C. 762-C

GEOLOGICAL SURVEY CIRCULAR 762-C

Seismic Engineering Program Report, September—December 1977

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

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1978

United States Department of the Interior
CECIL D. ANDRUS, *Secretary*

Geological Survey
H. William Menard, *Director*

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PREFACE

This Seismic Engineering Program Report is an informal document primarily intended to keep the ever-growing community of strong-motion data users apprised of the availability of data recovered by the Seismic Engineering Branch of the U.S. Geological Survey. The Seismic Engineering Program of strong-motion instrumentation is supported by the National Science Foundation (Grant CA-114) in cooperation with numerous Federal, State, and local agencies and organizations.

This issue contains a summary of the accelerograms recovered from the U.S. Strong-Motion Network during the period September 1 through December 31, 1977. Reports on accelerograph networks in Southeast Asia and on the San Juan, Argentina earthquake of November 23, 1977 are presented along with abstracts of recent reports, notes on strong-motion information sources and the availability of digitized data, and other information pertinent to the U.S. Strong-Motion Program. The strong-motion data summary presented in table 1 includes those accelerograms recovered (although not necessarily recorded) during the period September - December 1977. This procedure will be continued in future issues so that the dissemination of strong-motion data will be as expeditious and current as practicable.

R. L. Porcella, Editor
U. S. Geological Survey MS 78
Menlo Park, California 94025

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SEPTEMBER - DECEMBER 1977

RECENT STRONG-MOTION RECORDS

by R. L. Porcella

During the period September through December 1977, 108 accelerograph records were recovered from the National Strong-Motion Network. This figure brings the total number of records recovered in 1977 to 166, approximately 91 percent of the yearly average for the period 1972-1977 inclusive. The U.S. network is presently supported by the National Science Foundation in cooperation with both private organizations and governmental agencies for the purpose of recording strong ground motion and the response of various types of engineered structures during potentially damaging earthquakes and disseminating the data to the earthquake engineering research and design community. The accelerograms listed in table I (end of report) were recovered at various stations in the cooperative National Network that are owned by the California Division of Mines and Geology, California Institute of Technology (CIT), Veterans' Administration, and U.S. Geological Survey (USGS).

Eighty percent of the records recovered this period are related to the Imperial Valley, California earthquake swarms of October 20-30 and November 11-14. Twenty-four records were recovered that contain accelerations greater than 10 percent of gravity. Maximum recorded acceleration is 0.50 g at El Centro Array No. 6 and is attributed to the magnitude 3.9 event of November 14, 00:11:35.76 GMT. Event data were provided by Carl Johnson of the CIT.

Additional records recovered during this period include six from the island of Hawaii, four from Alaska, and five from Big Tujunga Dam in southern California. Magnitudes and epicenters for these events were obtained largely from data supplied by the National Earthquake Information Service of the USGS.

ESTABLISHMENT OF STRONG-MOTION ACCELEROGRAPH NETWORKS IN SOUTHEAST ASIA

by Richard P. Maley of the U.S. Geological Survey, Efren Uy of the Philippine Atmospheric Geophysical and Astronomical Services Administration, Quezon City, Philippines, and Soetardjo of the Indonesia Meteorological & Geophysical Institute, Jakarta, Indonesia

After several years of planning, UNESCO in 1973 authorized the establishment of a network of short-period seismographs to improve the completeness and accuracy of earthquake location throughout Southeast Asia (Hodgson, 1974). The project, entitled the Regional Seismological Program for Southeast Asia, was to be implemented by a branch of the United Nations Development Program (UNDP), with the project headquarters located in Manila. Although this was fundamentally an effort to provide data useful for seismic regionalization, some funds were made available for the development of UNDP strong-motion accelerograph networks. Small networks already existed in the Philippines and Indonesia, the two project countries with the greatest earthquake hazards.

In April 1976 a fact-finding tour was conducted in the Philippines, Indonesia, Malaysia, Thailand, and Hong Kong to assess the present status of strong-motion instrumentation programs and to determine the need for UNDP assistance in the development of small strong-motion networks. As a result of this investigation, it was decided that 15 accelerographs would be purchased by UNDP and installed in the Philippines and Indonesia. Sites were selected with the purpose of concentrating on the recording of ground-motion at representative sites in the major population zones of the two countries, respectively, the metropolitan Manila area and the Jarkarta-Bandung area. These specific regions were chosen after consultation with local earthquake engineers, seismologists, and geologists concerning the expected long-term needs.

During the summer of 1977, personnel from the Philippines, Indonesia, Hong Kong, Malaysia and Thailand attended a training course in strong-motion seismology sponsored by UNESCO and conducted at the U.S. Geological Survey facility in Menlo Park, California. Although no UNDP accelerographs were designated for Hong Kong, Malaysia, and Thailand, these countries had already made a commitment to develop small strong-motion networks to be funded by their own governmental agencies. Other organizations that contributed to the training course were the California Division of Mines and Geology and Kinemetrics, Inc., an accelerograph manufacturer.

Six Southeast Asian nations, including Singapore, were visited by the author (Maley) between September 19 and December 8, 1977 in order to assist in the establishment (or enlargement) of strong-motion instrumentation networks and to consult with authorities in those countries that have programs in the planning stage. The organizations in charge of national planning for earthquake investigations in the Philippines and Indonesia, the Philippine Atmospheric, Geophysical, and Astronomical Service Administration (PAGASA) and the Indonesian Meteorological and Geophysical Institute (MGI), accepted the responsibility for carrying out the UNDP strong-motion program.

UNDP accelerographs were installed by PAGASA on the ground floor of existing buildings at eight locations in the Metropolitan Manila Area (MMA). Criteria for site selection were based on the variety of soil conditions in the MMA and the consequent history of differential strong-motion response during damaging earthquakes. Figure 1 shows the location of accelerographs in the Philippines and includes some non-UNDP instruments owned by PAGASA and the National Irrigation Administration (NIA) (table 2). The PAGASA accelerographs were installed at two new sites in the MMA and at an existing station in Bagac, Bataan, the field headquarters for a nuclear power plant under construction 10 km away. The three NIA accelerographs are located at Pantabangan Dam, a modern earthfill structure constructed 140 km north of Manila between 1971 and 1974. Pantabagan Dam lies within the Master (Philippine) fault zone where it crosses central Luzon in a northwesterly direction. Previous acceleration records were obtained at the site in 1976 and again on March 18 and May 11, 1977. Although the earthquakes were recorded at considerable distances, significant data were obtained from the magnitude 6.2 (M_L) March 19 event that occurred approximately 215 km from the dam (fig. 2). The following maximum accelerations were recorded: 0.30 g at the crest and 0.15 g at the mid-level of the embankment.

UNDP accelerographs were installed by the Indonesian Meteorological and Geophysical Institute (MGI) at seven ground-level or basement locations in western Java: four in Jakarta, two in Bandung, and one in Sukabumi (fig. 3). In addition, other MGI accelerographs were relocated at Lembang, Java and at Medan, Sumatra (fig. 4). Including the existing MGI station at Padang, Sumatra, the Indonesian strong-motion network now consists of 10 instruments (table 2).

Modest strong-motion programs were established in Hong Kong, where the Royal Observatory purchased and installed three accelerographs (fig. 5), and in Malaysia where the Malaysian Meteorological Service located one accelerograph at its headquarters in Petaling, Jaya near Kuala Lampur (see fig. 4 and table 2).

Tentative plans call for the acquisition of five accelerographs by the Thailand Meteorological Department for installation in Bangkok and Chang Mai, and of one accelerograph by the Singapore Meteorological Service to be placed at a weather observation facility at a representative location on the island. The framework of Southeast Asian strong-motion programs will include the following efforts:

1. The agencies responsible for earthquake investigations will provide active leadership and coordinate the development of more comprehensive national programs.
2. Preliminary reports summarizing the characteristics of accelerograms and parameters of the triggering earthquakes will be prepared.
3. Records will be made available to the international community of strong-motion data users through NOAA's World Data Center in Boulder, Colorado.
4. With UNDP assistance, a strong-motion data expert will ensure that significant records are adequately analyzed.

Reference: Hodgson, J. H., 1974, Seismology for South-East Asia: Seismological Society of South West Pacific Newsletter, v. 2:1, p. 7-9.

PRELIMINARY REPORT ON THE SAN JUAN, ARGENTINA EARTHQUAKE OF NOVEMBER 23, 1977

By Christopher Rojahn

The epicenter of the destructive San Juan, Argentina earthquake of November 23, 1977 was located near the eastern slope of the Andes Mountains approximately 90 km northeast of San Juan (fig. 6), the capital city of San Juan Province. On the basis of teleseismic and local seismograph data, the earthquake has been assigned a magnitude of 7.4 (M_S), a depth of less than 30 km, and an epicenter of 31.1°S lat. and 67.9°W long. (S. T. Algermissen, oral comm., Feb. 22, 1978). The main shock was followed by a large aftershock sequence that included at least one event of magnitude 6 and was felt throughout much of southern South America, including Buenos Aires 940 km to the southeast and Sao Paulo 2,100 km to the northeast (fig. 6, insert). The earthquake caused extensive damage

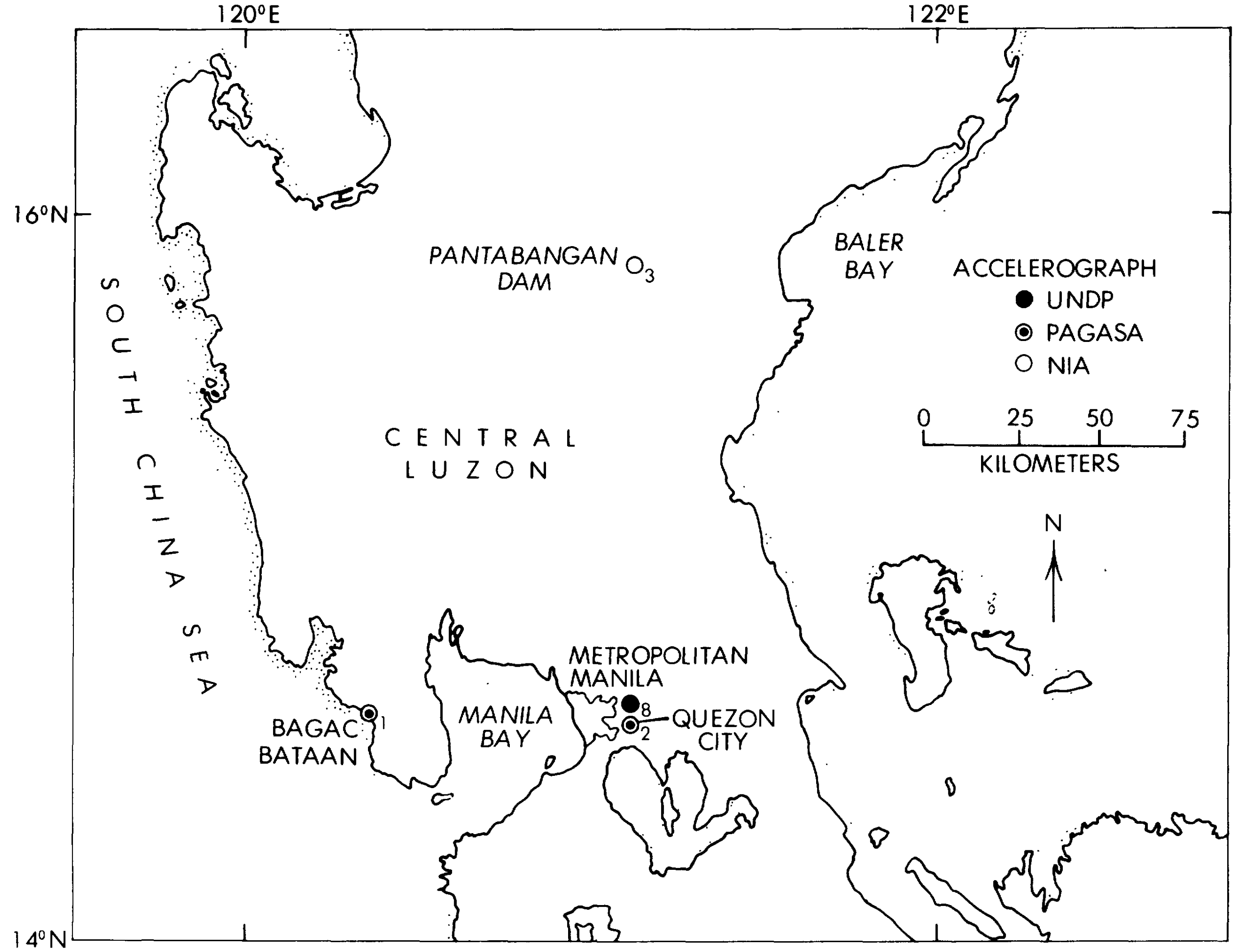


Figure 1.- Accelerograph stations located in the Philippines.

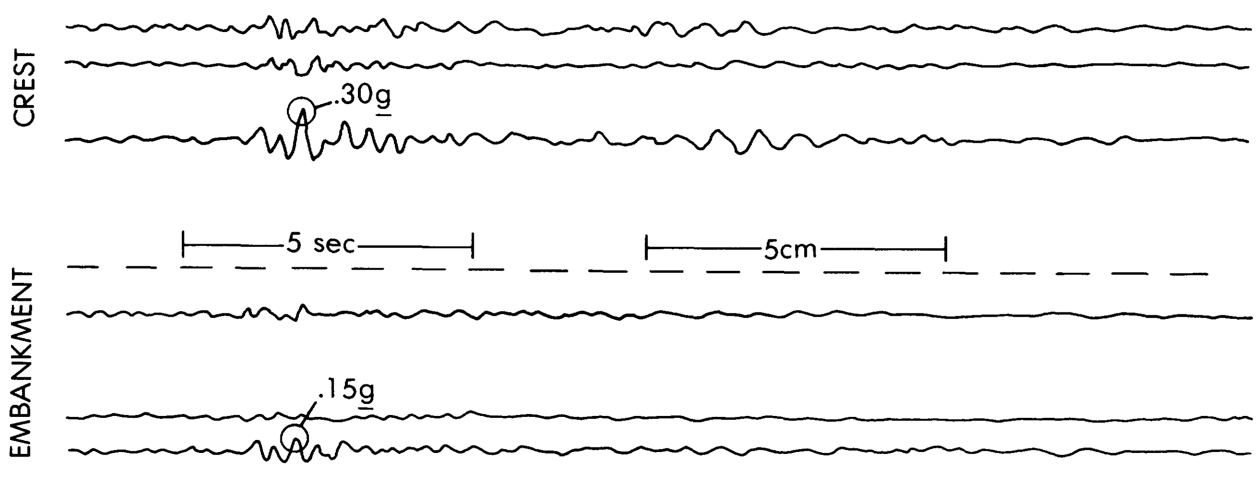


Figure 2.- Tracing of the main part of the Pantabangan Dam accelerograph records from the magnitude 6.2 (M_L) Philippine earthquake of 2144 GMT, March 18, 1977. Epicentral distance is approximately 220 km.

Table 2.- *Accelerograph Stations in Southeast Asia*

Station identification: Name	Coord.	Site geology	Structure type/size	Instrument location(s)	Data source*
HONG KONG					
Hong Kong Island Auxiliary Police Sta.	22.28°N 114.17°E	Fill	2-story bldg. steel frame	Ground level	ROHK
Kowloon Royal Observatory	22.30°N 114.17°E	Decomposed granite	Seismograph pier	Ground level	ROHK
New Territories Tates Cairn Radar Sta.	22.36°N 114.22°E	Granite	1-story reinf. conc.	Ground level	ROHK
INDONESIA - JAVA					
Bandung Regional Housing Ctr.	6.91°S 107.60°E	3 m alluvium over volcanic	4-story reinf. conc.	Ground level	MGI UNDP
Bandung Regional Housing Lab	6.93°S 107.63°E	Thin alluvium over volcanic	1-story reinf. conc.	Ground level	MGI UNDP
Jakarta Ancol Jaya	6.12°S 106.85°E	Alluvium	1-story reinf. conc.	Ground level	MGI UNDP
Jakarta Jaya Bldg.	6.19°S 106.83°E	Alluvium	13-story reinf. conc.	Ground	MGI UNDP
Jakarta Meteor. & Geophys. Inst.	6.18°S 106.84°E	Alluvium	Seismograph pier	Ground level	MGI UNDP
Jakarta Natl. Elect. Power	6.24°S 106.81°E	Alluvium	4-story reinf. conc.	Basement	MGI UNDP
Lembang Seismic Sta.	6.83°S 107.62°E	Alluvium	Seismograph pier	Ground level	MGI
Sukabumi Fiber Board Plant	6.88°S 106.77°E	Alluvium	2-story reinf. conc.	Ground level	MGI UNDP
INDONESIA - SUMATRA					
Medan Seismic Station	3.55°N 98.68°E	Alluvium	1-story reinf. conc.	Ground level	MGI
Padang Airport	0.87°S 100.34°E	Alluvium	1-story reinf. conc.	Ground level	MGI
MALAYSIA					
Petaling Jaya (Kuala Lumpur) Malaysian Meteor. Serv.	3.10°N 100.65°E	Granite	1-story wood frame	Ground level	MMS

See footnotes at end of table

in the province of San Juan, particularly in the towns of Bermejo and Caucete located approximately 55 km south and 80 km southwest of the epicenter, respectively. The most notable effects of the earthquake were the vast areas (hundreds of square kilometers) affected by liquefaction, complete or partial collapse of hundreds of adobe dwellings, and damage to tens of cylindrical wine storage tanks. Approximately 65 persons were killed, 284 injured, and 20,000 to 40,000 left homeless (J. C. Castano, oral commun., Dec. 1, 1977.)

Three accelerograph records and at least 14 seismoscope records were generated by the main shock. Two of the accelerograph records were recorded in the city of San Juan, and the other in the city of Mendoza, located approximately 275 km south-southwest of the epicenter. The maximum recorded acceleration in San Juan was 0.20 g (horizontal) and in Mendoza 0.07 g (horizontal) (J. Carmona, oral commun., Dec. 3, 1977). The strong-motion record shown in figure 7 was recorded on an AR-240 accelerograph located in the basement of a three-story building at the Instituto Nacional de Prevencion Sismica (INPRES) in the northwestern part of the

Table 2.- *Accelerograph Stations in Southeast Asia* - continued

Station identification: Name	Coord.	Site geology	Structure type/size	Instrument location(s)	Data source*
PHILIPPINES					
Bagac, Bataan Seismic station	14.61°N 120.39°E	Volcanic	1-story reinf. conc.	Ground level	PAGASA
Metro Manila Arellano High Sch.	14.61°N 120.98°E	Alluvium	4-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Cultural Center of the Philippines	14.55°N 120.98°E	Fill	1-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Don Bosco School	14.55°N 121.01°E	Thin alluvium over volcanic	1-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Far Eastern Univ.	14.61°N 120.98°E	Alluvium	1-story auditorium reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Intramuros Fire Sta.	14.59°N 120.97°E	Alluvium	2-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Makati Fire Sta.	14.57°N 121.03°E	Volcanic	2-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila Philippine College of Arts & Trades	14.59°N 120.98°E	Alluvium	1-story reinf. conc.	Ground level	PAGASA UNDP
Metro Manila University of the City of Manila	14.59°N 120.97°E	Alluvium	1-story reinf. conc.	Ground level	PAGASA UNDP
Pantabangan Dam	15.80°N 121.11°E	Rock	Earthfill dam	Abutment (tunnel) crest, embankment	NIA PAGASA
Quezon City Diliman Observ.	14.66°N 121.08°E	Volcanic	Seismograph pier	Ground level	PAGASA
Quezon City PAGASA Sci. Garden	14.64°N 121.04°E	Volcanic	1-story reinf. conc.	Ground level	PAGASA

* MGI - Meteorology & Geophysical Institute, Jakarta, Indonesia
MMS - Malaysian Meteorological Service, Petaling Jaya, Malaysia
NIA - National Irrigation Administration, Manila, Philippines
PAGASA - Philippine Atmospheric, Geophysical, and Astronomical Services Administration, Manila, Philippines
ROHK - Royal Observatory, Hong Kong
UNDP - United Nations Development Program, Box 1864, Manila, Philippines

city of San Juan. A preliminary analysis indicates that maximum accelerations for the north-south vertical, and east-west components were 0.20 g, 0.17 g, and 0.20 g, respectively; the duration of motion greater than 0.10 and 0.05 g were approximately 22 and 48 sec, respectively. The other San Juan accelerogram, recorded on a SMAC-B2 instrument located at the University of San Juan (approximately 1.5 km from INPRES), shows essentially the same levels of acceleration and durations (J. Carmona, oral commun., Dec. 3, 1977). The Mendoza accelerogram was also recorded on a SMAC-B2 instrument, located at ground level in a one-story building; the record was not available for analysis at the time of this writing.

Seismoscope records of the main shock were recorded at Caucete, Albardon, San Juan Airport, the city of San Juan, and Media Agua. A preliminary analysis of these records (eight are shown in figures 8 and 9) suggests that the intensity of shaking was greatest in Caucete and at San Juan Airport, located 80 km and 85 km southwest of the epicenter, respectively. The intensity of ground shaking was apparently lower at Media Agua, 117 km southwest of the epicenter, and lowest in Albardon and the city of San Juan, located 85 km and 90 km southwest of the

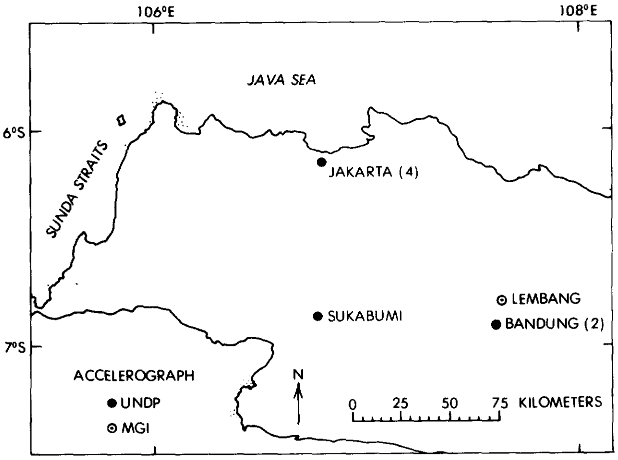


Figure 3.- Accelerograph stations located in West Java, Indonesia.

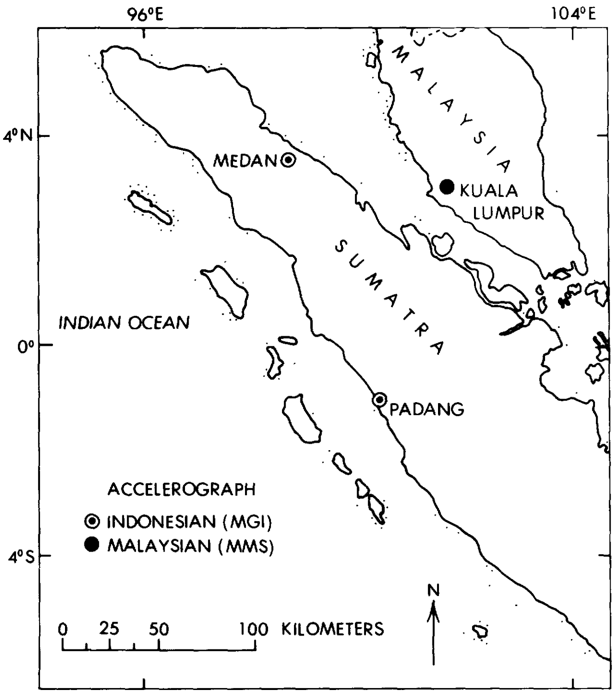


Figure 4.- Accelerograph stations in Sumatra, Indonesia and in Malaysia.

epicenter, respectively. The distribution of observed damage to man-made structures supports this interpretation.

Additional accelerograph records were generated by several aftershocks. A preliminary analysis of records from an aftershock of about magnitude 6 on December 6 indicates that the maximum acceleration at the INPRES site in San Juan was 0.03 g and in Caucete 0.08 g.

One fact evident from the distribution of damage related to the main shock is the weak correlation between epicentral distance and degree of damage. For example, the towns of

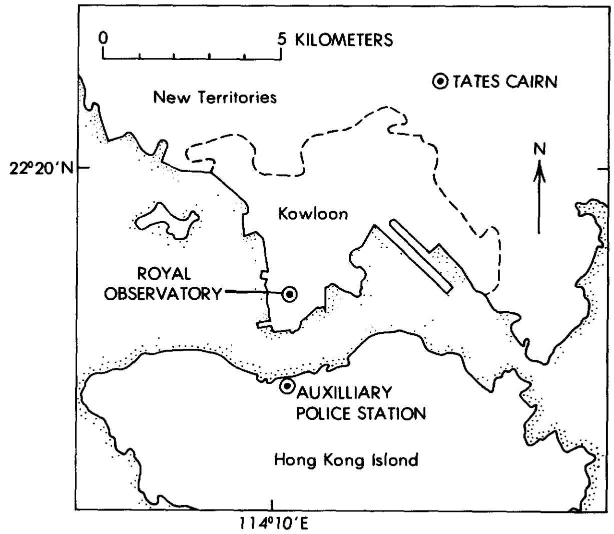


Figure 5.- Accelerograph stations established by Royal Observatory in Hong Kong.

Marayes and Vallecito, located approximately 50 km southeast and 75 km south-southwest of the epicenter, respectively, sustained little damage, whereas the towns of Bermejo and Caucete, located approximately 55 km south and 80 km southwest of the epicenter, respectively, were severely damaged. In the city of San Juan, approximately 90 km southwest of the epicenter, several dozen one-story adobe buildings partially or totally collapsed, and six or seven engineered buildings sustained significant structural damage but did not collapse. However, in Las Casuarinas, Media Agua, and Los Berros, located 100 km, 117 km, and 130 km southwest of the epicenter, respectively, the percentage of damaged structures appeared to be substantially greater. Approximately 100 adobe dwellings partially or totally collapsed in Los Berros, and in Media Agua a metal wine storage tank collapsed (fig. 10), several others were severely damaged (fig. 11), and numerous adobe dwellings partially or totally collapsed.

The towns of Caucete and Bermejo sustained the greatest damage. In Bermejo, more than a dozen adobe dwellings and unreinforced masonry-wall buildings collapsed, including the building that housed the town's electric power generating plant. Recently constructed reinforced masonry-wall buildings that were designed to resist earthquakes, however, were not damaged (fig. 12). In Caucete, hundreds of adobe dwellings partially or totally collapsed (fig. 13), and numerous wine storage tanks and modern engineered buildings were severely damaged. Some examples of damaged tanks and buildings were a reinforced concrete building at the Segura Winery (fig. 14), cylindrical steel tanks at the Los Nogales Winery (fig. 15), and cylindrical reinforced concrete tanks at the Esmeralda Winery. The damage to wine storage tanks was extensive, and an estimated 10 million liters of storage capacity was lost (J. Carmona, oral commun., Dec. 3, 1977). This loss is unfortunate, particularly from an economic standpoint because wine production is the major industry of the province.

Liquefaction occurred at various locations in and near those cities and towns on the San Juan River flood plain that were seriously damaged by the earthquake. Caucete, San Juan, Las Casuarinas, and Media Agua are located on this flood plain, which is bounded on the west by the Andes and the northeast by the small mountain range Sierra Pie de Palo (fig. 6). In many cases, as in Caucete, ground failure due to liquefaction caused severe damage to man-made structures (fig. 16 and 17) and was obvious even in those areas where structures were not present. On the north side of Sierra Pie de Palo, between its north face and the town of Punta del Agua 90 km to the north, ground failure occurred over hundreds of square kilometers (G. E. Brogan, oral commun., Dec. 15, 1977).

Acknowledgment.--The author gratefully acknowledges the information provided by S. T. Algermissen of the U.S. Geological Survey, Golden, Colorado; V. V. Bertero of the University of California, Berkeley; G. E. Brogan of Woodward-Clyde Consultants, Orange, California; J. C. Castano of INPRES, San Juan, Argentina; the other members of the Earthquake Engineering Research Institute team that investigated the earthquake; and the National Science Foundation for the financial support provided under Inter-Agency Agreement CA-114.

RECENT ACCELEROGRAPH INSTALLATIONS

Nine accelerographs were installed in the northern Mississippi embayment region in October 1977: Union City, Tenn.; Cairo, Ill.; Portageville, Mo.; Hayti, Mo.; Gideon, Mo.; Sikeston, Mo.; Campbell, Mo.; Corning, Ark.; and Blytheville, Ark. These new sites are part of a newly outlined, variable-grid network that will contain more than 35 accelerographs and incorporate two mututally perpendicular arrays in the New Madrid seismic zone. One array will extend from Poplar Bluff, Mo. to Obion, Tenn. at 10- to 15-km spacings; the other will extend along the axis of the embayment from Cape Girardeau, Mo. to Marked Tree, Ark. at 20- to 25-km spacings. The network is being established primarily for the purpose of obtaining data to be used in quantitative studies of the spectral characteristics and attentuation of strong ground motion in the central United States.

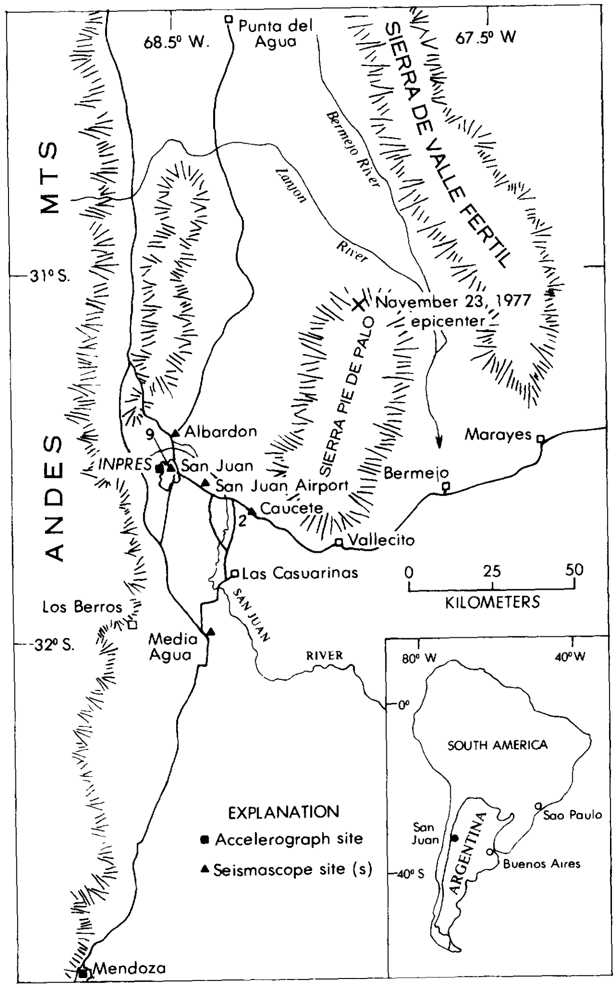


Figure 6.- Map showing area affected by San Juan, Argentina earthquake of November 23, 1977.

ABSTRACTS OF RECENT REPORTS

CALIFORNIA EARTHQUAKE OF JUNE 7, 1975

By R. P. Maley, R. L. Porcella, and Virgilio Perez

A magnitude 5.7(M_S) earthquake occurred on June 7, 1975 in southern Humboldt County 5 km south of Ferndale, California at a depth of 21 km. The earthquake had a maximum intensity of VII (Modified Mercalli) and was felt over an area of more than 25,000 km^2, causing landslides and rockfalls. Typical reported damage included fallen chimneys, broken plate glass windows, and cracked plaster and brick walls. Seven accelerograms were recovered at U.S. Geological Survey, California Division of Mines and Geology, and University of California Berkeley strong-motion stations located between 23 and 93 km of the hypocenter. Additionally, nine channels of acceleration data were recorded by

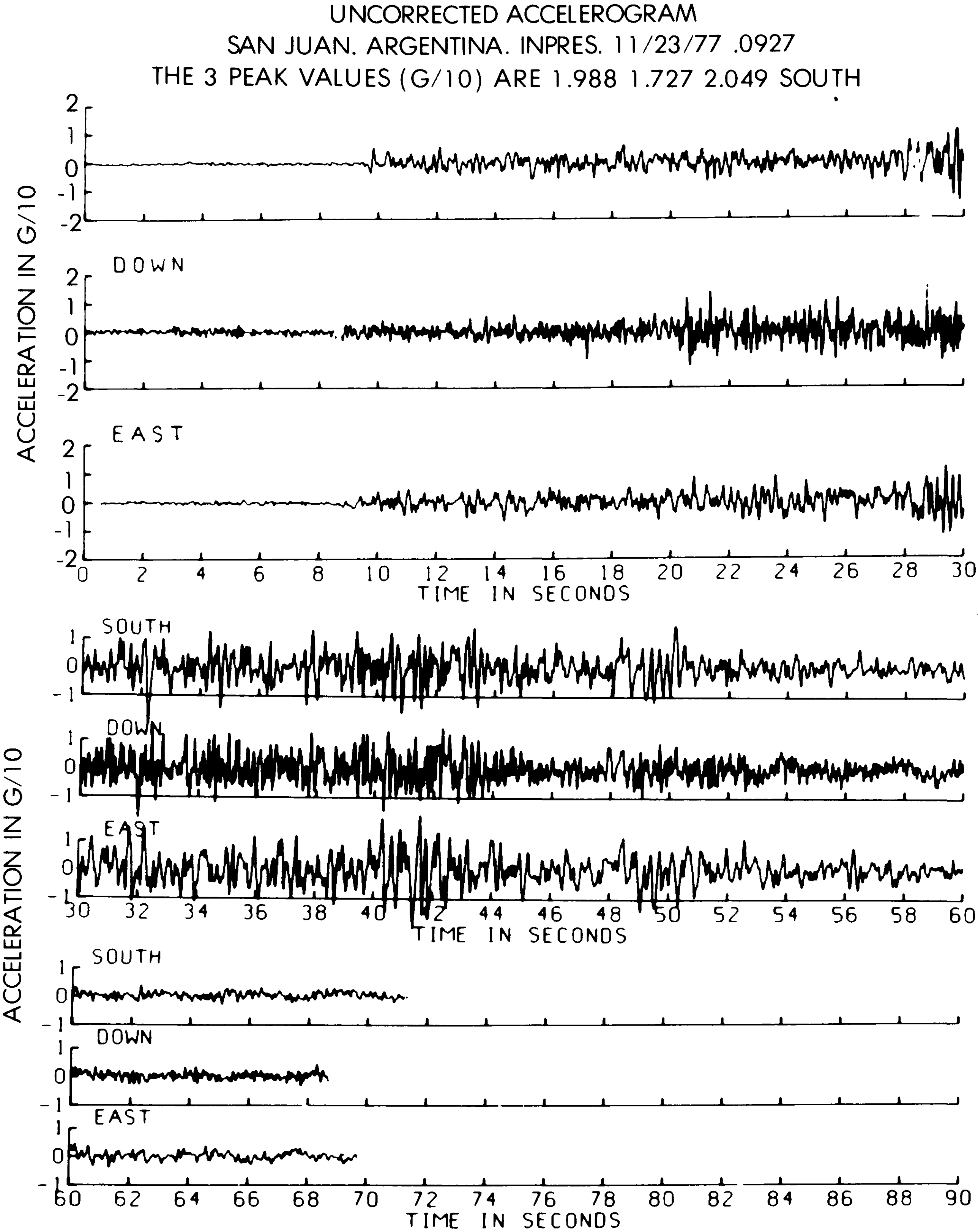
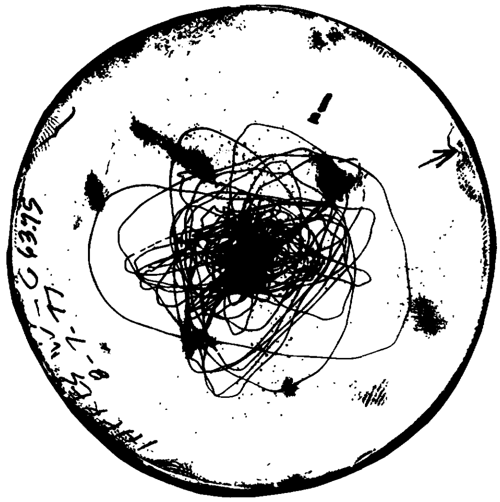


Figure 7.- AR-240 accelerogram recorded on November 23, 1977 in city of San Juan, Argentina. Accelerograph located in basement of three-story reinforced concrete shear-wall building located at Instituto Nacional de Prevencion Sismica (INPRES). Record provided by J. C. Castano and J. L. Samarbide of INPRES.

North

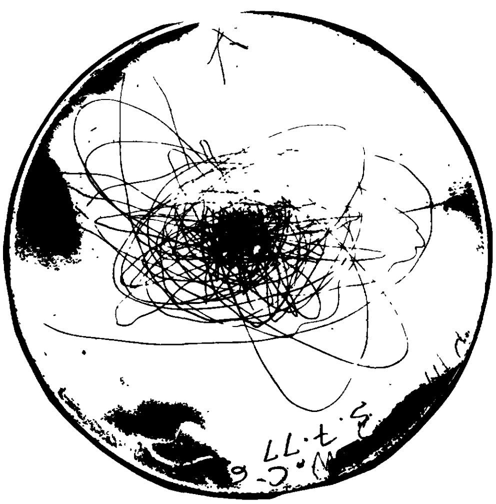


ALBARDON
Epic. Dist.= 70 km
S_d (max) = 5.07 cm
S_v (max) = 42.5 cm/sec

North

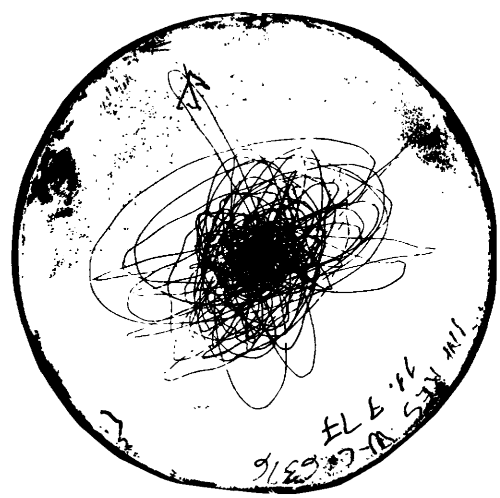
CAUCETE
Epic. Dist.= 70 km
S_d (max) > 6.89 cm
S_v (max) > 57.6 cm/sec

North



SAN JUAN AIRPORT
Epic. Dist.= 75 km
S_d (max) > 6.89 cm
S_v (max) > 57.6 cm/sec

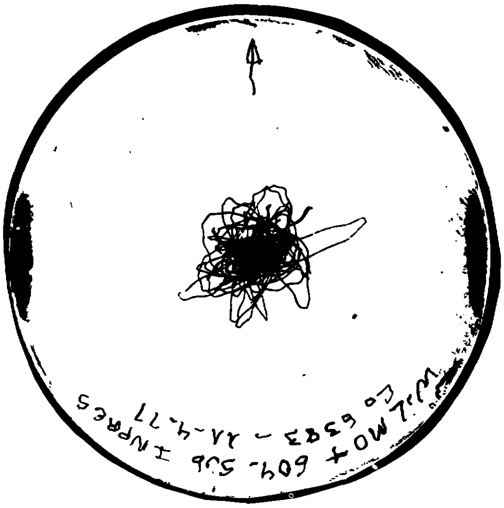
North



MEDIA AGUA
Epic. Dist.= 110 km
S_d (max) = 6.11 cm
S_v (max) = 51.2 cm/sec

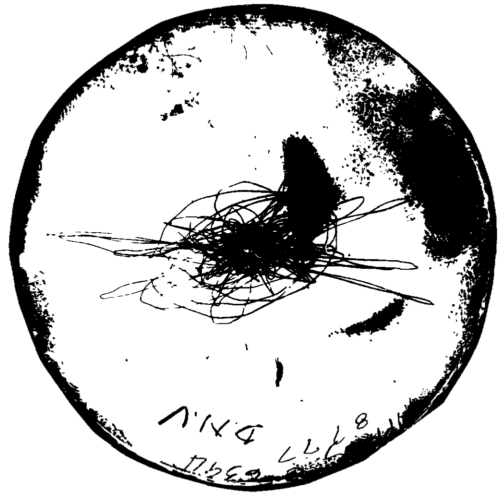
Figure 8.- Wilmot seismoscope records from November 23, 1977 San Juan, Argentina earthquake. Natural period of seismoscope 0.75 sec.; damping from 7 to 9 percent of critical for records shown here.

North



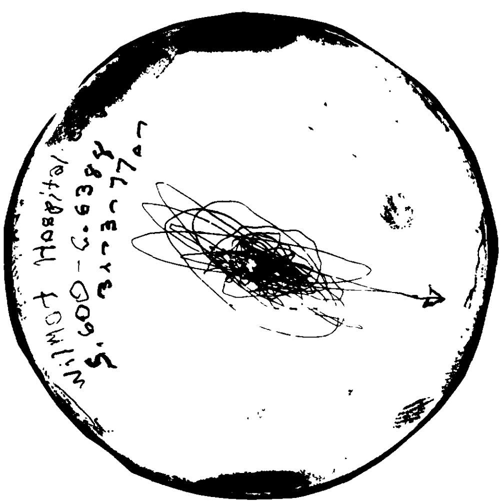
SAN JUAN INPRES
Epic. Dist.= 80 km
S_d (max) = 3.63 cm
S_v (max) = 30.4 cm/sec

North



SAN JUAN D N V (Dr. G. Rawson ST.)
Epic Dist.= 77 km
S_d (max) = 6.00 cm
Sv (max)=50.3 cm/sec

North



SAN JUAN—Hospital Espanol
Epic. Dist.= 80 km
S_d (max) = 4.26 cm
Sv (max) = 35.6 c m/sec

North

SAN JUAN Edificio 9 de Julio
Epic. Dist.= 78 km
S_d (max) = 4.26 cm
Sv (max) = 35.6 cm/sec

Figure 9.- Wilmot seismoscope records from November 23, 1977 San Juan, Argentina earthquake. Natural period of seismoscope 0.75 sec.; damping from 8 to 10 percent of critical for records shown here. Five similar seismoscope records were also recorded in same region (city of San Juan).

Figure 10.- Collapsed wine storage tank at Cavic Winery in Media Agua, 117 km southwest of epicenter. Vertical steel anchor ties at base pulled loose as a result of rocking action of tank.

the Pacific Gas and Electric Company at the Humboldt Bay Power Plant, a nuclear-fueled generating unit located at a hypocentral distance of 33 km.

Three instruments at hypocentral distances of 23 to 33 km recorded accelerations ranging from 0.19 to 0.23 g. Significant differences in both frequency and amplitude were observed on records obtained from two pairs of accelerographs located at hypocentral distances of 32 and 64 km. This dissimilarity in response is attributed to variations in the local site conditions.

Response spectra are presented and discussed for five of the more significant records; these are, in general, typical of spectra calculated for other earthquakes in the magnitude 5 range, although the records from the June 7 event also allow a comparison of strong-motion data recorded at sites with nearly identical seismic-wave travel paths.

Reference: Presented at 73rd Annual Meeting, Seismol. Soc. America, April 6-8, 1978.

PROCESSING ERRORS ASSOCIATED WITH ACCELEROGRAMS OF THE OROVILLE, CALIFORNIA AFTERSHOCKS

by J.B. Fletcher, A.G. Brady, and T.C. Hanks

Preliminary calculations of velocities and displacements from the strong-motion accelerograms written at distances $R \approx 1$ km for aftershocks of the Oroville earthquake had signal-associated errors that arose in the processing scheme. The accelerograms were characterized by short durations of strong ground motion ≤ 2 sec, small values of S-wave minus trigger time (< 2 sec), and enrichment at frequencies above 1 Hz. These characteristics caused severe distortions in the corresponding velocities and displacements when the accelerograms were processed using the computer programs documented in Trifunac and Lee, 1973[1]. The distortions were markedly reduced by eliminating nearly all the decimation steps in the processing scheme and by smoothing the response of the Ormsby high- pass filter. Additionally, a high-pass filter of the displacement was removed to preserve the finite area of the S-wave pulses. These revised procedures were then used to calculate the displacements for 20 horizontal components for a $M_L = 4.7$ aftershock to illustrate the quality of data available for 12 such well-recorded events. A ramplike signature leading to the S-phase that appears to be a near-field effect, an impulsive S-wave, and a SH-phase that has been multiply reflected within the Great Valley sediment wedge are easily identified on most records of this event.

Reference: Presented at 73rd Annual Meeting, Seismol. Soc. America, April 6-8, 1978.

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[1] Trifunac, M. D., and Lee, Vincent, 1973, Routine computer processing of strong-motion accelerograms: Calif. Institute of Tech., E.E.R.L. 73-03, 360 p.

Figure 11.- Damaged metal wine storage tanks at Cavic Winery in Media Agua, 117 km southwest of epicenter. Many steel anchor ties at base of both tanks failed in tension or shear.

Figure 12.- Undamaged recently constructed reinforced masonry dwellings in Bermejo, 55 km south of epicenter. Nearby unreinforced masonry and adobe buildings partially or totally collapsed.

Figure 13.- Collapsed one-story adobe dwellings in Caucete, 80 km southwest of epicenter. Tilted streetlight in background was pulled over when face of adjacent building collapsed on wires suspended between poles.

ANALYSIS OF STRONG-MOTION RECORDS FROM THE NOVEMBER 23, 1977 SAN JUAN, ARGENTINA EARTHQUAKE AND DECEMBER 6, 1977 AFTERSHOCK

By Christopher Rojahn, Virgilio Perez, J. L. Zamarbide, and J. C. Castano

On November 23, 1977 a destructive earthquake of about magnitude 7.0 occurred approximately 90 km (hypocentral distance) northeast of the provincial capital city of San Juan, Argentina. The main shock was followed by a large aftershock sequence including one event of about magnitude 6.0 on December 6, 1977. Two strong-motion accelerograph records of the main shock and one of the December 6 aftershock were recorded in the city of San Juan, where several engineered structures sustained significant structural damage and several dozen adobe structures partially or totally collapsed; one strong-motion accelerograph record of the December 6 aftershock was recorded in the town of Caucete, where the greatest concentration of damage occurred (approximately 80 km southwest of the epicentral area); and one strong-motion accelerograph record of the main shock was recorded in Mendoza, a city located approximately 200 km south of the epicentral area.

Standard response spectra, Fourier spectra, and response spectra as a function of time have been computed for three of the records: the main shock record from the INPRES site in the city of San Juan (0.19 $\underline{g}$ max. accel.), the December 6 aftershock record from the INPRES site in San Juan (0.03 $\underline{g}$ max. accel.), and the December 6 aftershock record from Caucete (0.08 $\underline{g}$ max. accel.). These spectra provide useful comparative information on the frequency content, duration, and amplitude of ground motion at these two locations.

Seismoscope records from the cities of San Juan, Caucete, and other locations indicate that the intensity of shaking at the natural frequency of the seismoscopes (1.3 Hz) was greatest in Caucete.

Reference: Presented at 73rd Annual Meeting, Seismol. Soc. America, April 6-8, 1978.

USE OF CENTRAL RECORDING SYSTEMS IN THE CALIFORNIA STRONG-MOTION INSTRUMENTATION PROGRAM

By L. D. Porter and Christopher Rojahn

The triaxial accelerograph was the principal instrument in use when the California Strong-Motion Instrumentation Program (CSMIP) was established in 1972. These instruments were deployed at sites primarily for measuring ground motion. Within recent years, it has become apparent that central recording systems with remotely located accelerometers are more appropriate for the instrumentation of structures and down-hole sites. Even though the per-channel purchase and installation price for central recording instrumentation is approximately 50 percent greater than it is for triaxial accelerographs, experience indicates that the per-channel maintenance cost is lower for central recording systems and that the total per-channel cost for purchase, installation, and maintenance for the two types of instruments will be approximately equal over the life of the instrumentation (estimated to be 20 to 40 years). The CSMIP has 35 sites with central recording systems: 30 buildings, 2 down-hole sites, 2 highway bridges, and 1 dam. Present instrumentation projections for the CSMIP call for the installation of 8130 channels; approximately 6500 will utilize central recorders.

Reference: Presented at 73rd Annual Meeting, Seismol. Soc. America, April 6-8, 1978.

FORCED-VIBRATION TESTS OF A THREE-STORY REINFORCED CONCRETE FRAME AND PRECAST PANEL BUILDING IN TADZHIK, S.S.R.

By C. Rojahn, F. D. Raggett, and S. H. Negmatullaev

Two tests in which chemical explosives were used to generate strong ground shaking were conducted on a full-scale three-story reinforced concrete frame and precast panel building at a test site near Laur, Tadzhik S.S.R. The building was instrumented with a U.S. 10-channel remote-recording accelerograph system utilizing accelerometers located at the foundation, second, third, and roof levels. In the first test, a 2-ton charge was detonated approximately 165 meters from the test building; peak accelerations of approximately 0.1 g were recorded at the foundation and the upper levels. In the second test, six 2-ton charges located between 159 and 234 meters from the building were successively detonated at 1/2 second intervals, causing approximately three seconds of strong ground shaking. Peak horizontal and vertical accelerations at the foundation were 0.15 g and 0.25 g, respectively, and at the roof level were approximately 0.2 g and 0.5 g, respectively.

The recorded structure motions have been analyzed; maximum force levels and maximum interstory displacements throughout the structure have been calculated from the recorded accelerations and computed displacements. Best-fit mathematical models of the dynamic behavior were identified and were compared for time segments of varying lengths. An analysis of these motions indicates that the strong ground shaking induced a torsional response of the structure, inplane bending of the roof, and, as expected, maximum interstory displacements between the foundation and second levels.

The tests were conducted as part of an engineering seismology project emanating from the 1972 Joint U.S.-U.S.S.R. Agreement for Cooper-

Figure 14.- Collapsed reinforced concrete wine-storage facility at Segura Winery in Caucete, 80 km southwest of epicenter.

Figure 15.- Damaged cylindrical metal wine-storage tanks at Los Nogales Winery in Caucete, 80 km southwest of epicenter. Tank at left apparently imploded; vertical steel anchor ties at base were severed, and tank wall at the base buckled. Third tank from the left was similarly damaged at its base; other tanks sustained little or no damage.

ation in the Field of Environmental Protection.

Reference: Sixth European Conference on Earthquake Engineering. Dubrovnik, Yugoslavia, September 18-22, 1978.

NOTES ON STRONG-MOTION INFORMATION SOURCES

EARTHQUAKE RECORDINGS ON OR NEAR DAMS

By Paul Morrison, Richard Maley, Gerald Brady, and Ronald Porcella

United States Committee on Large Dams
Panel on Instrumental Recordings at Dams

George W. Housner, Chairman
Committee on Earthquakes
California Institute of Technology
Pasadena, California 91125

This report presents data on earthquake recordings made on or near dams. The serious consequences of failure make it imperative that dams in seismic regions be designed to resist earthquake shaking safely and economically. To achieve this, designers of dams must be provided with information about those dams that have been subjected to strong ground shaking, with or without damage. The most valuable information is provided by seismic recordings made on or near dams during strong shaking, as these records show the nature of the earthquake shaking. Unfortunately, relatively few strong-motion recordings exist because only a few dams are instrumented for this purpose. This report provides a collection of seismic records that should be informative to engineers who design dams. There have been other cases where dams have been damaged by earthquakes, but they were not instrumented to record strong motion. It is hoped that in the future all instances of earthquake damage to dams or earthquake recordings on or near dams will be described in publications so that the information is available to dam designers in all parts of the world.

GEOPHYSICAL INSTRUMENTATION BY THE ITALIAN STATE POWER BOARD

ENEL, Direzione delle costruzioni
servizio geotecnico ROMA maggio 1977

In the framework of the activities carried out by the Italian Commission for Nuclear Energy and the Italian State Power Board (CNEN-ENEL) Joint Commission to achieve their goals, ENEL installed a network of 168 accelerographs extending over the whole country, excluding Sardinia. This network fulfills the requirement to record all major earthquakes that occur in Italy, thus allowing the acquisition of valuable experimental data and, consequently, a better use of the considerable historical data available.

Figure 16.- Subsidence due to liquefaction at a new housing development in Caucete, 80 km southwest of epicenter. Road surface to right of vertical offset subsided 35 cm.

The site for each monitoring station was selected on the basis of a statistical analysis of Italian earthquakes by E. Iaccarino and C. Zaffiro aimed at determining where the greatest number of earthquakes with an intensity exceeding the sixth degree of the modified Mercalli scale (MM VI) may occur within the shortest time interval.

This report contains sections on strong-motion instrumentation, network management, and information on seismographic, clinographic, and meteorologic stations in northeast Italy.

DATA REPORTS AND AVAILABILITY OF DIGITIZED DATA

ROMANIAN EARTHQUAKE OF MARCH 4, 1977

The digitization and processing of the Bucharest strong-motion record from the Romanian earthquake of March 4, 1977 have been completed. A set of punched cards of uncorrected accelerations and corrected acceleration, velocity, and displacement is available from NGSDC/EDS/NOAA, Mail Code D62, Boulder, CO 80302 (approximately 1/2 box; cost $20.00). A preliminary set of plots of the corrected data and the response and duration spectra are available from the Seismic Engineering Branch, USGS.

Figure 17.- Damaged one-story masonry-wall house in new development in Caucete caused by liquefaction. House is located near vertical offset in road pavement shown in figure 16.

GAZLI, U.S.S.R. EARTHQUAKE OF MAY 17, 1976

The accelerogram from the Gazli earthquake of May 17, 1976 was digitized on a Soviet-built semi-automatic digitizer at a constant time interval (ΔT) equal to 0.00657 sec. The data are in tabular form, with 75 units equivalent to 1000 cm/sec^2. The values listed are relative to a baseline that was drawn through the trace; no baseline correction has been applied. The order of data points is given in columns, from top to bottom, left to right. Further information on the earthquake and strong-motion record is published in two previous issues of the Seismic Engineering Program Report, U.S. Geol. Survey Circ. 736-D and 762-A. Copies of the digitized data and Program Reports are available from Seismic Engineering Branch, USGS.

U. S. STRONG-MOTION NETWORK DATA

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 digitization and analysis of the significant records subsequent to the San Fernando earthquake have been carried out by the U. S. Geological Survey (USGS). A report containing digitized data and spectra for the significant records collected in 1971 has been released as Open-file Report 76-609. A second report (Open-file Report 77-587) contains the results of the processing of 10 strong-motion records obtained from Lima, Peru during the period 1951 to 1974. These reports are available from the Open-File Services Section, Branch of Distribution, Box 25425, Federal Center, Denver, CO 80225. Tapes containing the numerical data are available from the Environmental Data Service (see below).

Future reports will summarize records recovered during 1972, 1973, 1974, and 1975; 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) and the National Information Service for Earthquake Engineering at the University of California, Berkeley (NISEE) in the forms indicated below. The magnetic tape digital data from subsequent years will be available from EDS and NISEE at approximately the same time as the data reports are published.

- CIT Volume I data (uncorrected) on cards: EDS
- CIT Volume I data on tape: EDS and NISEE
- CIT Volume II data (corrected) and Volume III data (response spectra) on tape: NISEE
- SEB 1971 data (complete): EDS and NISEE

Inquiries should be addressed to:

1. EDS/NOAA
   National Geophysical and Solar-Terrestrial Data Center
   Mail Code D-62
   Boulder, CO 80302
2. NISEE/Computer Applications
   Davis Hall
   University of California
   Berkeley, CA 94720
3. Seismic Engineering Branch, USGS
   345 Middlefield Rd., Mail Stop 78
   Menlo Park, CA 94025

ERRATA

Reference	Error	Correction
CIT; EERL S-M earthquake accelerograms, digitized & plotted data; vol II, III, IV; Part B; Record #037 (1966 Parkfield earthquake)	Temblor, Calif. No. 2 USGS Station No. 1097 35°45'07" N 120°15'52" W	Temblor, Calif. USGS Station No. 1438 35°42'36" N 120°10'12" W
same as above: vol I, II; Part C Record #041 (1971 San Fernando earthquake; Component direction - Pacoima Dam accelerogram)	L - S74W V - Down T - S16E	L - N76W V - Down T - S14W
USGS S-M Station No. 1250; Gilroy, Gavilan College (Component direction - all S-M records since Oct. 1972	L - S67W V - Down T - S13E	L - S67W V - Down T - S23E
USGS S-M Station No. 2420 New Madrid, Missouri (Component direction - events of 6-13-75 and 3-24-76)	L - S19W V - Down T - S71E	L - West V - Down T - South
USGS S-M Station No. 181; Los Angeles, 1640 Marengo, 1st floor (component direction prior to 7-15-70)	L - N36W V - Down T - S54W	L - S54W V - Down T - S36E
NOTE: Since 7-15-70, the 1st floor (also 4th floor and roof) component directions are:		L - N36W V - Down T - S54W
Geol. Survey Circ. 762-B Seismic Engineering Program Report, May-Aug. 1977	Figures 2, 3, and 4 reduced (strong-motion records)	Enlarge 38, 22, and 10 percent, respectively

Table 1.- *Summary of accelerograms recovered during September - December 1977*

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
8 September 1976- 9 June 1977 So. Hawaii Epicenters and magnitudes unknown	Honokaa, Hawaii High school (USGS)	20.08 N 115.47 W	-	S60E Down N30E	0.07 .06 .05	- - -
			-	East Down North	.04 .05 .06	- - -
	Wahaula, Hawaii Visitor center (USGS)	19.33 N 155.03 W	1.9	N35W Down S55W	.07 .03 .03	- - -
	Note: Four additional records were obtained at Wahaula. Maximum acceleration less than 0.05 g.					
17 October 1976 0538 GMT So. California 34.45N, 118.37W Magnitude 3.9	Big Tujunga Dam	34.29 N 118.19 W				
	Left abutment (CIT)		-		**	
	Crest (USGS)		-	N33W Down S57W	.02 .01 .06	- - -
	Toe (USGS)		-		**	
16 May 1977- 9 November 1977 Alaska Epicenters and magnitudes unknown	Talkeetna, Alaska FAA-VOR (USGS)	62.30 N 150.10 W				
	Note: Six unidentifiable records were obtained at Talkeetna. Maximum acceleration less than 0.05 g.					
18 May 1977- 13 September 1977 No. California Epicenter and magnitude unknown	Palo Alto, Calif. VA Hospital (VA)	37.40 N 122.14 W				
	Basement		-		**	
	Roof		-		**	
2 June 1977 1630 GMT Alaska 61.2N, 149.8W Magnitude 4.2	Anchorage, Alaska Westward Hotel (Roof) (USGS)	61.22 N 149.89 W	-		**	
17 September 1977 2126 GMT Alaska 64.8N, 147.8W Magnitude 4.0	Fairbanks, Alaska College observatory (USGS)	64.86 N 147.83 W	-		**	

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
23 September 1977 0725 GMT Aleutian Islands Epicenter and magnitude unknown	Adak, Alaska Fire Station (USGS)	51.89 N 176.58 W	7.5		**	
24 September 1977 2128 GMT So. California 34.47N, 118.42W Magnitude 4.2	Big Tujunga Dam	34.29 N 118.19 W				
	Left abutment (CIT)		3.4		**	
	Crest (USGS)		3.3	N33W Down S57W	0.01 .01 .08	- - -
20 October 1977 0817 GMT Imperial Valley 32.88N, 115.50W Magnitude 3.2	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.3		**	
20 October 1977 1029 GMT Imperial Valley 32.89N, 115.50W Magnitude 4.0	El Centro Array #5 James Rd. (USGS)	33.85 N 115.46 W	2.3	N50E Down N40W	.05 .06 .05	- - -
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-		**	
21 October 1977 1324 GMT Imperial Valley 32.90N, 115.50W Magnitude 4.2	El Centro Array #3 Pine Union School (CIT)	32.89 N 115.38 W	2.8		**	
	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.2	N50E Down N40W	.11 .02 .13	1-peak - 0.2
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-		**	
22 October 1977 0905 GMT Imperial Valley 32.88N, 115.50W Magnitude 3.0	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.2		**	

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
28 October 1977 2124 GMT Imperial Valley 32.88N, 115.50W Magnitude 3.9	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.4	N50E Down N40W	0.16 .05 .11	0.1 - 1-peak
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.0	N50E Down N40W	.08 .04 .08	- - -
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	1.1	N50E Down N40W	.08 .02 .07	- - -
30 October 1977 0530 GMT Imperial Valley 32.88N, 115.50W Magnitude 4.0	El Centro Array #5 James Rd. (USGS)	32.85 N 115.46 W	2.4	N50E Down N40W	.11 .08 .14	0.1 - 0.3
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	2.2		**	
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	2.4	N50E Down N40W	.07 .02 .03	- - -
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	3.5		**	
	Note: Six additional records were recovered from El Centro Array #9 (USGS, 1 record) and Imperial County Services Building (CDMG, 5 records) and are related to the Imperial Valley earthquake swarm of October 1977. Maximum acceleration less than 0.05 g.					
11 November 1977 2311 GMT Imperial Valley 32.84N, 115.47W Magnitude 2.5	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.3		**	
13 November 1977 0610 GMT Imperial Valley 32.83N, 115.47W Magnitude 2.3	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.2		**	
13 November 1977 0700 GMT Imperial Valley 32.83N, 115.47W Magnitude 2.4	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.1		**	

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
13 November 1977 1609 GMT Imperial Valley 32.83N, 115.47W Magnitude 2.6	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.2		**	
13 November 1977 1625 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.1	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.2	N50E Down N40W	0.05 .04 .06	- - -
14 November 1977 0011:37 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.9	El Centro Array #5 James Rd. (USGS)†	32.85 N 115.46 W	1.8	N50E Down N40W	.12 .05 .17	0.2 - 0.7
	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.2	N50E Down N40W	.50 .13 .45	0.5 0.2 0.3
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	.10 .04 .11	0.1 - 1-peak
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-	N50E Down N40W	.07 .02 .04	- - -
14 November 1977 0012:03 GMT Imperial Valley Epicenter and magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.3*		**	
14 November 1977 0033 GMT Imperial Valley 32.82N, 115.47W Magnitude 3.1	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.0	N50E Down N40W	.06 .02 .06	- - -
14 November 1977 0205 GMT Imperial Valley 32.82N, 115.47W Magnitude 4.2	El Centro Array #3 Pine Union School (CIT)	32.89 N 115.38 W	2.8		**	
	El Centro Array #4 Anderson Rd. (USGS)	32.86 N 115.43 W	-		**	
	El Centro Array #5 James Rd. (USGS)†	32.85 N 115.46 W	-	N50E Down N40W	.17 .04 .15	1-peak - 1-peak

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	1.9	N50E Down N40W	0.38 .11 .41	1.3 1-peak 1.2
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	.14 .03 .10	1-peak - 0.2
	El Centro Array #8 Cruickshank Rd (CDMG)	32.81 N 115.53 W	1.6	N50E Down N40W	.12 .04 .08	0.4 - -
	El Centro Array #11 McCabe School (CIT)	32.75 N 115.59 W	-		**	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	2.8	S45E Down N45E	.04 .02 .07	- - -
	Calexico, Calif. Fire Station (CIT)	32.67 N 115.49 W	3.4		**	
14 November 1977 0210 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.4	El Centro Array #6 Huston Rd (CDMG)†	32.84 N 115.49 W	2.2	N50E Down N40W	.12 .04 .10	1-peak - 1-peak
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7		**	
14 November 1977 0231 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.1	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.0		**	
14 November 1977 0319 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.0	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.2	N50E Down N40W	.09 .02 .10	- - 1-peak
14 November 1977 0505:19 GMT Imperial Valley 32.83N, 115.47W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)†	32.84 N 115.49 W	2.4		**	

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
14 November 1977 0505:22 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.8	El Centro Array #6 Huston Rd (CDMG)†	32.84 N 115.49 W	2.2*	N50E Down N40W	0.04 .03 .08	- - -
	Holtville, Calif. Post Office (CDMG)	32.81 N 115.38 W	2.9		**	
14 November 1977 0513 GMT Imperial Valley 32.83N, 115.46W Magnitude 3.1	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	.07 .02 .07	- - -
14 November 1977 0518 GMT Imperial Valley 32.83N, 115.46W Magnitude 3.7	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	.12 .06 .13	0.1 - 0.6
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.8	N50E Down N40W	.06 .01 .03	- - -
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-	N50E Down N40W	.11 .03 .10	0.1 - 1-peak
14 November 1977 0519 GMT Imperial Valley 32.84N, 115.45W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	
14 November 1977 0523 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.8	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.0	N50E Down N40W	.14 .04 .12	0.4 - 0.3
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	-		**	
14 November 1977 0524:11 GMT Imperial Valley 32.66N, 115.29W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	
14 November 1977 0524:31 GMT Imperial Valley 32.88N, 115.49W Magnitude unknown	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.4*		**	

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
14 November 1977 0530 GMT Imperial Valley 32.83N, 115.47W Magnitude 3.3	El Centro Array #6 Huston Rd. (CDMG)	32.84 N 115.49 W	2.3	N50E Down N40W	0.25 .04 .23	0.1 - 0.1
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.9		**	
14 November 1977 0536 GMT Imperial Valley 32.83N, 115.47W Magnitude 4.1	El Centro Array #4 Anderson Rd. (USGS)	32.86 N 115.43 W	-	N50E Down N40W	.05 .02 .03	- - -
	El Centro Array #5 James Rd. (USGS)†	32.85 N 115.46 W	-	N50E Down N40W	.06 .03 .17	- - 1-peak
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 W	1.7	N50E Down N40W	.08 .03 .07	- - -
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	1.8	N50E Down N40W	.13 .04 .23	0.4 - 0.3
	El Centro Array #11 McCabe School (CIT)	32.75 N 115.59 W	3.1		**	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 N	1.9		**	
	Bonds Corner, Calif. Ground level (CIT)	32.693N 115.338W	1.6		**	
	Calexico, Calif. Fire station (CIT)	32.67 N 115.49 W	3.3		**	
14 November 1977 1220 GMT Imperial Valley 32.82N, 115.45W Magnitude 4.3	El Centro Array #4 Anderson Rd. (USGS)	32.86 N 115.43 W	2.3	N50E Down N40W	.15 .06 .08	1-peak - -
	El Centro Array #5 James Rd. (USGS)†	32.85 N 115.46 W	2.4	N50E Down N40W	.16 .06 .15	0.3 - 0.3
	El Centro Array #7 Imp. Valley College (CIT)	32.83 N 115.50 N	1.9		**	
	El Centro Array #8 Cruickshank Rd. (CDMG)	32.81 N 115.53 W	2.3	N50E Down N40W	.09 .04 .08	- - -

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
	El Centro Array #11 McCabe School (CIT)	32.75 N 115.59 W	-		**	
	Holtville, Calif. Post Office (CIT)	32.81 N 115.38 W	2.6		**	
	Calexico, Calif. Fire station (CIT)	32.67 N 115.49 W	3.4		**	
4 November 1977- 15 November 1977 Imperial Valley Epicenters and magnitudes unknown	El Centro Array #9 Commercial Ave. (USGS)	32.79 N 115.55 W	-	Up South West	0.02 .05 .08	- - -
			-	Up South West	.02 .03 .05	- - -
			-	Up South West	.04 .10 .09	- 1-peak -
	Note: Two additional records were recovered at El Centro Array #9. Maximum acceleration less than 0.05 g.					
	El Centro Array #10 Community Hospital (USGS)	32.78 N 115.57 W	2.3		**	
	El Centro, Calif. Imperial County bldg. (CDMG)	32.79 N 115.56 W				
	Ground floor		-		**	
	Second floor		-		**	
	Sixth floor (end) (center) (center)		-	North North East	.10 .11 .06	1-peak 0.2 -
	Ground floor		-		**	
	Second floor		-		**	
	Sixth floor (end) (center) (center)		-	North North East	.12 .16 .05	0.3 0.5 -
	Note: Four additional records were recovered at Imperial County bldg. Maximum acceleration less than 0.05 g.					

See footnotes at end of table

Table 1.- *Summary of accelerograms recovered during September - December 1977* - continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
4 October 1977- 15 November 1977 Imperial Valley Epicenters and magnitudes unknown	El Centro, Calif. Meadows Union School (USGS)	32.80 N 115.47 W	1.4	N50W	0.07	-
				Down	.02	-
				S40E	.07	-
			1.8	S50W	.15	0.1
				Down	.04	-
				S40E	.10	1-peak

[1] CDMG - California Division of Mines and Geology
CIT - California Institute of Technology
USGS - U.S. Geological Survey
VA - Veterans' Administration
† - WWVB time code is incomplete; correlation of event and accelerogram is questionable.

[2] S-wave minus trigger time.
* denotes S-P interval, that is, the earthquake occurred within the instrumental run-time of a previous event.

[3] Unless otherwise noted, maximum acceleration recorded at ground or basement level.
** denotes maximum acceleration is less than 0.05 g at ground stations or less than 0.10 g at upper floors of buildings.

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

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

Date of event	Station location	Maximum accl (g)†
	1972	
January 3, 1972	Managua, Nicaragua; Esso Refinery	0.15
January 5, 1972	Managua, Nicaragua; Esso Refinery	.22
	Managua, Nicaragua; National University	.12
March 4, 1972	Bear Valley, Calif.; Melendy Ranch barn	.15
March 22, 1972	Bear Valley, Calif.; Melendy Ranch barn	.16
July 30, 1972	Sitka, Alaska; Magnetic Observatory	.11
August 27, 1972	Beverly Hills, Calif.; 8383 Wilshire*	.15
	Beverly Hills, Calif.; 9100 Wilshire*	.12
	Los Angeles, Calif.; 6300 Wilshire*	.10
	Los Angeles, Calif.; 6420 Wilshire*	.15
September 4, 1972	Bear Valley, Calif.; CDF Fire Station	.18
	Bear Valley, Calif.; Melendy Ranch barn	.48
	Bear Valley, Calif.; Stone Canyon East	.18
December 23, 1972	Managua, Nicaragua; Esso Refinery	.39
Aftershock B	Managua, Nicaragua; Esso Refinery	.17
Aftershock C	Managua, Nicaragua; Esso Refinery	.32
	1973	
February 21, 1973	Port Hueneme, Calif.; U.S. Naval Laboratory	0.13
March 31, 1973	Managua, Nicaragua; National University	.60
April 26, 1973	Kilauea, Hawaii; Namakani Paio Campground	.17
August 8, 1973	Ferndale, Calif.; Old City Hall	.14
September 16, 1973	Berryessa, Calif.; CDF Fire Station	.18
	1974	
January 31, 1974	Gilroy, Calif.; Gavilan College, Bldg. 10	0.16
February 11, 1974	Los Angeles, Calif.; 420 S. Grand*	.10
	Los Angeles, Calif.; 525 S. Flower, No. Tower*	.13
	Los Angeles, Calif.; 700 W. 7th*	.18
	Los Angeles, Calif.; 533 S. Fremont*	.25
August 14, 1974	Pacoima Dam, abutment	.12
	Vasquez Rocks Park, Calif.	.10
November 28, 1974	Hollister, Calif.; City Hall	.17
	San Juan Bautista, Calif.; 24 Polk St.	.12
	Gilroy, Calif.; Gavilan College Bldg. 10	.14
December 6, 1974	Imperial, Calif.; Imperial Valley College Adm. Bldg.	.11
	1975	
January 11, 1975	Petrolia, Calif.; General Store	0.10
	Cape Mendocino, Calif.; Petrolia	.19
January 23, 1975	Imperial, Calif.; Imperial Valley College Adm. Bldg.	.11
March 6, 1975	Bear Valley, Calif.; Melendy Ranch East	.18
May 6, 1975	Shelter Cove, Calif.; Station 2 Power Plant Yard	.18
June 7, 1975	Ferndale, Calif.; Old City Hall	.19
	Cape Mendocino, Calif.; Petrolia	.22
	Petrolia, Calif.; General Store	.19
	Shelter Cove, Calif.; Station 2 Power Plant Yard	.10

See footnotes at end of table.

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

Date of event	Station location	Maximum accl (g)†
June 19, 1975	El Centro Array, Calif.; Station 6, 551 Huston	0.10
June 20, 1975	El Centro Array, Calif.; Station 6, 551 Huston	.13
	Holtville, Calif.	.15
August 1, 1975	Oroville Dam, Calif.; Crest	.13
	Oroville Dam, Calif.; Seismograph station	.11
August 2, 1975	Pleasant Valley Pumping Plant, Calif.	.08
	Pleasant Valley, Calif.; Switchyard	.13
September 13, 1975	Parkfield Grade, Calif.; Jack Varian Ranch	.14
	Vineyard Canyon, Calif.	.18
November 14, 1975	Ferndale, Calif.; Old City Hall	.18
	Cape Mendocino, Calif.; Petrolia	.13
	Petrolia, Calif.; General Store	.10
November 29, 1975 0335 (local time)	Hilo, Hawaii; Univ. Hawaii Cloud Physics Lab.	.15
November 29, 1975 0447 (local time)	Honokaa, Hawaii; Central Service Bldg.	.11

† Maximum acceleration at ground or basement level.
* The records from the upper levels of these buildings are being digitized.

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