at ground stations or greater than 0.10 g at upper floors of buildings.

[3] Duration for which peaks of acceleration exceed 0.10 g.

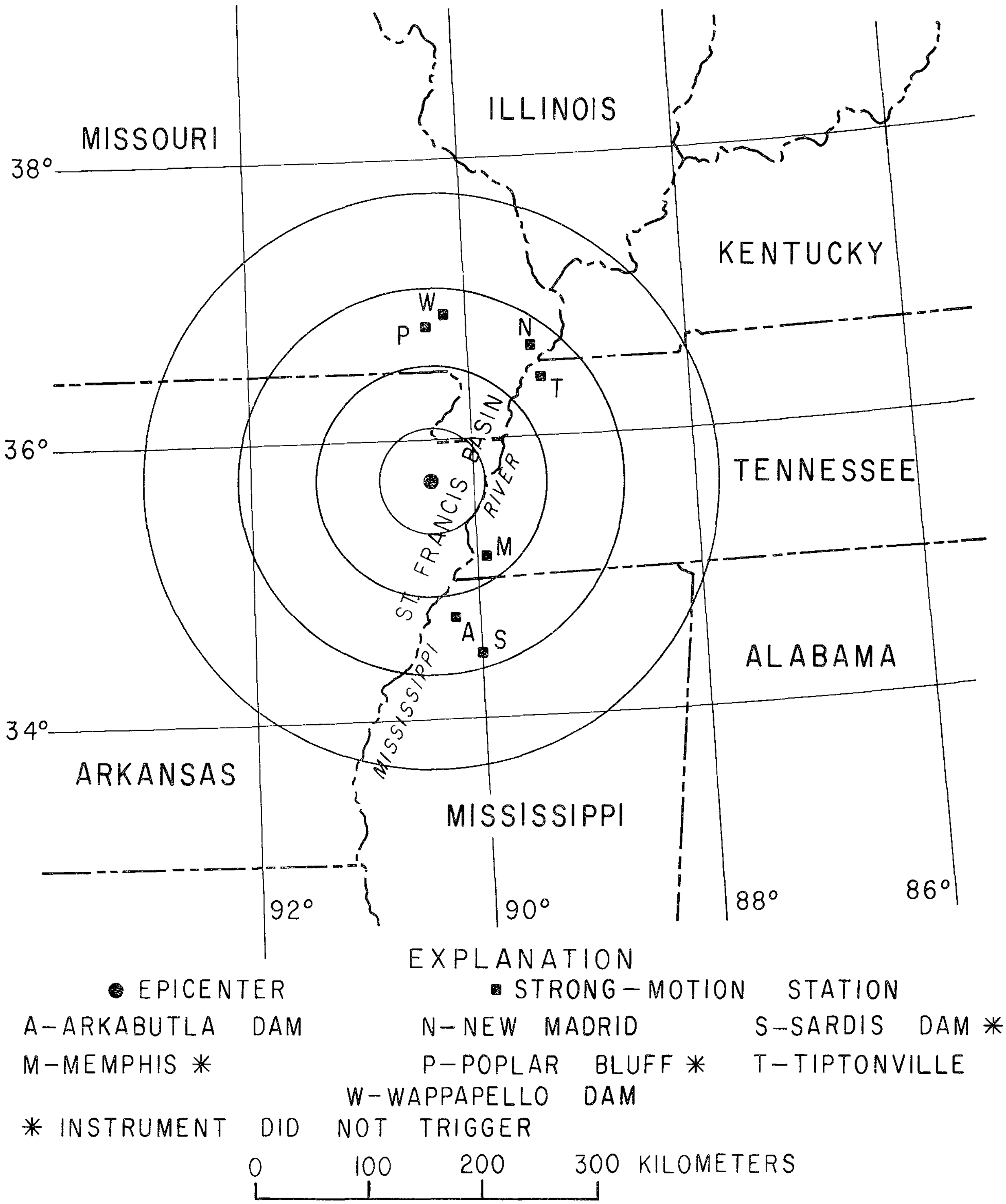

Figure 1.- Locations of strong-motion stations in vicinity of northeast Arkansas earthquake of March 24, 1976.

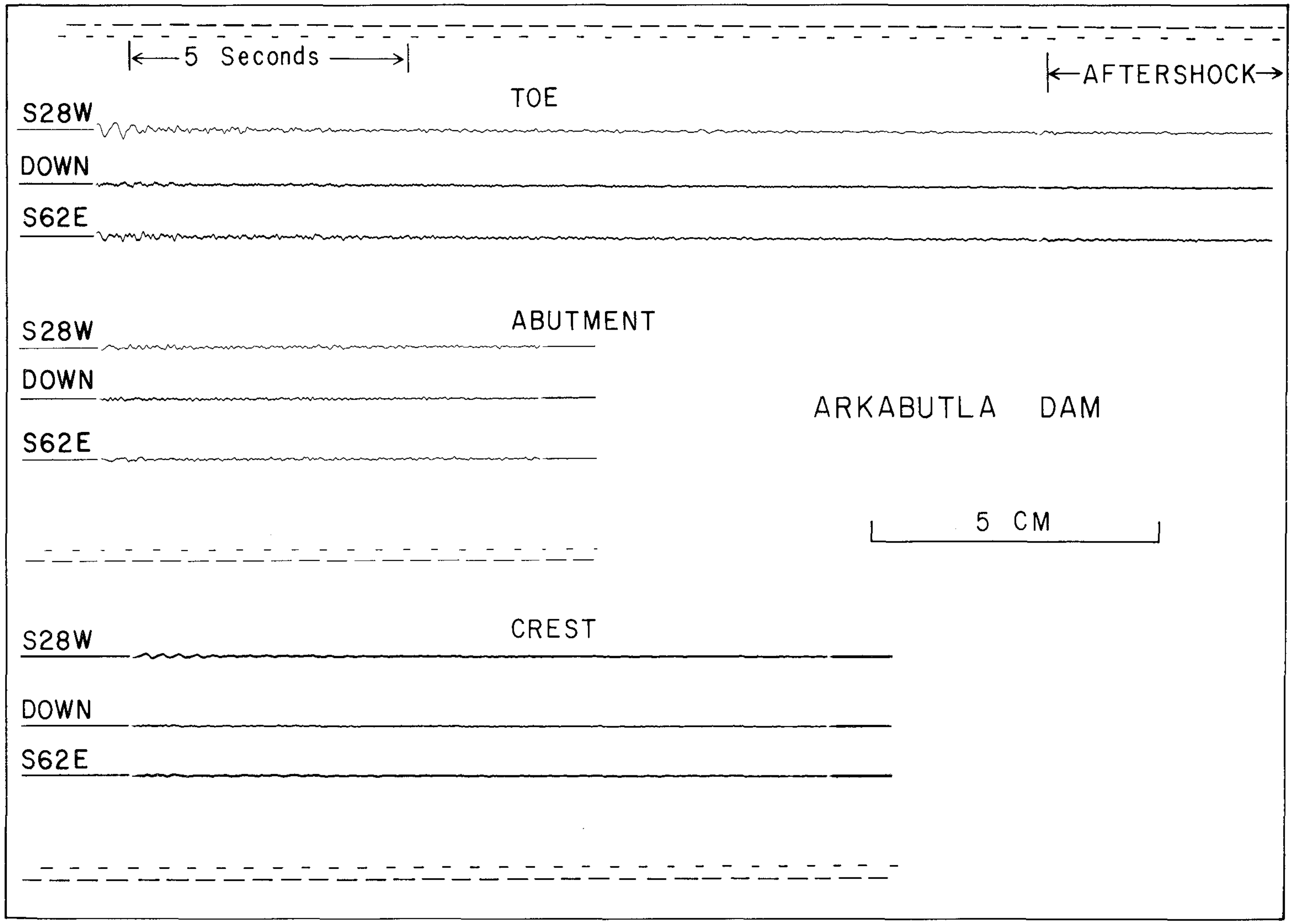

Figure 2.- Arkabutla Dam accelerograph records from the northeast Arkansas earthquake of March 24, 1976.

Tennessee and one in New Madrid, Missouri. Maximum accelerations on these records were .02 g. The instrument near Tiptonville is located in a one-story wood-frame building on the south shore of Reelfoot Lake, approximately 120 km northeast of the epicenter. The New Madrid accelerograph is located in a one-story concrete-block structure 130 km northeast of the epicenter.

Sites where records were not obtained include the following: Poplar Bluff, Missouri, 128 km north of the epicenter; Sardis Dam, Mississippi, 144 km southeast of the epicenter; and Memphis, Tennessee, 72 km southeast of the epicenter. The stations were operational, with instrument triggering levels set at .01 g.

STRONG-MOTION INSTRUMENTATION IN ALASKA

by J. D. Nielson and F. A. Ellis

After the 1964 Prince William Sound earthquake, 15 Teledyne AR-240 strong-motion accelerographs and 100 Wilmot seismoscopes were sent to Alaska for installation throughout the state, chiefly in larger communities along the southern Alaskan coastline and in the Aleutian Islands. This network extended from Ketchikan on the southeast to Shemya on the western tip of the Aleutians and included two inland stations at Mount McKinley National Park and the College Observatory. At each location one accelerograph was installed at the ground or basement level and a cluster of 6 to 10 seismoscopes were placed nearby on differing surficial deposits or rock. Over the years this network was gradually consolidated by relocating many of the instruments at more accessible sites and in structures where a greater degree of environmental control existed.

Recognizing the need for modernization and expansion of the strong- motion network in Alaska, the Seismic Engineering Branch began in 1970 to install accelerographs at new sites and to replace the older AR-240's with newer Teledyne RFT-250 and Kinemetrics SMA-1 model instruments. Subsequently stations have been established at three sites with known soil properties: at the relocated Valdez townsite, in the basement and on the 20th floor of the recently constructed Anchorage Westward tower, and at Yakataga in a central section of one of the larger recognized seismic gaps in Alaska (table 2, fig. 3). Recently, a number of accelerographs were installed along the perimeter of the Gulf of Alaska as part of the environmental studies being conducted for future offshore oil-drilling projects. In addition, four accelerographs were located along the Denali fault zone between the Mentasta Lodge and Summit in south-central Alaska. During the coming year the Geological Survey plans to install additional instruments at Chignik on the Alaskan Peninsula and at Cape St. Elias and Hinchinbrook Island, both south of Cordova.

Several other organizations have contributed instrumentation to the Alaskan strong-motion program. One accelerograph was installed by the U.S. Army Corps of Engineers at the crest of Snettisham Dam east of Juneau, and a second will soon be located at the base of the dam. The Federal Highway Works Administration has placed an RFT-250 at the bridge connecting Sitka with the airport on Japonski Island. Future plans call for the emplacement of 12 forced-balance accelerometers at critical locations on the bridge, with data to be transmitted by cable to a central recording location. The Lamont-Doherty Geophysical Observatory installed accelerographs at Yakutat in the southeast and at Sand Point and Dutch Harbor on the Alaskan Peninsula. During 1976 this small network will be increased by the addition of new stations at Cape Serichef and Port Moller in the Shumagin Islands seismic gap region. The University of Alaska has established eight stations in the Fairbanks-College area with plans for five more stations in the future. This network incorporates higher sensitivity accelerographs (full recording range of 1/2 and 1/4 g) and was designed to study the ground response over a range of soil conditions.

Since the establishment of a strong-motion recording program in Alaska during the mid 1960's, the network has been enlarged to 45 accelerographs distributed throughout the more seismic areas of the state. During the past 6 years, 10 of the original AR-240 accelerographs have

Table 2 - *Accelerograph stations in Alaska*

Location	Instruments
Adak	1
Anchorage	5
Cantwell	1
Cape Yakataga	1
Cold Bay	1
Cordova	2
Dutch Harbor	1
Fairbanks	10
Homer	1
Icy Bay	1
Juneau	1
Ketchikan	1
Kodiak	1
Mentasta Lodge	1
Middleton Island	1
Pelican	1
Sand Point	1
Seldovia	1
Seward	1
Snettisham Dam	1
Sitka	2
Sitkinak	1
Summit	1
Talkeetna	1
Trims Camp	1
Valdez	3
Whittier	1
Yakutat	1
Total	45

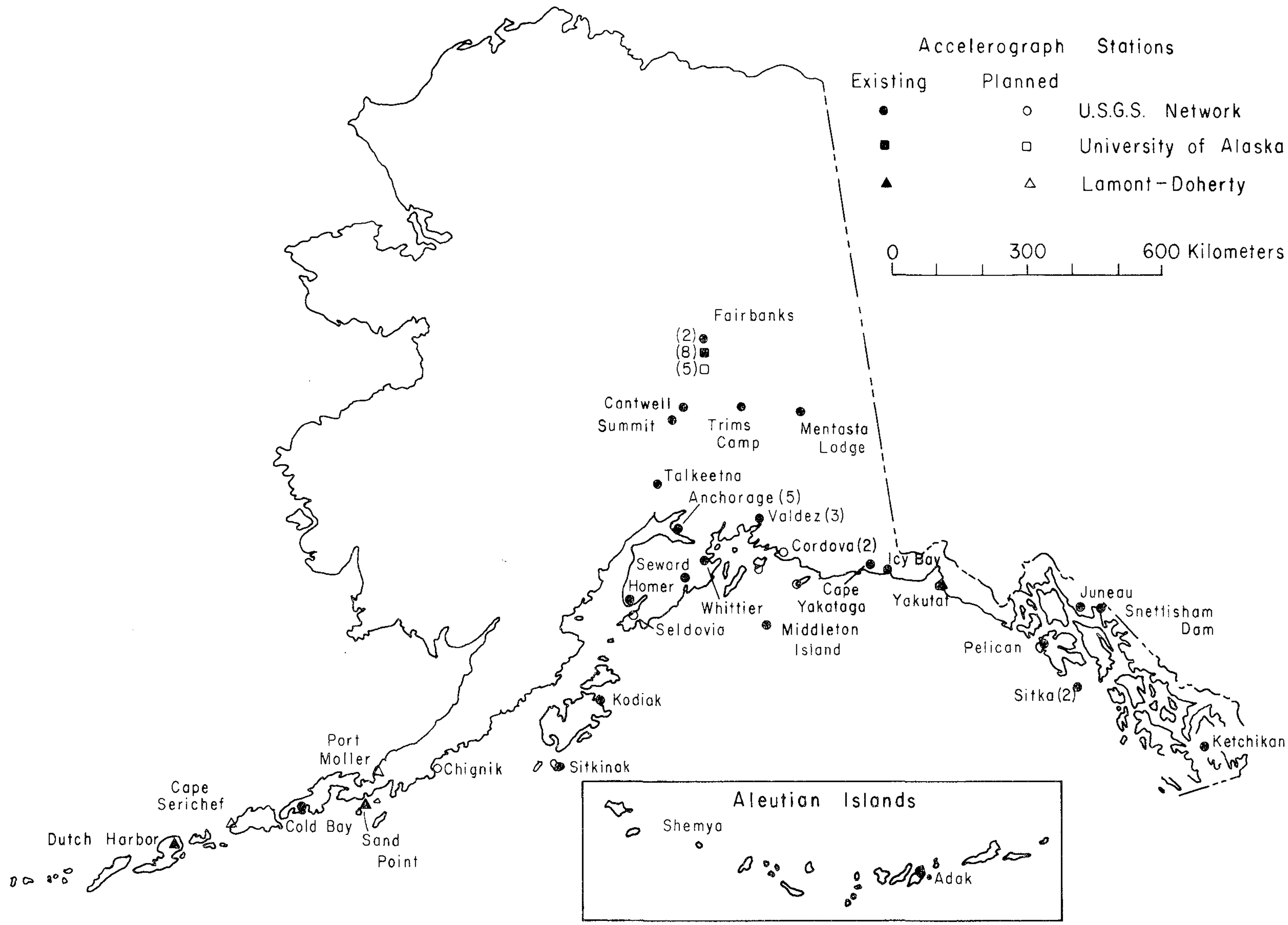

Figure 3.- Existing and planned accelerograph stations in Alaska. Numbers in parentheses indicate total accelerographs at each locality.

been replaced with more modern units and the remaining 5 will be changed during the coming year.

More than 30 records have been obtained from the Alaskan instruments including 4 from the magnitude 5.4 to 5.9 Fairbanks earthquakes of 1967 and 1 from the magnitude 7.3 earthquake near Sitka in 1972. Although significant strides have been made in upgrading the strong-motion network, the real task of developing a well-planned program is just beginning.

NOTES ON DIGITAL RECORDING ACCELEROGRAPHS

by R. B. Matthiesen

For the past 18 months, a concerted effort has been aimed at evaluating digital accelerographs for possible inclusion into the national strong-motion network. While the reliability of digital accelerographs on a long-term basis has yet to be established, the components that are used have been proven under a wide variety of conditions. A decision has been made to begin to incorporate digital accelerographs into the more active regions. It is anticipated that eventually the digital accelerograph will become the standard instrument in the national network.

In order to facilitate a smooth and orderly transition, the optical-mechanical instruments currently in active areas would be replaced by digital accelerographs, while the film recording units would be moved to less seismically active areas. The installation of digital systems initially in highly seismic areas will provide for a rapid and relatively economical assessment of their performance under field conditions, while alleviating the concern about rapid processing of data from a major event. Notwithstanding recent progress in methods of film digitization, a major earthquake in California would at present create a situation in which the timely dissemination of routine record analyses required by the strong-motion community would be extremely difficult to achieve. There exists a notable lack of interest in any past records that are not digitized.

A draft set of specifications for digital strong-motion systems is available upon request. Suggestions, criticisms, and general comments are requested and will be appreciated.

ABSTRACTS OF RECENT REPORTS

STRONG-MOTION ACCELEROGRAPH RECORDS FROM THE OROVILLE, CALIFORNIA EARTHQUAKE OF AUGUST 1975

by R. P. Maley, V. Perez, and B. J. Morrill

Strong-motion records were obtained from five accelerographs located within 35 km of the magnitude 5.7 Oroville earthquake. The nearest acceleration data were recorded on the Oroville Dam crest and at the adjacent seismograph station located 11 and 12 km, respectively, from the earthquake epicenter. Significant motion lasted only 2 to 3 seconds at these sites, and although nominal accelerations were somewhat less than 0.10 g, acceleration peaks were 0.13 g at the dam crest and 0.12 g at the seismograph station. Other records obtained between 28 and 34 km from the earthquake epicenter showed maximum accelerations of 0.07 to 0.08 g on alluvium and 0.04 g or less on rock. Comparisons of these accelerations with data from other magnitude 5.4 and 5.5 earthquakes indicate that in a strong-motion sense this earthquake was less severe than the reported magnitude of 5.7 would imply.

The records from the dam crest and the seismograph station were digitized, and the resulting time histories of accelerations, velocities, and displacements have been calculated. Fourier spectra obtained for the same records show the existence of many frequency components with a dominant period centering on 0.2 seconds at the seismograph station and 0.84 seconds at the dam crest. The period on the record from the dam crest reflects a transverse modal response of the dam.

Reference: Maley, R. P., Perez, Virgilio, and Morrill, B. J., 1975, Strong-motion accelerograph records from the Oroville California earthquake of August 1975 *in*

Sherburne, R. W. and Houge, C. J., Editors, 1975, Oroville, California earthquake, 1 August 1975: California Div. Mines and Geology Spec. Rept. 124, p. 115-122.

STRONG-MOTION RECORDS FROM THE HAWAII EARTHQUAKES OF 29 NOVEMBER 1975

by C. F. Knudson and V. Perez

Strong-motion records were obtained from three accelerographs and four seismoscopes from two earthquakes that were centered near Kalapana on the southeast coast of the island of Hawaii on November 29, 1975. The National Earthquake Information Service on December 17, 1975 assigned preliminary magnitudes of 5.7 for the largest foreshock and 7.2 for the main earthquake and assigned an epicenter for the main shock at 19°20.06'N, 155° 01.4'W. Although a magnitude 7.2 earthquake is considered a major shock, relatively low accelerations were recorded by the nearest instruments, 0.22 g at Hilo (42 km) and 0.14 g at Punaluu (56 km). A tsunami flooded the Punaluu station, and its arrival is believed to correspond to a shocklike signal shown on the record 84 seconds after triggering. An accelerograph located at Honokaa, 95 km from the epicenter, on the north coast of Hawaii, recorded a maximum acceleration of 0.11 g. Pseudo-velocities as calculated from the seismoscope plates were 29.4 cm/sec for the University of Hawaii (42 km), 27.2 cm/sec for Lyman Residence at Hilo (45 km), 13.0 cm/sec at Namakani Paio (33 km), and 2.7 cm/sec at Kailua (108 km). Integrated ground velocities and displacement curves, response spectra, and Fourier amplitude spectra have been calculated for the main shock.

Reference: Presented at the 1976 Joint Meeting of Seismol. Soc. America and Can. Geophys. Union, Edmonton, Alberta, May 11-14, 1976.

PLANNING AND DESIGN OF STRONG-MOTION INSTRUMENT NETWORKS

by R. B. Matthiesen

The types of research studies that utilize strong-motion data may be classified as: source mechanism studies, ground motion studies, soil failure studies, studies of the response of typical structures (including soil-structure interaction effects), and studies of the response of equipment.

In planning networks and arrays to make these studies, criteria must be established on the basis of the tectonic setting, the seismicity or recurrence of strong ground motions, the reliability of operations in different regions, and a cost/benefit and analysis of the data that may be obtained. A review of the strong-motion records that have been obtained during the past 40 years indicates significant variations in the recurrence of strong ground motions in the seismically active regions of the Western United States. When combined with instrument costs, maintenance costs, and the reliability of operations, these recurrence relations can be interpreted in terms of the cost per record for different levels of motion. The benefits to be derived from each type of study in each region need to be established.

Current plans call for additional arrays to be installed in California, the Mississippi embayment, the Yellowstone Park region, and Alaska to study the spectral characteristics of strong ground motions in these regions. Special studies of local site effects and structural response are being planned in the more seismically active regions of California. Similar criteria and planning should be applied in the establishment of arrays of strong-motion instruments on a worldwide basis.

Reference: Presented at U.S.-Japan Panel on Wind and Seismic Effect Meeting, May, 1976.

BUILDING STRONG-MOTION EARTHQUAKE INSTRUMENTATION

by Christopher Rojahn

On the basis of the recommendations of a special ad-hoc committee, 21 geographic areas will be instrumented under the building instrumentation phase of the California Strong-Motion Instrumentation Program, a statewide program established by law in 1971 and funded through an assessment of estimated construction costs collected statewide from building permits. The areas were selected on the basis of population density, locations of buildings already instrumented, and the probability for potentially damaging earthquakes. Buildings to be instrumented will be of typical construction, simple in framing and design, and of various heights with the instrumentation of low-rise buildings emphasized. Remote recording instrumentation, consisting of single or multi-axial accelerometers connected via data cable to a central recorder, will be installed in each building. The accelerometers will be placed on the lowest level, at the roof level, and, in many cases, at one or more intermediate levels. The instrumentation will be located so as to record separately both translational and torsional responses.

On the basis of current projected revenues, and instrument procurement, installation, and maintenance expenses, it is estimated that as many as 400 buildings may be instrumented under the State program.

Reference: Presented at the U.S.-Japan Panel on Wind and Seismic Effects meeting in Washington, D.C., May 1976.

DATA REPORTS AND AVAILABILITY OF DIGITIZED DATA

by A. G. Brady

The strong-motion records from the February 9, 1971 San Fernando earthquake and most of the significant records prior to that event have been digitized by the California Institute of Technology (CIT). Processing and analysis of the data have been presented in a series of reports containing 1) uncorrected digital data, 2) corrected accelerations, velocities, and displacements, 3) response spectra, and 4) Fourier amplitude spectra.

The digitizations and analysis of the significant records subsequent to the San Fernando earthquake have been carried out by the USGS. Reports containing digitized data and spectra for the records collected since 1971 are being prepared. Estimates of the publication dates for these reports are as follows:

Records from 1971:	June 1976
Records from 1972:	October 1976
Records from 1973:	December 1976
Records from 1974:	March 1977
Records from 1975:	June 1977

Table 3 presents a list of the records to be contained in each of these data reports.

The digitized data from the CIT digitization program are available from the Environmental Data Service (EDS) in the forms indicated below. The digital data from the subsequent years will be transferred to EDS for dissemination as soon as they have been verified and should be available from them at approximately the same time as the data reports are published.

* Volume I form of data (uncorrected) is available in punched card form (about 2000 cards each) for $20 per event and on magnetic tape (seven- or nine-track) for $60 per tape. The complete file of approximately 400 records is available on six magnetic tapes for $360.
* Inquiries should be addressed to:

National Geophysical and Solar-Terestrial Data Center
Code 62
EDS/NOAA
Boulder, CO 80302
(303) 499-1000, ext. 6472

Table 3 - *Records being processed for data reports*

Date of event	Station location	Maximum accel. (1) (g)
	1971	
March 8, 1971	Isabella Auxiliary Dam; abutment	0.11
May 1, 1971	Adak, Alaska; US Naval Base	0.19
July 9, 1971	Santiago, Chile; University of Chile	0.18
September 12, 1971	Ferndale, California; Old City Hall	0.10
November 29, 1971	Lima, Peru; Geophysical Institute	0.09
	1972	
January 3, 1972	Managua, Nicaragua; Esso Refinery	0.15
January 5, 1972	Managua, Nicaragua; Esso Refinery	0.22
	Managua, Nicaragua; National University	0.12
March 4, 1972	Bear Valley, Calif.; Melendy Ranch barn	0.15
March 22, 1972	Bear Valley, Calif.; Melendy Ranch barn	0.16
July 30, 1972	Sitka, Alaska; Magnetic Observatory	0.11
August 27, 1972	Beverly Hills, Calif.; 8383 Wilshire (2)	0.15
	Beverly Hills, Calif.; 9100 Wilshire (2)	0.12
	Los Angeles, Calif.; 6300 Wilshire (2)	0.10
	Los Angeles, Calif.; 6420 Wilshire (2)	0.15
September 4, 1972	Bear Valley, Calif.; CDF Fire Station	0.18
	Bear Valley, Calif.; Melendy Ranch barn	0.48
	Bear Valley, Calif.; Stone Canyon East	0.18
December 23, 1972	Managua, Nicaragua; Esso Refinery	0.39
Aftershock B	Managua, Nicaragua; Esso Refinery	0.17
Aftershock C	Managua, Nicaragua; Esso Refinery	0.32
	1973	
February 21, 1973	Port Hueneme, Calif.; U.S. Naval Laboratory	0.13
March 31, 1973	Managua, Nicaragua; National University	0.60
April 26, 1973	Kilauea, Hawaii; Namakani Paio Campground	0.17
August 8, 1973	Ferndale, Calif.; Old City Hall	0.14
September 16, 1973	Berryessa, Calif.; CDF Fire Station	0.18
	1974	
January 5, 1974	Lima, Peru; Zarate Station	0.16
	Lima, Peru; Geophysical Institute	0.11
January 31, 1974	Gilroy, Calif.; Gavilan College, Bldg. 10	0.16
February 11, 1974	Los Angeles, Calif.; 420 S. Grand (2)	0.10
	Los Angeles, Calif.; 525 S. Flower, No. Tower (2)	0.13
	Los Angeles, Calif.; 700 W. 7th (2)	0.18
	Los Angeles, Calif.; 533 S. Fremont (2)	0.25
	Los Angeles, Calif.; 420 S. Grand (2)	0.10
August 14, 1974	Pacoima Dam, abutment	0.12
	Vasquez Rocks Park, Calif.	0.10
October 3, 1974	Lima, Peru; Dr. Huaco residence	0.18
	Lima, Peru; Geophysical Institute	0.21
November 9, 1974	Lima, Peru; La Molina Station	0.14
November 28, 1974	Hollister, Calif.; City Hall	0.17
	San Juan Bautista, Calif.; 24 Polk St.	0.12
	Gilroy, Calif.; Gavilan College Bldg. 10	0.14
December 6, 1974	Imperial, Calif.; Imperial Valley College Adm. Bldg.	0.11

See footnotes at end of table.

Table 3 - *Records being processed for data reports* - Continued

Date of event	Station location	Maximum accel. (1) (g)
	1975	
January 11, 1975	Petrolia, Calif.; General Store	0.10
	Cape Mendocino,Calif.; Petrolia	0.19
January 23, 1975	Imperial, Calif.; Imperial Valley College Adm. Bldg.	0.11
March 6, 1975	Bear Valley, Calif.; Melendy Ranch East	0.18
May 6, 1975	Shelter Cove, Calif.; Station 2 Power Plant Yard	0.18
June 7, 1975	Ferndale, Calif.; Old City Hall	0.19
	Cape Mendocino, Calif.; Petrolia	0.22
	Petrolia, Calif.; General Store	0.19
	Shelter Cove, Calif.; Station 2 Power Plant Yard	0.10
June 19, 1975	El Centro Array, Calif.; Station 6, 551 Huston	0.10
June 20, 1975	El Centro Array, Calif.; Station 6, 551 Huston	0.13
	Holtville, Calif.	0.15
August 1, 1975	Oroville Dam, Calif.; Crest	0.13
	Oroville Dam, Calif.; Seismograph station	0.11
August 2, 1975	Pleasant Valley Pumping Plant, Calif.	0.08
	Pleasant Valley, Calif.; Switchyard	0.13
September 13, 1975	Parkfield Grade, Calif.; Jack Varian Ranch	0.14
	Vineyard Canyon, Calif.	0.18
November 14, 1975	Ferndale, Calif.; Old City Hall	0.18
	Cape Mendocino, Calif.; Petrolia	0.13
	Petrolia, Calif.; General Store	0.10
November 29, 1975 0335 (local time)	Hilo, Hawaii; UH Cloud Physics Lab.	0.15
November 29, 1975 0447 (local time)	Honokaa, Hawaii; Central Service Bldg.	0.11

(1) Maximum acceleration at ground or basement level.
(2) The records from the upper levels of these buildings are being digitized also.