GEOLOGICAL SURVEY CIRCULAR 785-B

Seismic Engineering Program Report May - August 1978

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

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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 National Strong-Motion Network during the period May 1 through August 31, 1978. Reports on the Sendai, Japan earthquake of June 12, the northern Greece earthquake of June 20, and the Santa Barbara, California earthquake of August 13 are included, 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 data summary presented in table 1 includes those accelerograms recovered (although not necessarily recorded) during the period May through August 1978; this procedure will be continued in future issues so that the dissemination of strong-motion data may be as expeditious and current as practicable.

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Seismic Engineering Program Report

May-August 1978

RECENT STRONG-MOTION RECORDS

by R. L. Porcella

Forty-one accelerograms were recovered from the cooperative National Strong-Motion Network during the period May 1-August 31, 1978 (see table 1, end of report). Records were also obtained from earthquakes near Sendai, Japan on June 12 and in northern Greece on June 20 (see the following preliminary reports).

Small earthquakes (magnitude 3.2-4.3) in the Imperial Valley produced several strong-motion records at the Brawley airport site and at four sites in the El Centro array; the array contains 13 accelerograph sites at 3- to 4-km spacings transverse to the 1940 earthquake surface rupture. Twenty-five strong-motion stations are currently installed in the Imperial Valley, including a six-story building instrumented with a nine-channel remote recording system. This network is the result of the cooperative efforts of the U.S. Geological Survey (USGS), the California Division of Mines and Geology (CDMG), and the California Institute of Technology and was designed to fulfill such specific research needs as source-mechanism and ground-motion attenuation studies. Since January 1975, nearly 200 records have been recovered from this network; although the data obtained to date are of minimal engineering significance, the accelerograms do contain seismologic information useful in magnitude and epicenter determinations, wave propagation, and source-mechanism studies of the Imperial Valley region.

Twenty-one earthquakes were recorded between February and November 1978 at Monticello Dam in north-central South Carolina (see table 1); the dam and reservoir are part of the Virgil C. Summer nuclear power facility operated by the South Carolina Electric and Gas Company (SCEG) and are located approximately 4 km northwest of Jenkinsville, S.C. The reservoir covers an area of about 2750 hectares and has an average depth of about 25 m. Filling of the reservoir began in late December 1977 and was accompanied by an abrupt increase in seismic activity (up to 100 events per day) recorded by a network of four seismographs operated by SCEG (Bob Whorton, oral commun., October 1978). Prior to filling of the reservoir, the USGS seismograph station at Jenkinsville had recorded one event about every 6 days. This increase in activity tapered off and then resumed abruptly in August 1978. Two strong-motion accelerographs were installed by the USGS in February 1978 as a result of the first increase in seismic activity. One accelerograph was placed in a steel-frame office building (45 m x 24 m) a few hundred meters west of the power plant; the other instrument was installed in a small plywood shelter (1.5 m x 1.5 m) on the south abutment of the largest of four embankment sections. The "abutment" instrument was removed in May 1978 and was replaced with the "office" instrument. Thirteen records with peak accelerations greater than 0.05 g have been recovered from these two stations (table 1). The largest acceleration was recorded at the abutment site and suggests a 0.253 g peak horizontal ground acceleration in the "south" direction; the duration of strong-motion (greater than 0.1 g) is about 0.06 s at approximately 25 Hz. This record has been attributed to a magnitude 2.7 event (depth 1.5 km) on August 27, 1978 at 1023:08 UTC (Pradeep Talwani, written commun., October 23, 1978) and contains the largest known recorded acceleration from an earthquake in central or eastern North America. Epicentral distance is about 1 km. The absence of trigger minus S or S-P intervals on any of the 21 records indicates sources very near the recording stations.

Two strong-motion records were recovered from the CDMG Halls Valley station after a series of small earthquakes occurred on May 11 along the Calaveras fault about 15 km northeast of San Jose, Calif. The four largest events occurred at 0456, 0457, 0518, and 0528 local time and were assigned magnitudes of 3.1, 3.8, 3.7, and 3.1, respectively (Roy Miller, oral commun., September 1978). The accelerograms have been attributed to the magnitude 3.7 and 3.8 earthquakes and contain peak accelerations less than 0.05 g.

The Santa Barbara earthquake of August 13, 1554 (local time) produced three strong-motion records at USGS stations, one at a Southern California Edison station, and at least four at CDMG stations (table 1). An assessment of earthquake damage and a summary of strong-motion data are contained in the following preliminary reports. Copies of the CDMG accelerograms were not available at this printing, although preliminary acceleration and duration data from four CDMG stations are included in table 1.

BRIEF REPORT ON THE JAPAN EARTHQUAKE OF JUNE 12, 1978

by A. Gerald Brady

An earthquake with Richter magnitude 7.4 occurred at 1714 (local time) on June 12, 1978 off the coast of Japan's Miyagi Prefecture. The following report contains an assessment of the earthquake and its effects. Numerical values and statements not clearly the author's observations await confirmation by both subsequent investigation teams and official Japanese reports.

Two reports are in preparation in the United States, one published by Earthquake Engineering Research Institute (EERI, P. Yanev, ed.) and the other by National Bureau of Standards (NBS, B. Ellingwood, ed.); these reports are based on observations made by teams of investigators who visited Japan for various periods between June 19 and July 5, 1978. The team members represented the following institutions: the U.S.-Japan Cooperative Program in Natural resources (UJNR), the U.S. Geological Survey (USGS), EERI, NBS, the Federal Highways Administration (FHWA), the Federal Disaster Assistance Administration (FDAA), and URS/J.A. Blume and Associates.

The main earthquake was preceded by a smaller shock (magnitude not available) at 1703 and by a magnitude 6.8 shock on February 20, 1978 in the same general area. The June 12 earthquake was located at 38.15° N. and 142.22° E. at a depth of 30 km. The nearest strong-motion record was recovered at an epicentral distance of 70 km. The city of Sendai (pop. 600,000), where there are several instrumented buildings, is located at an epicentral distance of 140 km. The intensity of shaking reached V on the JMA scale over an area of about 180 km by 60 km; strongest shaking was in the areas of Ofunato, Sendai, Shinjyo, and Fukushima. JMA V corresponds to MMI VII and VIII and is partially described as "Very Strong - cracks in walls, overturning of gravestones, stone lanterns, etc., damage to chimneys and mud-and-plaster warehouses."

Figure 1 shows the northern part of the island of Honshu. The accelerograph sites at ground level (or in the basements or at first floors of buildings) are indicated, together with the peak accelerations in two horizontal directions and the vertical direction. Also included in the figure are two idealized isoseismal curves surrounding the JMA 5 and 4 intensity areas; the curves were constructed from JMA intensities recorded throughout Japan. Table 2 lists the peak accelerations at a number of sites, including the upper stories of buildings. The total number of records, out to epicentral distances of almost 600 km, were collected from 90 stations, many of which had multiple instrumentation.

The record with the closest epicentral distance, about 80 km, is the Kaihoku Bridge record (fig. 1) with an acceleration of 0.3 g. Seismicity studies of aftershock data indicate an error in the location of the epicenter and that the main shock rupture plane, with a shallow dip to the west, actually reached a point about 70 km from the instrument, or within 30 km measured in plan. The record from an instrument located at the top of one of the bridge piers was off scale, at greater than 0.5 g.

The instrumented high-rise buildings in Sendai exhibited no obvious structural damage although several minor cases of architectural damage were apparent. These included broken windows, upset shelves, and loosened veneers of brick and tile.

Digitization and preliminary corrections for all significant records are expected to be carried out by the Japanese agencies responsible for the instruments (see table 2).

Acknowledgment. The author would like to thank all those representatives from participating agencies in both the U.S. and Japan whose efforts resulted in the success of the visit by members of the several teams, and especially Mr. M. Ohashi, his guide.

Reference:

National Research Center for Disaster Prevention, Science and Technology Agency, Japan (July, 1978) "Prompt Report on Strong-Motion Accelerograms No. 15, June 12, 1978 Miyagi-Ken-Oki Earthquake."

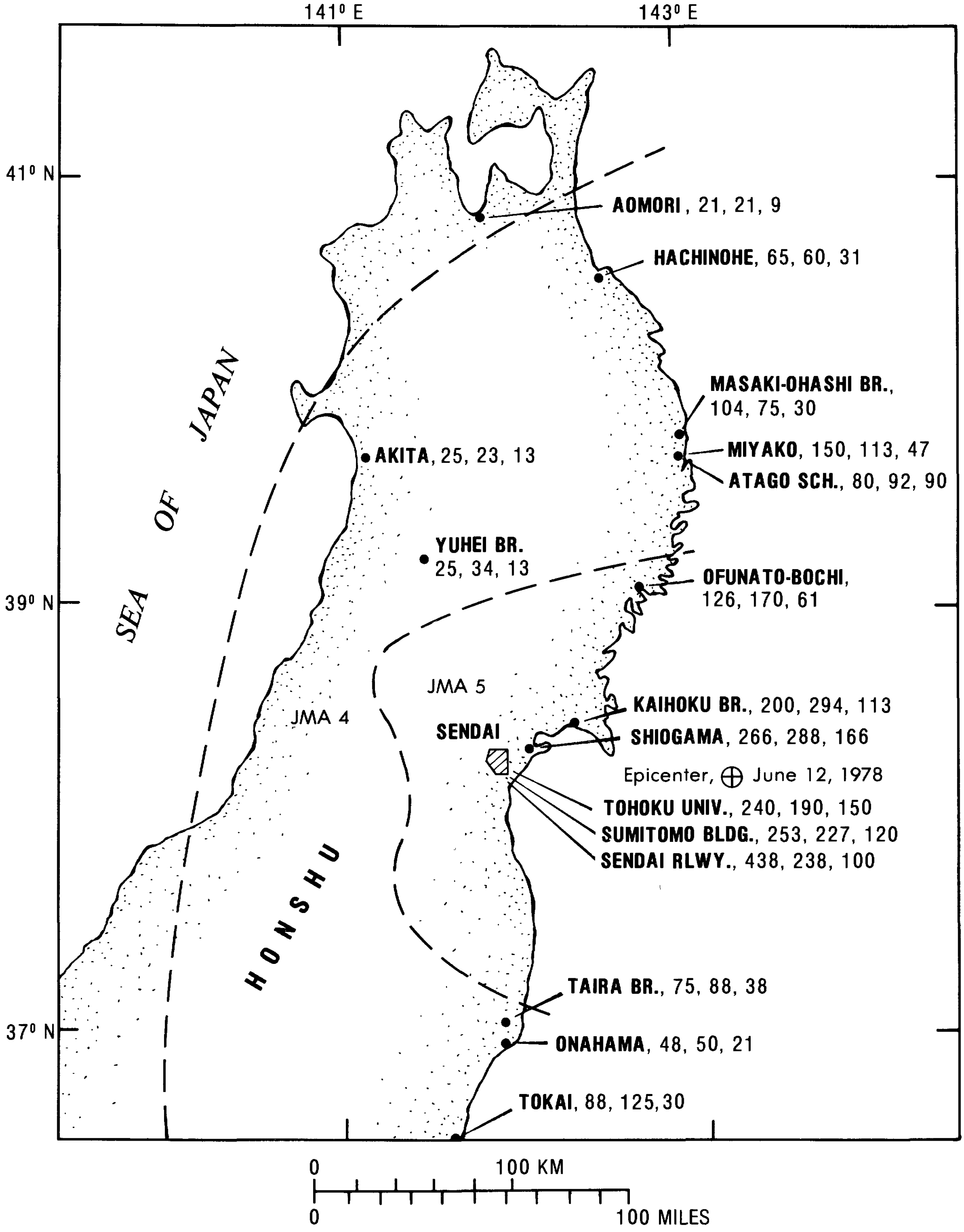

Figure 1.- Northern Honshu locations of ground level or basement accelerograph sites providing significant recordings, with peak accelerations in cm/s^2 (2 horizontal, 1 vertical), and isoseismals for JMA 5 and 4 (JMA 5 approximates MMI VII and VIII).

Table 2.- *List of strong-motion accelerograms*

Sta. No.	Owner*	Location	Structure	Inst. loc.**	Peak accelerations (cm/s^2)		
					L	T	V
TH038-1	Sumitomo	Sendai	Sumitomo Bldg.	B2F	253.3	226.7	120
-2	do	do	do	9F	393.3	520	206.7
-3	do	do	do	18F	486.7	553.3	226.7
TH030	BRI	do	Tohoku Univ.	1F	240	190	150
TH903	do	do	do	9F	980	480	300
TH009	do	Miyako	Atago School	1F	80	92	90
TH018	RTRI	Sendai	Sendai Office	B1F	306	238	100
TH028	PHRI	Shiogama	Shiogama Office	GL	266	280	166
TH014	do	Miyako	Miyako Office	GL	150	113	47
TH029	do	Hachinohe	Hachinohe Office	GL	65	31	60
TH020	do	Aomori	Aomori Office	GL	21	21	9
TH013	do	Iwaki	Onahama Office	GL	48	50	21
TH006	do	Akita	Harbor Office	GL	25	23	13
TH019	do	Ofunato-Bochi	Breakwater	GL	126	170	61
TH016-1	PWRI	Ishinomaki	Kaihoku Bridge	GL	200	294	113
TH021-1	do	Iwaki	Taira Bridge	GL	75	88	38
-2	do	do	do	AB	56	38	25
TH015	do	Akita	Yuhei Bridge	GL	25	34	13
TH032	do	Iwate	Masaki-Ohashi Br.	GI	104	75	30
KT001	JAERI	Ibaraki	Tokai	1F	88	125	30

* Organization responsible for collecting the original record and reporting accelerations:
BRI - Building Research Institute
RTRI - Railway Technical Research Institute
PHRI - Port and Harbor Research Institute
PWRI - Public Works Research Institute
JAERI - Japan Atomic Energy Research Institute
** Instrument location: B-basement, GL-ground, F-floor, AB-abutment

PRELIMINARY REPORT ON THE NORTHERN GREECE EARTHQUAKE OF JUNE 20, 1978*

INTRODUCTION

A destructive earthquake occurred in northern Greece at 2303 (local time) on June 20, 1978 approximately 30 km northeast of the port city of Thessaloniki (Salonica). World-wide data recorded by the U.S. Geological Survey indicate that the shock had a magnitude of 6.4 (m_b) and was located at 40.82° N. and 23.15° E. at a depth of 16 km (fig. 2).

The earthquake caused an estimated 50 deaths and substantial localized damage in Thessaloniki and a number of smaller towns and villages in the most strongly shaken area, the Langadha-Volvi Lakes valley located 20 to 30 km east of Thessaloniki. More than 100 buildings constructed with unreinforced masonry materials were shaken down, although the most significant collapse was an eight-story reinforced concrete building in Thessaloniki, where 38 deaths occurred. The Greek government estimated the total damage caused by the earthquake was $190 million; the fraction of this damage that resulted from the actual destruction of property is unknown.

Ground effects observed in the Langadha-Volvi Lakes valley include minor slope failure, sand boils associated with slumping and subsidence, and two zones of faulting, one extending northwest through the center of the valley and the second one trending approximately east-west along the southern margin of the valley (fig. 2). Although tectonic faulting at depth is clearly indicated, the surface rupturing and displacement may represent a combination of both primary and secondary effects. Surface expression of faulting through the center of the valley (total length about 10 km) indicates left-lateral strike-slip motion, probably not exceeding 2 cm. The rupture zone near the southern margin of the valley, approximately 8 km long, shows chiefly vertical offset with a maximum displacement of 30 cm.

*This report summarizes some of the observations of the USGS investigation team consisting of R. P. Maley, C. G. Bufe, and R. F. Yerkes that spent seven days in the epicentral area after the earthquake.

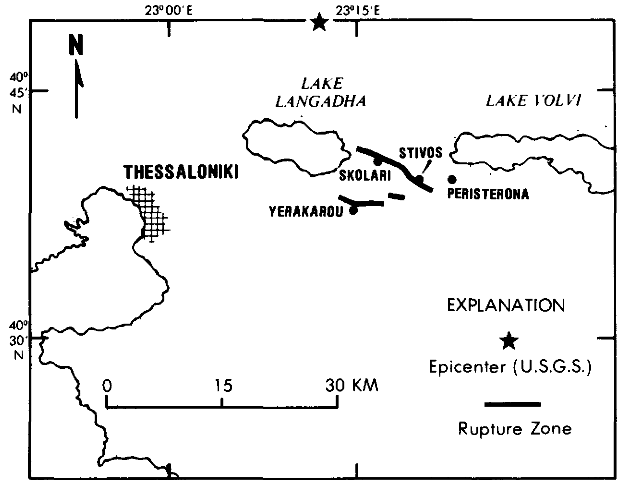

Figure 2.- Location map showing rupture zones for northern Greece earthquake of June 20, 1978.

GENERAL EFFECT ON THESSALONIKI

A series of strong foreshocks began approximately 33 hours before the main shock; thus, a considerable part of the Thessaloniki population had already evacuated their residences when the major earthquake occurred. Many others left the city immediately, causing severe traffic congestion and numerous serious accidents. Some of the remaining population began to erect "tent cities" in any available space, particularly in the parks. In response to this action, the Greek army distributed 60,000 large tents to residents and prepared adequate sanitary facilities at the sites of large tent concentrations. Because of continuing aftershocks and the fear of an even stronger earthquake, only a limited number of residents had elected to return to their homes by late July, despite the fact that many of them lived in structures that had been inspected and were considered safe for occupancy.

After the earthquake, 100 two-man inspection teams were sent into the field to assess the relative safety of all buildings in Thessaloniki. These teams then posted the entrances with large colored stickers indicating the condition of occupancy: green, the structure was safe and could be used for normal living or business purposes; yellow, the building required repairs and could not be occupied although residents could temporarily re-enter to gather up their belongings; and red, entry was prohibited until the structure had been repaired. By July 7, 30,000 dwellings had been inspected and 9 percent of these received red stickers. The yellow- and red-stickered buildings caused considerable hardships particularly for businesses and building owners. One of the serious problems for Greek authorities involved the accommodation of 40,000 Thessalonians in new or temporary housing until reconstruction of the damaged housing could be completed.

STRONG-MOTION RECORDS

Two strong-motion accelerographs were triggered by the earthquake, one in Thessaloniki 30 km from the epicenter and 20 to 30 km from the fault zone, and the second in Gevgelija, Yugoslavia, 80 km northwest of the epicenter. The Thessaloniki instrument, operated by the National Observatory of Athens, was installed in the basement of an eight-story building located on relatively poor alluvial soil a few hundred meters from the Gulf of Thessaloniki. A tracing of the record provided by J. Drakopoulos shows a maximum acceleration of 0.15 g, with each component recording 4 to 5 peak amplitudes exceeding 0.10 g for intervals of from 0.6 to 1.2 s (fig. 3). The maximum acceleration recorded at Gevgelija was 0.04 g (IZIIS, 1978).

The Thessaloniki instrument was triggered by several aftershocks that produced minor accelerations, except for the 0.12-g maximum acceleration recorded during the magnitude 5.0 July 4 aftershock.

Shortly after the June 20 earthquake, an investigation team from the Institute of Earthquake Engineering and Engineering Seismology, Skopje, Yugoslavia, installed three accelerographs in Greece: one at Skolari in the epicentral region and two in Thessaloniki, one on rock and the other near the collapsed eight-story building. Aftershock results from this network are not yet available.

DAMAGE

Damage effects from the earthquake were concentrated in Thessaloniki, the largest city in northern Greece (population estimated at one million), as well as in a number of small villages situated in the Langadha-Volvi Lakes valley. Although numerous unreinforced masonry structures collapsed, particularly in the villages, the casualty toll was not large, owing to the occurrence of foreshocks the day before the earthquake. As a consequence, most people had evacuated their residences and were on open ground at eleven in the evening when the earthquake struck. Had this forewarning not occurred, many more casualties could have resulted because of building failures and fallen parapets (overhangs and facades) that were shaken loose on hundreds of buildings in Thessaloniki.

Significant structural damage was limited to a few buildings in Thessaloniki, most notably the collapse of an eight-story reinforced concrete building that caused the majority of the fatalities during the earthquake. The remains of the structure had been demolished in the search for survivors before the USGS investigation team arrived. During the

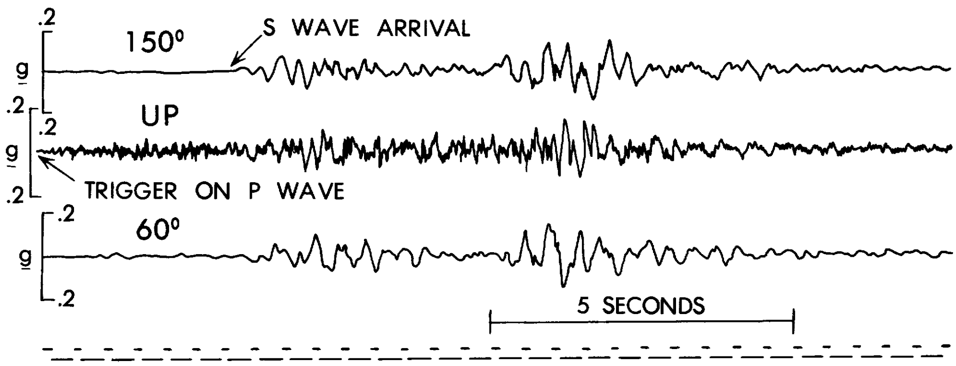

Figure 3.- Tracing of accelerogram from basement of eight-story building in Thessaloniki at epicentral distance of about 30 km; Greece earthquake of June 20, 1978.

collapse, the building, or part of it, apparently fell against an adjoining building, tearing out a section of the exterior wall and knocking down several balconies. A second eight-story reinforced concrete building, located two and a half blocks from the collapse site, had badly damaged first-floor columns. Engineers from the Minsitry of Public Works (MPW) reported that the soil conditions in this area are unusual and that some of the present structures are situated partly on old brick ruins that have sunk well below the present ground surface. Presumably the area was brought up to grade by landfill many years ago.

Nonstructural damage, though widespread throughout Thessaloniki, was concentrated in the older, more ornate buildings. Typical external damage consisted of fallen parapets , cornices and overhangs, plaster spalling from hollow-tile walls, fallen ornamental brickwork, marble facades that separated and dropped off walls, and spalling between adjacent buildings that were constructed with no seismic separation. In one instance, decorative hollow concrete blocks used as a facade for an exterior stairway collapsed both inward on the stair side and outward onto the street and sidewalk.

In the epicentral area the fault zone passed directly through Skolari, ruptured a concrete slab in a garage, cut through the main road in town, and extended beneath a house that was damaged but did not collapse. Numerous unreinforced mud-brick and concrete-block farm buildings collapsed entirely, and some residences sustained badly cracked tile walls and could not be safely occupied. A large part of the damage in Skolari was clearly related to the existence of faulting under or near buildings.

Ground rupturing in Yerakarou severely damaged a number of buildings, most notably several residential structures in the fault zone. The second floor of one two-story house was severely damaged; both exterior walls were near collapse and interior hollow-tile walls had toppled onto the bed, couch, table, and floor. Fortunately, the building had been evacuated when the foreshocks occurred (with the exception of the mother-in-law who survived the earthquake by sleeping on the ground floor).

Faulting was observed across the highway northwest of Stivos and within 10 to 20 m of a two-story reinforced concrete building under construction for the office and residence of a FINA service station. The most heavily damaged (west) side of the structure has no walls between ground level and the second-floor level, whereas the solid east wall of the building was undamaged except for the base of one corner column. The station operator reported that ground rupture occurred curing a large earthquake in 1932, but in a different location than the 1978 shock.

On the hill just above Peristerona a few stretches of linear fissures several hundred meters long appear to be a secondary faulting phenomenon, such as slumping or sliding. In contrast to other areas, the damage pattern in this village seems to bear no relation to the location of the fracture zone. The structures in the upper part of Peristerona are essentially intact, but at the base of the hill, just above the slope intersection with the highway, a number of houses and the entrance to a church were severely damaged. Several unreinforced concrete-block farm buildings in the valley northwest of Peristerona were flattened.

The USGS investigation team gratefully acknowledges the assistance of Minister M. Martis of northern Greece, Professors A. G. Galanopoulos and J. Drakopoulos of the National Observatory of Athens, Professor P. Carydis of the National Technical University of Athens, Professors B. C. Papazachos and G. Leventakis of the University of Thessaloniki, L. Semakis and Col. D. Beech of the U. S. Embassy in Athens, and members of the U. S. Consulate in Thessaloniki, Consulate General D. Zachary, Director of the American Center C. R. Sherak, and Nicos Papaconstininou who acted as interpreter.

Reference: IZIIS, 1978, Records of the Khalkidiki earthquakes in the period May 23-June 21, 1978 obtained at IZIIS seismographic station: Institute of Earthquake Engineering and Engineering Seismology, University "Kiril and Metodij", Skopje, Yugoslavia, Report IZIIS 78-48, 19 p.

THE SANTA BARBARA EARTHQUAKE OF AUGUST 13, 1978: A RECONNAISSANCE REPORT

by B. L. Silverstein

A magnitude 5.1 (M_L) earthquake occurred off the coast of Santa Barbara, California on August 13, 1978 at 2254:52.4 UTC (California Institute of Technology). The earthquake had a focal depth of about 12 km and was located at 34.37° N. and 119.72° W. in the Santa Barbara Channel (W. Lee, oral commun., August 1978, fig. 4). Earthquakes in this area have not caused any known fault rupture on land since 1912; however, there have been two earthquakes in the Santa Barbara Channel, a magnitude 6.3 in 1925 and a magnitude 6.0 in 1941.

According to press releases, general damage included fallen items from grocery and liquor store shelves, broken windows, and mobile homes knocked off their supports. Conversations with fire officials revealed that there were some broken gas mains, possibly some earthquake-related fires, and a potential tragedy that was avoided when an Amtrak passenger train was late coming to the area; a Southern Pacific freight train was derailed but damage was minimal (not observed by the author). No fatalities were reported; however, press releases indicate total damages of about $12 million.

Most of the damage occurred in the Goleta area and included some of the buildings at the University of California campus. One such building, North Hall, is instrumented with a CRA-1 9-channel remote-recording accelerograph system owned by the California Strong-Motion Instrumentation Program (CSMIP). North Hall is a rectangular-in-plan three-story reinforced concrete structure. Damage to North Hall was minor and consisted of hairline cracking in the interior north-south shear walls, with most cracks oriented at an angle of about 45°. These hairline cracks occurred at all three floors and were more extensive on the first floor. No evidence of soil-structure interaction was observed.

Other damage at the University occurred in the eight-story library building when thousands of books fell from shelves. No noticeable pattern of direction of fall was observed; however, most of the books came from the upper shelves, more falling at the upper two floors. Damage of the cover plates for seismic joints at floors one through four indicated relative movement at these joints.

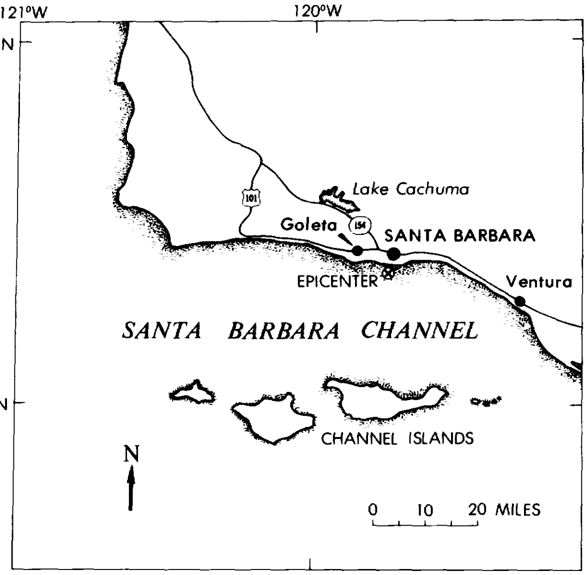

Figure 4.- Location map, Santa Barbara, California earthquake of August 13, 1978.

Structural damage to reinforced concrete overpasses occurred at the intersection of Highways 101 and 217. On one of these bridges, the fourth set of interior bents (from the southwest abutment) exhibited spalled concrete and buckled reinforcing bar. At the southwest abutment the road decking is connected to the abutment support by steel rocker assemblies with 1-inch bolts. All but one of the upper bolts on the abutment side were sheared.

Damage in downtown Santa Barbara occurred when an unreinforced brick parapet fell outward and through the roof of an adjacent wood-framed building.

The Freitas Building in downtown Santa Barbara is also instrumented with a CSMIP-owned CRA-1. Completed in 1970, this rectangular-in-plan building has four floors above and a half-basement below ground level. An inspection of this building indicated no structural damage, but damage such as cracked walls, fallen objects, sheared and bent bolts securing air conditioning units at the roof level, and jammed doors suggests a strong east-west motion.

STRONG-MOTION RESULTS FROM THE SANTA BARBARA, CALIFORNIA EARTHQUAKE OF AUGUST 13, 1978

by R. L. Porcella, R. P. Maley, and A. V. Acosta

Eight accelerograms were recovered from strong-motion stations at Santa Barbara, Goleta, Cachuma Dam, and the University of California, Santa Barbara campus (UCSB) in the days immediately following the August 13 earthquake. The main event occurred at 0354 in the afternoon (local time) and was assigned preliminary magnitudes (M_L) of 5.1 (California Institute of Technology), 5.5 and 5.9 (University of California, Berkeley), and 5.5 (U.S. Geological Survey, Golden, Colo.). The hypocenter was located offshore about 6 km south of Santa Barbara at a depth of 10-15 km (W.H.K. Lee, C. E. Johnson, T. L. Henyey, and R. F. Yerkes, unpub. data, 1978).

Strong-motion instruments that triggered during the earthquake include triaxial accelerographs located at crest and toe sites at Cachuma Dam, a U.S. Bureau of Reclamation facility at an epicentral distance of 34 km. A maximum horizontal ground acceleration of 0.12 _g_ (fig. 5) was recorded at the crest in a southwest direction, transverse to the axis of the embankment. A triaxial accelerograph installed at the basement level of the Santa Barbara Courthouse recorded a maximum horizontal ground acceleration of 0.21 _g_ in the southwest direction (epicentral distance 6 km); the duration of strong-motion (greater than 0.1 _g_) was approximately 1.3 s. Additionally, this instrument recorded a small aftershock about 14 s after triggering during the main shock (fig. 5).

The Southern California Edison (SCE) company recovered a strong-motion record from an SCE power facility on Glen Annie Road in Goleta; the triaxial recording system (SMA-2) employs FM modulation on a four-track magnetic tape cassette. The analog readout indicates a peak horizontal ground acceleration of 0.28 _g_ (north direction). Epicentral distance is 19 km.

The California Division of Mines and Geology strong-motion instrumentation program (CSMIP) includes four sites in the Santa Barbara area that produced records during the August 13 event. Three of these sites are buildings instrumented by CSMIP in accordance with recently developed building instrumentation criteria. The record from a nine-channel system installed at the three-story North Hall building on the UCSB campus indicates peak horizontal accelerations of 0.44 _g_, 0.66 _g_, and 0.99 _g_ for the ground, third floor, and roof levels, respectively. Durations of strong (horizontal) motion (greater than 0.1 _g_) range from 2 s at the ground level to approximately 9 s at the roof level (table 1). Epicentral distance is about 13 km.

The four-story Freitas Building in downtown Santa Barbara (epicentral distance 6 km) is instrumented with a nine-channel remote-recording system; the strong-motion record from the August 13 event shows peak horizontal accelerations of approximately 0.22 _g_, 0.30 _g_, and 0.67 _g_ at the basement, second floor, and roof levels, respectively. Durations of strong motion range from 0.5 s at the second floor to 7 s at the roof level.

The twelve-story Holiday Inn on Harbor Boulevard in Ventura is instrumented with a twelve-channel remote-recording system; accelerometers are located at ground, fourth floor, eighth floor, and roof levels. Maximum recorded acceleration is less than 0.05 _g_ at an epicentral distance of 40 km.

A CSMIP triaxial accelerograph at the Physical Plant station on the UCSB campus recorded a peak horizontal ground acceleration of about 0.37 _g_ in the south direction (epicentral distance 13 km). Duration of strong motion was approximately 1.5 s. Additionally, this instrument recorded a small aftershock about 17 s after triggering during the main event; maximum acceleration is less than 0.05 _g_.

Two seismoscope records were recovered from USGS stations at the Santa Barbara Courthouse and the Bioscience building on the UCSB campus; maximum relative displacements recorded at these stations are 3.42 cm and 4.06 cm, respectively. Apparently, during the earthquake, a door fell on the seismoscope at the Bioscience building and may have affected the record.

The accelerographs that recorded the Santa Barbara earthquake were actuated during the early phases by vertically sensitive triggers that have a turn-on threshold of 0.01 _g_ over a frequency range of 0.1 to 10 Hz. Generally this threshold means that relatively near-field instruments are triggered by early P wave arrivals and, consequently, S wave minus trigger (S-t) time intervals (which approximate S-P times) may be scaled off the records. Previous studies have shown that when the ground motion is of an impulsive nature, triggering usually occurs within one- to two-tenths of a second after the initial P-wave arrival. Thus, S-t times may be used to estimate the distance from an accelerograph to the source of a strong disturbance. Four instruments were located (in pairs) nearly equidistant from the Santa Barbara earthquake, two in Santa Barbara (Courthouse and Freitas Building) and two at the UCSB campus in Goleta (North Hall and Physical Plant). The S-t times on these records are approximately the same for the two UCSB stations, about 3 s, but vary by a factor of two for the Santa Barbara stations (table 3). Since the Santa Barbara sites are only a few hundred meters apart one may conclude that the Courthouse instrument, with a

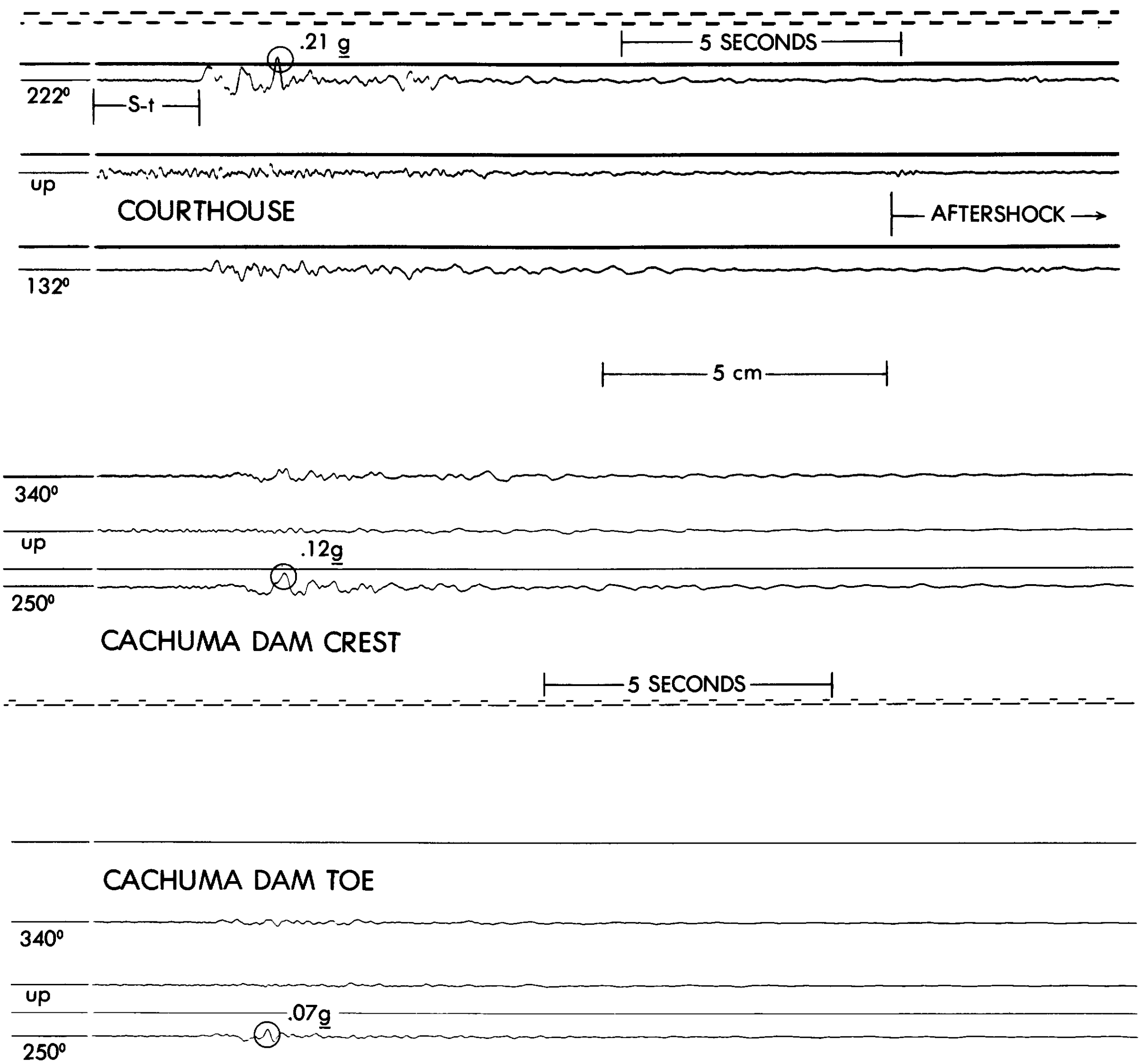

Figure 5.- Accelerograms from Santa Barbara courthouse and Cachuma Dam; Santa Barbara earthquake of August 13, 1978. Component direction refers to case acceleration for upward trace deflection.

S-t of 1.9 s, triggered normally, whereas the instrument at the Freitas Building, with a S-t of 0.9 s, triggered on later P-wave arrivals. Also, an aftershock was recorded at the UCSB Physical Plant and at the Santa Barbara Courthouse. Because the aftershock occurred during the instrument's operating cycle, the entire earthquake was recorded enabling the determination of true S-P intervals, 3.1 s at UCSB and 2.3 s at Santa Barbara. The S-P and S-t intervals at UCSB are nearly equal, whereas the S-P interval at Santa Barbara is about 0.4 s longer than the earlier S-t interval. This difference may be explained by a longer triggering delay (which seems unlikely considering the impulsive nature of the P-wave arrivals) or by a change in the source location of the aftershock relative to the main event.

The velocity model used by the California Institute of Technology Seismological Laboratory for locating earthquakes has P velocities of 5.5 km/s to a depth of 5.5 km and 6.3 km/s between 5.5 and 16.0 km depths (Kanamori and Hadley, 1975). Assuming a constant P to S wave ratio of 1.8, the respective S wave velocities would be 3.1 and 3.5 km/s. Using these values and a focal depth of about 12.5 km (W.H.K. Lee, C. E. Johnson, T. L. Henyey, and R.F. Yerkes, unpub. data, 1978) the aftershock records at Santa Barbara and UCSB indicate an epicenter located somewhat farther (5-6 km) from the strong-motion stations than has been determined

Table 3.- *S-trigger and S-P intervals from accelerographs near the sources of the Santa Barbara earthquakes*

Station No.	Station name	Main event epicentral distance (km)	Main event S-t (s)	Aftershock S-P (s)	Calculated aftershock epicentral distance (km)
283	Santa Barbara Courthouse - - -	5.6	1.9	2.3	11
5137	Freitas Building- (C302)	5.8	0.9	-	-
5093	North Hall - - - (C213)	13.1	3.0	-	-
885	Physical Plant - (C091)	13.2	3.0	3.1	19

from other recorded seismic data; these recalculated distance are 11 km for Santa Barbara and 19 km for UCSB. If the preceding assumptions are not too outrageous, we may suggest that the main shock rupture began at a location somewhat farther south or southeast of the location that teleseismic data indicate.

References:

Kanamori, H. and Hadley, D., 1975, Crustal structure and temporal velocity change in southern California: Pure and Applied Geophysics, v. 113, p. 257-280.

ABSTRACTS OF RECENT REPORTS*

SEISMIC ENGINEERING DATA REPORT--ROMANIAN AND GREEK RECORDS, 1972-77

by A. G. Brady, C. Rojahn, V. Perez, P. G. Carydis, and J. G. Sbokos

This report contains the results of digitizing and analyses of the Bucharest, Romania record of March 4, 1977, and of several strong-motion earthquake records recovered in Greece during the period from 1972 to 1975. The Bucharest record was provided by G. Serbanescu of the Building Research Institute (INCERC) in Bucharest, and the preliminary digitizing and analysis included here have been carried out by the U.S. Geological Survey. The section of the report on Greek records has been prepared by P. G. Carydis and J. G. Sbokos, of the National Technical University, Athens, Greece, who acknowledge the assistance in various ways of many of their co-workers.

The Geological Survey is publishing this report to bring these data to the attention of investigators throughout the world, but particularly to those in the United States. The analysis of the Bucharest record follows our standard techniques, which have been developed over recent years. It does represent, however, the first time that we have analyzed a record from a Japanese SMAC-B instrument, with 10-Hz natural frequency and critical damping. The digitizing and analyses of the Greek records represent an excellent addition to the data available for seismic engineering investigations. The processing is not identical to that used by the Earthquake Engineering Research Laboratory of the California Institute of Technology in their series of reports "Strong Motion Earthquake Accelerograms," nor to that used subsequently in the Seismic Engineering Data Reports of the U.S. Geological Survey, and we must stress that fact to prospective users. For example, a parabolic baseline has been fitted to the uncorrected acceleration data. Those investigators preferring a different form of long-period correction can refer to the uncorrected data as a starting point; those data are listed with the corrected data.

Reference: U.S. Geological Survey Open-file Report 78-1022, 1978, 221 p.

CONTRIBUTION TO THE STUDY OF THE FRUILI EARTHQUAKE OF MAY 1976

This book represents a joint effort by the Italian Commission for Nuclear Energy and the Italian State Power Board (CNEN-ENEL) and presents the results of various studies carried out during and immediately after the Fruili earthquakes of May-June 1976. The book is divided into chapters that roughly correspond to each line of research by the special working groups established by the CNEN-ENEL joint commission. The chapters contain information

*Inclusion of strong-motion information sources is intended as a service to our readers and does not constitute endorsement of these reports by the U.S. Geological Survey.

about research on the relation between surface geology and seismogenetic tectonic structures, macroseismic aspects and seismological and statistical considerations, processing and interpretation of strong-motion records, soil behavior, and earthquake damage and structural analyses.

Request copies from:

Commissione CNEN-ENEL
Per Lo Studio Dei Problemi Sismici
c/o ENEL-Servizio Geotecnico
Viale Regina Margherita, 137
00198 Roma, Italia

STRONG-MOTION EARTHQUAKE ACCELEROGRAMS, DIGITIZED AND PLOTTED DATA--UNCORRECTED ACCELEROGRAMS FROM THE FRUILI, ITALY EARTHQUAKE OF MAY 6, 1976 AND AFTERSHOCKS

Volume k, Part 3: Accelerograms 120 through 177 Commissione CNEN-ENEL per lo studio dei problemi sismici connessi con la realizzazione di imparti nucleari

The first two sets of uncorrected digitized accelerograms of the Fruili earthquake were published in July 1976 as Volume 1, Part 1 and in January 1977 as Volume 1, Part 2 of this series. The former volume also contained a description of the aims of the CNEN-ENEL Joint Study Commission and background information on the data processing techniques. This volume contains the uncorrected data relating to the third set of all the digitizable accelerograms recorded by the CNEN-ENEL stationary and mobile accelerograph stations up to September 15, 1976.

Copies available on request from:

Commissione CNEN-ENEL
c/o ENEL-Servizio Geotecnico
Viale Regina Margherita, 137
00198 Roma, Italia

GEOPHYSICAL AND STRONG-MOTION DATA FROM SELECTED CALIFORNIA ACCELEROGRAPH STATIONS

Prepared jointly by Shannon & Wilson, Inc.
and Agbabian associates
for
U.S. Nuclear Regulatory Commission,
Office of Nuclear Regulatory Research,
Division of Reactor Safety Research

Seismic and geotechnical data have been compiled for 37 accelerograph stations in California in an attempt to verify subsurface conditions and thus provide additional information for new studies of both existing and future strong-motion records. Selected sites include Santa Barbara Courthouse, Ferndale, Cholame, El Centro, Taft, Hollister, Pasadena, and 30 southern California stations in the central Los Angeles and northern mountains regions. These reports include information about the accelerograph station, seismicity of the site, soil boring logs made in the general vicinity of the site, and selected time history plots and response spectra curves. Information about these reports is available from National Technical Information Service, Springfield, VA 22161.

STRONG-MOTION INFORMATION, DATA REPORTS, AND AVAILABILITY OF DIGITIZED DATA

U.S. STRONG-MOTION NETWORK DATA

A Strong Motion Information Retrieval System (SMIRS) has been developed to provide up-to-date information about strong motion records and the circumstances in which they were recorded to anyone having a computer data terminal. The system is operating, but the information within it is incomplete and needs to be verified. A user's manual is available (Converse, 1978), and the system was described in the January - April Program Report (USGS, Circular 785-A).

The strong-motion records from the February 9, 1971 San Fernando, California earthquake and most of the significant records prior to that event have been digitized by the California Institute of Technology (Hudson, 1976). 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. All of these data reports are available through the National Technical Information Service (NTIS).

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). Processing and analysis of this data is presented in a series of USGS open-file Reports. When published, these reports are available from the USGS, Open-File Services Section.

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
- USGS data (complete): EDS and NISEE

For reports or data regarding strong-motion records and data, address inquiries to the appropriate agency listed below:

1. EDS/NOAA
   National Geophysical and Solar-Terrestrial Data Center
   Boulder, CO 80302

2. NISEE/Computer Applications
   Davis Hall, UC Berkeley
   Berkeley, CA 94720

3. Open-file Services Section
   Branch of Distribution
   U.S. Geological Survey
   Box 25425
   Federal Center
   Denver, CO 80225

4. California Division of Mines and Geology
   Office of Strong-motion Studies
   2811 "O" Street
   Sacramento, CA 95816

5. National Technical Information Service
   U.S. Dept. of Commerce
   Springfield, VA 22151

References:

Converse, A., (1978) Strong motion information retrieval system user's manual, USGS Open-file report 79-289, 51 p.

Hudson, D. E. (1976), Strong motion earthquake accelerograms - index volume, Caltech, EERI report 76-02, 72 p.

FOREIGN STRONG-MOTION DATA

Because of the long history of close cooperation between the U.S. and the central and south American strong-motion programs, much of the data from those programs are available from the same sources as the U.S. data (see above). Information about strong-motion data from the western hemisphere will be included in the Strong-Motion Information Retrieval System operated by the USGS. The USGS does not attempt to obtain first class copies of records from those foreign organizations which prepare data reports comparable to those prepared by the USGS. Abstracts of the data reports from such organizations are presented in this Seismic Engineering Program Report series, and through informal arrangements, copies of the data and records are made available. The Environmental Data Service of NOAA has attempted to obtain copies of digitized strong-motion data from all organizations world-wide.

Table 1.- *Summary of accelerograms recovered during May - August, 1978*

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
25 March 1977 1544 UTC Imperial Valley 32.97N, 115.50W Magnitude 3.4	Brawley Airport Ground level (USGS)	32.99 N 115.51 W	1.8	315° Up 225°	0.06 .02 .07	- - -
21 October 1977 0612 UTC Imperial Valley 32.90N, 115.50W Magnitude 4.3	Brawley Airport Ground level (USGS)	32.99 N 115.51 W	-		**	
24 February 1978- 16 March 1978 Jenkinsville, S.C. Epicenters and magnitudes unknown	Jenkinsville, S.C. Monticello Dam (USGS)	34.30 N 81.33 W				
	Abutment (Office)		-	090° Up 360°	.05 .03 .03	- - -
			-		**	
			-		**	
	Shared abutment (Center crest)		-	180° Up 090°	.15 .10 .07	1-peak 1-peak -
			-	180° Up 090°	.06 .06 .07	- - -
			-		**	
			-		**	
16 March 1978- 3 May 1978 Jenkinsville, S.C. Epicenters and magnitudes unknown	Jenkinsville, S.C. Monticello Dam (USGS)	34.30 N 81.33 W				
	Shared abutment (Center crest)		-	180° Up 090°	.06 .04 .09	- - -
			-		**	
			-		**	

Note: One additional (questionable) event was recorded; maximum acceleration less than 0.05 g.

See footnotes at end of table.

Table I.- *Summary of accelerograms recovered during May - August, 1978* -Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
20 March 1978- 31 May 1978 Imperial Valley Epicenter and magnitude unknown	El Centro Array 2 Keystone Rd (USGS)	32.92 N 115.37 W	-		**	
	El Centro Array 9 Commercial Ave (USGS)	32.79 N 115.55 W	-		**	
2 May 1978 0617 UTC (a) Imperial Valley 32.85N, 115.42W Magnitude 3.2	El Centro Array 4 Anderson Rd (USGS)	32.86 N 115.43 W	-	230° Up 140°	0.05 .02 .05	- - -
	El Centro Array 6 Huston Rd[†] (CDMG)	32.84 N 115.49 W	2.7		**	
2 May 1978 0617 UTC (b) Imperial Valley Epicenter and magnitude unknown	El Centro Array 4 Anderson Rd (USGS)	32.86 N 115.43 W	2.0*	230° Up 140°	.03 .07 .05	- - -
	El Centro Array 6 Huston Rd[†] (CDMG)	32.84 N 115.49 W	2.8*		**	
5 May 1978 0533 UTC Cent. Alaska 63.14N, 150.85W Magnitude 5.0	Talkeetna, Alaska FAA-VOR (USGS)	62.30 N 150.10 W	-		**	
11 May 1978 1157 UTC San Jose, Ca. 37.38N, 121.76W Magnitude 3.8	Halls Valley Grant Ranch (CDMG)	37.34 N 121.71 W	1.1		**	
11 May 1978 1218 UTC San Jose, Ca. 37.37N, 121.77W Magnitude 3.7	Halls Valley Grant Ranch (CDMG)	37.34 N 121.71 W	-		**	
12 May 1978 1216 UTC Cent. Alaska 62.1N, 149.2W Magnitude 5.0	Talkeetna, Alaska FAA-VOR (USGS)	62.30 N 150.10 W	-		**	

See footnotes at end of table.

Table I.- *Summary of accelerograms recovered during May - August, 1978* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
4 June 1978 0357 UTC S. California 33.92N, 117.83W Magnitude 3.6	Carbon Canyon Dam (ACOE)	33.91 N 117.84 W				
	Crest		1.8		**	
	R. Abutment		1.8		**	
	Diemer Filter Plant (MWD)	33.91 N 117.82 W				
	Admin. Bldg.		1.8		**	
	Reservoir		1.8		**	
	Orange Co. Reservoir (MWD)	33.94 N 117.88 W	2.0		**	
13 August 1978 2254 UTC Santa Barbara, Ca. 34.37N, 119.72W Magnitude 5.5	Cachuma Dam (USBR)	34.59 N 119.98 W				
	Crest		2.1	340° Up 250°	0.08 .02 .12	- - 1-peak
	Toe		2.1	340° Up 250°	.03 .02 .07	- - -
	Santa Barbara Courthouse basement (USGS)	34.424N 119.712W	1.9	222° Up 132°	.21 .07 .10	1.3 - 1-peak
	U.C. Santa Barbara Physical Plant (CDMG)	34.422N 119.851W	3.0	180° Up 090°	.37 .14 .31	1.5 1-peak 1.5
	U.C. Santa Barbara North Hall (CDMG)	34.416N 119.846W	3.0			
	Ground floor (center) channel (1)			360°	.44	2.0
	Ground floor (center) channel (2)			Up	.11	1-peak
	Ground floor (center) channel (3)			090°	.27	2.5
	Ground floor (end) channel (4)			360°	.38	2.0
	Third floor (center) channel (5)			360°	.64	5
	Third floor (center) channel (6)			090°	.56	6

See footnotes at end of table.

Table 1.- *Summary of accelerograms recovered during May - August, 1978* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
	Roof level (center) channel (7)			180°	0.99	9
	Third floor (west end) channel (8)			360°	.59	5
	Third floor (east end) channel (9)			360°	.66	5
	Santa Barbara Freitas bldg. (CDMG)	34.424N 119.698W	0.9			
	Roof level (center) channel (1)			360°	.30	5
	Second floor (center) channel (2)			090°	.30	1
	Basement (center) channel (3)			090°	.22	1
	Roof level (center) channel (4)			090°	.67	7
	Roof level (west end) channel (5)			360°	.21	5
	Second floor (center) channel (6)			360°	.17	1
	Second floor (west end) channel (7)			360°	.16	0.5
	Basement (center) channel (8)			360°	.13	1-peak
	Basement (center) channel (9)			Up	.10	1-peak
	Note: Acceleration and duration data for UCSB (Physical Plant and North Hall) and Goleta (Freitas Bldg.) are approximations.					
	Ventura, Calif. Holiday Inn (CDMG)	34.276N 119.294W	-	**		
	Note: Building is 12 stories above ground level and is instrumented with a 12-channel CRA-1 remote recording system. Accelerometers are located at ground, 4th floor, 8th floor, and roof levels. A vertical starter is located at ground level; a horizontal starter is located at the roof level.					

See footnotes at end of table.

Table 1.- *Summary of accelerograms recovered during May - August, 1978* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
	Goleta, Calif Glen Annie Rd (SCE)	34.47 N 119.89 W	2.4	090° Up 360°	0.24 .08 .28	1.0 - 1.8
	Note: A small aftershock was recorded at U.C. Santa Barbara Physical Plant and Santa Barbara Courthouse. Maximum acceleration less than 0.05 g. Two seismoscope records were recovered at UCSB and Santa Barbara Courthouse; maximum relative displacements are 4.06 and 3.42 cm, respectively.					
27 August 1978 1023 UTC Jenkinsville, S.C. 34.31N, 81.33W Magnitude 2.7	Jenkinsville, S.C. Monticello Dam (USGS)†	34.30 N 81.33 W				
	Shared abutment (Center crest)		-	180° Up 090°	.25 .08 .20	0.06 - .16
			-		**	
			-	180° Up 090°	.08 .04 .06	- - -
31 August 1978- 6 November 1978 Jenkinsville, S.C. Epicenters and magnitudes unknown	Jenkinsville, S.C. Monticello Dam (USGS)	34.30 N 81.33 W				
	Shared abutment (Center crest)		-	180° Up 090°	.06 .03 .06	- - -
			-	180° Up 090°	.07 .03 .10	- - 1-peak
			-	180° Up 090°	.04 .03 .06	- - -
			-		**	
			-	180° Up 090°	.05 .05 .12	- - 1-peak
			-	180° Up 090°	.08 .06 .09	- - -

See footnotes at end of table.

Table I.- *Summary of accelerograms recovered during May - August, 1978* - Continued

Event	Station name (owner)[1]	Station coord.	S-t[2] (s)	Accl direction[3]	Max accl[4] (g)	Duration[5] (s)
			-	180°	0.22	0.1
				Up	.11	1-peak
				090°	.16	0.1
			-	180°	.13	0.3
				Up	.17	0.2
				090°	.24	0.3

[1] ACOE - U.S. Army Corps of Engineers
CDMG - California Division of Mines and Geology
MWD - Metropolitan Water District
SCE - Southern California Edison
USBR - U.S. Bureau of Reclamation
USGS - U.S. Geological Survey
† - WWVB time code is incomplete or nonexistent; correlation of accelerogram with event 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] Azimuthal direction of case acceleration for upward trace deflection on accelerogram (opposite direction to pendulum motion). Case acceleration for vertical component indicated as up or down.

[4] 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.

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