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GEOLOGICAL SURVEY CIRCULAR 762-B

Seismic Engineering Program Report, May—August 1977

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

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1977

United States Department of the Interior

CECIL D. ANDRUS, *Secretary*

Geological Survey

V. E. McKelvey, *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 brief summary of the accelerograph records obtained from the U.S. Strong-Motion Network during the period May 1 through August 31, 1977. Reports on the Livermore earthquake of June 22 and the current U.S.-Soviet strong-motion network are also 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 strong-motion data summary presented in table 1 includes those records recovered (although not necessarily recorded) during the period May through August, 1977. This procedure will be continued in future issues in order that the dissemination of strong-motion data may be as expeditious and timely as practicable.

> Note: The Seismic Engineering Program Report will no longer be published quarterly. Future issues will contain information on strong-motion records recovered from the national network during the periods January through April, May through August, and September through December.

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CONTENTS

TABLES

ILLUSTRATIONS

Seismic Engineering Program Report May—August 1977

RECENT STRONG-MOTION RECORDS

by R. L. Porcella

Twenty-five accelerograph records were recovered from the national strong-motion network during the period May 1 through August 31, 1977. The current seismic engineering program of strong-motion instrumentation is supported by the National Science Foundation in cooperation with both private industry and educational institutions as well as various Federal, State and local agencies and organizations. The primary objective of this program is to record both strong ground motion and the response of representative types of structures during potentially damaging earthquakes and to disseminate these data and information to external users in earthquake engineering research and design practice. The 25 accelerograph records obtained during this last period were recovered from instrumentation owned by nine different organizations that are involved in this national strong-motion program (table 1).

The magnitude 4.6 Livermore, California earthquake of June 23 produced five strong-motion records; two were recovered at the Livermore Veterans Administration hospital and two at Del Valle Dam. An additional accelerogram was recorded by an AR-240 model accelerograph installed on the second floor of the Test Reactor Building at the General Electric Vallecitos Nuclear Center 18 km from the epicenter (see the following preliminary report).

The southern California earthquake (magnitude 4.4) of August 11 produced 14 accelerograph records at nine strong-motion stations in the San Fernando Valley area. Accelerograph sites that operated during this event and the maximum recorded acceleration include Newhall fire station (0.07 g), Jensen filter plant (0.08 g), Santa Susana (0.06 g), the 8244 Orion St. Holiday Inn (less than 0.05 g) and the 15233 Ventura Blvd. Union Bank (less than 0.05 g). The 13-story reinforced concrete Union Bank building has been instrumented by the California Division of Mines and Geology (CDMG) in accordance with recently developed high-rise building instrumentation criteria and includes a 12-channel CRA-1 remote recording system and an SMA-1 triaxial accelerograph. This building sustained structural damage during the 1971 San Fernando earthquake (John A. Blume & Associates, 1973), but was not instrumented at that time. The CDMG Building Instrumentation Program's current projected revenues provide for the instrumentation of as many as 400 buildings in California (Rojahn, 1976), including several that sustained damage in the 1971 event.

In addition, minor records were obtained from two unidentified events in Alaska and from three small earthquakes in the Hollister-Gilroy area of central California (table 1).

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Rojahn, Christopher, 1976, California building strong-motion earthquake instrumentation program, *in* Dynamic response of structures: instrumentation testing methods and system identification: Am. Soc. Civil Engineers, Eng. Mechanics Div. specialty conference, March 30-31, 1976, Proc., part 1, p. 46.

PRELIMINARY REPORT ON
THE LIVERMORE, CALIFORNIA
EARTHQUAKE OF JUNE 22, 1977

By R. P. Maley

A magnitude 4.6 earthquake occurred 10 km east of Livermore, Calif. on June 22, 1977 at 1943 PDT (June 23, 0243 GMT). The earthquake had a focal depth of 10 km and was located at lat 37.65° N. and long 121.64° W. (Berkeley Seismograph Station) near the northwest-trending Tesla fault (fig. 1). It has been suggested that no movement has occurred on this fault during the past two million years (Jennings and others, 1973). Numerous earthquakes have occurred in this same area; the largest of these was a magnitude 4.6 event located at lat 37.68° N. and long 121.60° W. on May 1, 1946 (Bolt and Miller, 1975). Brown and Lee (1971) cited a series of small earthquakes centered near the 1977 epicenter during the two-year interval 1969 through 1970.

According to various press reports, the earthquake was felt throughout the San Francisco Bay area and caused minor damage including cracked plaster, broken window panes, and fallen objects.

Five strong-motion accelerograph records were recovered from instruments at three sites located 10 to 18 km west of the epicenter; the Livermore Veterans Administration (VA) Hospital, the California Department of Water Resources Del Valle Dam, and the General Electric Vallecitos Nuclear Center (fig. 1).

The VA Hospital building, completed in 1949, is a sixstory reinforced concrete structure, 14.7 m wide, 84 m long and 25 m high (basement to roof). The building was constructed on unconsolidated sediments, chiefly alluvium and gravel, estimated by Fischer and Leeds (1972) to be 210 m deep. The sediments are underlain by Pliocene sandstone and conglomerate. Strong-motion data were recorded on instruments located in the basement and on the roof (fig. 2); peak accelerations were 0.06 _g_ and 0.15 _g_, respectively. Note the dominant period of approximately 0.28 sec on the S38W component (parallel to the narrow dimension of the structure). The influence of a higher mode is indicated by the shorter period data that are superimposed on the wave train during the early part of the record. The S-wave minus trigger (S-t) interval shown on the basement record is 2.2 sec.

Del Valle Dam, a facility in the California State Water Project, impounds water supplied by the South Bay branch of the California Aqueduct. The water is redistributed to various utilities located in Contra Costa and Santa Clara Counties. The dam, completed in 1968, is an earthfill structure with a storage capacity of 95,100,000 m^3, and a crest length of 268 m, height of 72 m, and width of 25 m. The dam foundation rests on Pliocene sedimentary rock, primarily sandstone. Two records were obtained from accelerographs located in concrete bunkers, one embedded at the center toe and the other situated downstream from the centerline of the crest (fig. 3). Peak accelerations on both records are 0.07 _g_. The S-t interval shown on the toe record is 1.8 sec and is consistent with the 2.2-sec S-t interval on the records obtained at the nearby but slightly more distant Livermore VA Hospital.

One record was obtained from an instrument installed on the second floor of the test reactor building located at the General Electric Vallecitos Nuclear Center near Pleasanton, 18 km from the epicenter. The reactor building is a reinforced concrete structure located within a flat-bottomed, domed-top, cylindrical steel tank 22 m across and 34 m high. The structure rests on sand fill and natural sand and silt. The record was obtained 7 m above ground level and shows a maximum acceleration of 0.05 _g_ on the N54E component (fig. 4). Note the dominant frequency response shown by the structure, particularly in the northeast direction at approximately 0.2 sec.

Accelerographs at the Delta Pumping Plant, 18 km from the epicenter, were not triggered by the event.

References:

Bolt, Bruce A., and Miller, Roy D., 1975, Catalogue of earthquakes in northern California and adjoining areas, 1 January 1919 - 31 December 1972: Berkeley Seismograph Station, University of California, 567 p.

Brown, R. D., and Lee, W.H.K., 1971, Active faults and preliminary epicenters (1969-1970) in the southern part of the San Francisco Bay region: U.S. Geol. Survey Misc. Field Studies Map MF-307, scale 1:250,000.
Fischer, Joseph A., and Leeds, David J., 1972, Report, site evaluation studies earthquake hazard, Veterans Administration Hospital: Office of Construction, Report to Veterans Administration, 16 p.
Jennings, C. W., Strand, R. G., Rogers, T. H., Stinson, M.C., Burnett, J. L., Kahle, J. E., and Streitz, R., 1973, State of California, Preliminary fault and geologic map: California Div. of Mines and Geology, Prelim. Rept. 13.

THE ESTABLISHMENT OF A JOINT U.S.-U.S.S.R. STRONG-MOTION INSTRUMENT NETWORK IN TADZHIK, S.S.R.

by Christopher Rojahn and P. N. Mork
U.S. Geological Survey
and
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Dushanbe, Tadzhik, S.S.R.

During the fall of 1975 and 1976, a network of 20 joint U.S.-U.S.S.R. strong-motion instrument stations was established in the central Asian republic of Tadzhikistan, the most highly active seismic area in the continental Soviet Union. The network was established jointly by the U.S. Geological Survey (USGS) and the Tadzhik Institute of Seismic Resistant Construction and Seismology (TISRCS) as part of an engineering seismology project emanating from the 1972 U.S.-U.S.S.R. Joint Agreement for Cooperation in the Field of Environmental Protection. The National Science Foundation provided funding for the U.S. part of the network, which consists of 17 triaxial self-contained accelerographs and one 12-channel remote-recording accelerograph system; TISRCS provided the 8 Soviet-built strong-motion instruments that are included in the network.

Tadzhikistan, located in the southernmost part of the Soviet Union, is bordered on the south by Afghanistan and on the east by China (fig. 5). Seismicity throughout the Republic is believed to be related to the ongoing tectonic processes that contributed to the migration and eventual collision of the subcontinent of India with the continent of Asia in Cenozoic time (Gansser, 1966). On the basis of world seismicity data (Tarr, 1974), the focal depths of recent earthquakes in the sparsely populated southeastern part of the Republic have generally been in the 71 to 300 km range, whereas those in the more heavily populated northwestern part (Dushanbe-Garm and vicinity) have been less than 71 km. Figure 5 shows epicenters of earthquakes in the magnitude range 5.0 to 7.9 with maximum MSK-64 intensity of 7 or greater occurring between 1895 and 1973. (The MSK-64 scale is approximately equivalent to the Modified Mercalli Scale of 1931.) During the past 80 years, more than 20 earthquakes with maximum MSK-64 intensity of 8 or greater have occurred in or adjacent to Tadzhikistan, three of which were catastrophic earthquakes: the 1907 Karatog earthquake (magnitude 7.6), the 1911 Sarez earthquake (magnitude 7.4), and the 1949 Khait earthquake (magnitude 7.6), (Lunyov, Negmatullaev, and Rojahn, 1977). The Karatog and Khait earthquakes occurred in heavily populated regions and took thousands of lives. The historical record indicates that Tadzhikistan has experienced one strong earthquake every 4 years and one destructive earthquake every 10 to 15 years.

The joint network has been established in the central part of the west half of Tadzhikistan (figs. 5 and 6) primarily because of the high degree of seismicity and the presence of numerous engineered structures there. The stations are adjacent to a rather complex system of faults trending east-west in the vicinity of Dushanbe and southwest-northeast from Ragun to Garm to beyond Dzhirgital. The capital city of Dushanbe (population approximately 500,000) contains many modern multistory reinforced concrete frame, large panel, and other types of masonry buildings and is located on the floor of the high Gissar Valley (elevation 858 m). To the north of Dushanbe is the Gissar Mountain Range with peaks 4,640 m and higher, and to the east, beyond Garm, is the Peter the First Mountain Range with peaks as high as 7,497 m; to the southeast is Nurek Dam, a 300-meter-high earthfill dam which is due to be completed in 1979 and which is the most notable engineered structure in the area.

The strong-motion network consists of 18 ground stations and two instrumented structure stations (table 2). The ground stations are situated in various geologic settings in order to provide a balanced geographic distribution relative to the active faults in the area. Nine of the ground stations have been installed in two linear arrays that are oriented perpendicular to the Gissar-Kokshaal fault zone. The first array includes stations at Gushari, Zimchurood, Dushanbe (Detsad), Lyaur, and Obi-kiik; the second includes stations at Ramit, Faizabad, Langar and Igron. The purpose of each array is to obtain data on the attenuation of motion with distance from the causative fault. The instrumented structures are Nurek Dam and a typical seven-story, rectangular-in-plan, reinforced concrete frame building located in Dushanbe.

Instrumentation at the 18 ground stations consists of 15 U.S. SMA-1 triaxial self-contained accelerographs, two Soviet SSRZ triaxial self-contained accelerographs, three Soviet N-700 recorders with OSP seismometers (accelerometers) and S5S displacement meters, one N-700 recorder with OSP seismometers, and one ISO-2M recorder with OSP seismometers (Shishkevish, 1975). Fourteen of the stations contain one accelerograph each, two contain U.S. and Soviet accelerographs installed side by side, one contains a U.S. accelerograph in an instrument shelter and the Soviet accelerograph in a nearby building, and one contains a U.S. accelerograph on alluvium and a Soviet accelerograph on nearby bedrock. Some of the Soviet instrumentation has a dual-sensitivity capability that includes one triaxial package of transducers designed to record earthquakes in the I to IV intensity range and another package designed to record earthquakes in the V to IX intensity range.

The seven-story building in Dushanbe has been instrumented with a U.S. 12-channel CRA1 remote recording accelerograph system with accelerometers located at the foundation, fourth, sixth, and roof levels (fig. 7). The accelerometer locations are based on criteria recently developed by the USGS (Rojahn and Matthiesen, in press). Instrumentation at Nurek Dam is minimal and consists of a U.S. SMA-1 accelerograph and a Soviet N-700 system (N-700 recorder with OSP accelerometers and S5S displacement meters) on the left abutment and near the center of plan at the base of the dam; expansion of the instrumentation is planned when the dam is completed in 1979 if additional funding is available.

The network is being maintained quarterly by TISRCS technicians and will be monitored by the USGS every 12 to 18 months, funding permitting. All original records obtained from the U.S. instruments will be archived at the USGS office in Menlo Park, and all original records from the Soviet instrumentation will be archived at TISRCS in Dushanbe. High-quality copies of all records will be made available to both parties for analysis and publication. To date, only two records have been recovered from the network; both are low-level records from the April 8 and May 17, 1976 Gazli earthquakes (magnitude 7.0 and 7.2, respectively) that occurred approximately 500 km from Dushanbe.

References:

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Lunyov, A. A., Negmatullaev, S. H., and Rojahn, C., 1977, Strong-motion network of Tadzhikistan: Collection of Soviet-American work on earthquake prediction: Moscow-Dushanbe, Acad. Sci. USSR, v. 1, Bk. 2, p. 171-187.

Rojahn, C., and Matthiesen, R. B., (in press), Earthquake response and instrumentation of buildings: Am. Soc. Civil Engineers, Jour. Technical Councils, 28 p.
Shishkevish, C., 1975, Soviet strong-motion and vibration-and-blast seismographs: Santa Monica, Calif., Defense Advanced Research Projects Agency, Rept. #R-1652-ARPA, 84 p.
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SOME HIGH-FREQUENCY CONSIDERATIONS OF HAND DIGITIZING

by A. Gerald Brady

Excerpts from a paper presented at the 9th Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects, Tokyo, Japan, May 1977

This note describes some of the problems that have arisen in analyzing the high-frequency content in hand-digitized earthquake accelerograms and indicates a possible solution. Hand digitizing refers to moving a crosshair by hand, following a trace, and selecting individual points whose coordinates are recorded automatically when signaled by the operator. Subsequent computer programs, which assume that the traces are straight lines between selected points, demand that among the points chosen are all the local peaks and all changes of slope. In order that the same control on high-frequency noise be maintained throughout the duration of the digitized record, the average density of selected points in the weak-motion parts must be equivalent to the level maintained in the strong-motion parts (Berrill and Hanks, 1974).

The following line of reasoning can be applied to the further analysis of hand-digitized raw data. Suppose that the average digitizing rate of a particular trace corresponded to 50 points per second of record time (chosen because 25 Hz content could be seen and the trace was considered capable of digitization). The capability for digitization was the main reason for the selection of the 25-Hz upper frequency limit for the Caltech digitization project. The parts of the record that contained 20- to 25-Hz signals are digitized just at the peaks, (that is, two points per cycle) whereas signals at the 10-Hz frequency level are identified with approximately 5 points per cycle. Lower frequency content, which appears smoother in the record, are well defined with many points per cycle. For analyses that require the highest degree of accuracy (that is, maintenance of the accuracy already present) equal-step interpolation must be performed at a time interval equal to the least count of the digitizing machine; otherwise, peaks will be missed during interpolation. A compromise must be reached, however, if the large volume of data of this density is to be processed on a timely basis. The density of the final data must provide approximately 6 points per cycle (150 points per second) in order to portray the initial 25-Hz content accurately. The 25-Hz content could be satisfactorily represented with 50 points per second only if, each time the 25-Hz waves appeared, they were each in phase with each other and their peaks occurred at multiples of 0.02 sec; this coincidence never occurs. If 25 Hz is the highest frequency that can be seen and digitized, the digitization (at an average density of 50 points per second) will contain unacceptable noise at frequencies above 25 Hz; thus, low-pass filtering at 25 Hz and maintenance of a final data density of 150 points per second are required.

The compromise between data density and the accuracy of peak values leads to some confusion when the maximum acceleration of a record (scaled off the original or off the raw digitized data) is compared with the maximum acceleration after correction (California Institute of Technology, 1976). If the correction procedures require interpolation using a time interval greater than the least count of the machine, then this scaled peak will probably be lost, and a lower peak value will result. As an example, for records containing a short-duration burst of 12- to 16-Hz components (the peak accelerations occur during this burst of energy), the corrected data with a time interval of 0.02 sec may contain peak values as low as one-third of the uncorrected peak values.

Another procedure that can be adopted to ensure that the peak acceleration of one particular trace retains its position as a data point in an interpolated array is to start the interpolation at the point in question, move backward through the trace to the beginning, and then forward to the end. For a record with three or more simultaneous traces, however, this procedure would not be satisfactory, as the simultaneity would be lost.

Various other methods of selecting points are available and in use on some digitizing systems. Although the cross-hair is moved by hand along the trace in question, the automatic relaying of points into some storage device can take the form of a set number of points transferred either each centimeter or each second of real time in the X-direction.

Totally automatic digitizing can be of two principle types. The first involves automatically scanning the entire recorded film and measuring the grayness at each matrix element location and using subsequent computer analysis to recover the traces. The second involves automatically following a particular trace and recording X and Y coordinates according to some fixed procedure.

The procedure used in all of these methods can be compared with the preceding description of hand digitizing, and adjustments can be made to ensure that the quality of the high-frequency content remaining in the record is accurately known.

References:

J. B. Berrill and T. C. Hanks, 1974, High-frequency amplitude errors in digitized strong motion accelerograms, *in* Analyses of strong-motion earthquake accelerograms: Pasadena, Calif., California Inst. Technology Rept. No. EERL 74-104, v. IV, Parts Q, R, and S, p. 10-16.

California Institute of Technology, 1976, Strong-motion earthquake accelerograms Pasadena, Calif., California Inst. Technology Rept. No. EERL 76-02, index vol., p. 41-64.

RECENT ACCELEROGRAPH INSTALLATIONS

by R. L. Porcella

Five strong-motion instruments have been installed in the Hawaiian Islands during the past 12 months, and seven additional accelerographs and seven seismoscopes will be installed in 1978 as part of a redistribution effort aimed at establishing a more comprehensive national network without substantially increasing the number of instruments in the current USGS strong-motion program. This effort has been made possible largely because of the extensive amount of instrumentation recently installed by the State of California, which has consequently made available numerous USGS instruments for installation elsewhere in the United States. Current plans for the Hawaii strong-motion network include 12 accelerographs and 6 seismoscopes for the island of Hawaii, and 2 accelerographs and 1 seismoscope each for the islands of Maui, Molokai, and Oahu. Figure 8 shows the planned strong-motion instrumentation and the seismic zones for the Hawaiian Islands (Uniform Building Code, 1976).

The USGS, working with the Federal Highways Administration, has instrumented three highway bridges with strategically placed accelerometers designed to record strong-motion data useful in the evaluation of the structural response of these bridges. The objective of this program is to record and disseminate engineering data such as modal response, damping characteristics, and generalized motions and displacements of bridge structures, and to develop a standardized procedure by which these data can be analyzed to produce the maximum amount of information.

In October 1976 three approach spans of the International Bridge at Massena, N. Y. were instrumented with 14 channels of strong-motion instrumentation: a Kinemetrics model CRA-1 remote-recording system with eight accelerometers and two Teledyne-Geotech model RFT-350 triaxial accelerographs. The Interstate 5 Ship Canal Bridge at Seattle, Wash. was instrumented in December 1976 with an eight-channel CRA-1 system and a Kinemetrics model SMA-1 triaxial accelerograph. In July 1977 the cable-stayed Sitka Harbor Bridge at Sitka, Alaska was instrumented with a 12-channel CRA-1 and a Teledyne-Geotech model RFT-250 triaxial accelerograph. In general, the remote accelerometer packages are located on the bridge so as to measure structure response; the triaxial accelerographs are located on one of the piers at ground level to measure base motion of the bridge or at some specified distance from the structure to measure the free-field ground motion.

Reference: International Conference of Building Officials, 1976, Uniform building code: Whittier, Calif., Internat. Conf. Bldg. Officials, 728 p.

ABSTRACTS OF RECENT REPORTS

STRONG-MOTION NETWORKS FOR LATIN AMERICA

by C. F. Knudson

A review was made of strong-motion instruments known to be installed in Latin America. Recent destructive earthquakes clearly indicate the inadequacy of the present strong-motion networks. A minimal plan for the installation of an additional 117 accelerographs and 126 seismoscopes in 14 Latin American countries is described in this report.

Reference: Central American Conference on Earthquake Engineering, San Salvador, El Salvador, January 9-14, 1978. (In press)

STRONG-MOTION INSTRUMENTATION IN THE CENTRAL AND EASTERN UNITED STATES

By R.L. Porcella and R.P. Maley

Since 1969, 140 three-component accelerographs have been deployed in the central and eastern regions of the United States, primarily for use in USGS programs with the Army Corps of Engineers to monitor strong shaking at dams and with the Veterans Administration to measure base motions of large hospital buildings. In addition, the USGS, working with the Federal Highways Administration, has instrumented a concrete and steel suspension bridge at Massena, N. Y. with strategically located transducers to record 14 channels of both structural and ground-motion data. Other organizations, including the Lamont-Doherty Geological Observatory (LDGO) and a number of power utilities with nuclear generating units, have established small strong-motion arrays in the central and eastern United States.

The LDGO obtained the first of several accelerograms in July 1973 from a series of earthquakes in northern New York. Subsequent minor events have been recorded by strong-motion instruments located at Charleston, S. C. and at Oak Ridge, Tenn. Thus far the maximum ground acceleration recorded in an eastern United States earthquake has been less than 0.04 _g_.

In the central United States, strong-motion instruments have recorded two earthquakes. A magnitude 4.3 (m_b) event on June 13, 1975 in southeastern Missouri triggered the accelerograph located south of New Madrid at an epicentral distance of approximately 10 km, producing a maximum acceleration of 0.076 _g_. A magnitude 5.0 (m_b) earthquake on March 24, 1976 in northeastern Arkansas triggered seven accelerographs installed on dams and at ground stations located 100 to 150 km from the epicenter. Although the maximum acceleration did not exceed 0.04 _g_, the peak acceleration recorded at Arkabutla Dam toe was approximately twice that recorded at the crest or abutment. Three additional accelerographs at epicentral distances of 70, 130 and 145 km were not triggered.

As a result of recent studies of the recurrence of strong ground motion, efforts are being directed toward instrumentation of the New Madrid seismic zone, one of the most active regions in the central and eastern United States.

Thirteen accelerographs are now being maintained by the USGS in this region. Beginning in the later part of 1977, the USGS will install about 24 additional accelerographs that will constitute a grid network with station spacings ranging from 15 to 30 km. The closer spacings will be utilized in a north-south array between Cape Girardeau, Mo. and Marked Tree, Ark. and in a northwest-southeast array between Poplar Bluff, Mo. and Obion, Tenn.

The primary objective of this network is to obtain data for use in the investigation of the spectral characteristics and attenuation of strong ground motion. The data may also be used in conducting other investigations including the studies of source mechanisms, magnitude and epicenter determination, local site effects, and evaluation of seismic hazards of the New Madrid seismic zone.

Reference: Presented at 49th Annual Meeting, Seismol. Soc. America, Eastern Section, Oct. 13-14, 1977.

STRONG-MOTION EARTHQUAKE ACCELEROGRAMS: DIGITIZATION AND ANALYSIS RECORDS FROM LIMA, PERU: 1951 TO 1974

This is the second in a series of reports planned to include the results of digitization and routine analyses of strong-motion earthquake accelerograms published by the U.S. Geological Survey. Serving as a model for this effort is the collection of data reports published by the Earthquake Engineering Research Laboratory of the California Institute of Technology during the years 1969 - 1975 and covering the significant records of the period from 1933 up to the San Fernando earthquake of February 9, 1971. The first of the present series of reports, Open-file Report No. 76-609, covered the significant records of 1971 subsequent to the San Fernando earthquake. The present report includes the results of some ongoing work on Peru records. The following ten records are included for the period 1951 to 1974:

1. Geological Institute, Plaza Habich, January 31, 1951
2. Instituto Geofisico del Peru, Avenida Araquipa, October 17, 1966
3. Instituto Geofisico del Peru, Avenida Araquipa, May 31, 1970
4. Instituto Geofisico del Peru, Avenida Araquipa, November 29, 1971
5. Instituto Geofisico del Peru, Avenida Araquipa, January 5, 1974
6. Zarate Station, January 5, 1974
7. Instituto Geofisico del Peru, Avenida Araquipa, October 3, 1974
8. Las Gardenias, Huaco Residence, October 3, 1974
9. Instituto Geofisico del Peru, Avenida Araquipa, November 9, 1974
10. La Molina Station, November 9, 1974

Copies of this report may be obtained from the Seismic Engineering Branch, Menlo Park.

Reference: U.S. Geol. Survey Open-file Rept. 77-587, 160 p.

NOTES ON STRONG-MOTION INFORMATION SOURCES

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

VOLUME I, Part 2: Accelerograms 065 through 119

Commissione CNEL-ENEL per lo studio dei problemi sismici connessi con la relizzazione de impianti nucleari.

This first set of twenty-five uncorrected digitized accelerograms of the Fruili earthquake was published in July 1976 as Volume I, Part I of this series. The volume also contained a description of the aims of the Italian State Power Board and the Italian Commission for Nuclear Energy (CNEN-ENEL) Joint Study Commission, and background information on the data processing techniques.

This volume contains the uncorrected data relating to the second set of all the digitizable accelerograms recorded by the CNEN-ENEL.

The information from the recorded accelerograms is being arranged in volumes in the same pattern adopted by the California Institute of Technology:

- Volume I - Print-outs and plots of the uncorrected digitized accelerograms
- Volume II - Print-outs and plots of base-line corrected accelerations, velocities, and displacements
- Volume III - Print-outs and plots of the response spectra

Volume I, Part 2, available on request from:

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

ANALYSIS OF STRONG-MOTION RECORDS OF THE VRANCEA-ROMANIA EARTHQUAKE OF MARCH 4, 1977, OBTAINED IN NIS, YUGOSLAVIA
Publication No. 55, Skopje, May 1977

Published by the Institute of Earthquake Engineering and Engineering and Engineering Seismology, University "Kiril and Metodij," Skopje Yugoslavia

This publication presents the results of an analysis of the strong-motion records from the Vrancea - Romania earthquake of March 4, 1977. Records were obtained at Nis, Yugoslavia from one SMA-1 accelerograph and from three WM-1 seismoscopes. Accelerograph data include uncorrected accelerations, response spectra, and Fourier amplitude spectra. Spectral displacement and pseudo-relative velocity values for 10 percent of critical damping and for natural periods are given for the three seismoscope records.

ANALYSIS OF STRONG-MOTION DATA FROM THE NEW MADRID SEISMIC ZONE: 1975 - 1976

by Robert B. Herrmann

Sponsored by the National Science Foundation Research Applied to National Needs (RANN)
Grant ENV 76-20875, August 1977
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St. Louis, MO 63103

This volume presents strong-motion data from three earthquakes in the New Madrid seismic zone. One accelerograph was triggered by the magnitude 4.2 (m_b) June 13, 1975 event, seven were triggered by a magnitude 5.0 (m_b) event on March 25, 1976, and one was triggered by a magnitude 4.5 (m_b) aftershock on March 25, 1976. The strong-motion data were processed using the computer programs developed at the California Institute of Technology. The raw digitized accelerograms, as well as the calculated ground acceleration, velocity and displacements, are presented in tabular and graphic form.

CORRELATION OF STRONG GROUND MOTION AND LOCAL SITE GEOLOGY IN LOS ANGELES DURING THE SAN FERNANDO EARTHQUAKE, FEBRUARY 1971

By S.T. Cerri and T.L. Teng

University of Southern California
Geophysical Laboratory,
Technical Report No. 76-4, 1976.

Using strong-motion data from the San Fernando earthquake and the subsurface geology from oil drilling data, a correlation analysis is made to study the effects of sediment thickness and basement topography on strong ground motion. The results of this analysis are presented as a special technical report.

SOURCE, PATH, AND SITE EFFECTS ON STRONG-MOTION RECORDS FROM THE KERN COUNTY, BORREGO MOUNTAIN, AND SAN FERNANDO EARTHQUAKES

A. F. Shakal,
Dept of Earth and Planetary Sciences,
Massachusetts Institute of Technology,
Cambridge, Mass. 02139

Acceleration seismograms were analyzed to investigate the relative contributions of source mechanism, propagation path and local site geology. Accelerations recorded at various azimuths around the source show variations attributable to the radiation pattern, but marked variations are also observed between nearby stations that are clearly not due to source effects. Site effects are investigated by comparison of the records from a set of sites for different earthquakes. Increased amplitudes and a reduction in high frequency content are observed at sites over a thick sedimentary layer as compared to sites on basement. A reduction in high-frequency content is also observed in records from a building basement site as compared to a nearby free-field site. Records are analyzed as a function of distance (10-150 km) from the source to determine the effect of attenuation on the frequency content and the effect of the medium on the generation of surface waves.

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.

GAZLI, USSR 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 Seismic Engineering Branch, USGS, upon request. Tapes containing the numerical data are available from the Environmental Data Service (see below).

Estimates of the publication dates of some future reports are as follows:

Records from 1972: December 1977
Records from 1973: March 1978
Records from 1974: June 1978
Records from 1975: September 1978

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, UC Berkeley
   Berkeley, CA 94720

3. Seismic Engineering Branch, USGS
   345 Middlefield Rd., Mail Stop 78
   Menlo Park, CA 94025

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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

Table 1.- *Summary of accelerograph records recovered during May - August 1977*

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
14 September 1976- 13 May 1977 Alaska Epicenter and magnitude unknown	Fairbanks, Alaska College Observatory (USGS)	64.86N 147.83W	-		**	
24 September 1976- 22 May 1977 Alaska Epicenter and magnitude unknown	Whittier, Alaska Begiuh Tower (USGS)	60.77N 148.68W	-		**	
26 November 1976 1852 GMT Cent. California Epicenter and magnitude unknown	Melendy Ranch NE Ground level (USGS)	36.59N 121.18W	-		**	
15 January 1977 1220 GMT Cent. California Epicenter and magnitude unknown	Melendy Ranch East Ground level (CDMG)	36.59N 121.19W	-		**	
16 March 1977 0755 GMT Cent.California Epicenter and magnitude unknown	Gilroy Array #3 Sewage plant (USGS)	36.99N 121.54W	-		**	
	Gilroy Array #4 San Ysidro School (USGS)	37.00N 121.53W	-		**	
23 June 1977 0243 GMT No. California 37.65N, 121.64W Magnitude 4.6	Livermore, Calif. VA Hospital (VA)	37.62N 121.76W				
	Basement		2.3	N52W Down S38W	0.05 .04 .06	- - -
	7th (roof) level		2.3	N52W Down S38W	.11 .09 .16	1-peak - 3.7

See footnotes at end of table

Table 1.- *Summary of accelerograph records recovered during May - August 1977* - Continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
	Livermore, Calif. Del Valle Dam (CDWR)	37.61N 121.74W				
	Crest station		1.8	N66E	0.07	-
				Down	.05	-
				N24W	.07	-
	Toe station		1.8	N66E	.03	-
				Down	.02	-
				N24W	.06	-
12 August 1977 0219 GMT So. California 34.38N, 118.47W Magnitude 4.4	Newhall, Calif. L.A. County fire sta. (CDMG)	34.39N 118.53W	1.9	N58E	.07	-
				Down	.03	-
				N32W	.04	-
	San Fernando, Calif. Nordhoff fire station (CDMG)	34.24N 118.44W	3.4		**	
	Sherman Oaks, Calif. 15233 Ventura Blvd (CDMG)	34.15N 118.46W	-		**	
	Note: An additional record (12 channels of data) was obtained at 15233 Ventura Blvd (CDMG) from a CR-1 remote-recording system interconnected with an SMA-1 triaxial accelerograph. Maximum acceleration less than 0.05 g.					
	Sepulveda, Calif. VA Hospital (VA)	34.25N 118.48W	3.4		**	
	Jensen Filter Plant 13100 Balboa Ave, L.A. (MWD)	34.31N 118.50W	2.4	S25W	.08	-
				Down	.03	-
				S65E	.06	-
	Sepulveda Dam Crest (ACOE)	34.17N 118.47W	-		**	
	Santa Susana Bldg 462, 6th floor (ERDA)	34.23N 118.71W	-	West	-	-
				Down	.02	-
				South	.06	-
	Santa Susana Bldg 026, ground level (ERDA)	34.23N 118.71W	-		**	

See footnotes at end of table

Table 1.- *Summary of accelerograph records recovered during May - August 1977* - Continued

Event	Station (owner)[1]	Station coord.	S-t time[2] (sec)	Comp	Max accl[3] (g)	Duration[4] (sec)
	Los Angeles 15910 Ventura Blvd (LACO)	34.16N 118.48W	3.6			
	Basement				**	
	9th floor				**	
	19th floor (roof)				**	
	Los Angeles 8244 Orion St (LACO)	34.22N 118.47W	-			
	Ground				-	
	4th floor				**	
	8th floor (roof)				**	
12 August 1977 0441 GMT So. California Epicenter and Magnitude unknown	Newhall, Calif. L.A. County fire sta. (CDMG)	34.39N 118.53W	1.9		**	

1 ACOE - U.S. Army Corps of Engineers
CDMG - California Division of Mines and Geology
CDWR - California Department of Water Resources
CIT - California Institute of Technology
ERDA - Energy Research Development Administration
LACO - Los Angeles City Ordinance
MWD - Metropolitan Water District of Southern California
USGS - U.S. Geological Survey
VA - Veterans Administration

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 2.- *Stations in Joint U.S.-U.S.S.R. Strong-Motion Network*

Station identification: Name	Coord.	Site geology	Structure type/size	Instrument location(s)	Data source
Boge-Zagon seismic station	38.45 N 69.74 E	Sandstone	-	Ground level	TISRCS
Komarov seismic station	39.12 N 70.21 E	Conglomerate; shale	Inst shltr[1]	Ground level	USGS
Chil-Dora seismic station	38.79 N 70.32 E	Sandstone	Tunnel	Ground level	USGS
Dushanbe, TRDI 14 Aini Street	38.56 N 68.79 E	Loess; conglomerate	7-story bldg	Basement, 4th, 6th & roof	USGS
Dushanbe, Detske-sod 127 Koval Street	38.54 N 68.76 E	Pebble gravel	Inst shltr[1]	Ground level	USGS
Dushanbe, seismic station 59 Shevchenko Street	38.57 N 68.78 E	Loess (17 m); conglomerate	Inst shltr[1]	Ground level	USGS TISRCS
Dzhirgital seismic station	39.22 N 71.19 E	Loess and pebble gravel	1-story bldg, wood frame	Basement	USGS TISRCS
Faizabad	38.55 N 69.33 E	Pebble gravel	Inst shltr[1]	Ground level	USGS
Gushari Sanatorium	38.88 N 68.83 E	Conglomerate, granite	Inst shltr[1]	Ground level	USGS
Igron seismic station	38.24 N 69.33 E	Sandstone	Inst shltr[2]	Ground level	USGS
Khait seismic station	39.18 N 70.90 E	Sedimentary rock	Tunnel	Ground level	USGS
Langar seismic station	38.40 N 69.36 E	Limestone	Tunnel	Ground level	USGS
Lyaur Polygon Test Site	38.35 N 68.65 E	Loess (>175 m)	Inst shltr[1]	Ground level	USGS TISRCS
Nurek Dam	38.38 N 69.35 E	Sandstone	Earth dam	Lower gallery, abutment	USGS TISRCS
Obi-kiik Forest Management Sta.	38.16 N 68.68 E	Loess	Inst shltr[1]	Ground level	TISRCS
Ragun seismic station	38.71 N 69.78 E	Loess; sandstone	Inst shltr[1]	Ground level	USGS
Ramit Forest Management Sta.	38.72 N 69.32 E	Pebble gravel	Inst shltr[1]	Ground level	USGS
Shakhrinau Champagne Factory	38.51 N 68.33 E	Loess	Inst shltr[1]	Ground level	USGS
Simigandzh seismic station	38.65 N 69.00 E	Conglomerate; granite	-	Ground level	TISRCS
Zimchurood Young Pioneer Camp	38.78 N 68.80 E	Conglomerate; granite	Inst shltr[1]	Ground level	USGS TISRCS

[1] Instrument located in small prefabricated building

[2] Instrument located in metal box

Table 3 - *Records being processed for data reports*

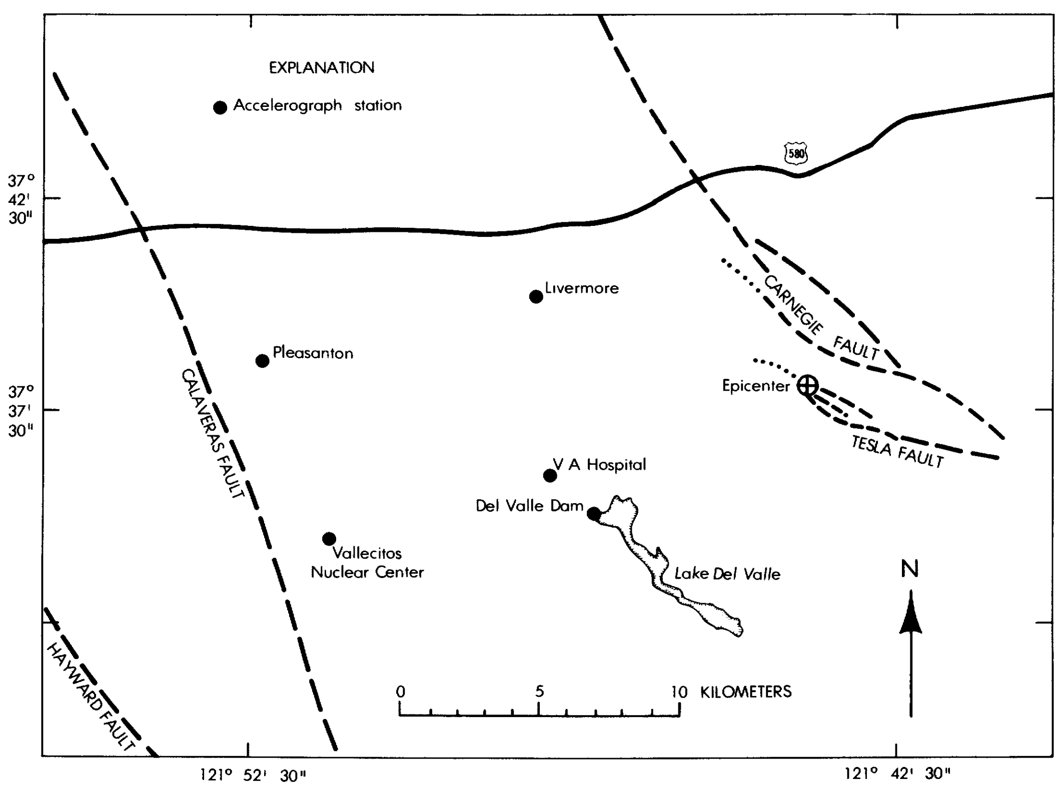
Date of event	Station location	Maximum accl (g)†
	1972	
January 3, 1972	Managua, Nicaragua; Esso Refinery	0.15
January 5, 1972	Managua, Nicaragua; Esso Refinery	.22
	Managua, Nicaragua; National University	.12
March 4, 1972	Bear Valley, Calif.; Melendy Ranch barn	.15
March 22, 1972	Bear Valley, Calif.; 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

See footnotes at end of table.

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

Date of event	Station location	Maximum accl (g)†
	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
June 19, 1975	El Centro Array, Calif.; Station 6, 551 Huston	.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.



˜igure 1.- Location of accelerographs during June 22, 1977 Livermore earthquake.

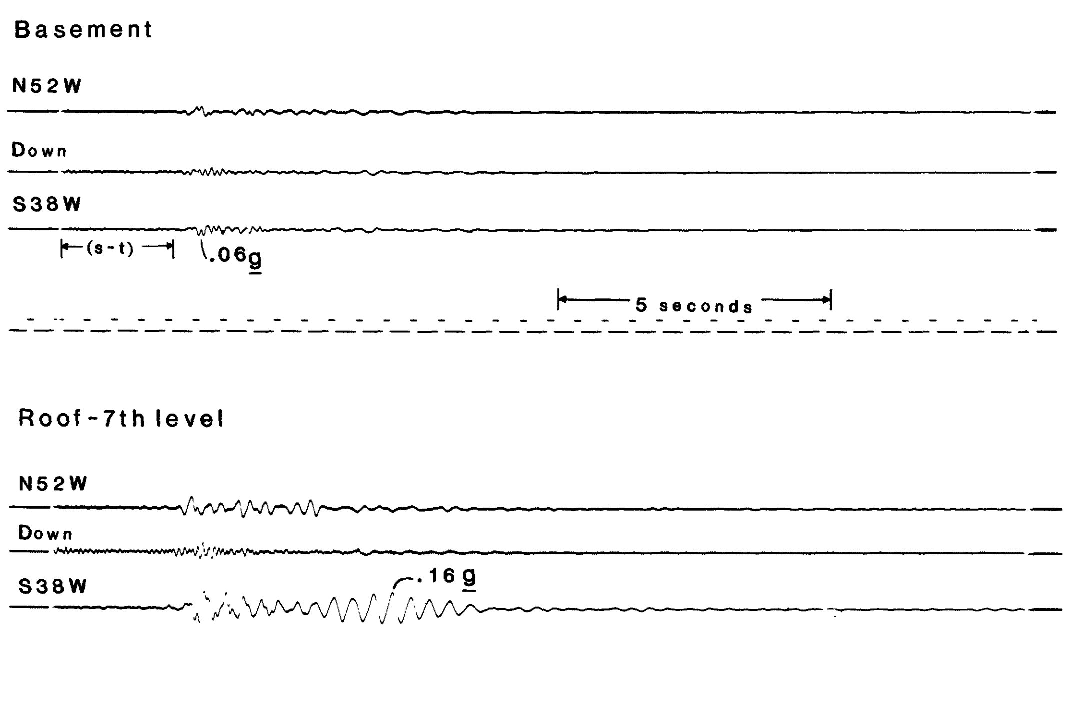


Figure 2.- Accelerograms from the Livermore Veterans Administration Hospital.

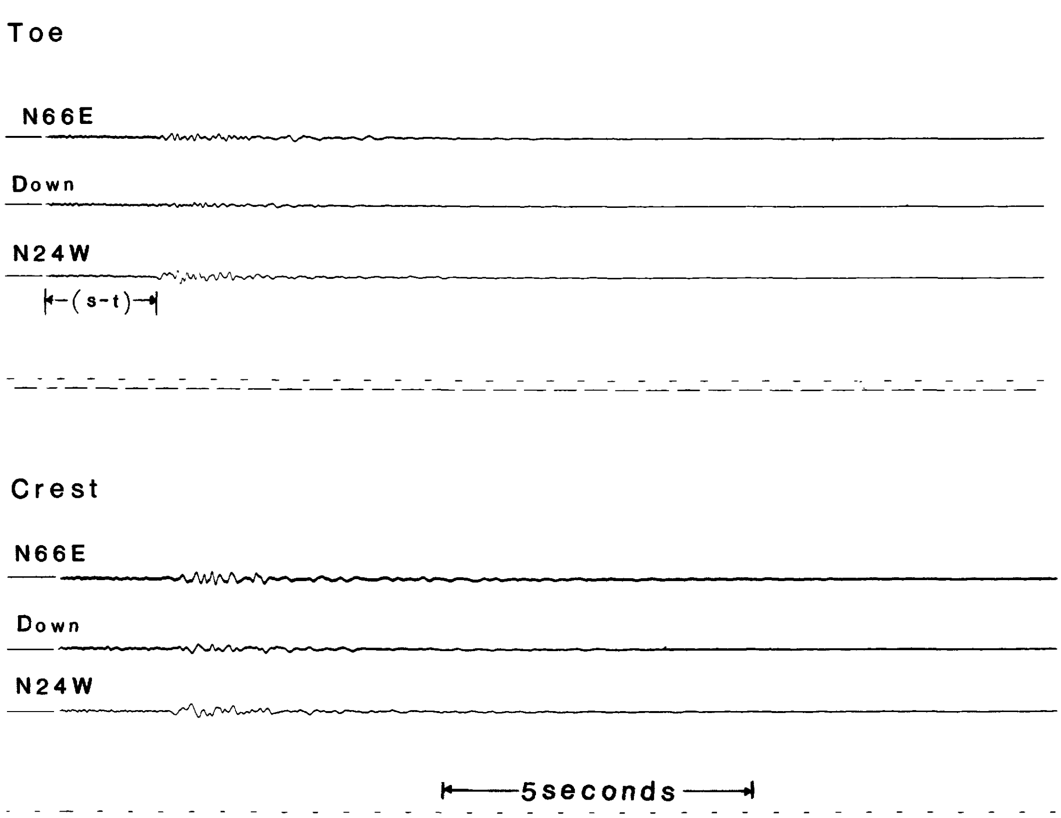


Figure 3.- Accelerograms from Del Valle Dam.

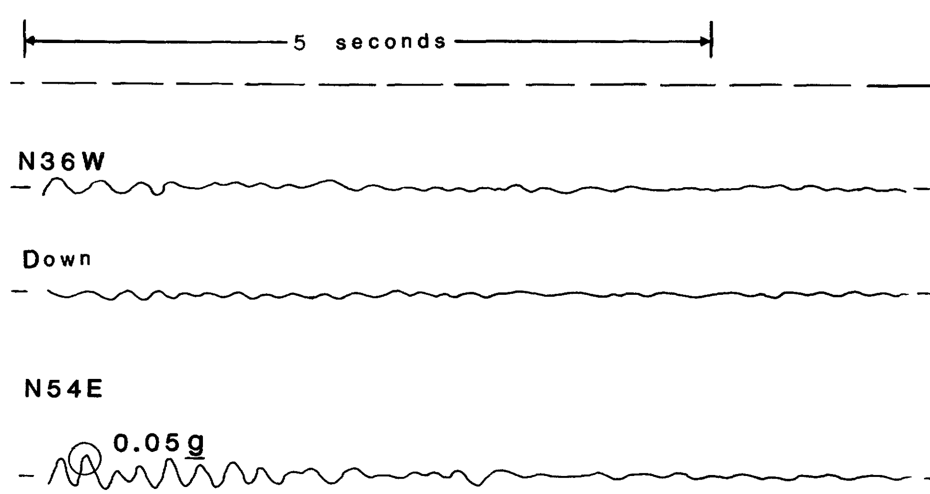
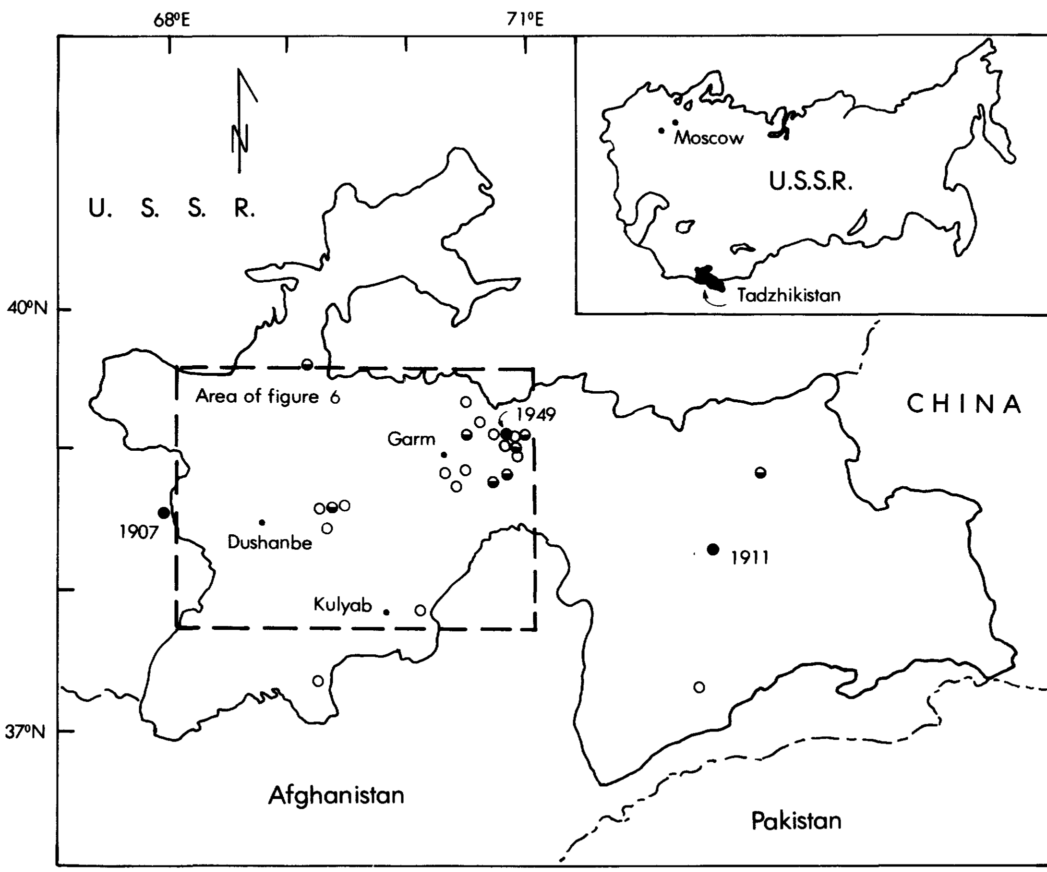


Figure 4.- Accelerograms from Valecitos Nuclear Center.



EXPLANATION

Epicenters of earthquakes with maximum MSK-64 intensity of 7 or greater.

• Magnitude 7.0-7.9 ⦿ Magnitude 6.0-6.9 o Magnitude 5.0-5.9

Figure 5.- Map of Tadzhikistan showing epicenters of earthquakes in the magnitude range 5.0 to 7.9 with maximum MSK-64 intensity of 7 or greater occurring between 1895 and 1973 (Lunyov, Negmatullaev, and Rojahn, 1977).

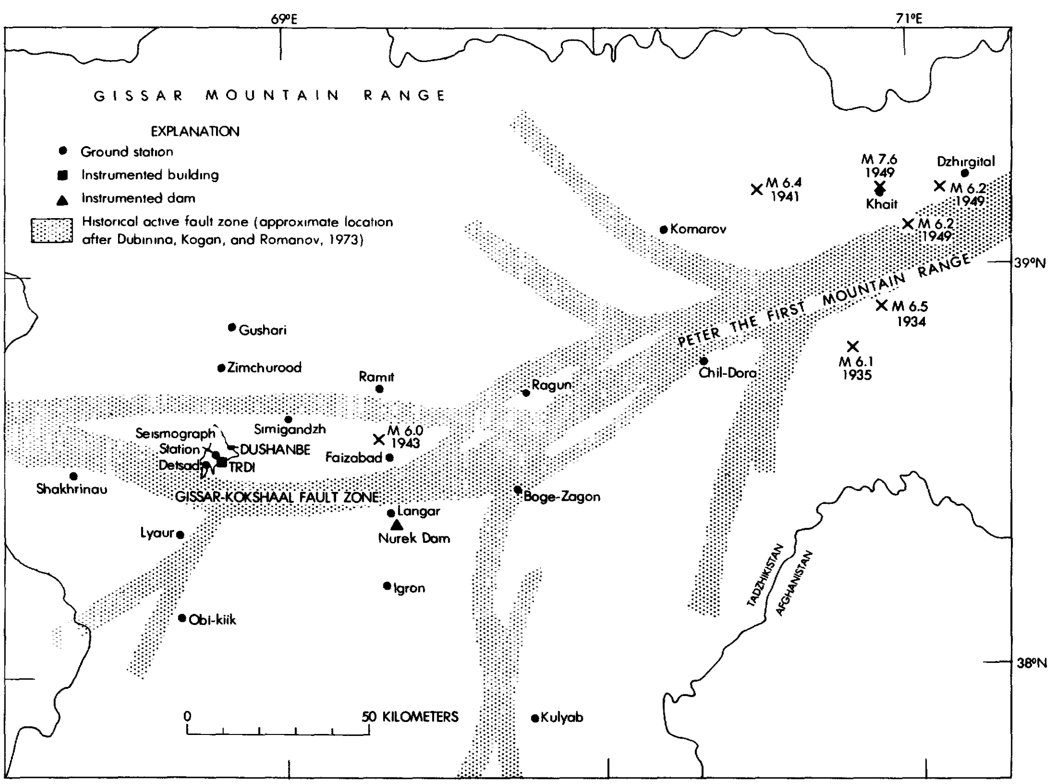
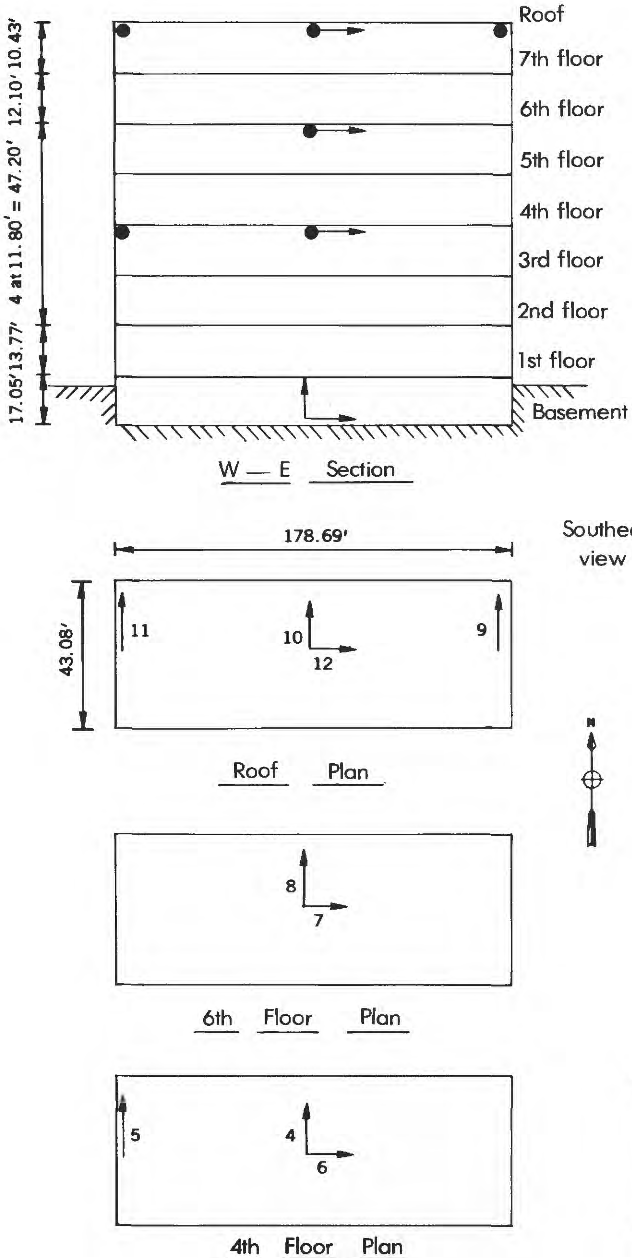


Figure 6.- Map showing locations of joint U.S.-U.S.S.R. strong-motion accelerograph stations.



Note: Accelerometers 1, 2, and 3 installed on basement floor slab; accelerometers 4, 5, 6, 7, and 8 attached to underside of floor slab; accelerometers 9, 10, 11, and 12 attached to underside of roof slab. Single-axis horizontal starter located on seventh floor beneath and parallel to accelerometer 10

Recorder located in northwest corner of basement

Southeast view

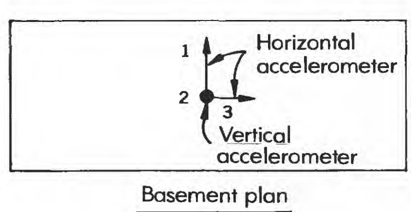


Figure 7.- Strong-motion instrumentation scheme, Tadzhik Road Design Institute, 14 Aini Street, Dushanbe, Tadzhik S.S.R.

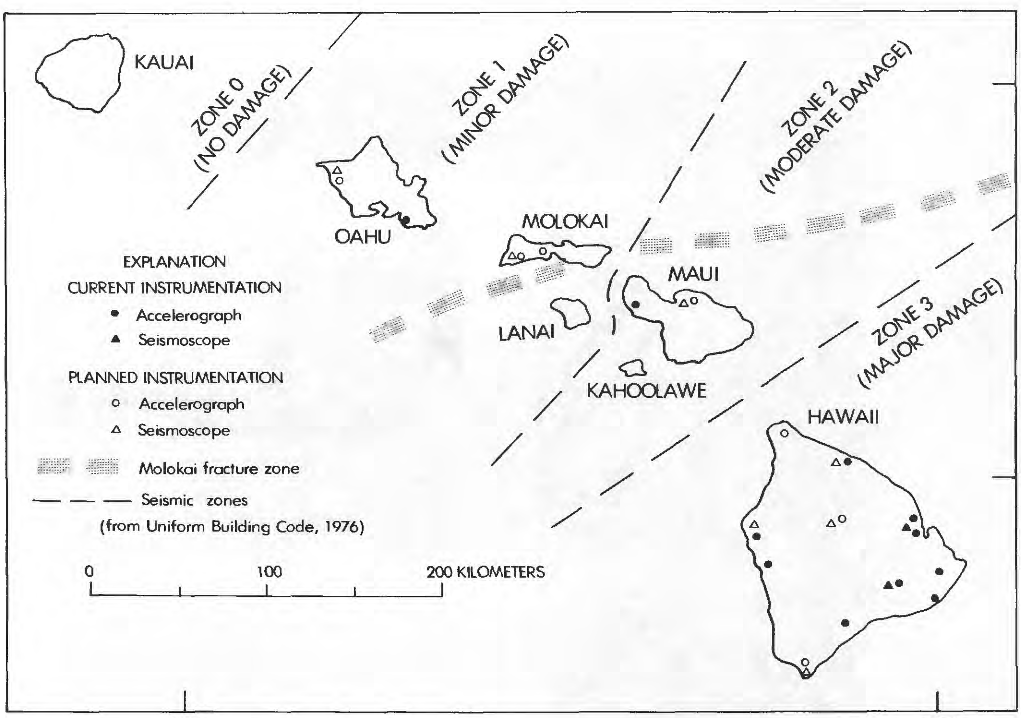


Figure 8.- Strong-motion instrumentation in the Hawaiian Islands.