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Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations

Fairbanks, AK (UA Duckering Hall)
Petrolia, CA (General Store)
Hollister, CA (City Hall)
Los Angeles, CA (Hollywood Storage Building)
New Madrid, MO (Noranda Aluminum Plant)

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ABSTRACT

This is the fifth in a series of reports presenting geotechnical and seismic data for selected accelerograph stations. This volume discusses the findings at five stations, one each in the following locations: Fairbanks, Alaska; Petrolia, California; Hollister, California; Los Angeles, California; and New Madrid, Missouri. The report contains information for each site describing the station building and instrumentation, geology and seismicity of the area, and site conditions. Deep borings, downhole geophysical measurements, and laboratory tests were conducted at each station to evaluate the subsurface conditions.

SUMMARY

The accelerograph stations discussed in this report include the University of Alaska (UA) Duckering Hall in Fairbanks, the General Store in Petrolia, the City Hall in Hollister, the Hollywood Storage Building in Los Angeles, and the Noranda Aluminum Plant near New Madrid. Subsurface conditions that were encountered in the borings at each of the sites are summarized below.

Subsurface conditions at Duckering Hall in Fairbanks consist of 5 feet of loess overlying the Birch Creek Schist, to a depth of at least 157 feet. The loess is a medium dense, fine sandy silt. Because the upper 20 feet of material in the Birch Creek Schist was severely weathered, it was classified as a dense, slightly clayey, fine sandy silt. Below a depth of 25 feet, the material was more competent and it was classified as a moderately hard, moderately weathered, mica schist. Shear wave velocities in the loess and upper 20 feet of the Birch Creek Schist were 750 and 1550 fps, respectively. Velocities of 3300 fps and greater were obtained in the Birch Creek Schist below a depth of 25 feet.

Subsurface conditions near the General Store in Petrolia consist of 56 feet of alluvium overlying the Yager Formation, to a depth of at least 180 feet. The alluvium consists of layers of medium stiff to very hard, silty clay alternating with layers of very dense, silty, gravelly, fine to coarse sand. The underlying Yager Formation, which contains siltstone and shale, was classified as a hard, highly-fractured, silty clay between depths of 56 and 120 feet. Below 120 feet, the material was classified as a soft, highly-fractured siltstone. Shear wave velocities in the alluvium increased from 600 fps at the ground surface to 1400 fps at depth. Velocities in the Yager Formation increased from 1400 fps near the top of the formation to 2000 fps below a depth of 80 feet; a constant velocity of 3300 fps was obtained below a depth of 120 feet.

Subsurface conditions near the City Hall in Hollister consist of at least 349 feet of alluvial sediments. The surficial 86 feet of these sediments are primarily stiff to very stiff, silty clays. Materials between depths of 86 and 183 feet are very dense, silty, gravelly sands interbedded with hard, sandy, clayey silts. Below a

depth of 183 feet the materials are primarily very dense sands with some hard, silty clay layers. Shear wave velocities steadily increased from 500 fps near the ground surface to 1250 fps at a depth of about 180 feet. The velocity was relatively constant at 2000 fps below a depth of 200 feet.

Subsurface conditions at the Hollywood Storage Building in Los Angeles consist of 146 feet of alluvium overlying the Repetto Formation, to a depth of at least 360 feet. The alluvium at the site consists of very stiff to hard, sandy, silty clay which overlies very dense, silty sand at a depth of 93 feet. The underlying Repetto Formation, which contains siltstone, sandstone and shale, was classified as a hard, sandy, clayey silt to a silty clay. Shear wave velocities in the alluvium increased from 850 fps near the ground surface to 1400 fps at depth. Velocities in the underlying Repetto Formation were constant at 2000 fps.

Subsurface conditions at the Noranda Aluminum Plant near New Madrid consist of 190 feet of alluvium overlying unconsolidated sands and clays of the Wilcox Group, to a depth of at least 329 feet. The alluvial sediments are primarily medium dense to very dense, clean to silty sands with some gravel. The materials in the underlying Wilcox Group consist of hard, silty clay with some zones of sand and gravel. The shear wave velocities in the alluvium increased from 500 fps near the surface to 1100 fps at depth. Velocities in the Wilcox Group increased to a constant value of 1650 fps below a depth of 240 feet.

GEOTECHNICAL AND STRONG MOTION EARTHQUAKE DATA
FROM U.S. ACCELEROGRAPH STATIONS

VOLUME 5

FAIRBANKS, AK. (UA DUCKERING HALL)
PETROLIA, CA. (GENERAL STORE)
HOLLISTER, CA. (CITY HALL)
LOS ANGELES, CA. (HOLLYWOOD STORAGE BLDG.)
NEW MADRID, MO. (NORANDA ALUMINUM PLANT)

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INTRODUCTION

Purpose and Scope

Although many theoretical and analytical advancements have been made in the seismic design of major structures, they have far outstripped our understanding of the basic earthquake data base. This data base consists of earthquake ground motions that have been recorded at accelerograph stations located in various parts of the United States as well as other countries. Together, these earthquake records constitute a set of maximum ground motion values, time histories of acceleration, and response spectra, upon which seismic design recommendations are formulated. Effective use of this data, however, has been clouded by incomplete information and by inconsistencies in reported subsurface conditions at many of the earthquake recording stations (Duke and Leeds, 1972; EERI and NOAA, 1971; Seed, et al., 1974 and 1975; Trifunac and Brady, 1975; etc.). Thus, to make better use of the earthquake data base, it is necessary to have a more clear understanding of the subsurface characteristics at the various accelerograph stations.

The purpose of this report is to compile basic geotechnical and strong motion earthquake data for selected accelerograph stations in the United States. This report contains information on a total of five accelerograph stations, one each in the following locations: Fairbanks, Alaska; Petrolia, California; Hollister, California; Los Angeles, California; and New Madrid, Missouri. Information on the site conditions was obtained from a reconnaissance, deep boring, in situ geophysical measurements and laboratory tests conducted for each station. In addition, geological and seismological information was compiled and is presented for each site. By providing this information for the more significant accelerograph stations, the earthquake data base may be used more effectively, leading to more refined seismic design practices.

Authorization

This study was performed under Contract No. NRC: 04-76-200 between the U.S. Nuclear Rgulatory Commission and the joint venture of Shannon & Wilson, Inc., and Agbabian Associates (SW-AA). This study is part of an overall research program to evaluate soil behavior under earthquake loading conditions.

Previous Reports

As part of the SW-AA joint venture work, over 80 accelerograph stations have been studied since the program began in 1975. This particular study represents the fifth in a series of reports on accelerograph stations that are generally regarded as being founded on "soil" deposits. Other studies have been conducted for stations located on "rock" and for selected stations in Los Angeles, California. Reports in the series are listed below:

a) "Soil" Site Studies:

Volume No.	Stations Studied
1 (SW-AA, 1975)	Ferndale, Cholame and El Centro California
2 (SW-AA, 1976a)	Pasadena, Santa Barbara, Taft, and Hollister, California
3 (SW-AA, 1977a)	Gilroy, California; Logan, Utah; Bozeman, Montana; Tacoma, Washington; and Helena, Montana

4 (SW-AA, 1978)	Anchorage, Alaska; Seattle, Washington; Olympia, Washington; and Portland, Oregon
5 (this report)	Fairbanks, Alaska; Petrolia, California; Hollister, California; Los Angeles, California; and New Madrid, Missouri

b) "Rock" Site Studies:

Volume No.	Stations Studied
1 (SW-AA, 1976b)	19 accelerograph stations in southern California
2 (SW-AA, 1977b)	29 accelerograph stations in both northern and southern California

c) Studies were also conducted for 11 accelerograph stations in three areas within the city of Los Angeles. The results of this work are presented in SW-AA, 1976c.

Acknowledgements and Contributors

This study benefited from the efforts of numerous individuals. We especially acknowledge and thank Dr. J. Harbour of the U.S. Nuclear Regulatory Commission for his recognition of the need for accurate geotechnical information at strong motion accelerograph station sites and for his support and contributions as project monitor.

We also acknowledge a number of other individuals and organizations for their assistance and cooperation in this work. For granting drilling access, we thank Mr. H. A. Cutler, Chancellor of the University of Alaska; the Petrolia Volunteer Fire District; the City of Hollister; Mr. Walt Westphaling, Los Angeles District Manager of Bekins Storage Company; and Mr. Ralph Ebersol, Plant Manager of the Noranda Aluminum Company. For assistance in expediting the field work and for contributing station data, we thank Mr. G. Neubert, Associate Director of Land Planning at the University of Alaska and Mr. Walt Ellison, Plant Engineer with Noranda Aluminum Company. The staffs of the Seismic Engineering Branch of the U.S. Geological Survey and of the California Division of Mines and

Geology Strong Motion Instrumentation Program have been particularly helpful in contributing geotechnical and seismic data relating to the strong motion stations.

The SW-AA joint venture efforts were directed by Dr. R. P. Miller, Project Manager. Project Engineer and principal investigator for this task was Mr. W. P. Grant. Field efforts were coordinated by Mr. R. D. Perry. Geological information in this report was organized by Mr. Perry and reviewed by Mr. H. H. Waldron. Mr. J. Musser obtained the field geophysical data, and Mr. A. Azzam supervised laboratory testing.

REPORT ORGANIZATION

General

This report is organized into a main text and three appendices. Within the main text and each appendix are five sections (18-22), presenting information for the individual accelerograph stations. Figure 1 shows the locations of the accelerograph stations that were investigated and their corresponding section numbers.

The main text, under the heading of Station Data, has station information organized into three main areas: Station Description, Geology and Seismicity, and Site Conditions. Details of particular items presented in the main text are included in the appendices. The structure and format of the data contained in the report are discussed below.

Station Data

Station Description

For each site, information is presented on the accelerograph station location and building as well as a discussion of the station instrumentation and a listing of earthquakes recorded at the site. This narrative is supplemented with drawings showing the location and layout of the building, and with photos of the building exterior and instrumentation. Information on the instrumentation at the station was primarily obtained from records on file with the USGS Seismic Engineering

Branch in Seattle, Washington, and Menlo Park, California, and from the files of the California Division of Mines and Geology (CDMG) Strong Motion instrumentation program.

Geology and Seismicity

The geology of each station is discussed on a regional and local level. This discussion is accompanied by a map displaying the regional geology and a subsurface cross-section through or adjacent to the site.

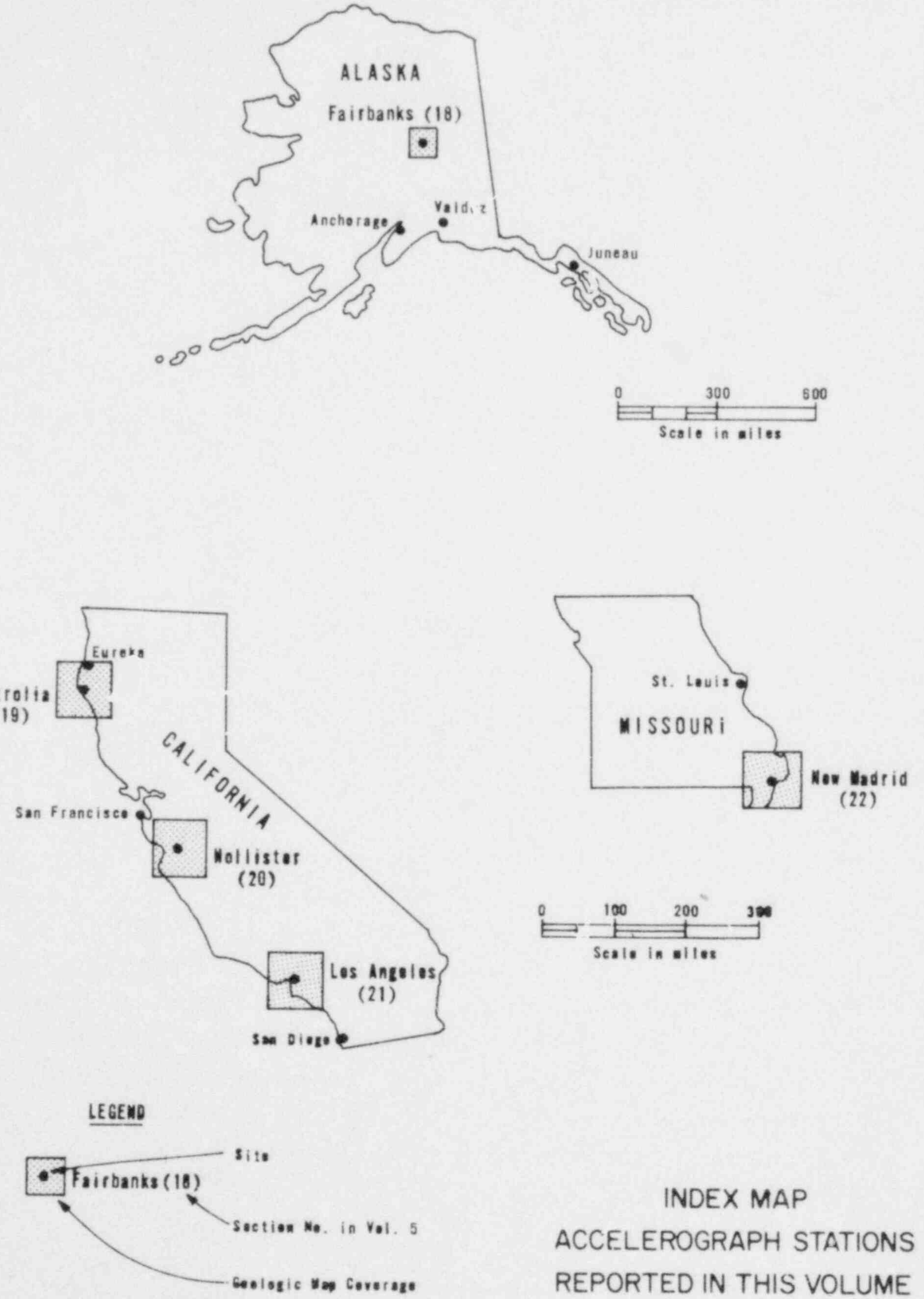
The geologic structure and seismicity of each region are also discussed. Significant faults and structural trends are indicated on the geologic map, as are the epicenters of some of the more significant historic earthquakes. The text also discusses tectonic activity of the more significant faults.

Site Conditions

The site conditions at each station are discussed in terms of surficial features, subsurface conditions and dynamic soil properties. The subsurface conditions at all sites were evaluated based on a deep boring, geophysical measurements and laboratory tests performed for this study. Findings of the field studies and results of the laboratory tests are all summarized on a single figure for each site.

Appendices

Following the main text are three appendices: A - Earthquake Records, B - Field Explorations, and C - Laboratory Testing. Appendix A presents a listing of earthquakes that have been recorded at each station. Time history plots of ground motion and response spectra are also presented for those records that have been digitized. Appendix B presents detailed findings of the field drilling and geophysical testing program. A description of the general laboratory testing procedures and the results of the individual tests are presented in Appendix C.



INDEX MAP
ACCELEROGRAPH STATIONS
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FIG. I

STATION DATA

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UA Duckering Hall
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SECTION 18

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18.1 STATION DESCRIPTION

18.1.1 Location and Building

Fairbanks is in the central part of Alaska, about 100 miles south of the Arctic Circle and 400 miles north of Anchorage. The city is located near the confluence of the Tanana and Chena Rivers. Fairbanks, the largest city in the interior, lies within the Fairbanks North Star Borough.

The Fairbanks campus of the University of Alaska lies in the suburban town of College, 3 miles west-northwest of downtown Fairbanks. Duckering Hall, which houses the engineering department at the university, is located in the southeast portion of the campus (Fig. 18-1).

Duckering Hall is a low-rise, wedge-shaped structure, which consists of a main building adjoined by wings on the north and south and by a basement annex between the two wings (Fig. 18-2). Plan dimensions of the entire structure are about 160 by 200 feet. Except for the annex, the structure has three stories located above grade and a daylight basement. The basement has about a 10 foot embedment on the west side of the building but is completely exposed on the east side. Finished floor elevation in the basement is 503 ft. MSL.

Duckering Hall was constructed in three phases. The first phase of construction, which was completed in 1961, consisted of erecting the basement and first floors for the main building and south wing. The second and third floors were added to these units during the Phase II construction, which was completed in 1964. Also, the north wing was completely constructed during this second phase. The final phase of construction consisted of building the basement annex. This was completed in 1967.

Duckering Hall is constructed of steel and reinforced concrete. The building consists of structural steel members encased in concrete. A reinforced concrete beam and girder system is used for floor support. Lateral resistance is provided through the 8-inch thick, reinforced concrete exterior walls of the structure. Internal partitions indicated in the basement plan of Fig. 18-2 are concrete block. A seismic joint separates the main building from the wings and annex.

A spread footing foundation system is used for Duckering Hall. Typical spread footings vary in size from 5 to 9 feet square and result in contact pressures of 3 to 4 ksf. Typically, footings bear at an elevation of about 500 feet.

18.1.2 Instrumentation and Earthquake Recordings

The accelerograph station at Duckering Hall is owned and operated by the USGS and is identified as station number 2721 in the USGS strong motion instrument network. Duckering Hall was initially instrumented in July 29, 1965 with an AR-240 accelerograph (S/N 111) and a seismoscope (S/N 3072). The accelerograph remained in place until September 7, 1967, when it was moved to the College Magnetic Observatory vault (station 2707) which is located about 4000 feet northwest of Duckering. Duckering remained without an accelerograph for nine years until September 14, 1976, when an SMA-1 recorder (S/N 1926) was installed at the station. Pendulum motion orientations for the original and replacement accelerographs are as follows (Jordan, et al., 1968 and USGS, unpub.):

	Original AR-240 Accelerograph	Replacement SMA-1 Accelerograph
Longitudinal	South	North
Vertical	Down	Down
Transverse	East	West

Both instruments at Duckering Hall have been located in the electrical switch room (room U-5) in the basement of the main building (Fig. 18-2). A plan of the accelerograph room and a photo of the current instrumentation are shown in Fig. 18-3. All instruments at the site have been bolted directly to the concrete floor slab. In this portion of the building, the basement floor slab is about 5 feet below the adjacent outside grade.

The only event recorded at Duckering Hall was the magnitude 5.6, June 21, 1967, Fairbanks earthquake. This earthquake consisted of several separate shocks, four of which were recorded on the Duckering Hall accelerograph (Jordan, et al., 1968). Currently, none of these records has been digitized and processed. Details of this earthquake, including the raw accelerogram and response spectra plots for the triggering shock, are presented in Appendix A. Summary data from the recordings are as follows:

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity	Shock No.	Peak Acceleration (g)
06-21-67	5.4-5.6	VII	1	0.06
			2	0.07
			3	0.14
			4	0.08

18.2 GEOLOGY AND SEISMICITY

18.2.1 Regional Geology

A geologic map of the Fairbanks region is presented in Fig. 18-4. The Fairbanks region, as defined for this report, includes the area within about 60 kilometers (37 miles) of Fairbanks. The geology indicated on the map was obtained from the data sources cited in Fig. 18-4. In the following discussions the symbols in parentheses refer to geologic units on the map.

The major physiographic provinces in the Fairbanks region are the Yukon-Tanana Upland of the North Plateaus province in the north and the adjacent Tanana-Kuskokwim Lowland of the Western Alaska province in the south. The Yukon-Tanana Upland is a westerly-trending highland between the Yukon and Tanana Rivers. It is a maturely dissected area of accordant rounded ridges 2000 to 3000 feet in altitude with scattered groups of higher mountains which reach altitudes of 5000 to 6000 feet (Pewe, 1958). South of the Yukon-Tanana Upland lies the Tanana-Kuskokwim Lowland. The Lowland is an alluvial filled trough bounded by the Upland on the north and the Alaska Range on the south. The city of

Fairbanks is located in the northern portion of the Lowland, adjacent to the boundary of the Lowland with the Yukon-Tanana Upland.

The Tanana-Kuskokwim Lowland is a broad, generally westerly-trending, structural and topographic depression. Basement rock in the Lowland consists of metamorphosed Paleozoic and Precambrian rocks (lPzp€,Pz), intrusive and extrusive igneous rocks of Mesozoic age (Mzg) and locally some ultramafic rocks of uncertain age (um). These older rock units are unconformably overlain by Quarternary sediments consisting of alluvial, colluvial, glaciofluvial, glaciolacustrine, and eolian deposits (Q and Qal) of silt, sand, and gravel. The Quaternary sediments in the Tanana River flood plain may be as much as several hundred feet thick.

In the Uplands to the north, the basement assemblage primarily consists of metamorphic, sedimentary, igneous, and volcanic rocks of Paleozoic and/or Precambrian age (lPzp€ , Pzmi, and Pz). These units include a variety of schist and gneiss, carbonate and clastic sedimentary rocks, and mafic and ultramafic igneous rocks. Northwest of Fairbanks, these older units are in fault contact with younger Mesozoic rocks (Mz), which are chiefly of sedimentary origin but also include some lavas and volcanoclastic rocks. Igneous rocks of Mesozoic and/or Tertiary age (TKg) and ultramafic rocks of an undetermined age (um) crop out locally in the Uplands. Quaternary sediments, which mantle the bedrock in the Uplands generally are not shown on the geologic map.

Most of the area within about 50 miles of Fairbanks has not been glaciated. However, the Lowland and Upland areas are generally underlain by discontinuous and isolated masses of permafrost. Permafrost in the Lowland areas may be as much as 265 feet thick (Johnson and Hartman, 1969; Pewe, 1958).

18.2.2 Local Geology

The local geology in the vicinity of Fairbanks is depicted in Geologic Cross-Section R-R' of Fig. 18-5. This southeasterly-trending section is located approximately 2 miles southwest of Duckering. The section includes portions of both the Yukon-Tanana Upland and the Tanana-Kuskokwin Lowland. Fairbanks is located near the confluence of the Tanana and Chena Rivers in the

Lowland, and Duckering Hall is located near the boundary between the Upland and the Lowland.

Precambrian and/or Paleozoic bedrock and late Tertiary and Quaternary sediments underlie Fairbanks and its immediate vicinity. Bedrock in the area is the Lower Paleozoic and/or Precambrian Birch Creek Schist (lPzp-C), which includes graphite, quartz-calcite and quartz-mica schist, amphibolite, quartzite, slate, and gneiss. In the Lowland, the bedrock is unconformably overlain by the Quaternary Chena flood-plain alluvium (Qc) consisting of gravel, sand and silt. Bedrock in the Upland is overlain by the Plio-Pleistocene Cripple Gravel (QTc), and the Quaternary Fox Gravel (Qfo), Tanana Formation (Qt) and eolian silt (Qs).

18.2.3 Structure and Seismicity

The structural geology of the Fairbanks region is illustrated on the Geologic Map and in Cross-Section R-R' in Figs. 18-4 and 18-5, respectively. As indicated on the Geologic Map, faulting has been recognized in the Uplands, both northwest and southeast of Fairbanks. Additionally, there are some post-Wisconsin fault scarps in the Lowlands on the south side of the Tanana Valley about 75 miles from Fairbanks. These fault scarps indicate major seismic activity in the last few thousand years (Pewe, 1958). Structural conditions in the vicinity of Fairbanks are very poorly known, owing to the thick cover of unconsolidated deposits that mantles bedrock in the area. Relief on the bedrock surface is moderate, and little structure exists in the Quarternary sediments, other than stratification in alluvial sand and gravel deposits, much of which has been disturbed by permafrost.

Fairbanks is located in a zone of moderate seismic activity. The historic record of this activity, effectively dates back only to the turn of the century. Prior to this time, the sparse population that existed throughout much of Alaska precluded obtaining more than a very fragmentary record of this activity.

The more significant historic earthquakes (those of Modified Mercalli Intensity V or greater) that have occurred in the Fairbanks region are listed in Table 18-1 and their approximate epicentral locations are shown on Fig. 18-4. Of the 15 events listed, three had intensities of VII or greater. The largest events in the region were the earthquakes of July 22, 1937 and October 15, 1947.

Both of these events were centered southeast of Fairbanks and had maximum intensity ratings of VIII. The most recent significant event was the intensity VII, Fairbanks earthquake of June 21, 1967. This earthquake consisted of a series of shocks, all located about 13 miles east-southeast of Fairbanks.

18.3 SITE CONDITIONS

Site conditions at Duckering Hall were studied with a site reconnaissance, deep boring, in situ geophysical measurements, and limited laboratory testing. A 157-foot deep boring was drilled at a location about 55 feet east of Duckering Hall to study the subsurface conditions. A downhole geophysical survey was performed for the full depth of the boring to obtain shear wave velocities of the materials. Soil samples retrieved from the boring were tested in the laboratory to determine their index properties. Detailed results of the field drilling and geophysical testing are presented in Appendix B, and detailed results of the laboratory tests are presented in Appendix C. Summary findings from the field and laboratory studies are discussed below.

18.3.1 Surface Features

The Fairbanks campus of the University of Alaska is situated on a low-lying hill, adjacent to the flood plain of the Tanana and Chena Rivers (Fig. 18-1). Most of the major buildings on the campus, including Duckering Hall, are located on a terraced portion of the hillside at an elevation of approximately 500 ft. MSL. The hillside slopes steeply to the south and east and merges with the flood plain at an elevation of about 430 ft. MSL. Bedrock is exposed in a road cut at the base of the hill.

18.3.2 Subsurface Conditions

Except for a thin mantle of loess, the 157-foot deep boring at Duckering Hall was drilled entirely within weathered schist of the Birch Creek Schist. The materials encountered in the boring are generalized in Fig 18-6 and are briefly discussed below.

The surficial 5 feet of material encountered in the boring consisted of medium dense, fine sandy silt. This silt had a water content of about 8 percent and a shear wave velocity of 750 fps.

The Birch Creek Schist was encountered at a depth of 5 feet. The materials in this formation have been generalized into two layers, with the break indicated at a depth of 25 feet. Although the materials in both layers are similar geologically, the material above a depth of 25 feet has engineering properties more similar to a hard soil than a soft rock.

The material in the Birch Creek Schist between depths of 5 and 25 feet was given a primary classification as a dense, slightly clayey, sandy silt and a secondary classification as a very soft, very severely weathered mica schist. Within this zone, blow counts were generally over 60, and water content values were less than 5 percent. A 1550 fps value of shear wave velocity was obtained in this stratum.

The Birch Creek Schist from a depth of 25 feet to the base of the boring at 157 feet was classified as a moderately hard, moderately weathered, mica schist. Blow counts within this zone were all over 100, and water content values were less than 5 percent. Values of shear wave velocity increased from 3300 fps at the top of the stratum to 4950 fps below a depth of 49 feet.

The water table was measured at a depth of 83 feet in the completed boring.

18.3.3 Dynamic Soil Properties

Since only drive samples were retrieved from the boring below a depth of 5 feet, laboratory testing was not conducted to determine the dynamic properties of the subsurface materials.

TABLE 18-1

SIGNIFICANT EARTHQUAKES IN THE FAIRBANKS REGION[1]

Source[2]	Year	Date Mo. Day	Time (AST)	Latitude[3] North (°)	Longitude[3] West (°)	Magnitude[4] (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral[5] Distance (miles)
A	1911	1 - 7	04:43	65	148	-	V	-	11 NNW
B	1937	7 - 22	07:09	64.75	146.75	7.3(p)	VIII	16	40 ESE
A	1939	2 - 13	21:52	65	148	-	V		11 NNW
A	1940	8 - 29	21:32	65	148	-	V	-	11 NNW
B	1947	10 - 15	16:10	64.5	147.5	7.0(p)	VIII	31	27 SSE
A	1956	5 - 17	18:19	65	148	-	V	-	11 NNW
A	1957	3 - 9	04:07	65	149	-	V	-	37 WNW
A	1958	1 - 13	00:29		148	-	V	-	11 NNW
A	1963	12 - 7	18:18	65	148	-	V	-	11 NNW
A	1967	2 - 6	04:49	64.8	147.4	4.5	V	-	13 ESE
C	1967	6 - 21	$\left\{\begin{matrix}08:05\\08:13\\08:25\end{matrix}\right\}$	64.8	147.4	$\left\{\begin{matrix}5.4\\5.6\\5.4\end{matrix}\right\}$ (m_b)	VII	-	13 ESE
D	1971	4 - 14	05:18	64.9	147.7	4.1 (M_L)	V	15	5 NE
D	1973	5 - 31	18:53	65.1	147.3	4.2 (M_L)	V	20	23 NE
D	1976	4 - 16	20:09	64.90	148.31	4.0 (M_L)	V	20	15 WNW
E	1977	7 - 11	05:57	64.56	147.27	4.6 (M_L)	V	9	27 SE

Notes:

1. Earthquakes selected for this tabulation have maximum intensities of V or greater and have occurred within about 60 km (37 miles) of Fairbanks. The intent of this table is to provide a general indication of the seismicity in the region; it is not a complete list of all earthquakes.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Van Hake (1973)
   B. Meyers (1976)
   C. Jordan, et al. (1968)
   D. United States Earthquakes
   E. Earthquakes in the United States

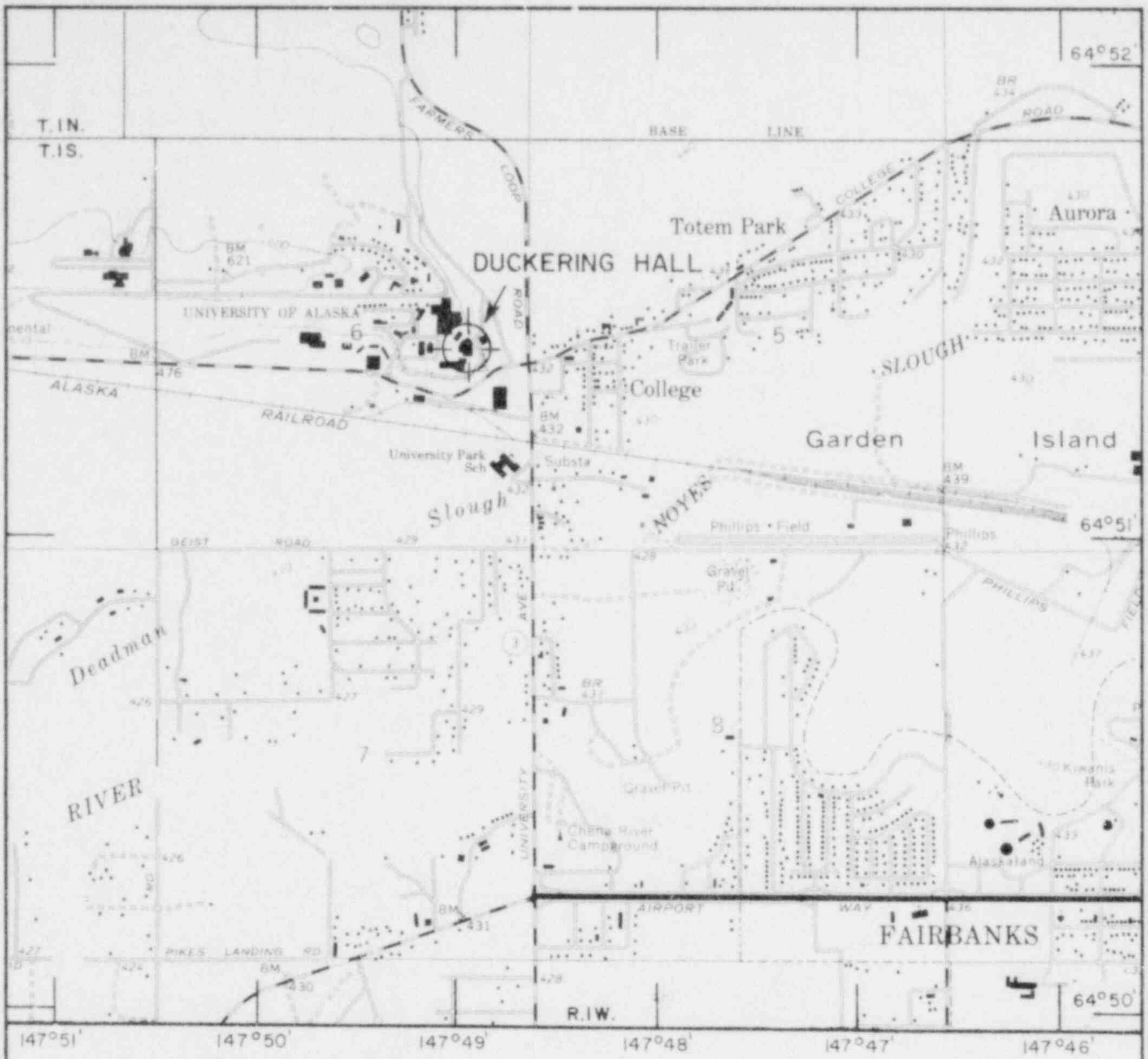
3. The range of uncertainty for epicentral locations may be taken as about ± 0.5° for earthquakes prior to 1960 and as about ± 0.2° for those since 1960.

4. Magnitudes are as follows:

   P - Computed by the California Institute of Technology, Pasadena.
   m_b - Computed from body waves on a seismogram (C&GS).
   M_L - Local magnitude (USGS).

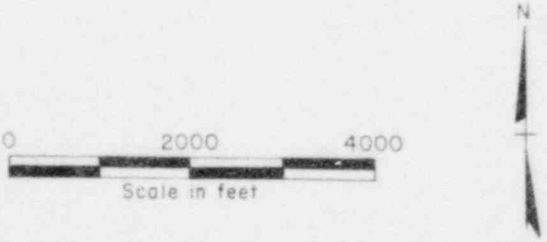
5. All distances have been scaled relative to the accelerograph station at Duckering Hall.

POOR ORIGINAL



<u>DUCKERING HALL</u>

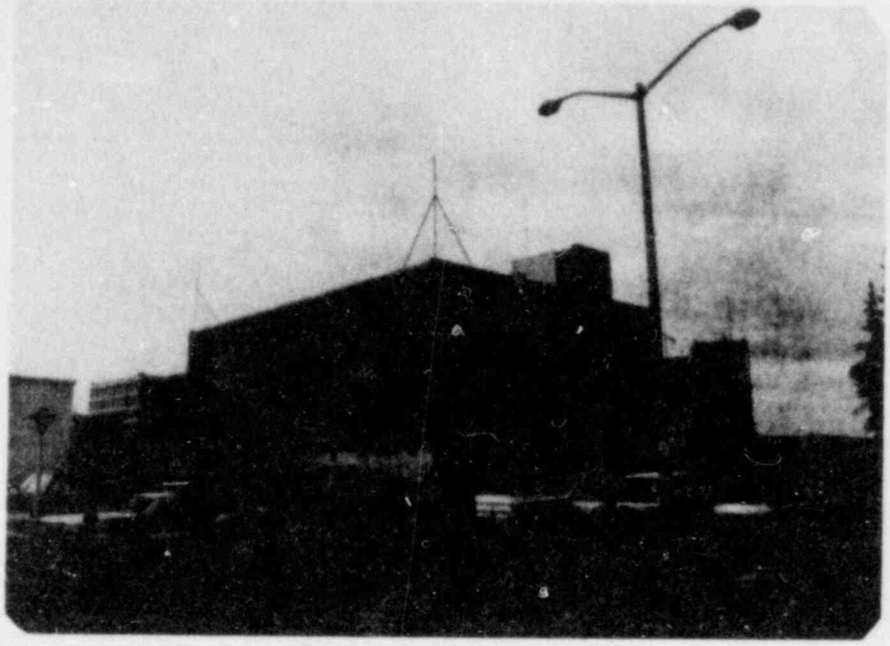
USGS Station No.:	2721
Borough:	Fairbanks North Star
USGS Topographic Quadrangle:	Fairbanks D-2 SW, Alaska
Coordinates:	64°51'24"N. 147°48'57"W.
Location:	University of Alaska (Fairbanks Campus) Southeasetern portion of campus
Building:	Three stories with a daylight basement; steel framing and reinforced concrete construction.



STATION LOCATION
UA DUCKERING HALL
FAIRBANKS, ALASKA

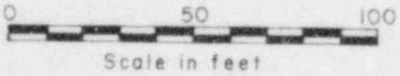
POOR ORIGINAL

FIG.18-1



Duckering Hall
View-Northwest

Basement Plan

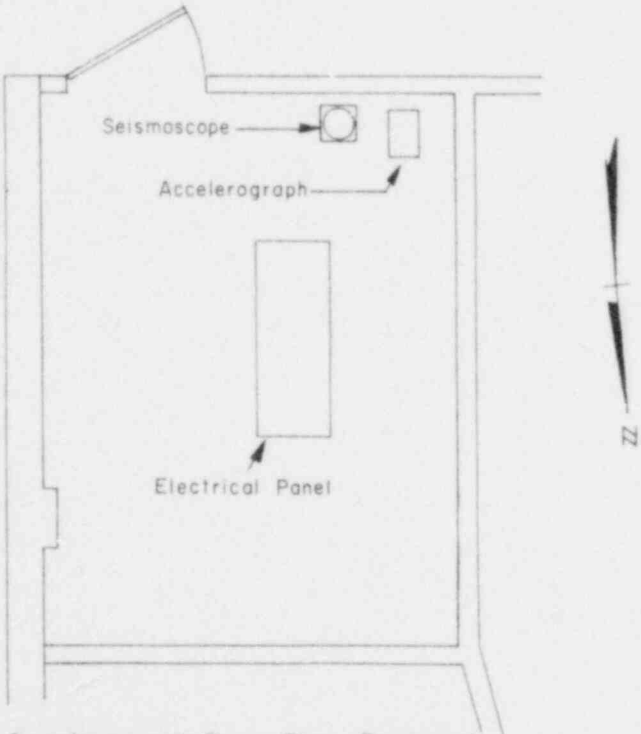


POOR ORIGINAL

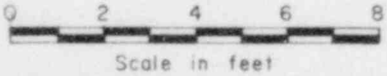
BUILDING PLAN
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18-2

SMA-1 Accelerograph
Duckering Hall-Basement

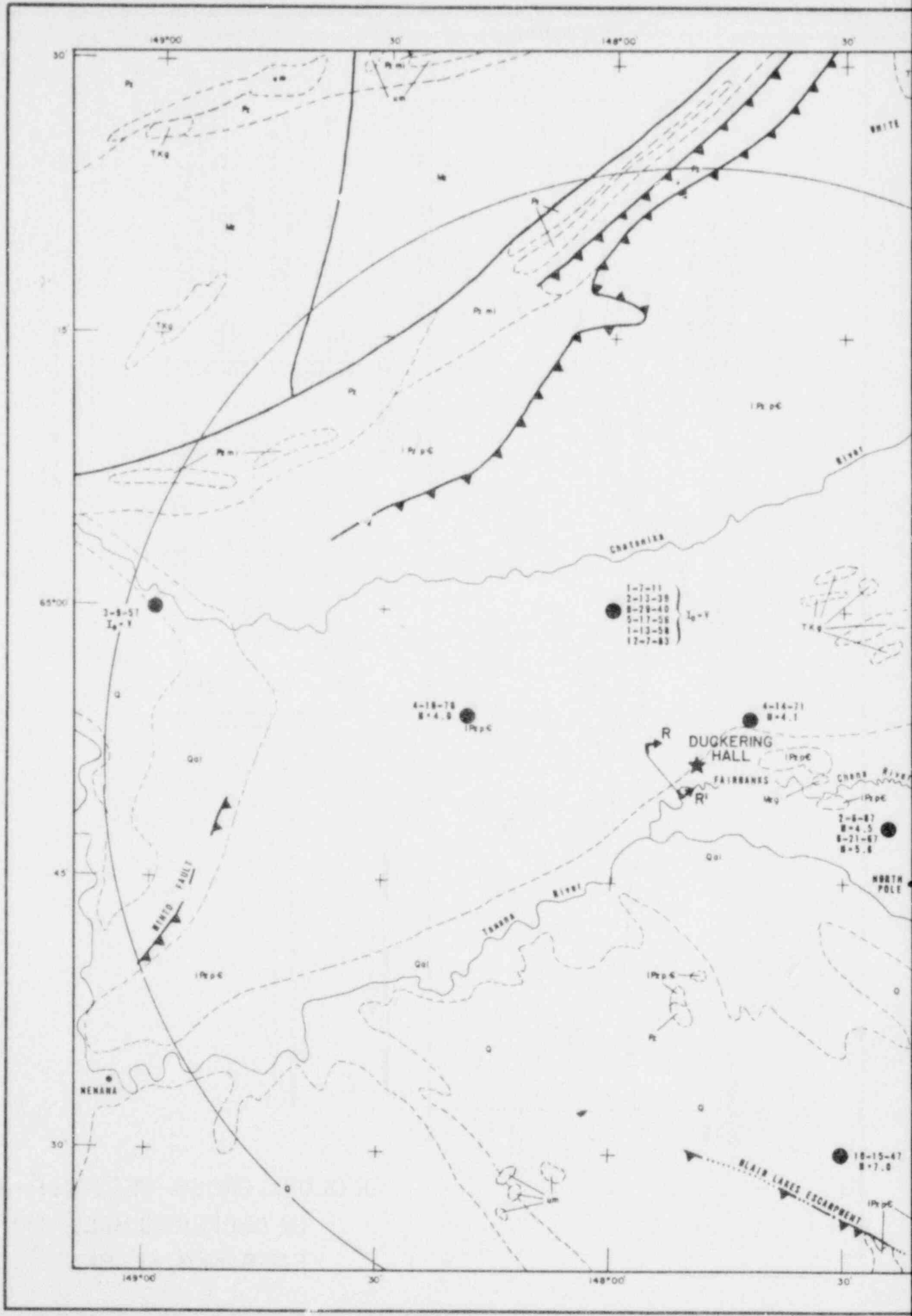


Accelerograph Room Plan-Basement

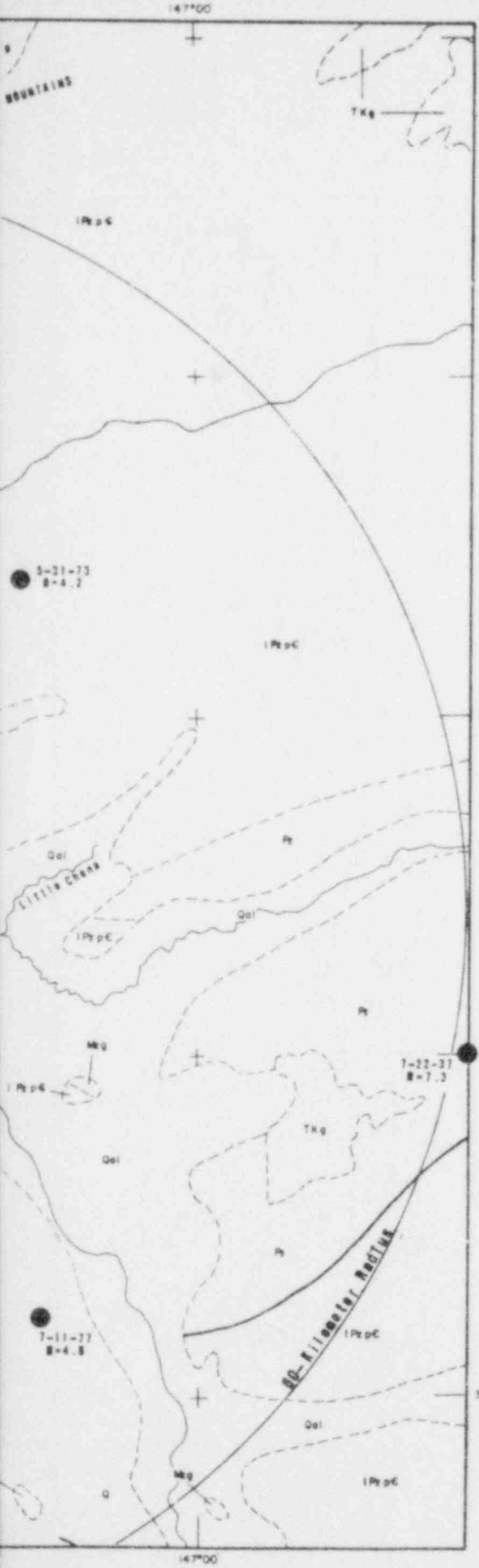


STATION INSTRUMENTATION
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18-3



POOR ORIGINAL



EXPLANATION

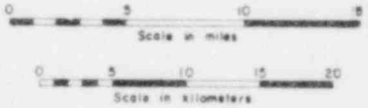
Qal	Holocene deposits: Includes alluvial, glacial, lacustrine and landslide deposits.
Q	Quaternary deposits: Includes alluvial fan, terrace and pediment gravel, windblown sand and silt, morainal and outwash deposits.
TKg	Tertiary and Cretaceous granitic rocks; mainly ranging in composition from granite to quartz diorite; local aplite, alaskite and pegmatite.
Mz	Mesozoic rocks; shale, carbonaceous shale, sandstone, quartzite, conglomerate, graywacke, argillite, mudstone and claystone. Mafic lava, volcanic graywacke and conglomerate, agglomerate and bentonite. Some coal beds.
Mzg	Mesozoic granitic rocks; mainly granodiorite and quartz diorite with subordinate granite, syenite, quartz monzonite, and diorite and associated fine-grained hypabyssal equivalents of Triassic and Cretaceous age. Includes extensive migmatic granodiorite bodies in and along the central Alaska Range.
Pz	Paleozoic rocks; graywake, sandstone and shale, siltstone, mudstone, conglomerate, calcareous shale and sandstone, limestone, dolomite, chert and quartzite with subordinate greenstone. In places metamorphosed to greenschist and amphibolite facies.
Pzm	Paleozoic mafic rocks; mainly gabbro, diorite, and diabase; includes mafic and ultramafic rocks of Devonian age in the Livengood area.
lPzp€	Lower Paleozoic and(or) Precambrian sedimentary and volcanic rocks; quartz-mica schist, mafic greenschist, calcareous chloritic quartz schist, phyllite slate and quartzite. Includes phyllite, sandstone, siltstone chert, quartzite, and mafic volcanic rocks in the White Mountains area, and schist and gneiss of many different compositions, primarily greenschist and amphibolite facies.
um	Ultramafic rocks of uncertain [illegible], primarily gabbro and diabase serpentinized dunite, peridotite and pyroxenite.

★	Accelerograph Station location
●	Epicentral locations of selected historic earthquakes listed in Table 18-1.
8-21-67	Date of occurrence (month-day-year)
I_0 = VII	Maximum Intensity (MM)
M = 5.8	Magnitude (Richter)
Cross-section location	
Contact	Dashed where approximately located.
Fault	Dashed where approximately located, dotted where concealed.
Thrust Fault	Barbs on upper plate.

NOTES:

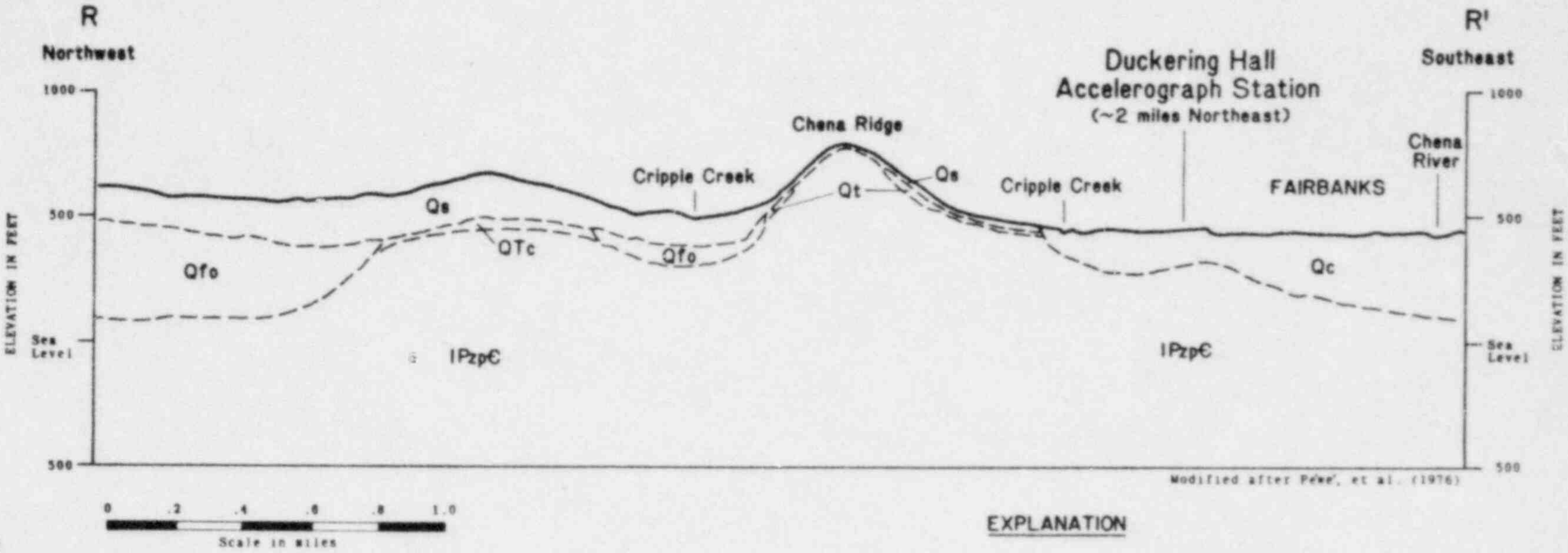
1) The geology has been generalized from Eberlein, et al. (1977), Pewe (1958) and Pewe, et al. (1966 and 1976). Not all Quaternary deposits are shown on the map in order to depict bedrock relationships.
2) Cross-section R-R' is shown on Fig. 18-5.

Location of Geologic Map



GEOLOGIC MAP
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18-4



Modified after Péwé, et al. (1976)

NOTES: 1) See Fig. 18-4 for location of section.
2) The cross-section is diagrammatic.

EXPLANATION

QUATERNARY

Qs Eoliar Silt
Massive, homogeneous, unconsolidated silt.

Qc Chena Alluvium
Chiefly unconsolidated silt, sand and gravel. Includes swale and slough, and alluvial fan silt and stity sand deposits.

Qt Tanana Formation
Solifluction layer of angular bedrock fragments in a silty sand matrix.

TERTIARY QUATERNARY

Qfo Fox Gravel
Poorly sorted, angular, sandy gravel

QTc Cripple Gravel (Plio-Pleistocene)
Stratified, coarse, angular sandy gravel.

UNCONFORMITY

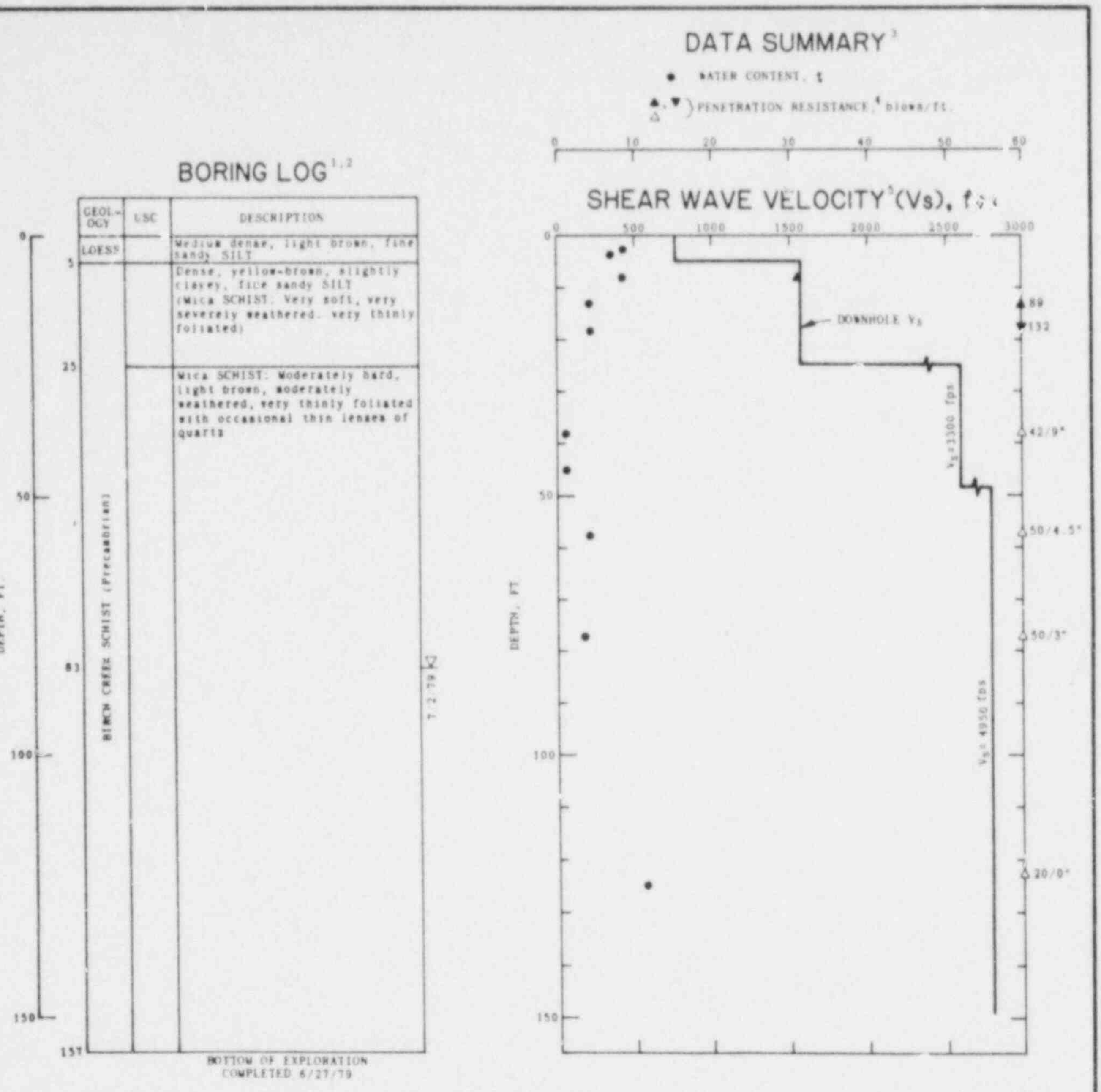
PRE-TERTIARY

IPzpЄ Lower Paleozoic and (or) Precambrian sedimentary and volcanic rocks.
Includes schist and gneiss of many different compositions, primarily green schist and amphibolite facies.

— — — — —
CONTACT
Dashed where approximately located.

GEOLOGIC CROSS-SECTION R-R'
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18-5



NOTES: 1) THE BORING IS LOCATED ABOUT 55 FT. EAST OF DUCKERING HALL. THE STRATIFICATION LINES IN THE BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES, AND THE TRANSITION MAY BE GRADUAL.

2) THE BORING ELEVATION OF 500 FT. MSL WAS OBTAINED BY INTERPOLATION FROM A USGS TOPO MAP AND CHECKED WITH STRUCTURAL DRAWINGS FOR DUCKERING.

3) LIMITED LABORATORY TESTING WAS PERFORMED SINCE ONLY SPT DRIVE SAMPLES WERE TAKEN IN THE BORING BELOW A DEPTH OF 5 FEET. LABORATORY TEST RESULTS ARE PRESENTED IN APPENDIX C.

4) PENETRATION RESISTANCES WERE OBTAINED WITH THE FOLLOWING EQUIPMENT:

- ▲ 2" O.D. SPLIT SPOON; 140 LB. WEIGHT AT 30"
- ▼ 3" O.D. SPLIT SPOON; 340 LB. WEIGHT AT 30"
- △ 2" O.D. SPLIT SPOON; 340 LB. WEIGHT AT 30"

5) DETAILED RESULTS OF THE DOWNHOLE GEOPHYSICAL TESTING ARE PRESENTED IN APPENDIX B.

POOR ORIGINAL

BORING LOG AND
SUMMARY OF TEST RESULTS
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18-6

Section 19

General Store
Petrolia, California

SECTION 19

GENERAL STORE, PETROLIA, CALIFORNIA

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GENERAL STORE, PETROLIA, CALIFORNIA

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SECTION 19
GENERAL STORE
PETROLIA, CALIFORNIA

19.1 STATION DESCRIPTION

19.1.1 Location and Building

Petrolia, a small community in northern California, is located in Humboldt County about 200 miles north-northwest of San Francisco and 30 miles south-southwest of Eureka. The town is located on the Mattole River, about 3.5 miles east of the Pacific Ocean.

The current accelerograph in Petrolia is a free field installation located about 50 feet north of the General Store, on property owned by the Petrolia Volunteer Fire District (Figs. 19-1 and 19-2). Prior to May 3, 1978, the accelerograph was located south of the General Store, adjacent to the Post Office entrance (Fig. 19-2). This was another free field installation with the instrument housed in a small, corrugated metal shed. The elevation of the ground surface in the vicinity of both locations is approximately 105 ft. MSL.

19.1.2 Instrumentation and Earthquake Recordings

The accelerograph station at the General Store is owned and operated by the California Division of Mines and Geology (CDMG) and is identified as station number 156 in their Strong Motion Instrumentation Program. The General Store accelerograph station is also a part of the USGS strong motion instrument network and is identified as station number 1398.

The station at the general store was initially instrumented on August 11, 1974, with an SMA-1 accelerograph (S/N 1684). This installation was at the free field site immediately south of the store. The SMA-1 recorder remained at the station until January 22, 1976, when it was replaced with another SMA-1 unit (S/N 1815) which had time-recording capabilities. On May 3, 1978, the station was moved 100 feet north to its present location (Fig. 19-2) and the instrument was installed in a small, fiberglass shelter at the same bearings as the previous installation. A plan of the shelter and a photo of the current instrument are presented in Fig. 19-3.

There is some conflict in the reported bearings for the instrumentation at the general store. There is a 16 degree difference in orientation between the initial SMA-1 accelerograph (S/N 1684) and the replacement SMA-1 unit (S/N 1815). The following are the pendulum motion orientations for both accelerographs corresponding to their location in the original instrument shelter immediately south of the General Store (CDMG, unpub.):

	Original SMA-1 (S/N 1684)	Replacement SMA-1 (S/N 1815)
Longitudinal	N75E	S89E
Vertical	Down	Down
Transverse	N15W	N01E

Since both the original and replacement instruments are SMA-1 accelerographs, it is quite unlikely that the replacement instrument would be remounted in the same shelter at an orientation 16 degrees different from the original instrument. Also, the second set of bearings is more in agreement with the grid on the topographic sheet (Figs. 19-1 and 19-2). From these facts it is concluded that the instrument was not physically remounted at a new orientation, but rather, that a new and more accurate set of bearings was taken when the replacement instrument was installed. Consequently, both the original and replacement instruments should have the following bearings for pendulum motion: Longitudinal - S89E; Vertical - Down; and Transverse - N01E.

Three earthquakes have been recorded at the General Store accelerograph station, all on the original SMA-1 accelerograph (S/N 1684). Details of these records are presented in Appendix A. Summary data is given below.

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity (MM)	Peak Acceleration (g)
01-11-75	4.4	VI	0.19
06-07-75	5.2	VII	0.19
11-14-75	4.8	VI	0.10

All three of the station records are significant in earthquake engineering as they have peak accelerations of 0.05g or greater. The first two records have been digitized and processed by the USGS (Brady and Perez, 1979). Time histories of ground motion and response spectra for both of these records are presented in Appendix A.

19.2 GEOLOGY AND SEISMICITY

19.2.1 Regional Geology

A geologic map of the Petrolia region is presented in Fig. 19-4. The Petrolia region, as defined for this report, includes the area within about 60 kilometers (37 miles) of Petrolia. The geology indicated on the map was obtained from the data sources cited in Fig. 19-4. In the following discussions, the symbols in parentheses refer to the geologic units on the map.

Most of the Petrolia region lies within the California Coast Range physiographic province. This province is characterized by a series of prominent, northwest-trending mountains separated by intermountain valleys. Mountains within the range have peaks at elevations exceeding 3500 feet. The Coast Range is bordered by the Klamath Mountains province in the extreme northeast portion of the map region (Fig. 19-4). On the west, the Coast range merges with the narrow Continental Shelf, which in turn, is bordered by the steep Continental Slope of the Pacific Ocean. The town of Petrolia is located adjacent to the Mattole River near the western edge of the Coast Range province, approximately 3.5 miles east of the Pacific Ocean.

The Coast ranges in the Petrolia region are underlain principally by sedimentary rocks of the Franciscan Assemblage (KJf) and Great Valley Sequence (TK) and locally intruded by ultramafics (ub), all of which are chiefly Mesozoic in age. In places these rocks are overlain by thick sequences of sedimentary rocks of Tertiary age (Ts) and by unconsolidated Quaternary sediments (Qc and Qal) (Bailey, 1966; Bailey, Irwin and Jones, 1964; and Strand, 1962 and 1963). The adjacent Klamath Mountains province on the northeast primarily consists of marine sedimentary and metasedimentary rocks (Ju and m), which are Mesozoic and older in age and which have been intruded locally by Mesozoic granitic (gr) and ultramafic (ub) rocks (Bailey, 1966; and Irwin, 1960).

19.2.2 Local Geology

The local geology in the vicinity of Petrolia is shown by a north-south section drawn through the town of Petrolia (Geologic Cross-Section S-S' of Fig. 19-5).

Tertiary and Pre-Tertiary bedrock and local accumulations of Quaternary sediments underlie Petrolia and the immediate vicinity. Undifferentiated Cretaceous and Tertiary sedimentary rocks (TK) in the vicinity of Petrolia include mudstone, shale, graywacke and conglomerate of the Yager Formation. Younger Tertiary sedimentary rocks (Ts) include mudstone, siltstone and sandstone of the Wildcat Group. Undifferentiated Quaternary alluvium and terrace deposits (Qal), which are chiefly unconsolidted gravel, sand, silt, and clay, mantle the Tertiary deposits in the immediate vicinity of Petrolia.

19.2.3 Structure and Seismicity

The structural geology of the Petrolia region is illustrated on the Geologic Map and in Cross-Section S-S' in Figs. 19-4 and 19-5, respectively.

Petrolia is situated in the vicinity of a triple interplate junction; i.e., at the junction of three lithospheric plates - North American, Farallon, and Pacific Plates. Differential movements between the plates is occurring at their boundaries along the major transform faults of the Mendocino fracture zone and the San Andreas fault system (Atwater, 1970). Thus, Petrolia is located in a very complex tectonic area, one in which intense shearing and deformation has occurred frequently in the past, and where active movement is still occurring today.

The Tertiary rocks throughout the region have been highly deformed. Generally they are folded and faulted along west-northwesterly trends, and frequently they are in fault contact with older rock units. Large shear zones more than several thousand feet wide occur in the vicinity of Petrolia (Nason, 1968). These shear zones consist of broken and separated tectonic "clasts" in a matrix of sheared rock fragments. Commonly, shearing may not be uniform throughout the entire zone but will vary in its intensity. The shear zones appear to be major zones of adjustment in the North American plate at this triple junction.

Many of the faults shown on Fig. 19-4 have been active during Quaternary time, but only the San Andreas has a historic record of surface rupture. Ground breakage along the San Andreas occurred at Point Delgada during the 1906 San Francisco, magnitude 8.3 earthquake (Jennings, 1975; Greensfelder, 1972; and Lawson, 1908). The Little Salmon fault, the northern portion of the Freshwater fault, and all of the offshore faults show evidence of Quaternary movement. The Mendocino fracture zone, which is a major transform fault at the boundary between the Farallon and Pacific plates, follows the Gorda Escarpment, a prominent submarine ridge that trends westward from Cape Mendocino across the Pacific Ocean basin (Strand, 1962 and 1963; and Jennings, 1975).

Petrolia is in a region of very high seismic activity. Most of the larger historic earthquakes in the region have had their epicenters on or near the Mendocino fracture zone. The more significant historic earthquakes (those of Modified Mercalli Intensity VI or greater) that have occurred in the Petrolia region are listed in Table 19-1, and their approximate epicentral locations are shown on Fig. 19-4. Of the 18 events listed, seven were intensity VII's and one an intensity VIII. The largest historic shock in the region (intensity VIII) occurred on October 28, 1909, approximatley 20 miles northeast of Petrolia.

19.3 SITE CONDITIONS

Site conditions at the General Store in Petrolia were studied with a site reconnaissance, deep boring, in situ geophysical measurements, and laboratory tests. A 180-foot deep boring was drilled at a location about 65 feet northeast of the current accelerograph shelter to study the subsurface conditions. A downhole geophysical survey was performed for the full depth of the boring to obtain shear wave velocities of the materials. Soil samples retrieved from the boring were tested in the laboratory to determine their index and engineering properties. Detailed results of the field drilling and geophyical testing are presented in Appendix B, and detailed results of the laboratory tests are presented in Appendix C. Summary findings from the field and laboratory studies are discussed below.

19.3.1 Surface Features

Petrolia lies at the north side of an alluvial valley of the Mattole River (Fig. 19-1). The town is situated near the base of a 650 foot hill. The ground surface in the vicinity of the town, which is relatively flat but slopes gently to the southwest, is at an average elevation of about 100 feet MSL.

19.3.2 Subsurface Conditions

The 180-foot deep boring drilled near the General Store encountered 56 feet of alluvium overlying siltstone of the Yager Formation. These materials are generalized in the boring log of Fig. 19-6 and are briefly discussed below.

The 56 feet of alluvium at the site is composed of alternating layers of medium stiff to very hard, silty clay and very dense, silty, gravelly, fine to coarse sand. Individual layers may be up to 20 feet thick. Water contents for the sands and the clays generally ranged between 10 and 30 percent, with most values being less than 15 percent. Blow counts in the materials in the upper 30 feet were generally over 60, and below a depth of 30 feet the blow counts were in excess of 100. A shear strength value of 2.1 tsf was obtained from an unconsolidated-undrained triaxial compression test on one of the clay specimens. Shear wave velocities increased from 600 fps near the ground surface to about 1400 fps near the base of the alluvium.

Below a depth of 56 feet, the materials encountered in the boring were siltstones of the Yager Formation. These materials have been generalized into two layers, with the break indicated at a depth of 120 feet. Although the materials in both layers are similar geologically, the material above a depth of 120 feet has engineering properties more similar to a hard soil than a soft rock.

The material in the Yager Formation between depths of 56 and 120 feet was given a primary classification as a hard, silty clay with numerous fractures and slickensides, and a secondary classification as a very soft siltstone. Water content values for this material are less than 10 percent, well below the plastic limit of the soil. Blow counts are not available because only pitcher samples were taken below a depth of 60 feet. The shear wave velocity of this material increased from 1400 fps near the contact with the alluvium, to 2000 fps below a depth of 80 feet.

The material encountered in the Yager Formation below a depth of 120 feet was identified as a soft, highly-fractured siltstone which locally grades to a soft, fine-grained sandstone. Within this zone, water content values ranged from 5 to 10 percent, and the computed shear wave velocity was relatively constant at 3300 fps.

The water table was not measured in the boring since the hole was drilled using a bentonite slurry.

19.3.3 Dynamic Soil Properties

The dynamic properties of the subsurface materials were studied in the laboratory with resonant column and cyclic triaxial tests. Both types of tests were performed on the very dense, clayey sands and hard, silty clays encountered in the upper 30 feet of the boring. The strain-dependent, dynamic soil properties of shear modulus attenuation and damping ratio determined from these tests are presented in Fig. 19-6. For comparison purposes, these plots also contain commonly used relationships for "sand," "clay," and "rock" (SW-AJA, 1972; Schnabel, et al., 1971).

The laboratory shear moduli presented in Fig. 19-6 have been normalized to low-strain values (10^{-4} percent shear strain). The low-strain moduli were computed from the downhole shear wave velocities corresponding to the individual sample depths. This normalization permits direct comparison of the laboratory data with the modulus attenuation relationships proposed by others.

Review of the data in Fig. 19-6 indicates:

1) Excellent agreement exists between the modulus values determined from the resonant column and cyclic triaxial tests. The plot of these values in Fig. 19-6 indicates a relatively smooth transition from low strain to high strain.

2) The normalized moduli exhibit a somewhat lower rate of attenuation with strain than commonly used relationships (SW-AJA, 1972). This lower rate of attenuation, however, is in general agreement with the results of field tests performed at other locations (SW-AA, 1976a and 1977a).

3) The normalized resonant column moduli in the low-strain region are much lower than the values determined from the field geophysical measurements. The reason for this difference is unclear. However, assuming that the modulus attenuation rate of the laboratory data is correct, then the resonant column and cyclic triaxial test data for each sample may be adjusted by a single factor to provide better agreement with the field results. This correction factor would be on the order of 2.0 to 2.5 for the very dense sands and hard clays that were tested.

   The adjusted laboratory moduli would plot between the "clay" and "rock" curves in Fig. 19-6. This adjustment seems reasonable since the site soils are much stiffer than the soft to medium stiff soils that were used to develop the "clay" curve, but yet, they are probably not as competent as the materials upon which the "rock" curve is based. Additionally, the assumption that the rate of laboratory modulus attenuation is correct and the use of only one adjustment factor seems reasonable considering points 1 and 2, above.

4) Although there is significant scatter in the data, the laboratory damping values generally follow the "sand" curve. Considering that the site materials are stiffer than the soils used to develop the "sand" curve, lower damping values of the site materials would be expected.

TABLE 19-1

SIGNIFICANT EARTHQUAKES IN THE PETROLIA REGION[1]

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude[3] North (°)	Longitude[3] West (°)	Magnitude[4] (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral[5] Distance (miles)
A	1871	3 - 2	13:05	40.5	124	-	VII	-	20 NE
A	1890	7 - 26	01:40	40.5	124.5	-	VII	-	17 NW
A	1909	10 - 28	22:45	40.5	124	6+	VIII	-	20 NE
A	1938	9 - 11	22:11	40.3	124.8	5.5	VI	-	28 W
A	1951	10 - 7	20:11	40.3	124.8	6.0	VII	-	28 W
A	1951	11 - 14	00:40	40.4	124.0	4.9	VI	-	16 ENE
A	1952	9 - 22	03:41	40.2	124.4	5.4	VII	-	10 SW
A	1954	12 - 21	11:56	40.8	124.1	6.6	VII	-	35 NNE
A	1958	5 - 24	15:05	40.3	124.2	4.8	VI	-	5 ESE
A	1960	6 - 5	17:18	40.8	124.9	5.7	VI	-	47 NW
A	1961	4 - 5	20:05	40.1	124.8	5.0	VI	-	31 WSW
A	1967	12 - 10	04:07	40.5	124.6	5.8	VI	-	21 NW
A	1968	6 - 25	17:42	40.1	124.4	5.5	VII	-	17 SSW
A	1969	2 - 7	13:26	40.4	124.5	4.6	VI	-	13 NW
B	1973	8 - 8	18:18	40.3	124.2	4.7 (B)	VI	1	5 ESE
B	1975	1 - 11	17:37	40.22	124.26	4.4 (B)	VI	1	7 SSE
B	1975	6 - 7	00:46	40.57	124.14	5.2 (B)	VII	13	18 NNE
B	1975	11 - 14	01:30	40.62	124.31	4.8 (B)	VI	14	21 N

Notes:

1. Earthquakes selected for this tabulation have maximum intensities of VI or greater and have occurred within about 60 km (37 miles) of Petrolia. The intent of this table is to provide a general indication of the seismicity in the region; it is not a complete list of all earthquakes.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Von Hake (1973)

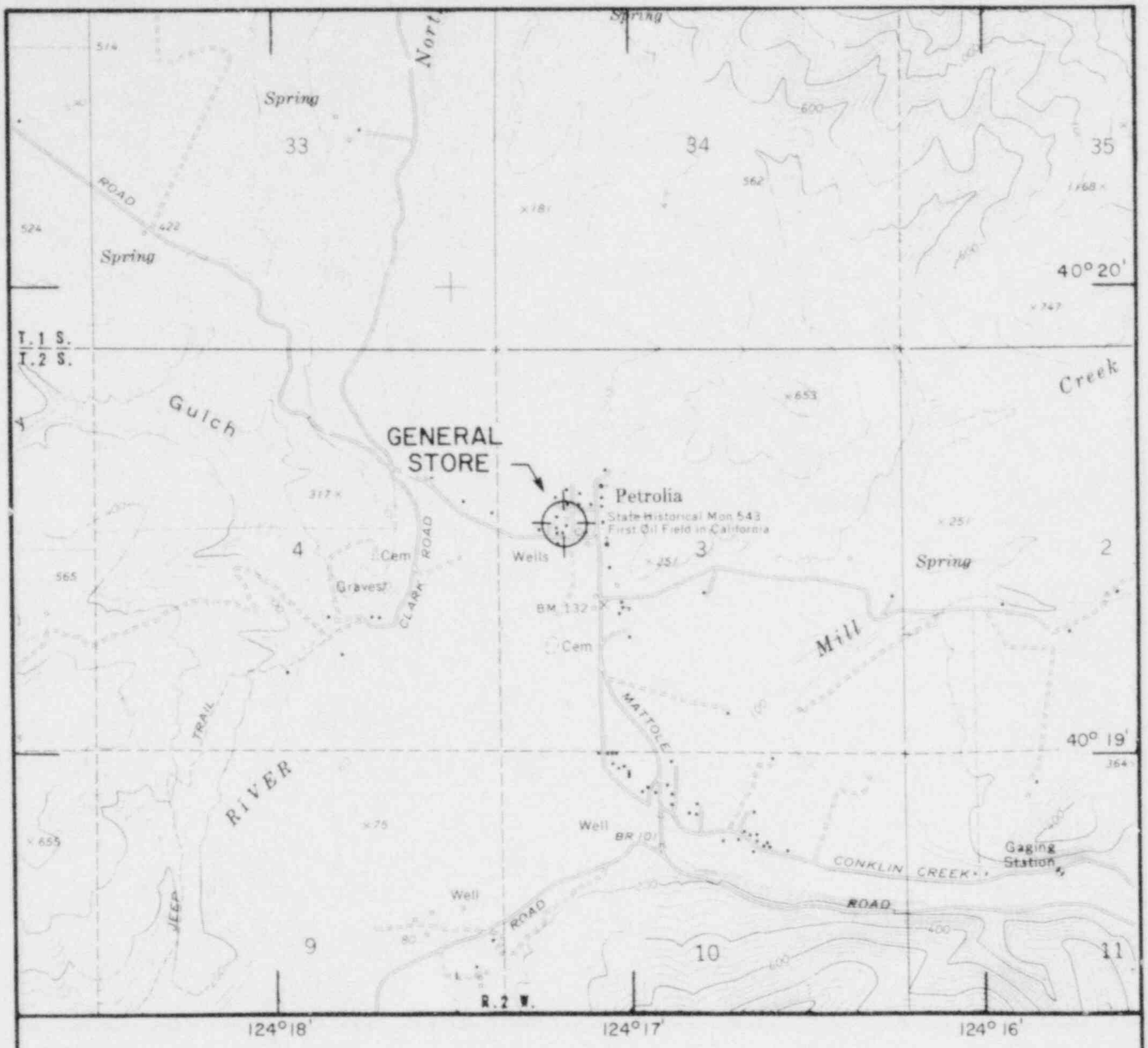
   B. United States Earthquakes

3. The range of uncertainty for epicentral locations may be taken as ± 0.5° for earthquakes prior to 1960 and as about ± 0.2° for those since 1960.

4. Magnitudes designated as B have been computed by the University of California at Berkeley.

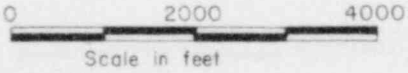
5. All distances have been scaled relative to the accelerograph station at the general store in Petrolia.

POOR ORIGINAL



GENERAL STORE

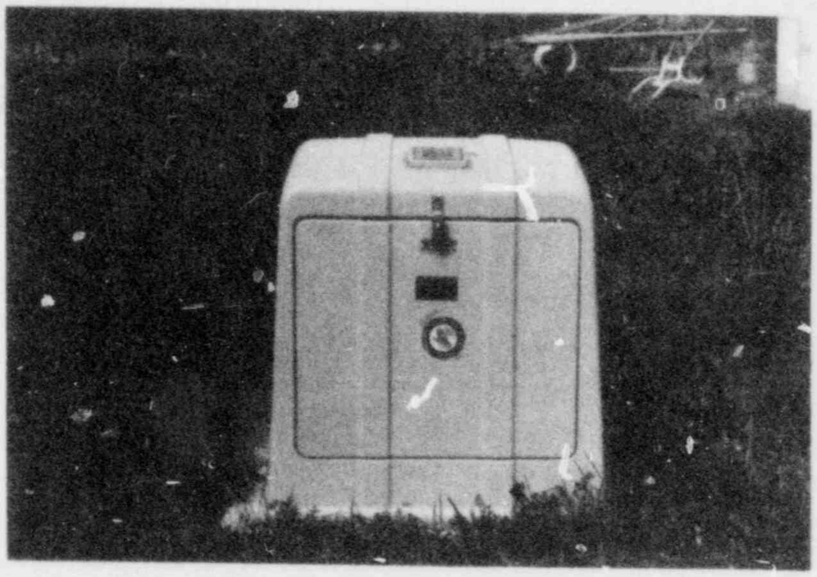
USGS Station No.:	1388
CDMG No.:	156
County:	Humbolt
USGS Topographic Quadrangle:	Petrolia, California
Coordinates:	40°19'30"N. 124 17' 10"W.
Location:	Mattole Road, Petrolia, California
Building:	Small, fiberglass instrument shelter.



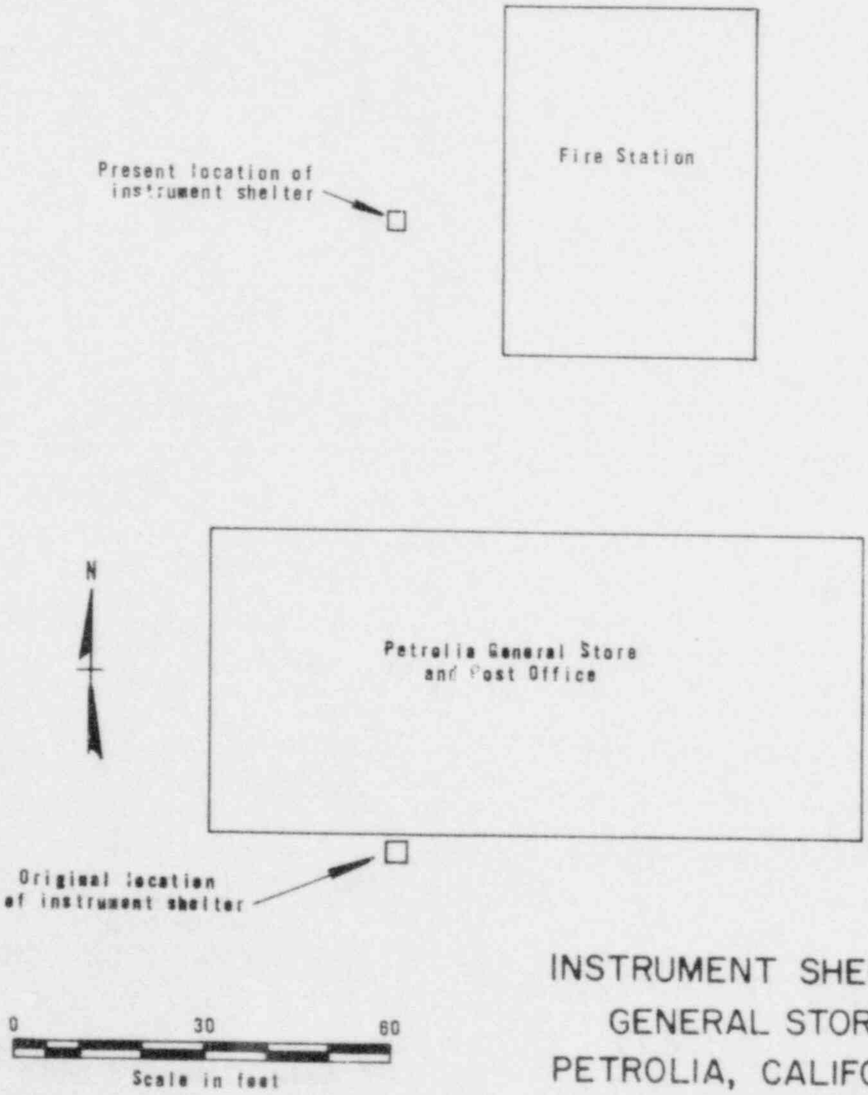
STATION LOCATION
GENERAL STORE
PETROLIA, CALIFORNIA

POOR ORIGINAL

FIG. 19-1



Present Instrument Shelter
View - East

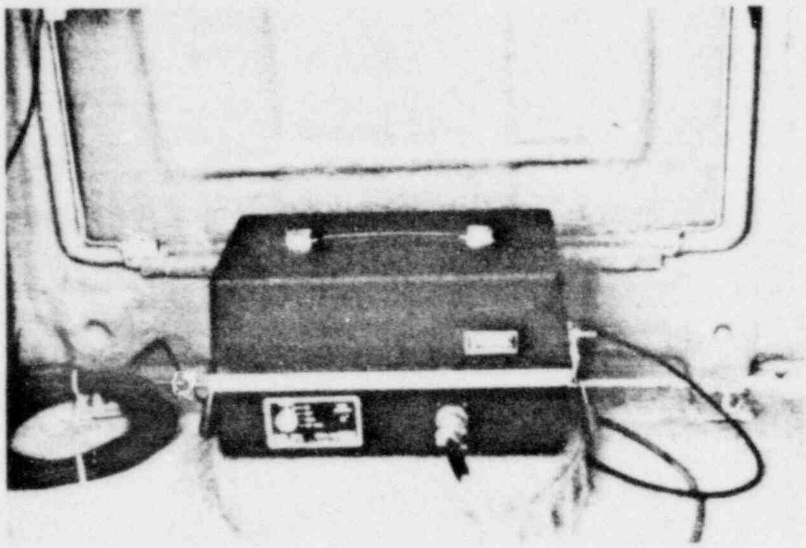


INSTRUMENT SHELTER
GENERAL STORE
PETROLIA, CALIFORNIA

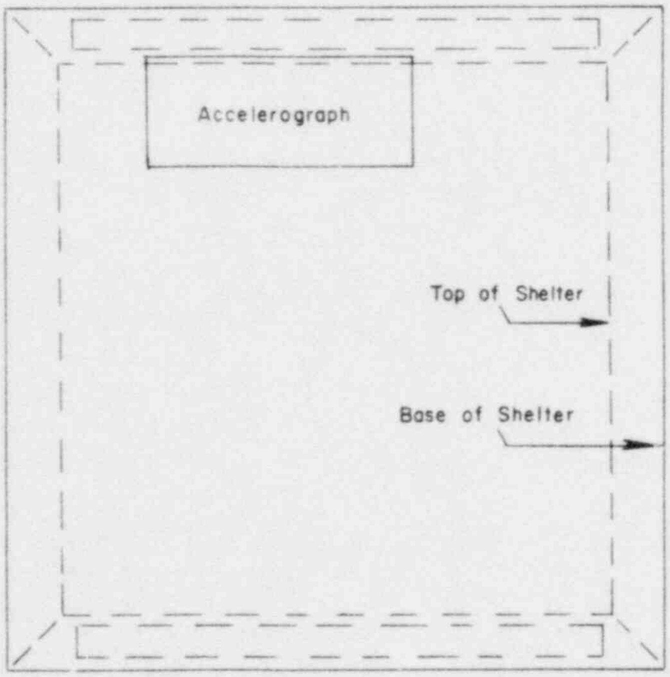
POOR ORIGINAL

FIG.19-2

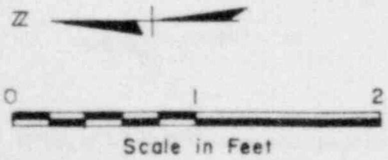
POOR ORIGINAL



SMA - I Accelerograph
General Store Instrument - Present Location

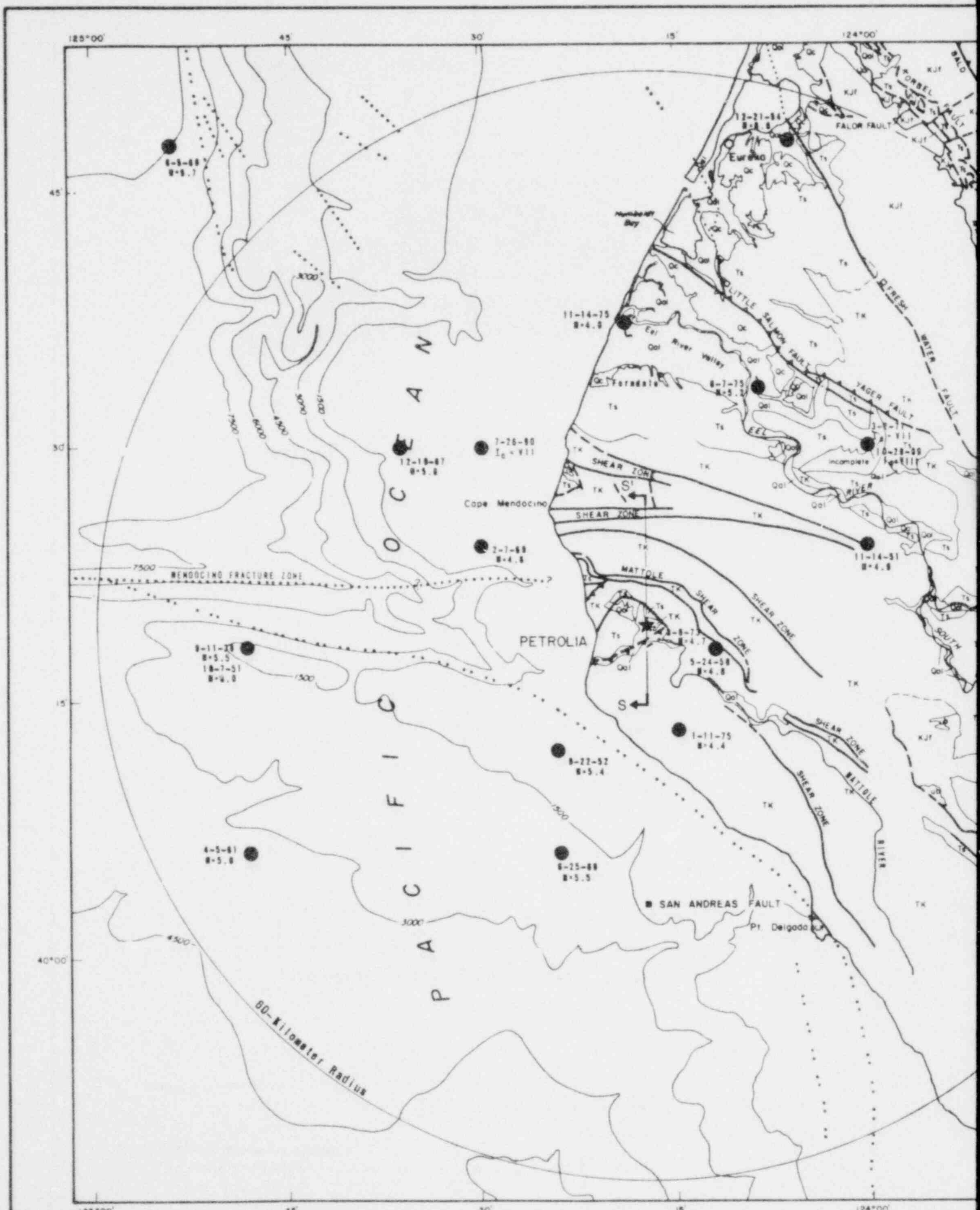


Instrument Shelter Plan - Present Location



STATION INSTRUMENTATION
GENERAL STORE
PETROLIA, CALIFORNIA

FIG.19-3



POOR ORIGINAL

EXPLANATION

Qal	Quaternary deposits. Undifferentiated alluvium, including Rohnerville Formation terrace deposits.
Qc	Upper Pleistocene Hookton Formation.
Ts	Teriatry sedimentary rocks; includes the Pullen, Eel River, Rio Dell, Scotia Bluffs and Carlotta Formations, all of the Wildcat Group.
TK	Upper Cretaceous Yager Formation; includes undifferentiated Cretaceous and Tertiary sedimentary rocks.
Ju	Upper Jurassic marine sedimentary a d metasedimentary rocks.
KJf	Mesozoic Franciscan Assemblage.
ub	Mesozoic ultramafic rocks.
gr	Mesozoic granitic rocks.
m	Pre-Cretaceous metasedimentary rocks; includes crystalline limestone.

★	Accelerograph Station location
●	Epicentral locations of selected historic earthquakes listed in Table 19-1.
11-14-75	Date of occurrence (month-day-year)
I_0=VI	Maximum Intensity (MM)
M=4.5	Magnitude (Richter)
○	Faults having moved during Quaternary time without historic record (approx. past 2 million years).
■	Faults having moved during historic time (approx. 200 years).
▲——▲	Cross-Section location.
Contact	Dashed where approximately located.
Fault	Dashed where approximately located; dotted where concealed.
Thrust Fault	Barbs on upper plate; dashed where approximately located.
Offshore Fault	Location approximate; queried where continuation is uncertain.
1500	Submarine contours.

NOTES:

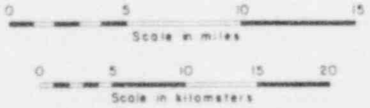
1) Geology is simplified and modified from Strand (1962) and Jennings and Strand (1960).

2) Major faults and information on fault activity is from Jennings (1975).

3) All offshore faults shown on this figure have evidence of Quaternary activity.

4) Cross-Section S-S' is shown on Fig. 19-5.

Location of Geologic Map

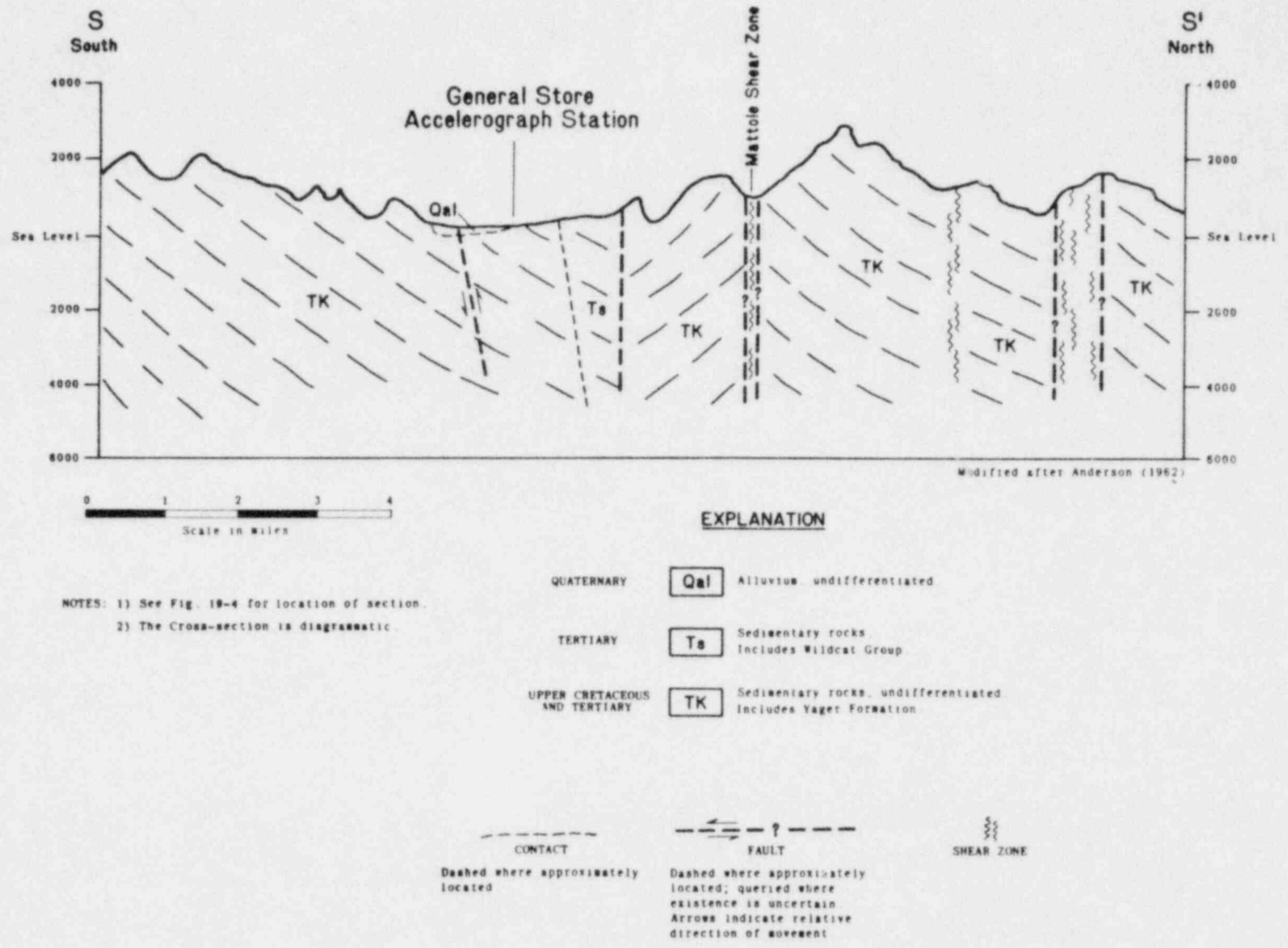


Submarine contour interval 1500 feet

GEOLOGIC MAP
GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19-4

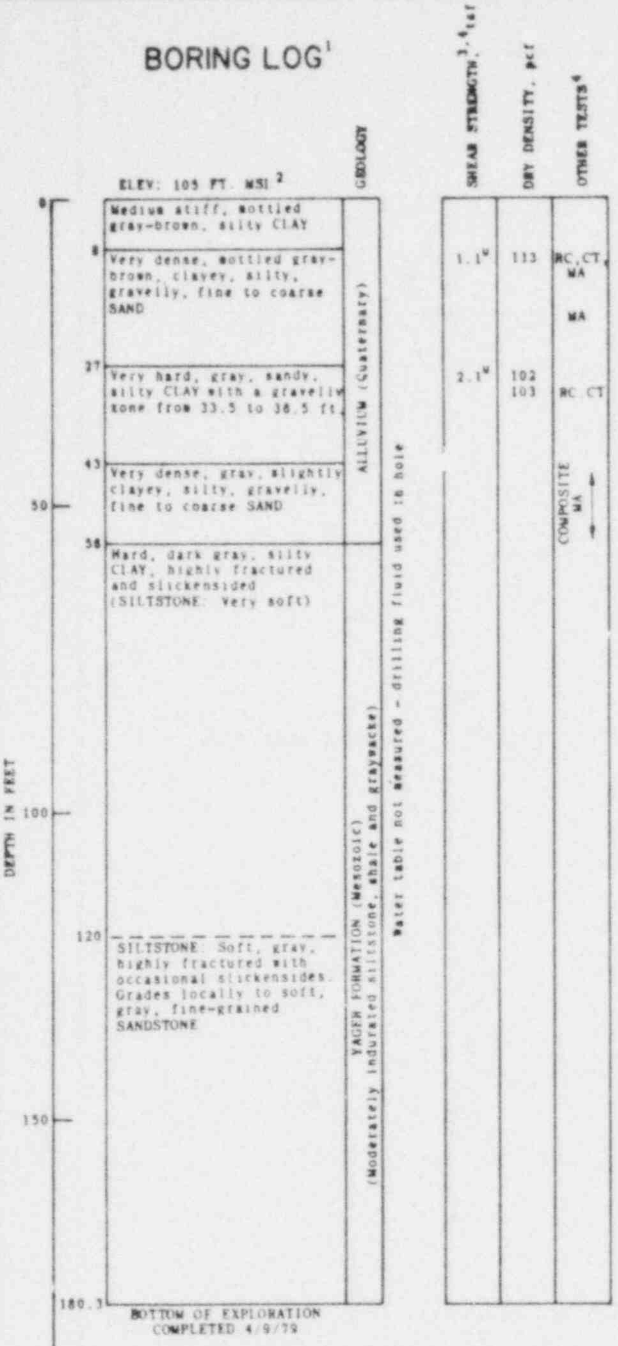
POOR ORIGINAL

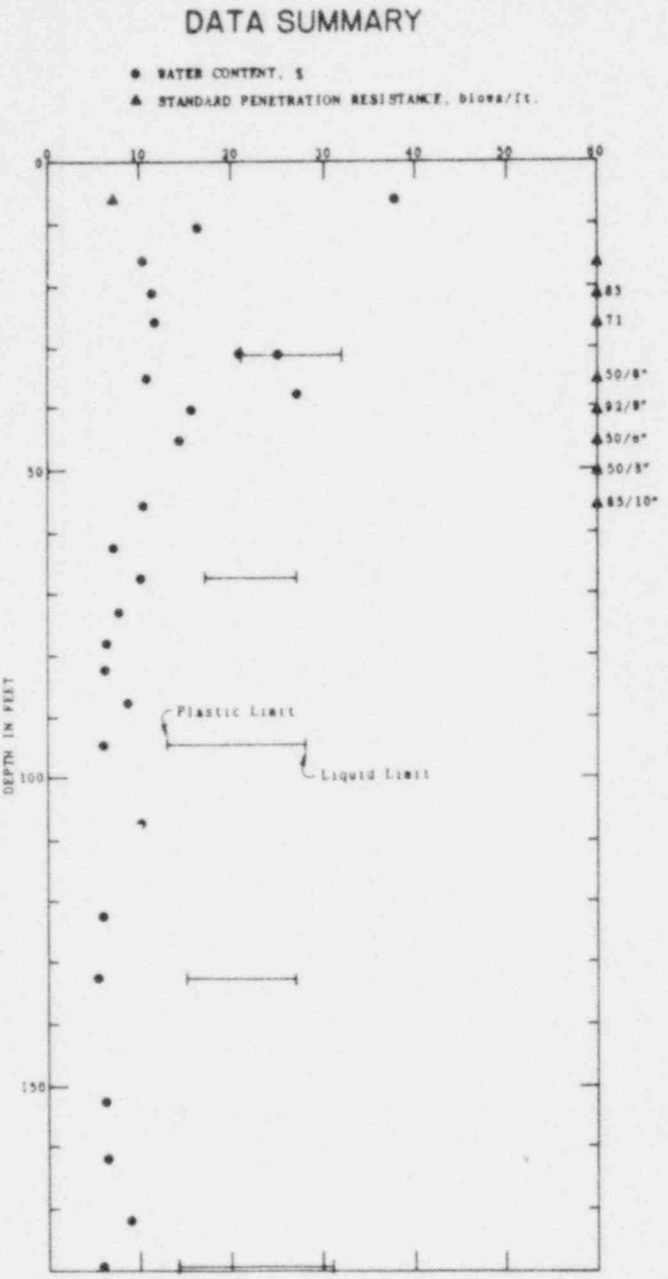


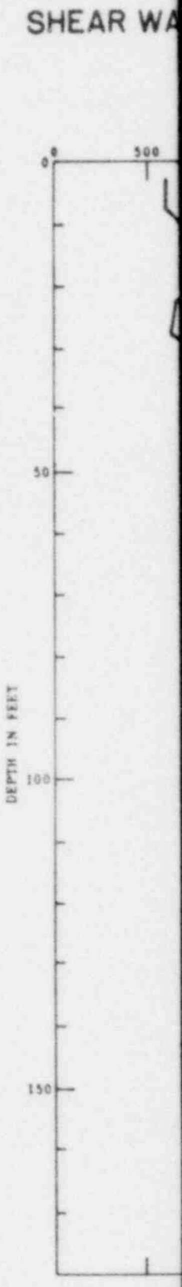
NOTES: 1) See Fig. 19-4 for location of section.
2) The Cross-section is diagrammatic.

GEOLOGIC CROSS-SECTION S-S'
GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19-5







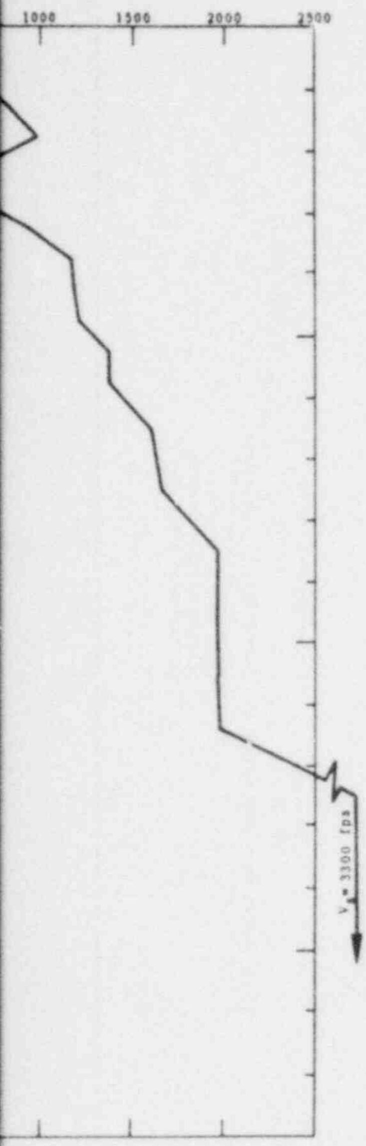
NOTES:
1) THE BORING IS LOCATED ABOUT 65 FT. NORTHEAST OF THE INSTRUMENT SHELTER AND 110 FT. NORTH OF THE GENERAL STORE. THE STRATIFICATION LINES IN THE BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES, AND THE TRANSITION MAY BE GRADUAL.
2) THE BORING ELEVATION WAS INTERPOLATED FROM THE USGS TOPOGRAPHIC QUADRANGLE "PETROLIA, CALIF." (20 FT. CONTOURS).
3) SHEAR STRENGTHS DENOTED BY "u" WERE DETERMINED FROM UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TESTS.
4) DETAILED RESULTS OF THE LABORATORY TESTS ARE PRESENTED IN APPENDIX C. TEST ABBREVIATIONS ARE AS FOLLOWS:

RC - RESONANT COLUMN
CT - CYCLIC TRIAXIAL
MA - MECHANICAL ANALYSIS (GRADATION)

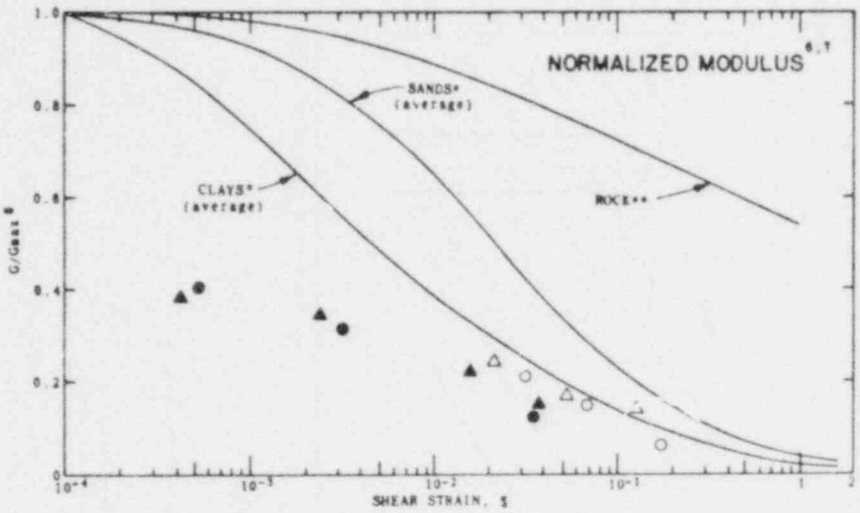
5) DETAILED RESULTS OF THE DOWNHOLE GEOPHYSICAL TESTING ARE PRESENTED IN APPENDIX B.
6) LABORATORY RESONANT COLUMN AND CYCLIC TRIAXIAL TEST DATA ARE NORMALIZED TO Gmax ($G_{max} = V_s{}^2\rho$) AS DETERMINED FROM DOWNHOLE GEOPHYSICAL SHEAR WAVE VELOCITY MEASUREMENTS.
7) NORMALIZED LABORATORY MODULI ARE UNCORRECTED FOR POSSIBLE SAMPLE DISTURBANCE.

POOR ORIGINAL

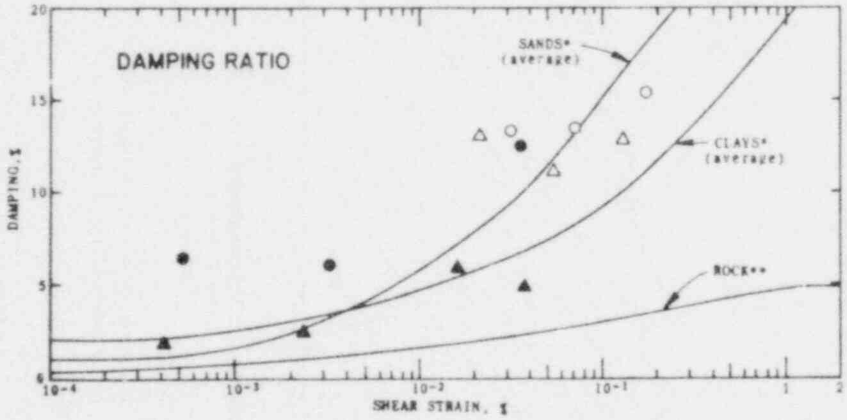
VE VELOCITY[5] – V_s (fps)



DYNAMIC PROPERTIES OF SUBSURFACE MATERIALS



RESONANT COLUMN	CYCLIC TRIAXIAL	SAMPLE DEPTH, FEET	Gmax[8] psi	V_s[6] fps
●	○	10	20,000	840
▲	△	30	23,800	940



* FROM SW-AJA (1972)
** FROM SCHNABEL, et al. (1971)

BORING LOG AND
SUMMARY OF TEST RESULTS
GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19-6

Section 20

City Hall
Hollister, California

SECTION 20

CITY HALL, HOLLISTER, CALIFORNIA

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CITY HALL, HOLLISTER, CALIFORNIA

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SECTION 20
CITY HALL
HOLLISTER, CALIFORNIA

20.1 STATION DESCRIPTION

20.1.1 Location and Building

Hollister, a small town in western California, is located in San Benito County about 80 miles southeast of San Francisco and 20 miles east of Monterey Bay.

The accelerograph station in Hollister is located in the City Hall building, which was formerly the Carnegie Library. The City Hall building, at 375 Fifth Street, is about 300 feet west of the intersection of Fifth and San Benito Streets (Fig. 20-1).

The City Hall is a one-story, reinforced concrete structure with a daylight basement (Fig. 20-2). The building is rectangular in plan, with dimensions of about 30 by 65 feet. The exterior walls of the structure on the front and sides are 12 inches thick. The exterior wall in the back is about 6 inches thick and contains several pilasters for additional support. The daylight basement of the building has a depth of embedment of about 3 feet on all sides.

20.1.2 Instrumentation and Earthquake Recordings

The accelerograph station at the City Hall has been owned and maintained by the USGS and is identified as station number 1028 in the USGS strong motion instrument network. Recently, the USGS has stopped maintaining the station, anticipating that this site or one nearby may be incorporated in the California Division of Mines and Geology Strong Motion Instrumentation Program.

Instrumentation at the City Hall (Carnegie Library) includes a succession of Coast and Geodetic Survey (C&GS) standard accelerographs. The site was initially instrumented on February 11, 1947, with a C&GS standard accelerograph (S/N 23) recording on 6-inch photographic paper. This instrument was replaced in August 1947 with unit S/N 27, which remained in place until November 8, 1950, when it was replaced with instrument S/N 16. Instrument S/N 16 was replaced on July 9, 1952, with a 12-inch, C&GS standard accelerograph (S/N 24) which had a Carder Displacement Meter. This unit is currently at the site today. All of the standard accelerographs at the station have had the following orientations for pendulum motion (USGS, unpub.): Longitudinal - S01W; Vertical - Up; and Transverse - N89W.

In addition to the standard accelerographs, several other instruments, including a seismoscope and newer type accelerographs, have been installed at the site. On July 27, 1959, seismoscope S/N 1607 was installed at the City Hall and remains at this station today. An AR-240 accelerograph was at the site from August to October 1963 and from June 1964 to June 1970. An MO-2 accelerograph also was in operation at the station between August 1966 and June 1968. A third accelerograph at the site was an RFT-250, which remained in service from June 1967 to June 1970. All these accelerographs were prototype models which were evaluated under field conditions at the station.

All instrumentation at the City Hall has been located in the northwest corner of the basement (Fig. 20-2). A plan of the accelerograph room and a photo of the current instrumentation are shown in Fig. 20-3. All of the standard accelerographs at the site have been bolted to a concrete pier which is about 1.5 feet high. Floor level in the basement is about 3 feet below the adjacent outside grade.

Over 70 earthquakes have been recorded at the City Hall accelerograph station. Of these station records, only seven are of significance in earthquake engineering since they have peak accelerations of 0.05g or greater. Details of these seven events, including ground motion time histories and response spectra plots for the processed records, are presented in Appendix A. Summary data is given below.

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity (MM)	Peak Acceleration (g)
03-09-49	5.3	VII	0.19
04-25-54	5.25	VIII	0.06
09-04-55	5.8	VII	0.05
01-19-60	5.1	VI	0.06
04-08-61	5.6	VII	0.16
04-08-61	5.6	VII	0.08
11-28-74	5.2	VI	0.17

20.1.3 Other Installations

The first accelerograph station in Hollister was located in the county courthouse building. The courthouse is located on the northwest corner of Fifth and Monterey Streets, about 300 feet northwest of the City Hall. The station was established on June 8, 1940, when a Weed accelerograph (S/N 8) was installed at grade level in the southeast corner of the building. This instrument remained at the site until about 1947 when the station was abandoned. During this period, the accelerograph recorded several earthquakes.

The county courthouse building is a three-story structure founded at grade. The building is rectangular in plan, with dimensions of about 92 by 72 feet. The structure was built of brick and strap iron reinforcement in 1887. Although the building is founded at grade, its lowest level may be called the ground floor, first floor or basement level, interchangeably.

20.2 GEOLOGY AND SEISMICITY

20.2.1 Regional Geology

A geologic map of the Hollister region is presented in Fig. 20-4. The Hollister region, as defined for this report, includes the area within about 60 kilometers (37 miles) of Hollister. The geology indicated on the map was obtained from the data sources cited in Fig. 20-4. In the following discussions, the symbols in parentheses refer to the geologic units on the map.

Hollister is situated in the California Coast Range physiographic province. This province is characterized by a series of northwest-trending mountain ranges, such as the Gabilan and Diablo Ranges, separated by narrow valleys. Mountains within the Gabilan and Diablo ranges have peaks at elevations exceeding 3500 feet. The Coast Range province is bounded on the east by the Great Valley province and on the west by the Pacific Ocean. The town of Hollister is located in the Santa Clara Valley approximately 20 miles east of the Pacific Ocean.

Basement rocks in the Coast ranges include two distinct lithologic types that, generally, are separated by the northwest-trending San Andreas fault zone. West of the San Andreas fault, Mesozoic granitic intrusive rocks (gr) predominate with some pre-Cretaceous metamorphic and metasedimentary rocks (m) locally occurring as roof pendants. East of the fault, the area is underlain by sedimentary rocks of Jurassic-Cretaceous age, including the Franciscan Assemblage (Mz), which is a heterogeneous assemblage of sedimentary and volcanic rocks of eugeosynclinal origin (Page, 1966). Cretaceous (K) and Tertiary (Ts) shallow-water marine sedimentary rocks and Tertiary volcanic rocks (Tv) overlie the two basement complexes and, in turn, are overlain by Plio-Pleistocene non-marine sedimentary rocks (QP) and Pleistocene and Holocene marine and non-marine deposits (Qt,Qf, and Qal).

20.2.2 Local Geology

The local geology in the vicinity of Hollister is depicted on Geologic Cross-Section T-T' of Fig. 20-5. This northeast-trending section passes approximatley 1.5 miles southeast of the City Hall accelerograph station.

Cross-Section T-T' shows that granitic basement rocks (gr) underlie the area west of the San Andreas fault. East of the fault, the town of Hollister is underlain by basement rocks of the Franciscan Assemblage (Mz) which are unconformably overlain by Cretaceous and Tertiary sedimentary rocks. The Cretaceous sedimentary rocks (K) include sandstone, shale and conglomerate. The Tertiary units are represented by relatively poorly consolidated clay, silt, sand, and gravel of the Purisima Formation (Ts) and a series of undifferentiated Tertiary volcanics (Tv).

Quaternary alluvial deposits (Qal) unconformably overlie the Mesozoic and Cenozoic rocks in the Santa Clara and San Benito River Valleys. These alluvial sediments primarily consist of gravel, sand and clay. Locally, the San Benito gravels have been consolidated into conglomerate, sandstone, and clay-shale.

20.2.3 Structure and Seismicity

The structural geology of the Hollister region is illustrated on the Geologic Map and in Cross-Section T-T' in Figs. 20-4 and 20-5, respectively.

Structural conditions differ markedly east and west of the San Andreas fault. East of the fault the Mesozoic (Mz and K) and Cenozoic (Ts and Tv) rocks have been compressed and folded into a series of northwest-trending synclines and anticlines that are broken by numerous northwest-trending, high-angle faults. West of the San Andreas fault, the Mesozoic granitic rocks (gr) and associated metamorphics are not significantly deformed.

Several faults in the Hollister region (Fig. 20-4) have historic records of surface rupture. These include the Hayward, Calaveras, and San Andreas faults (Jennings, 1975). Fault movement occurred along the San Andreas in the Hollister region in 1857(?), 1890, and 1906. In addition to ground rupture caused by earthquakes, the San Andreas fault zone reveals evidence of tectonic creep or slippage, a type of movement along a fault not usually accompanied by felt earthquakes. The Calaveras fault zone in the vicinity of Hollister also shows evidence of tectonic creep or slippage.

Many other faults in the area show evidence of Quaternary displacement but have no recorded historic activity. These include the Bear Valley, Carmel Canyon, King City, Ortigalita, Paicines, Pine Rock, San Benito, Sargent, Shannon, Silver Creek, and Tularcitos faults (Jennings, 1975). In addition, several unnamed faults show evidence of Quaternary displacement.

Hollister is in a region of relatively high seismic activity. The more significant historic earthquakes (those of Modified Mercalli Intensity VII, or greater) that have occurred in the region are listed in Table 20-1 and their approximate epicentral locations are shown on Fig. 20-4. Of the 17 events listed, four had maximum intensities of VIII. These events, which occurred in 1897, 1911, 1926 and 1954, were located at distances of approximately 12 to 35 miles from Hollister. The most significant earthquake in this part of California is the San Francisco earthquake of April 18, 1906, which occurred outside the Hollister region. This earthquake, which was centered on the San Andreas fault about 100 miles northwest of Hollister, had a maximum intensity of XI and a magnitude of 8.3.

20.3 SITE CONDITIONS

Site conditions at the City Hall were studied with a site reconnaissance, deep boring, in situ geophysical measurements, and laboratory tests. A 349-foot deep boring was drilled at a location about 700 feet west of the City Hall to study the subsurface conditions. A downhole geophysical survey was performed for the full depth of the boring to obtain shear wave velocities of the soils. Soil samples retrieved from the boring were tested in the laboratory to determine their index and engineering properties. Detailed results of the field drilling and geophysical testing are presented in Appendix B, and detailed results of the laboratory tests are presented in Appendix C. Summary findings from the field and laboratory studies are discussed below.

20.3.1 Surface Features

Hollister is situated at the southern end of the alluviated Santa Clara Valley at an average elevation of 290 ft. MSL (Fig. 20-1). The mountain ranges east and west of Hollister rise to elevations in excess of 2500 feet. The City Hall lies about 1000 feet southeast of the base of a 400-foot hill. The ground surface in the vicinity of the City Hall is relatively flat at an elevation of approximately 285 ft. MSL.

20.3.2 Subsurface Conditions

The 349-foot deep boring near the City Hall was drilled entirely within alluvial sediments and did not encounter rock. The strata encountered in the drilling are generalized in the boring log of Fig. 20-6 and are briefly discussed below.

The surficial 86 feet of material encountered in the boring consisted of stiff to very stiff, silty clay. Blow counts in the upper 50 feet of this material were generally less than 10, while below this depth the blow counts ranged from 20 to 50. Water contents of this material ranged from 20 to 40 percent and were close to the plastic limit values of the soil. The results from unconsolidated-undrained triaxial compression tests indicate soil shear strengths on the order of 0.7 to 2.3 tsf. Shear wave velocities increased from 500 fps at the ground surface to 900 fps at depth.

Materials between depths of 86 and 183 feet were very dense, silty, gravelly, sands interbedded with hard, sandy, clayey silts. These materials had blow counts generally greater than 100 and water content values in the range of 10 to 25 percent. Only one unconsolidated-undrained triaxial compression test was performed on this material for a shear strength of 2.5 tsf. Shear wave velocities generally increased with depth in this zone, from 900 fps to 1250 fps.

A very dense, fine to coarse sand with occasional hard, silty clay layers as thick as 33 feet, was encountered below a depth of 183 feet to the base of the boring at 349 feet. Similar to the overlying soils, materials in this zone had blow counts of over 100 and water content values ranging from 10 to 25 percent. However, the shear wave velocity increased from 1700 fps near the top of the stratum, to a relatively constant value of 2000 fps below a depth of approximately 200 feet.

The water table was not measured in the boring since the hole was drilled using a bentonite slurry.

20.3.3 Dynamic Soil Properties

The dynamic properties of the subsurface materials were studied in the laboratory with resonant column and cyclic triaxial tests. Both types of tests were performed on the hard silts and clays encountered in the boring at depths from 20 to 305 feet. The strain-dependent, dynamic soil properties of shear modulus attenuation and damping ratio determined from these tests are presented in Fig. 20-6. For comparison purposes, these plots also contain commonly used relationships for "sand," "clay" and "rock" (SW-AJA, 1972; Schnabel, et al., 1971).

The laboratory shear moduli presented in Fig. 20-6 have been normalized to low-strain values (10^{-4} percent shear strain). The low-strain moduli were computed from the downhole shear wave velocities corresponding to the individual sample depths. This normalization permits direct comparison of the laboratory data with the modulus attenuation relationships proposed by others.

Review of the data in Fig. 20-6 indicates:

1) With one exception, good to excellent agreement exists between the modulus values determined from the resonant column and cyclic triaxial tests. The plot of these values in Fig. 20-6 indicates a relatively smooth transition from low strain to high strain.

2) For several of the samples tested, the normalized moduli exhibit a somewhat lower rate of attenuation with strain than commonly used relationships (SW-AJA, 1972). This lower rate of attenuation, however, is in general agreement with the results of field tests performed at other locations (SW-AA, 1976a and 1977a).

3) For three of the five test specimens, the normalized resonant column moduli in the low-strain region are much lower than the values determined from the field geophysical measurements. The reason for this difference is unclear. However, assuming that the modulus attenuation rate of the laboratory data is correct, then the resonant column and cyclic triaxial test data for each sample may be adjusted by a single factor to provide better agreement with the field results. This correction factor would be on the order of 2 to 4 for the samples from depths of 20, 140 and 305 feet.

   The adjusted labortory moduli would plot between the "clay" and "rock" curves in Fig. 20-6. This adjustment seems reasonable since the site soils are much stiffer than the soft to medium stiff soils that were used to develop the "clay" curve, but yet, they are probably not as competent as the materials upon which the "rock" curve is based. Additionally, the assumption that the rate of laboratory modulus attenuation is correct and the use of only one adjustment factor for each test seems reasonable considering points 1 and 2, above.

4) Moduli values corresponding to the silt sample from a test depth of 40 feet seem reasonable without any adjustment. The laboratory modulus attenuation for this material is continuous and it falls between the "clay" and "rock" curves. Consequently, moduli adjustments do not seem necessary.

5) Damping values determined in the cyclic triaxial test all cluster around the "clay" curve. Considering that the site materials are stiffer than the soils used to develop the "clay" curve, lower damping values of the site materials would be expected.

TABLE 20-1

SIGNIFICANT EARTHQUAKES IN THE HOLLISTER REGION[1]

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude[3] North (°)	Longitude[3] West (°)	Magnitude[4] (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral[5] Distance (miles)
A	1885	3 - 30	23:56	36.5	121	-	VII	-	34 SE
A	1890	4 - 24	03:36	37	121.5	-	VII	-	12 NNW
A	1897	6 - 20	12:14	37	121.5	-	VIII	-	12 NNW
A	1911	7 - 1	14:00	37	122	6.6	VII-VIII	-	35 WNW
A	1914	11 - 8	18:31	37	122	-	VII	-	35 WNW
A	1916	8 - 6	11:38	36.5	121	-	VII	-	34 SE
A	1926	10 - 22	{04:35 05:35}	36.75	122	6.1	VIII	-	35 WSW
A	1939	6 - 24	05:02	36.8	121.4	5.25	VII	-	4 S
A	1948	12 - 31	17:18	36.9	121.6	4.5	VII	-	11 WNW
A	1949	3 - 9	04:29	37.0	121.5	5.3	VII	-	12 NNW
A	1954	4 - 25	12:33	36.9	121.7	5.25	VIII	-	17 W
A	1955	9 - 4	18:01	37.4	121.8	5.8	VII	-	44 NNW
A	1960	1 - 19	19:26	36.8	121.4	5.1	VI	-	4 S
A	1961	4 - 8	{23.23 23.26}	36.7	121.3	5.6	VII	-	13 SSE
A	1963	9 - 14	{11:46 12:28}	36.8	121.6	5.4	VII	-	12 WSW
A	1964	11 - 15	18:47	37.0	121.7	5-5.25	VII	-	19 NW
B	1974	11 - 28	15:01	36.91	121.50	5.2 (B)	VI	6	6 NW

Notes:

1. Earthquakes selected for this tabulation generally have maximum intensities of VII or greater and have occurred within about 60 km (37 miles) of Hollister. The intent of this table is to provide a general indication of the seismicity in the region; it is not a complete list of all earthquakes.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Von Hake (1973)

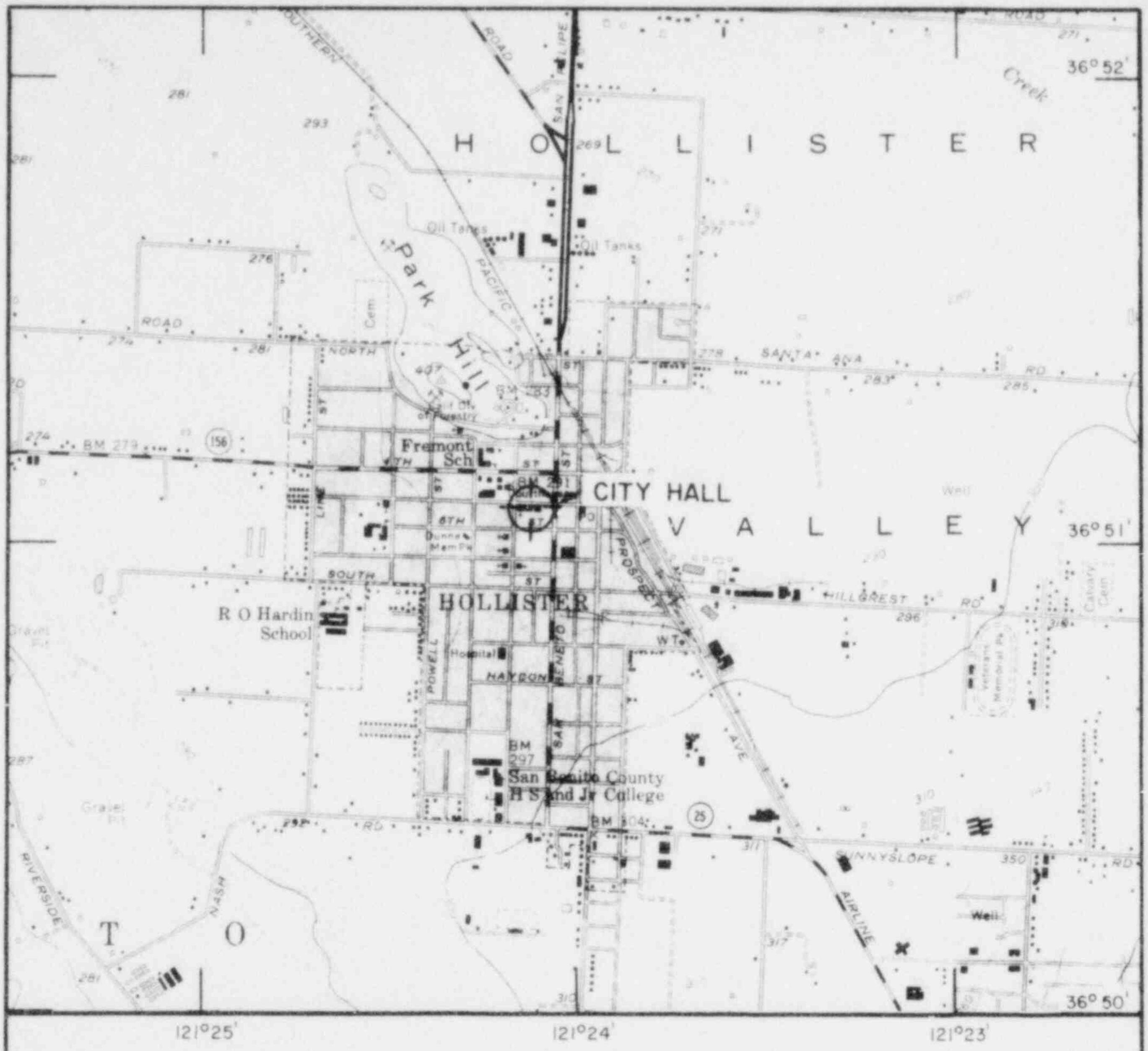
   B. United States Earthquakes

3. The range of uncertainty for epicentral locations may be taken as ± 0.5° for earthquakes prior to 1960 and as about ± 0.2° for those since 1960.

4. Magnitudes designated as B have been computed by the University of California at Berkeley.

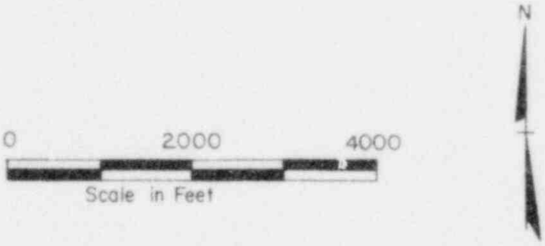
5. All distances have been scaled relative to the accelerograph station at the City Hall.

POOR ORIGINAL



CITY HALL

USGS Station No.:	1028
County:	San Benito
USGS Topographic Quadrangle:	Hollister, California
Coordinates:	36°51'05"N. 121°24'07"W.
Location:	375 Fifth St. (approx. 300 ft. west of the intersection of Fifth and San Benito Sts.)
Building.	One story with a daylight basement; reinforced concrete construction.

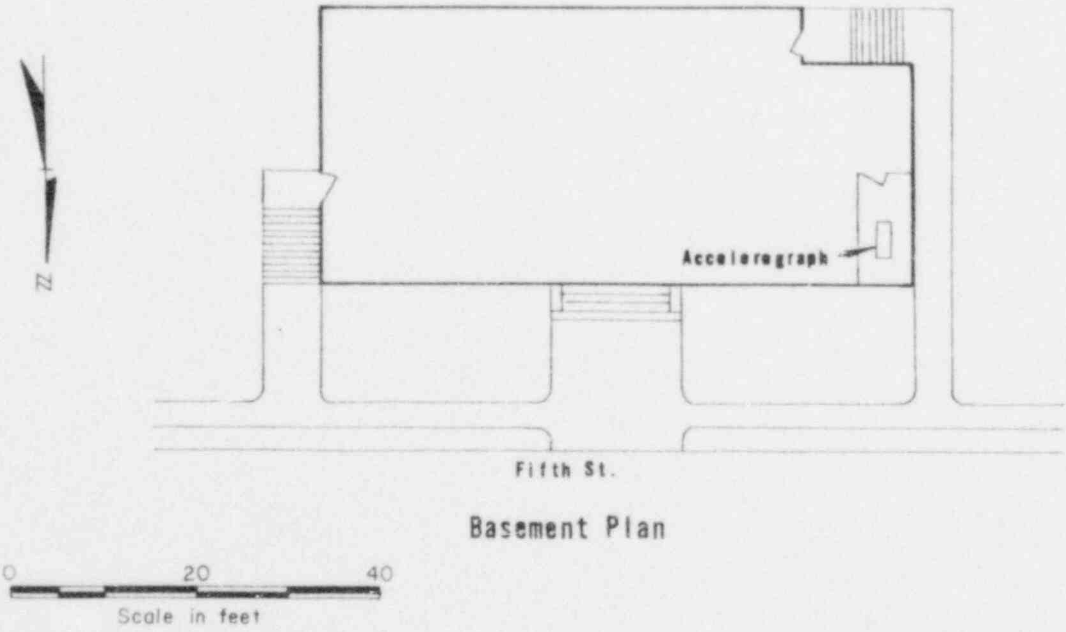


POOR ORIGINAL

STATION LOCATION
CITY HALL
HOLLISTER, CALIFORNIA

FIG.20-1

City Hall
View - South



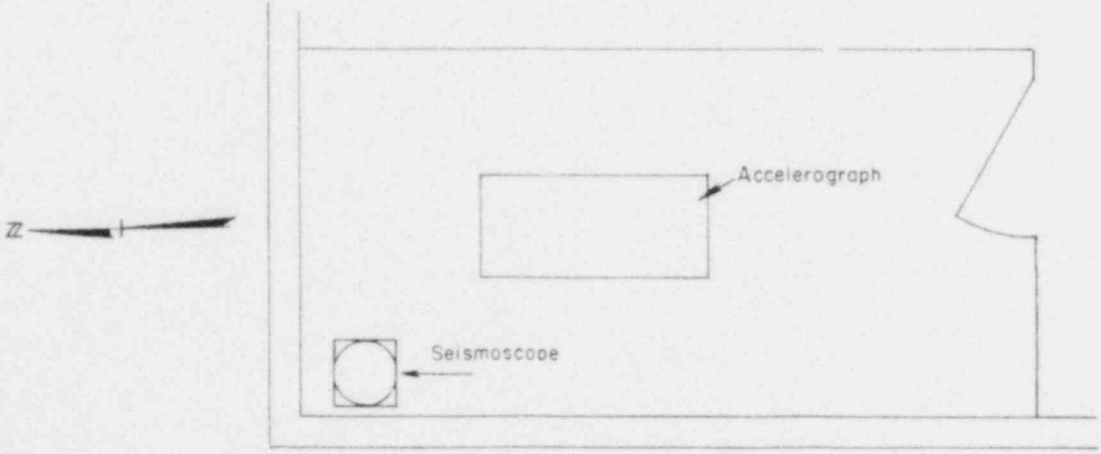
Basement Plan

POOR ORIGINAL

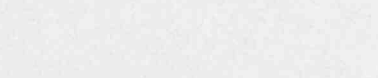
BUILDING PLAN
CITY HALL
HOLLISTER, CALIFORNIA

FIG.20-2

C & GS Standard Accelerograph
City Hall - Basement



Accelerograph Room Plan — Basement

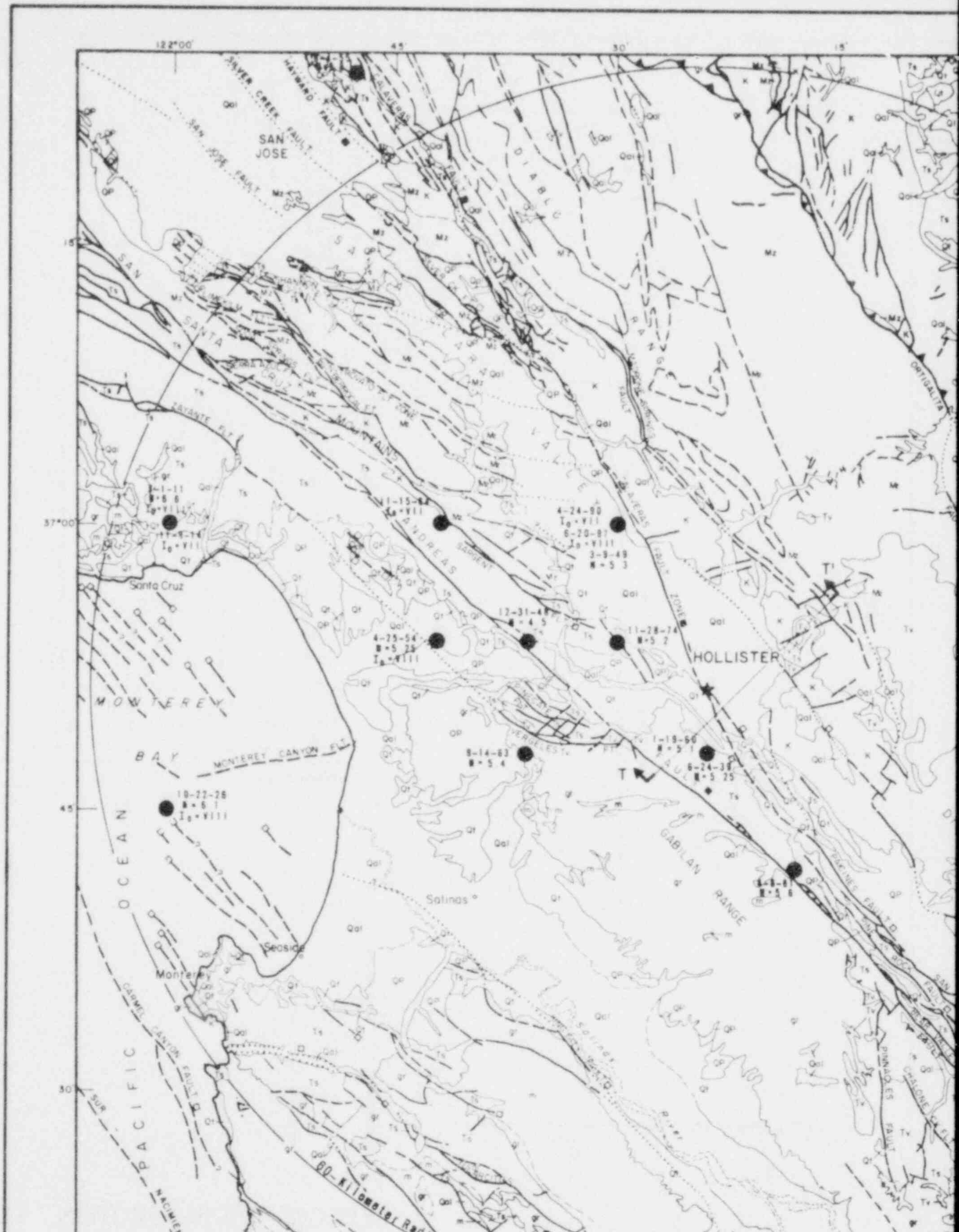


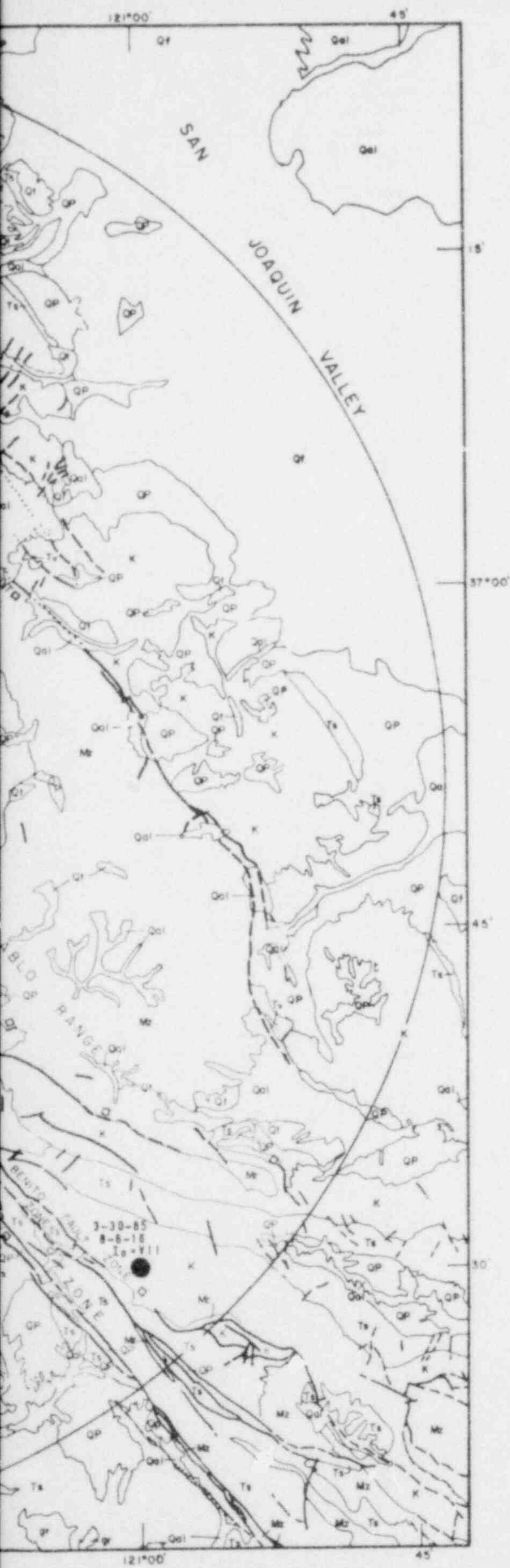
POOR ORIGINAL

STATION INSTRUMENTATION
CITY HALL
HOLLISTER, CALIFORNIA

FIG.20-3

POOR ORIGINAL





EXPLANATION

Qal	Holocene alluvium; includes some dune deposits.	K	Cretaceous sedimentary rocks.
Qf	Holocene stream channel, fan, and basin deposits.	Mz	Mesozoic sedimentary rocks; includes volcanic and metamorphic rocks of the Franciscan Assemblage.
Qt	Quaternary marine and nonmarine terrace deposits, includes some upper Pliocene marine deposits.	gr	Mesozoic granitic rocks; also includes some pre-Cenozoic metamorphic, volcanic, and ultramafic rocks.
QP	Plio-Pleistocene nonmarine sedimentary deposits; includes some Pleistocene volcanic rocks.	m	Pre-Cretaceous metamorphic and metasedimentary rocks.
Tv	Tertiary volcanic and igneous intrusive rocks.		
Ts	Tertiary sedimentary rocks		

★	Accelerograph Station location.	Contact	Dashed where approximately located
●	Epicentral locations of selected historic earthquakes listed in Table 20-1.	Fault	Dashed where approximately located, dotted where concealed, queried where existence is uncertain.
11-28-74	Date of occurrence (month-day-year)		
I_0 = VI	Maximum Intensity (MM)	Thrust Fault	Barbs on upper plate, dashed where approximately located, dotted where concealed.
M = 5.2	Magnitude (Richter)		
□	Faults that have moved during Quaternary time without historic record (approx. past 2 million years).		Cross-section location.
■	Faults that have moved during historic time (approx. 200 years).		

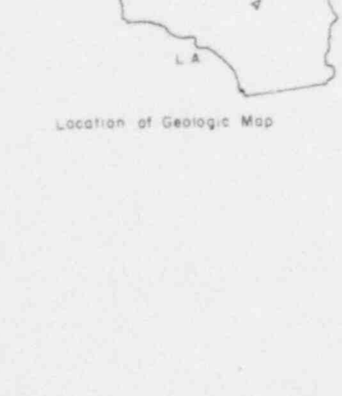
NOTES:

1) Geology is simplified and modified form Jennings and Strand (1958), Jennings and Burnett (1961), and Rogers (1966).

2) Major faults and information on fault activity is from Jennings (1975).

3) Individual faults within the San Andreas fault zone show evidence of Quaternary and historic activity. (See Jennings, 1975, for details).

4) Cross-Section T-T' is shown on Fig. 20-5.

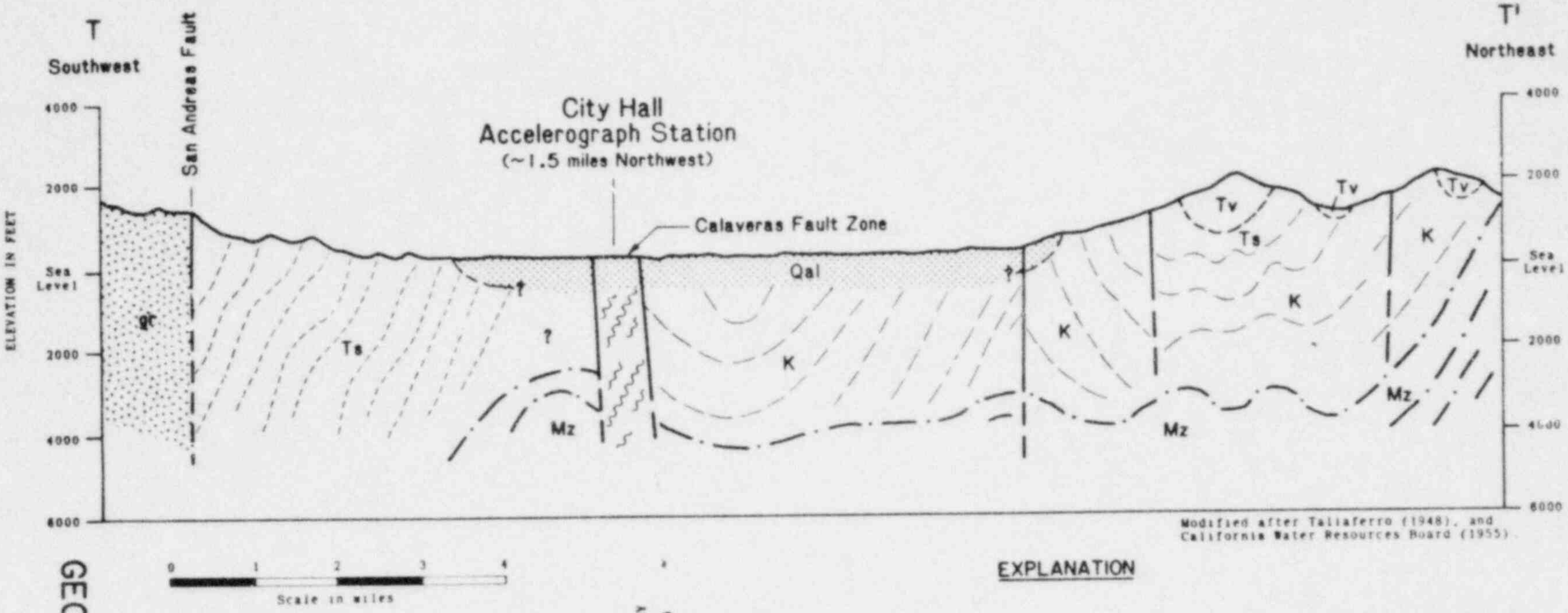


Location of Geologic Map

GEOLOGIC MAP
CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20-4

POOR ORIGINAL



Modified after Taliaferro (1948), and California Water Resources Board (1955).

NOTE: See Fig. 20-4 for location of section.

EXPLANATION

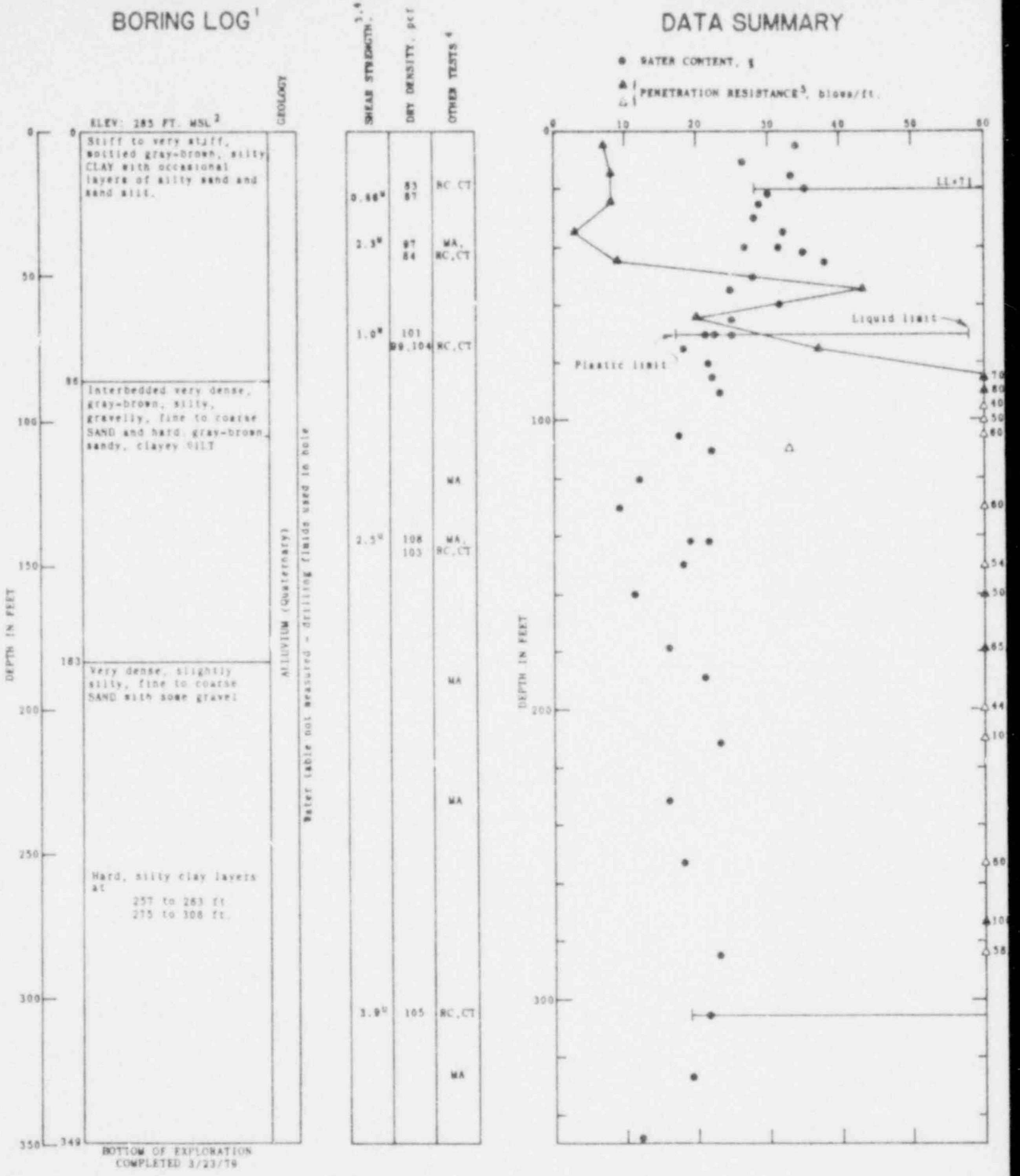
QUATERNARY	Qal	Alluvium Includes dune deposits and marine and non-marine deposits.
TERTIARY	Tv	Volcanic and igneous intrusive rocks.
	Ts	Sedimentary rocks.
MESOZOIC	K	Sedimentary rocks.
	Mz	Sedimentary rocks. Includes volcanic and metamorphic rocks of the Franciscan Assemblage.
	gr	Granitic rocks. Includes some metamorphic, volcanic and ultramafic rocks.

CONTACT	Dashed where approximately located; queried where existence is uncertain
FAULT	Dashed where approximately located.
SHEAR ZONE	

GEOLOGIC CROSS-SECTION T-T'
CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20-5

POOR ORIGINAL



NOTES: 1) THE BORING IS LOCATED ABOUT 700 FT. WEST OF THE CITY HALL. THE STRATIFICATION LINES IN THE BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES, AND THE TRANSITION MAY BE GRADUAL.

2) THE BORING ELEVATION WAS INTERPOLATED FROM THE USGS TOPOGRAPHIC QUADRANGLE "HOLLISTER, CALIF." (10 FT. CONTOURS).

3) SHEAR STRENGTHS DENOTED BY "u" WERE DETERMINED FROM UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TESTS.

4) DETAILED RESULTS OF LABORATORY TESTS ARE PRESENTED IN APPENDIX C. TEST ABBREVIATIONS ARE AS FOLLOWS:

RC - RESONANT COLUMN
CT - CYCLIC TRIAXIAL
MA - MECHANICAL ANALYSIS (GRADATION)

5) PENETRATION RESISTANCES ARE BASED ON DRIVING A 2-INCH O.D. SPLIT SPOON SAMPLER WITH:

▲ - 140 LB. HAMMER DROPPED 30 INCHES
△ - 285 LB. DOWN HOLE HAMMER (SLIP JARS) DROPPED 18 INCHES

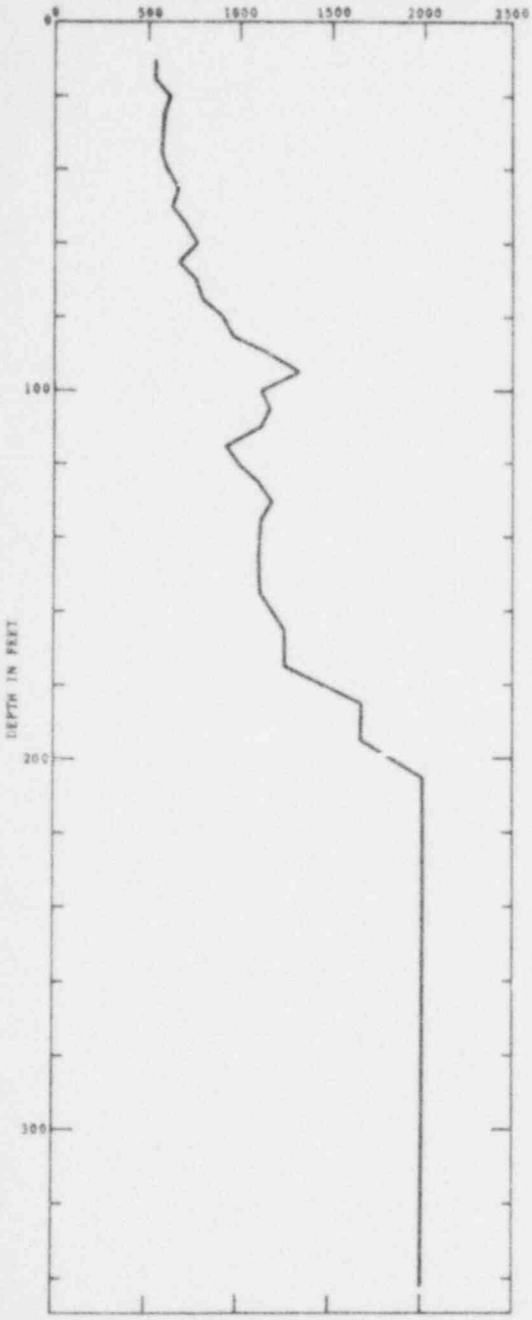
6) DETAILED RESULTS OF THE DOWNHOLE GEOPHYSICAL TESTING ARE PRESENTED ON APPENDIX B.

7) LABORATORY RESONANT COLUMN
TO Gmax ($G_{max} = V_s^2 \rho$) AS DE
VELOCITY MEASUREMENTS.

8) NORMALIZED LABORATORY MODU

SHEAR WAVE VELOCITY⁶ – V_s (fps)

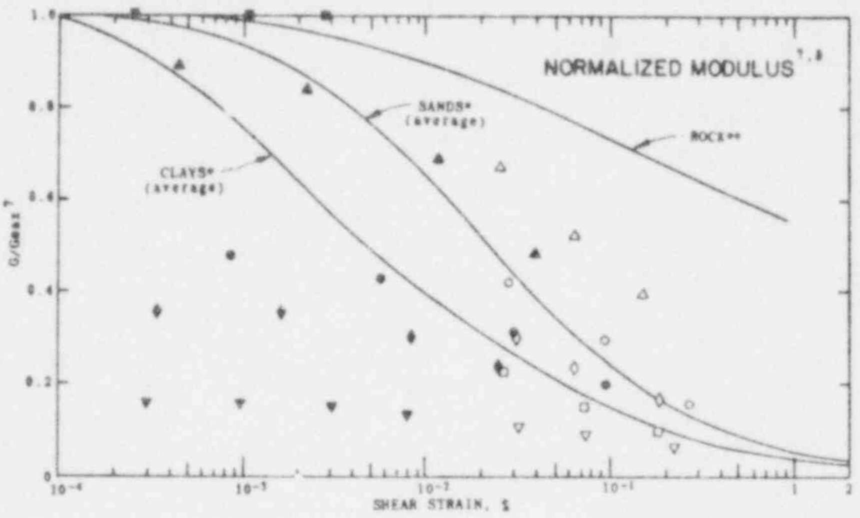
/10"
/7"
/8"
/8"
/5"
/8"
/10"
/3"
9"
/8"
/14"
/5"
/5.5"
11"



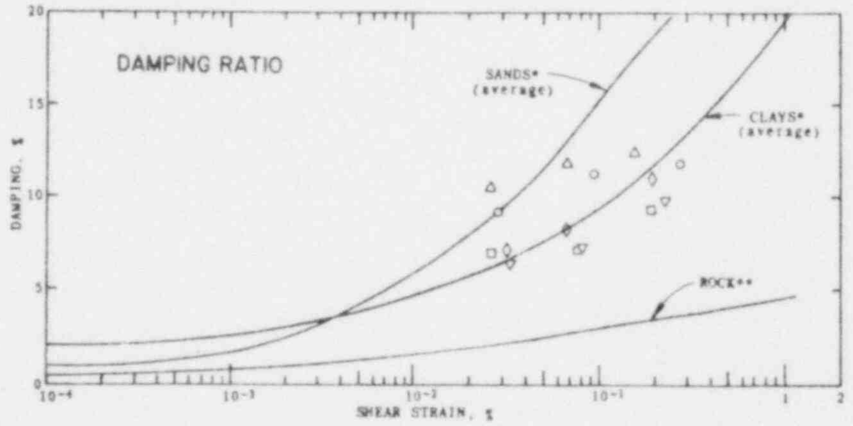
AND CYCLIC TRIAXIAL TEST DATA ARE NORMALIZED
ERMINED FROM DOWNHOLE GEOPHYSICAL SHEAR WAVE

I ARE UNCORRECTED FOR POSSIBLE SAMPLE DISTURBANCE.

DYNAMIC PROPERTIES OF SUBSURFACE MATERIALS



RESONANT COLUMN	CYCLIC TRIAXIAL	SAMPLE DEPTH, FEET	Gmax⁷ psi	V_s⁷ fps
●	○	20	8670	600
▲	△	40	9800	640
■	□	70	17,000	800
◆	◇	140	33,200	1110
▼	▽	305	109,300	2000



* FROM SW-AJA (1972)
** FROM SCHNABEL, et al. (1971)

BORING LOG AND
SUMMARY OF TEST RESULTS
CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20-6

Section 21

Hollywood Storage Building
Los Angeles, California

SECTION 21

HOLLYWOOD STORAGE BUILDING, LOS ANGELES, CALIFORNIA

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SECTION 21

HOLLYWOOD STORAGE BUILDING, LOS ANGELES, CALIFORNIA

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SECTION 21
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

21.1 STATION DESCRIPTION

21.1.1 Location and Building

Los Angeles, the largest city in California, is located in the southern part of the state, about 15 miles east of the Pacific Ocean. Hollywood is a district within the city and county of Los Angeles. The Hollywood district lies about 6 miles northwest of the Los Angeles Civic Center.

The Hollywood Storage Building is located at 1025 North Highland Avenue, about 300 feet south of the intersection of Highland Avenue and Santa Monica Boulevard (Fig. 21-1). The building is owned by the Bekins Storage Company and used as a warehouse for the temporary storage of household items.

The Hollywood Storage Building is a 14-story, reinforced concrete structure with a full basement (Fig. 21-2). The building is rectangular in plan, with dimensions of 217 by 50 feet. The basement of the building is embedded about 12 feet below grade. The building is founded on concrete piles that range in length from 12 to 30 feet.

21.1.2 Instrumentation and Earthquake Recordings

The Hollywood Storage Building has been instrumented at various locations, both within and outside the structure. Specific instrument locations discussed in this section are the basement and the parking lot installations. Both the basement and parking lot installations are part of the USGS strong motion instrument network and are identified as station numbers 133 and 135, respectively. All instrumentation at the Hollywood Storage Building is currently owned and maintained by the California Division of Mines and Geology (CDMG) under their Strong Motion Instrumentation Program. Both instrument locations are identified in the CDMG program as station numbers 236 and 303, respectively. Details applicable to each instrument location are discussed below.

21.1.2.1 Basement

The basement installation was established on June 27, 1933. The original accelerograph, a Coast and Geodetic Survey (C&GS) standard (S/N 21), remained at the site until January 2, 1935, when it was replaced with another C&GS standard (S/N 42). Recorder S/N 42 was replaced with another C&GS standard (S/N 22) in August 1942. This recorder was removed from the building on April 4, 1975, by the USGS since the CDMG was scheduled to take over the operation of the station. On April 27, 1976, the CDMG installed a CRA-1 replacement accelerograph (S/N 124) in the basement of the building. Pendulum motion orientations for the C&GS standard and the CRA-1 accelerographs are as follows:

	C&GS Standard (USGS, Unpub.)	CRA-1 (CDMG, Unpub.)
Longitudinal	East	South
Vertical	Up	Down
Transverse	South	West

The CRA-1 accelerograph is located in the western portion of the basement, adjacent to the elevator shafts (Fig. 21-2). A plan of the instrument room and a photo of the instrument are shown in Fig. 21-3. The CRA-1 accelerograph is fastened directly to the basement floor slab, approximately 12 feet below grade.

Over 40 earthquakes have been recorded at the basement accelerograph installation. Of these station records, only three are of significance in earthquake engineering since they have peak accelerations of about 0.05g or greater. All three of these records have been digitized and processed by the California Institute of Technology (Hudson, et al., 1971-1975a and b). Ground motion time histories and response spectra plots for these records are presented in Appendix A. Summary data from these records is given below.

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity (MM)	Peak Acceleration (g)
10-02-33	5.4	VI	0.04
07-21-52	7.7	XI	0.04
02-09-71	6.4	XI	0.15

21.1.2.2 Parking Lot

An instrument was installed in a parking lot adjacent to the Hollywood Storage Building in December 1934. The original instrument was a C&GS standard accelerograph (S/N 41). The accelerograph was housed in a 6- by 9-foot galvanized metal shed founded at grade. The shed was located 112 feet west of the west wall of the Hollywood Storage Building, on property owned then by the Pacific Gas & Electric Company.

Several instrument changes have been made at the parking lot site since it was established. The original instrument was replaced with another C&GS standard accelerograph (S/N 1) around August 1942. On April 16, 1973, the C&GS standard accelerograph and the instrument shelter were removed from the site by the USGS since the CDMG was scheduled to take over operation of the station. All of the C&GS standard accelerographs at the site were installed at the following bearings for pendulum motion (USGS, unpub.): Longitudinal - East; Vertical - Up; and Transverse - South.

On April 4, 1975, the CDMG constructed a new free field instrument shelter about 80 feet west of the southwest corner of the Hollywood Storage Building. This new shelter contains an RFT-250 accelerograph (S/N 371).

Over 40 earthquakes have been recorded at the parking lot accelerograph installation. Of these station records, only two are of significance in earthquake engineering since they have peak accelerations of about 0.05g or greater. Both of these records have been digitized and processed by the California Institute of Technology (Hudson, et al., 1971-1975a and b). Ground motion time histories and response spectra plots for these records are presented in Appendix A. Summary data from these records is given below.

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity (MM)	Peak Acceleration (g)
07-21-52	7.7	XI	0.04
02-09-71	6.4	XI	0.22

21.2 GEOLOGY AND SEISMICITY

21.2.1 Regional Geology

A geologic map of the Los Angeles region is presented in Fig. 21-4. The Los Angeles region, as defined for this report, includes the area within about 60 kilometers (37 miles) of Los Angeles. The geology indicated on the map was obtained from the data sources cited in Fig. 21-4. In the following discussions, the symbols in parentheses refer to the geologic units on the map.

The two major physiographic provinces in the Los Angeles region are the Transverse Ranges on the north and the coastal Peninsular Ranges on the south. The Transverse Ranges province is characterized by west-trending mountain ranges and intermontane valleys, including the San Gabriel and Santa Monica Mountains and the San Fernando Valley. The Peninsular Ranges are characterized by elongated, northwest-trending mountain ranges and valleys. Within the Los Angeles region, this province includes the Los Angeles Basin and continental borderland to the west; and the San Joaquin Hills, Puente Hills, San Gabriel Valley, and Santa Ana Mountains to the east and southeast. The city of Los Angeles is situated near the northern end of the Los Angeles Basin at the foot of the Santa Monica Mountains, where the Peninsular Ranges province meets the Transverse Ranges.

The mountainous areas of the Transverse Ranges are largely underlain by a complex of pre-Tertiary metamorphic and plutonic igneous rocks (m, gr, and p€g). This crystalline basement complex plunges beneath a thick cover of Mesozoic (K, Mz) and Cenozoic sedimentary (Ts) and volcanic (Tv) rocks in the mountains west of the San Gabriel fault and in the San Fernando Valley.

The Peninsular Ranges are also underlain at depth by a pre-Cretaceous crystalline basement complex (m, gr, and p€g), similar to those exposed in the San Gabriel Mountains (Woodford, et. al., 1954; Yerkes, et. al., 1965). This basement complex is unconformably overlain by Cretaceous to Tertiary sedimentary rocks (K and Ts) and some volcanic rocks (Tv). These Tertiary strata may be more than 30,000 feet thick in parts of the Los Angeles Basin, which was the site of a former marine embayment or depression (Yerkes, et. al., 1965)

Quaternary sediments, which locally mantle the Tertiary strata in both the Peninsular and Transverse ranges, include sequences of late Pliocene to Pleistocene non-marine sedimentary deposits (QP), marine and non-marine terrace deposits (Qt), and wide expanses of Holocene alluvium in the lowland areas (Qal).

21.2.2 Local Geology

The local geology in the vicinity of Los Angeles is depicted in Geologic Cross-Section U-U' of Fig. 21-5. This northeast-trending section passes approximately 3 miles southeast of the Hollywood Storage Building accelerograph station.

In the vicinity of the accelerograph station, the crystalline basement complex (m, gr, and pЄg) is unconformably overlain by more than 12,000 feet of Tertiary and Quaternary strata (Ts, Tv, QP, Qt and Qal) (Schoellhamer, et. al., 1954; Yerkes, et. al., 1965). At the base of the Tertiary sequence (Ts) is the Topanga Formation, a sequence of middle Miocene shale, sandstone and conglomerate (Duke, et. al., 1971). Overlying the Topanga Formation are siliceous and diatomaceous shale, siltstone, sandstone and conglomerate of the upper Miocene Puente and Modelo Formations. At the top of the Tertiary section are the Repetto and Pico Formations, collectively know as the Fernando Formation (Lamar, 1970). These formations, which are early to late Pliocene in age, chiefly consist of marine siltstone, sandstone and conglomerate (Jennings and Strand, 1969).

These Tertiary sedimentary strata, which locally include some interbedded volcanic rocks (Tv), generally crop out in the eastern portion of Cross-Section U-U' (Fig. 21-5). Late Tertiary and Quaternary deposits (QP, Qt, and Qal), principally clay, silt, sand and some gravel, which are more extensive in the western portion of the basin, thin eastward until they form only a thin veneer over the Tertiary rocks.

21.2.3 Structure and Seismicity

The structural geology of the Los Angeles region is illustrated on the Geologic Map and in Cross-Section U-U' of Figs 21-4 and 21-5, respectively.

The structural framework of the Los Angeles region is characterized by two distinct tectonic regimes: the predominantly northwest-trending faults and folds of the Peninsular Ranges, and the west-trending faults and folds of the Transverse Ranges. The structural development of both provinces is geologically young, as evidenced by the deformation of Quaternary strata and by the many faults throughout the region that have been active during Quaternary time.

The Los Angeles Basin is subdivided into four tectonic blocks, each having different basement rocks, and each bounded by major fault zones or structural trends along which deformation has occurred since middle Miocene time. Downtown Los Angeles, including the Hollywood District, is situated on the central block, which is bounded by the Santa Monica fault zone on the north, the Whittier-Elsinore fault zone on the east and southeast, and the Newport-Inglewood fault zone on the west and southwest.

The rocks within the central block are folded and faulted along northwesterly trends. The sedimentary rocks primarily dip to the southwest from an anticlinal axis in the Elysian Hills into a synclinal trough near the Newport-Inglewood fault zone. Tertiary rocks exposed in the eastern part of the Cross-Section have been relatively uplifted by a number of high-angle faults. These faults are apparently inactive, as they show no evidence of displacement occurring during Quaternary time (Jennings, 1975).

Both major and minor faults within the map area have historic records of ground rupture and surface displacement. These incude the San Andreas, San Fernando, and a small fault transverse to the Whittier fault (Fig. 21-4). The Newport-Inglewood structural zone, although it has no historic record of offset, also is considered tectonically active, owing to the numerous earthquakes that have occurred along it in historic time (Barrows, 1974).

Although a number of faults within the map area (Fig. 21-4) have no historic record of surface displacement, i.e., they show no positive evidence of movement during the last two million years, they also should be considered to be potentially active. These include the Palos Verdes fault zone, Whittier-Elsinore fault zone, San Gabriel and Sierra Madre fault zones, Malibu Coast-Santa Monica-Raymond Hill fault zone, Verdugo fault, and the Santa Susana, Santa Rose, and Northridge Hills faults. The Newport-Inglewood structural zone, mentioned previously with regard to its seismic activity, also has had significant surface displacement during the last two million years.

Los Angeles is in a region of relatively high seismic activity. The more significant historic earthquakes (those of Modified Mercalli Intensity VII or greater) that have occurred in the Los Angeles region are listed in Table 21-1 and their approximate epicentral locations are shown on Fig. 21-4. Of the 12 events listed, five have had intensities of VIII or greater. The largest of these were the magnitude 6.3, intensity IX, Long Beach earthquake of March 10, 1933; and the magnitude 6.4, intensity XI, San Fernando earthquake of February 9, 1971. Outside the map area, the most significant historic earthquake to affect Los Angeles was the magnitude 7.7, Kern County Earthquake of July 21, 1952. This event was centered about 75 miles northwest of Los Angeles.

21.3 SITE CONDITIONS

Site conditions at the Hollywood Storage Building were studied with a site reconnaissance, deep boring, in situ geophysical measurements, and laboratory tests. A 360-foot deep boring was drilled at a location about 25 feet south of the Hollywood Storage Building to study the subsurface conditions. A downhole geophysical survey was performed for the full depth of the boring to obtain shear wave velocities of the soils. Soil samples retrieved from the boring were tested in the laboratory to determine their index and engineering properties. Detailed results of the field drilling and geophysical testing are presented in Appendix B, and detailed results of the laboratory tets are presented in Appendix C. Summary findings from the field and laboratory studies are discussed below.

21.3.1 Surface Features

The Hollywood District of the city of Los Angeles is located at the north end of the Los Angeles Basin, an alluviated lowland plain (Fig. 21-1). The

Hollywood Storage Building lies 8000 feet south of the Santa Monica Mountains, which rise to elevations of over 1000 feet. The ground surface in the vicinity of the Hollywood Storage Building is relatively level with an average elevation of approximately 290 ft. MSL.

21.3.2 Subsurface Conditions

The 360-foot deep boring drilled near the Hollywood Storage Building encountered 146 feet of alluvium overlying the Repetto Formation. These strata are generalized in the boring log of Fig. 21-6 and are briefly discussed below.

The surficial 93 feet of alluvium encountered in the boring consisted of very stiff to hard, sandy, silty clay with occasional layers of dense to very dense, silty sand. Blow counts within this zone generally ranged between 10 and 50. Values of water content for this material ranged from 15 to 30 percent and are close to the plastic limit of the soil. Shear strengths of 0.7 and 1.5 tsf were obtained from unconfined compression tests of the material. Shear wave velocities increased from 850 fps near the ground surface to 1300 fps at depth.

Between depths of 93 and 146 feet, a very dense, silty, fine to coarse sand with some gravelly zones was encountered. This sand had blow counts over 50 and water contents ranging from 15 to 25 percent. The shear wave velocity in this zone was relatively constant at 1400 fps.

Materials of the Repetto Formation were encountered in the boring below a depth of 146 feet. Geologically, the Repetto Formation contains poorly indurated siltstone, sandstone and shale. However, the material encountered in the boring was identified as a hard, sandy, clayey silt overlying a hard sandy, silty clay at a depth of 300 feet. The materials were classified as soils as they had engineering properties more similar to a hard soil than a soft rock. Blow counts for these materials were over 60, and water contents ranged from 20 to 25 percent. The shear wave velocity in this layer was relatively constant at 2000 fps.

The water table was not measured in the boring since the hole was drilled using a bentonite slurry. However, information from Duke, et al. (1971) places the water table at a depth of 40 feet near the site.

21.3.3 Dynamic Soil Properties

The dynamic properties of the subsurface materials were studied in the laboratory with resonant column and cyclic triaxial tests. Both types of tests were performed on the hard silts and clays encountered in the boring between depths of 80 and 347 feet. The strain-dependent, dynamic soil properties of shear modulus attenuation and damping ratio determined from these tests are presented in Fig. 21-6. For comparison purposes, these plots also contain commonly used relationships for "sand," "clay," and "rock" (SW-AJA, 1972; Schnabel, et al., 1971).

The laboratory shear moduli presented in Fig. 21-6 have been normalized to low-strain values (10^{-4} percent shear strain). The low-strain moduli were computed from the downhole shear wave velocities corresponding to the individual sample depths. This normalization permits direct comparison of the laboratory data with the modulus attenuation relationships proposed by others.

Review of the data in Fig. 21-6 indicates:

1) Excellent agreement exists between the modulus values determined from the resonant column and cyclic triaxial tests, particularly for the samples that were tested from the Repetto Formation. These test results indicate that the modulus undergoes a smooth transition from low strain to high strain. This agreement is not as good for the alluvium samples that were tested. Test results from these specimens indicate a discontinuity of the moduli in the mid-strain level.

2) The normalized moduli for specimens from the Repetto Formation exhibit a lower rate of attenuation with strain than commonly used relationships (SW-AJA, 1972). This lower rate of attenuation, however, is in general agreement with the results of field tests performed at other locations (SW-AA, 1976a and 1977a).

3) For test specimens from the Repetto Formation, the normalized resonant column moduli in the low-strain region are much lower than the values determined from the field geophysical measurements. The reason for this difference is unclear. However, assuming that the modulus attenuation rate of the laboratory data is correct, then the resonant column and cyclic triaxial test data for each sample may be adjusted by a single factor to provide better agreement with the field results. This correction factor would be on the order of about 3 for the samples from the Repetto Formation. Lower correction factors would be applicable for the alluvial materials.

   The adjusted laboratory moduli would plot between the "clay" and "rock" curves in Fig. 21-6. This adjustment seems reasonable since the materials of the Repetto Formation are much stiffer than the soft to medium stiff soils that were used to develop the "clay" curve, but yet, they are probably not as competent as the materials upon which the "rock" curve is based. Additionally, the assumption that the rate of laboratory modulus attenuation is correct and the use of only one adjustment factor for each test seems reasonable considering points 1 and 2, above.

4) Damping values determined in the cyclic triaxial test all cluster around the "clay" curves. Considering that the site materials are stiffer than the soils used to develop the "clay" curve, lower damping values of the site materials would be expected.

POOR ORIGINAL

TABLE 21-1

SIGNIFICANT EARTHQUAKES IN THE LOS ANGELES REGION[1]

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude[3] North (°)	Longitude[3] West (°)	Magnitude[4] (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral[5] Distance (miles)
A	1855	7 - 10	20:15	34	118.5	-	VIII	-	11 WSW
A	1893	4 - 4	11:40	34.5	118.5	-	VIII-IX	-	30 NNW
A	1920	6 - 21	18:48	34	118.5	4.9	VIII	-	11 WSW
A	1929	7 - 8	08:46	34	118	4.7	VII	-	21 ESE
A	1930	8 - 30	16:41	33.9	118.6	5.2	VII	-	21 SW
A	1933	3 - 10	17:54	33.6	118.0	6.3	IX	-	40 SE
A	1933	10 - 2	01:10	33.8	118.1	5.4	VI	-	24 SE
A	1941	10 - 21	22:57	33.8	118.2	4.9	VII	-	22 SSE
A	1941	11 - 14	00:42	33.8	118.2	5.4	VII-VIII	-	22 SSE
B	1971	2 - 9	06:01	34.4	118.4	6.4 (P)	XI	5	22 N
B	1971	3 - 31	06:52	34.29	118.52	4.6 (P)	VII	2	17 NW
B	1973	2 - 21	06:46	34.1	119.0	5.9 (P)	VII	5	39 W

Notes:

1. Earthquakes selected for this tabulation generally have maximum intensities of VII or greater and have occurred within about 60 km (37 miles) of Los Angeles. The intent of this table is to provide a general indication of the seismicity in the region; it is not a complete list of all earthquakes.

2. The following sources were used in compiling the earthquake data:

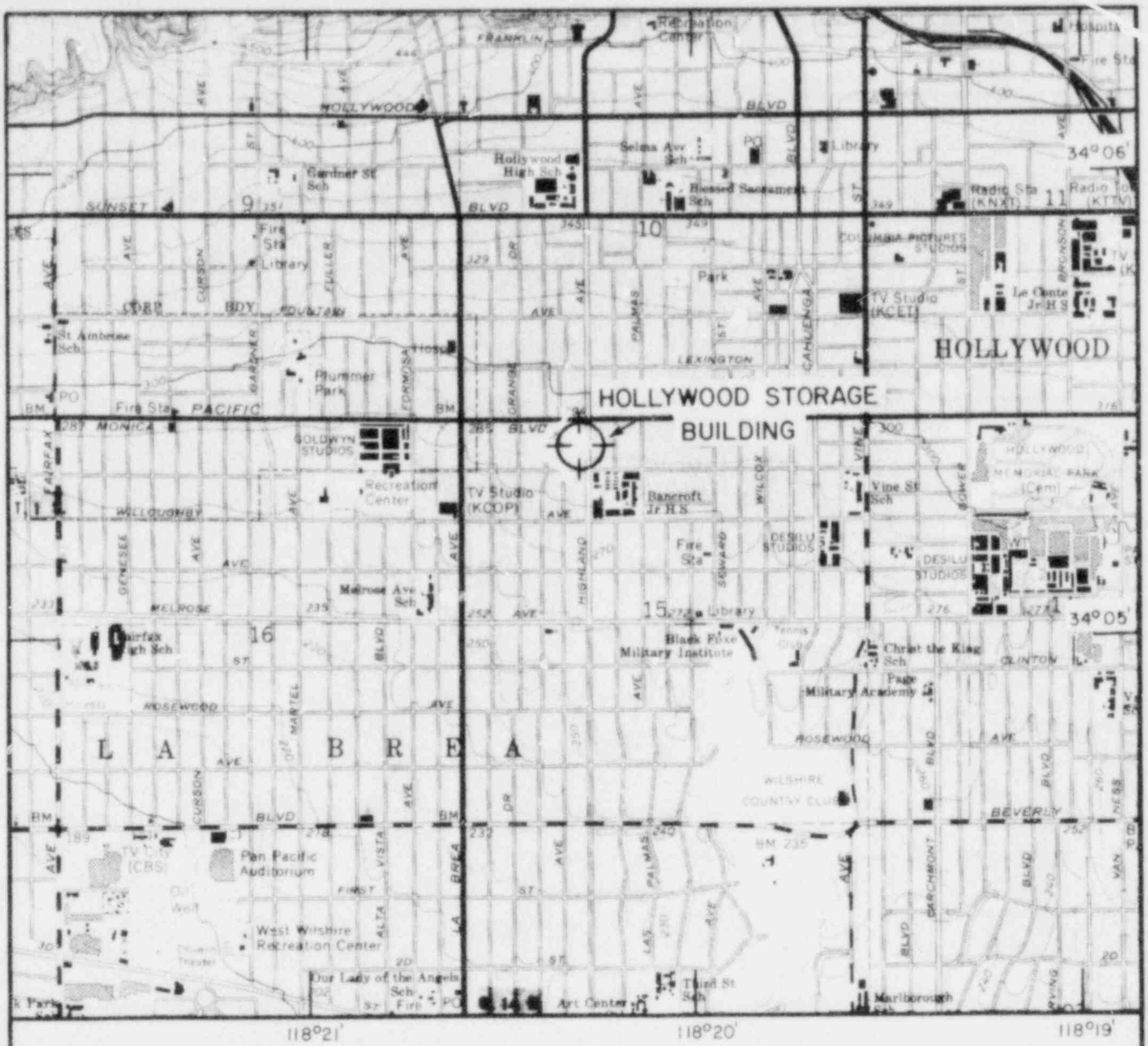
   A. Coffman and Von Hake (1973).

   B. United States Earthquakes

3. Thr range of uncertainty for epicentral locations may be taken as ± 0.5° for earthquakes prior to 1960 and as about ± 0.2° for those since 1960.

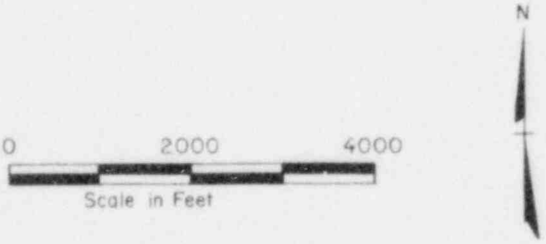
4. Magnitudes designated as P have been computed by the California Institute of Technology, Pasadena.

5. All distances have been scaled relative to the accelerograph station at the Hollywood Storage Building.



HOLLYWOOD STORAGE BUILDING

USGS Station No.:	133, 135
CDMG No.:	236, 303
County:	Los Angeles
USGS Topographic Quadrangle:	Hollywood, California
Coordinates:	34°05'23"N. 118°20'17"W.
Location:	1025 N. Highland Ave. (approximately 300 feet south of the intersection of Highland Ave. and Santa Monica Blvd.)
Building:	14 stories with a basement; reinforced concrete construction.

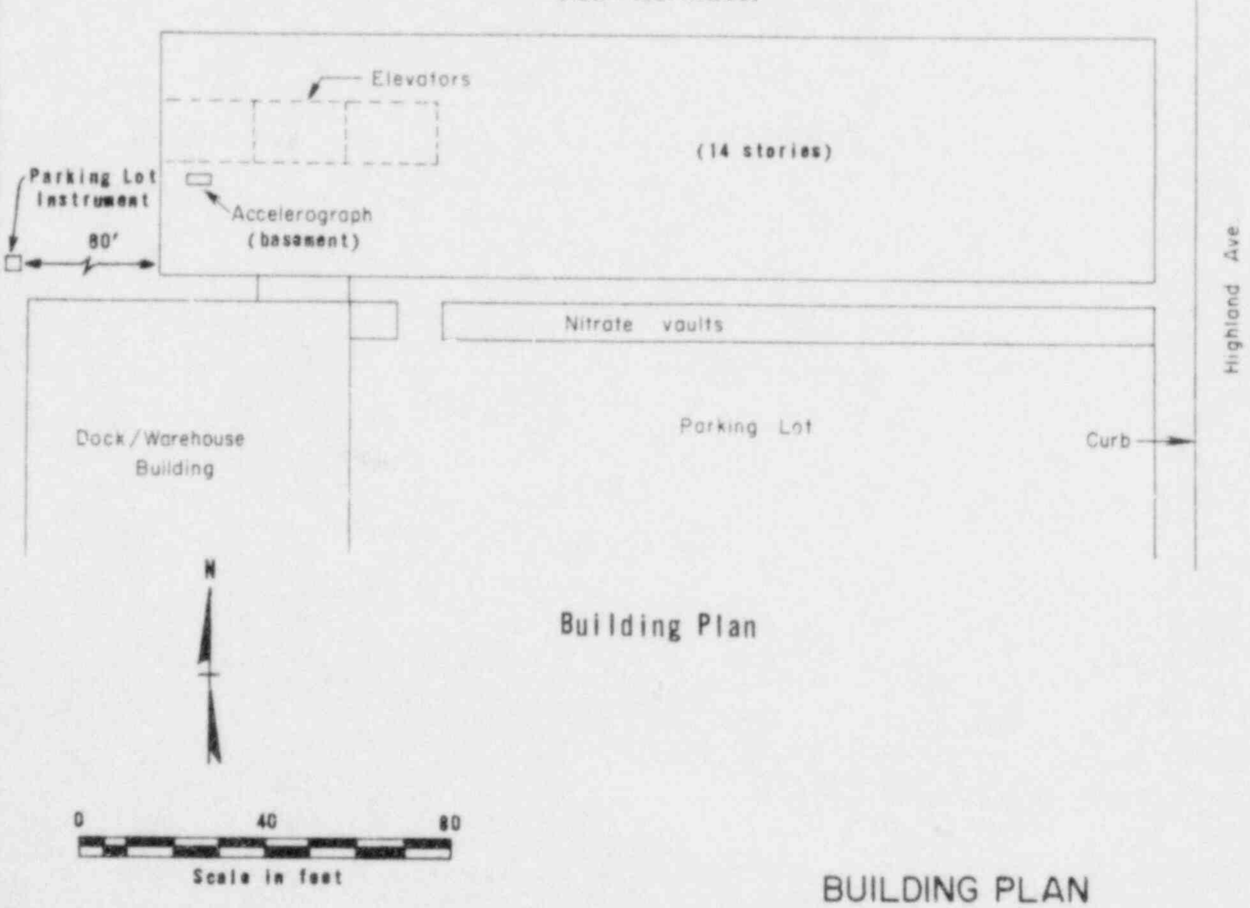


STATION LOCATION
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

POOR ORIGINAL

FIG. 21-1

Hollywood Storage Building
View - Northwest

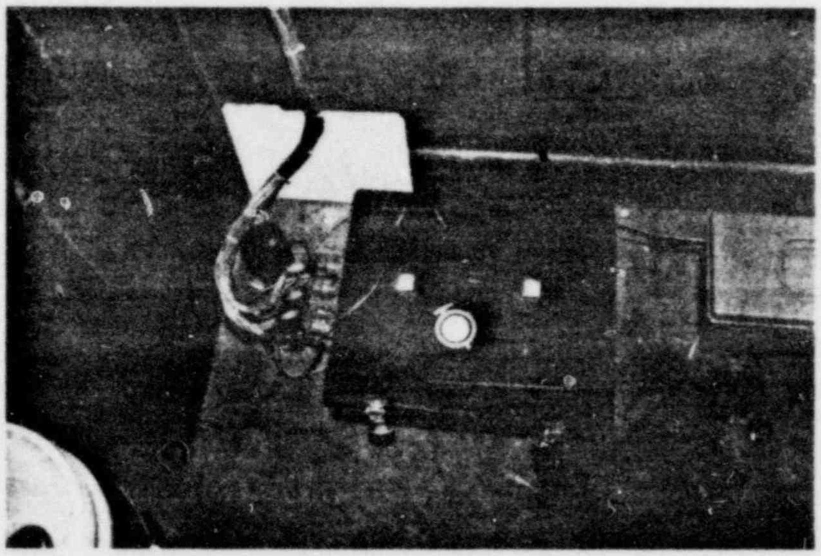


Building Plan

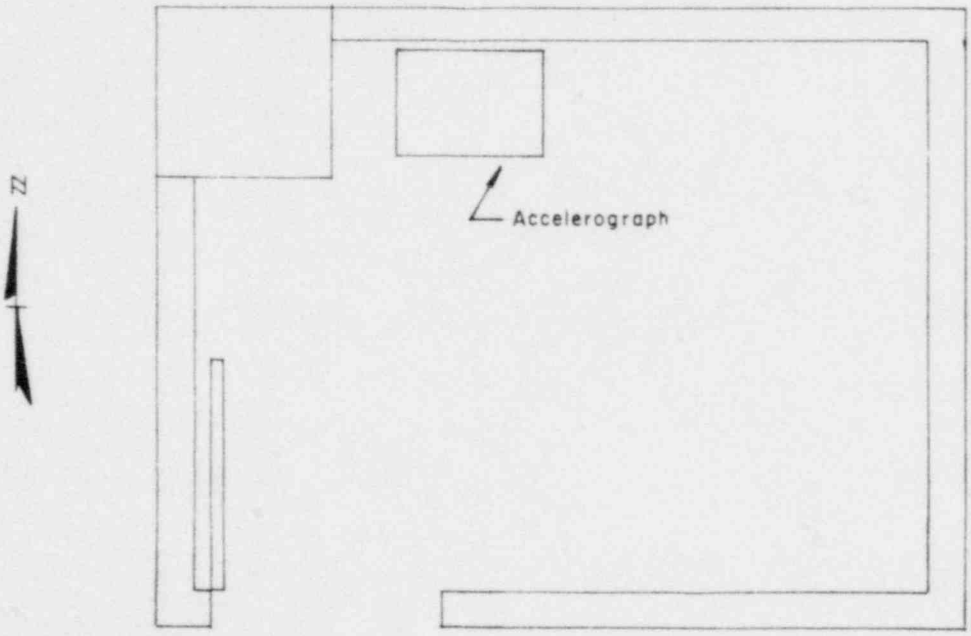
POOR ORIGINAL

BUILDING PLAN
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

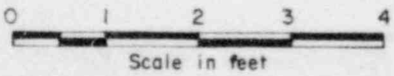
FIG. 21-2



CRA-1 Accelerograph
Hollywood Storage Building - Basement



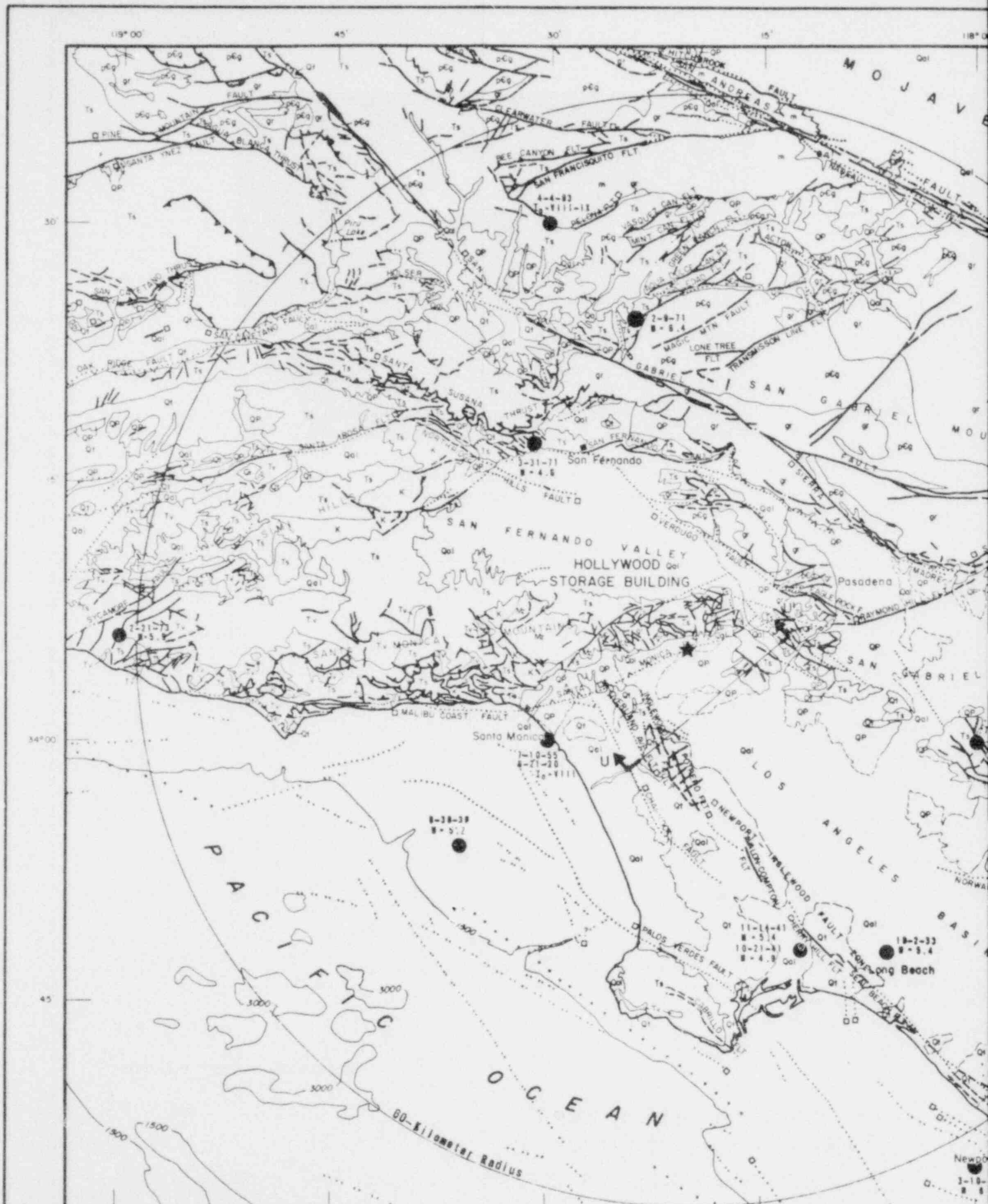
Accelerograph Room Plan - Basement



STATION INSTRUMENTATION
HOLLYWOOD STORAGE BU'LDING
LOS ANGELES, CALIFORNIA

POOR ORIGINAL

FIG. 21-3



POOR ORIGINAL

EXPLANATION

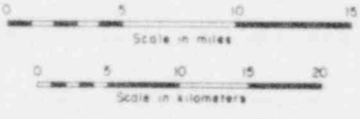
Qal	Holocene alluvial deposits; includes dune and lacustrine deposits.
Qt	Quaternary marine and nonmarine terrace deposits; includes some upper Pliocene marine deposits.
QP	Plio-Pleistocene nonmarine sedimentary deposits.
Tv	Tertiary volcanic and igneous intrusive rocks.
Ts	Tertiary sedimentary rocks.
K	Cretaceous sedimentary rocks.
Mz	Mesozoic sedimentary rocks; also includes some metamorphic rocks.
gr	Mesozoic granitic rocks; also includes some pre-Cenozoic metamorphic, volcanic, and ultramafic rocks.
m	Pre-Cretaceous metamorphic and metasedimentary rocks.
pCg	Precambrian igneous and metamorphic rocks; includes some crystalline rocks which may be as young as Mesozoic.

★	Accelerograph Station location.
●	Epicentral locations of selected historic earthquakes listed in Table 21-1.
2-9-71	Date of occurrence (month-day-year)
I_0 = XI	Maximum Intensity (MM)
M = 6.4	Magnitude (Richter)
□	Faults that have moved during Quaternary time without historic record (approx. past 2 million years)
■	Faults that have moved during historic time (approx. 200 years).
Topographic Lineament	May represent possible fault or fault zone.
Contact	Dashed where approximately located.
Fault	Dashed where approximately located, dotted where concealed, queried where existence is uncertain.
Thrust Fault	Barbs on upper plate; dashed where approximately located, dotted where concealed.
Offshore Fault	Location approximate; spaced dots where fault is inferred.
	Cross-section location.

NOTES:

1) Geology is simplified and modified from Jennings and Strand (1969), Rogers (1967), Jennings (1962), and Rogers (1965).
2) Major faults and information on fault activity is from Jennings (1975).
3) Individual faults within the San Andreas fault zone show evidence of Quaternary and historic activity. (See Jennings, 1975, for details).
4) Cross-Section U-U' is shown on Fig. 21-5.

Location of Geologic Map

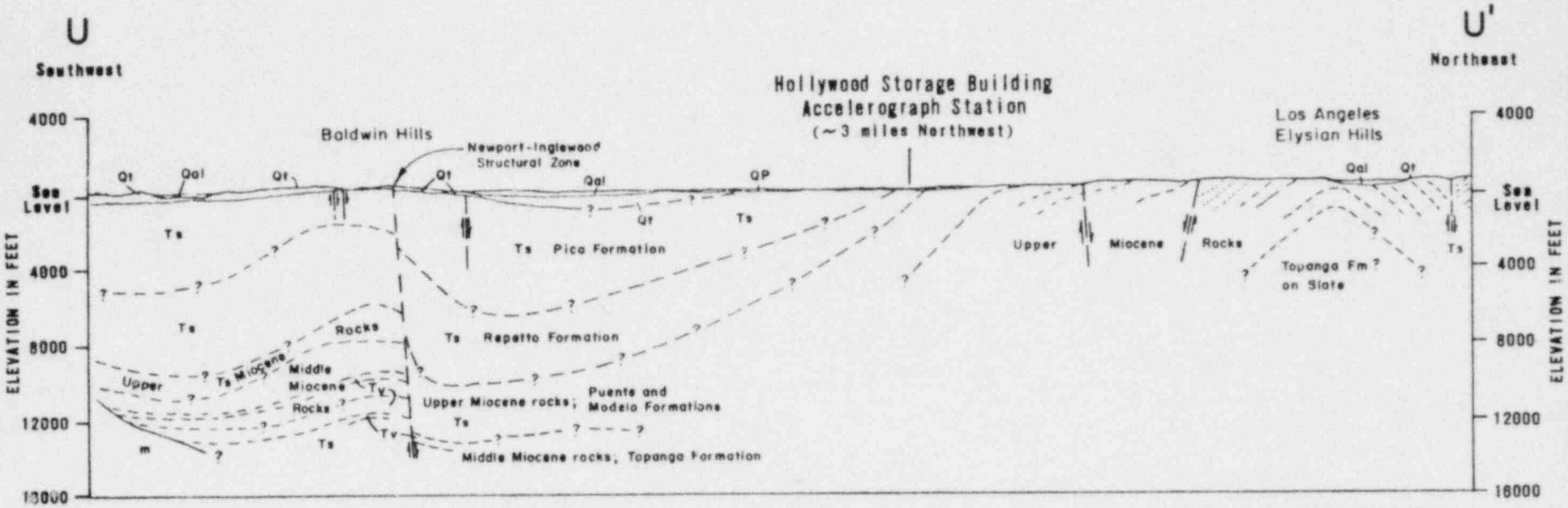


Submarine contour interval 1500 feet

GEOLOGIC MAP
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21-4

POOR ORIGINAL



0 8000 16000
Scale in feet

Cross-section modified after Schoellhamer et al, 1954

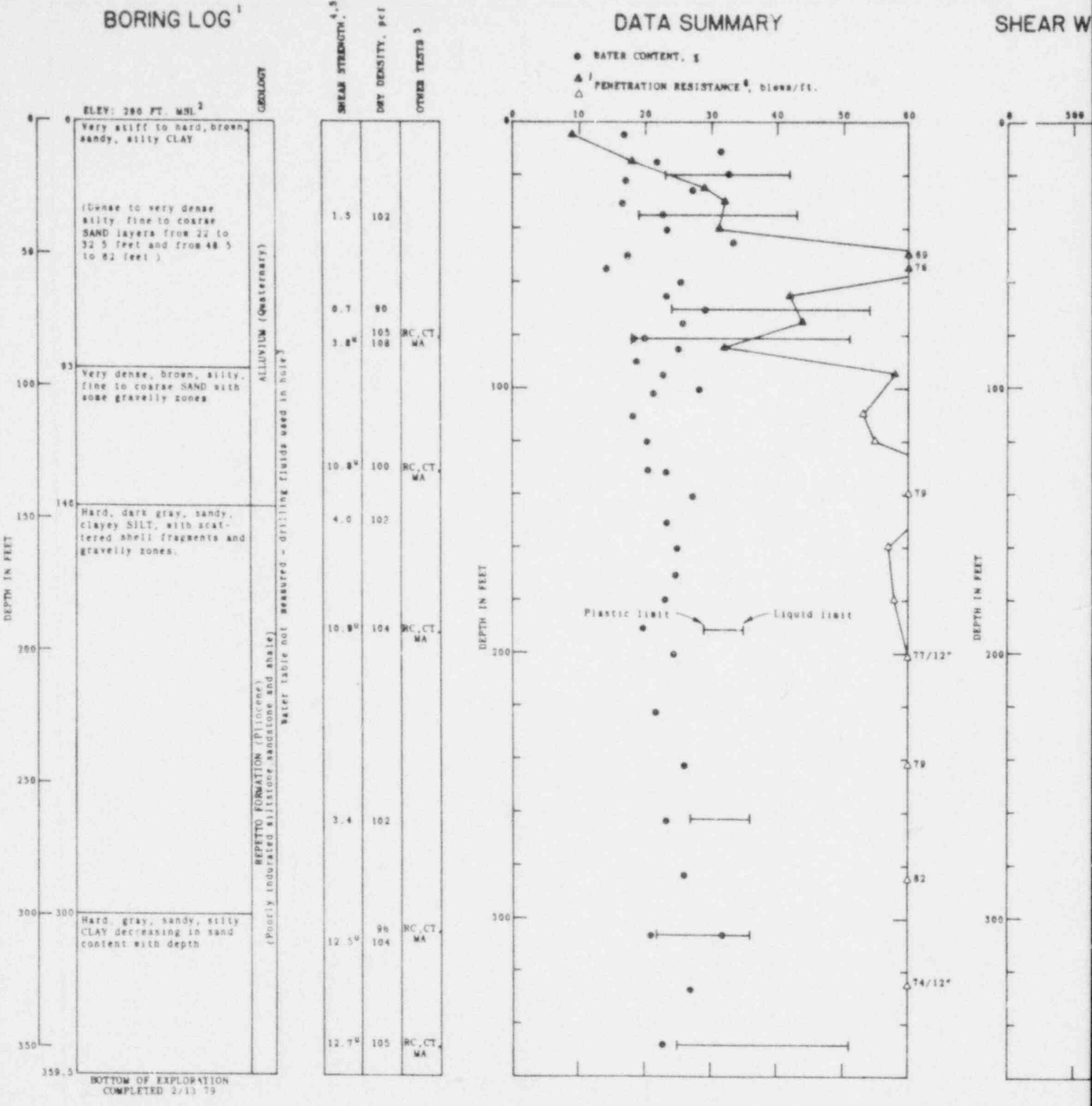
Notes: 1) See Fig. 21-4 for location of section.
2) The cross-section is diagrammatic.

EXPLANATION

Holocene	Qal	Alluvium
Quaternary	Qt	Marine and non-marine terrace deposits
Plio-Pleistocene	QP	Non-marine sedimentary deposits
Pliocene-Miocene	Ts	Tertiary sedimentary rocks includes Pico and Repetto Formations, Puente and Modelo Formations, and the Topanga Formation
Tertiary	Tv	Volcanic rocks
Pre-Cretaceous	m	Basement rock complex; Catalina Schist west of the Newport-Inglewood fault, chiefly granitic rocks east of the fault

GEOLOGIC CROSS-SECTION U-U'
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21-5



NOTES: 1) THE BORING IS LOCATED ABOUT 25 FT. SOUTH OF THE HOLLYWOOD STORAGE BUILDING. THE STRATIFICATION LINES IN THE BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

2) THE BORING ELEVATION WAS INTERPOLATED FROM THE USGS TOPOGRAPHIC QUADRANGLE "HOLLYWOOD, CALIF." (10 FT. CONTOURS).

3) INFORMATION FROM OTHERS (DUKE, et al., 1971) PLACES THE WATER TABLE AT A DEPTH OF ABOUT 40 FEET NEAR THE SITE.

4) SHEAR STRENGTHS WERE DETERMINED FROM UNCONFINED COMPRESSION TESTS (qu/2) EXCEPT VALUES DENOTED BY "u" WHICH CORRESPOND TO UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TESTS.

5) DETAILED RESULTS OF LABORATORY TESTS ARE PRESENTED IN APPENDIX C. TEST ABBREVIATIONS ARE AS FOLLOWS:

RC - RESONANT COLUMN
CT - CYCLIC TRIAXIAL
MA - MECHANICAL ANALYSIS (GRADATION)

6) PENETRATION RESISTANCES ARE BASED ON DRIVING A 3-IN
SAMPLER WITH:

▲ - 140 LB. HAMMER DROPPED 30 INCHES
△ - 325 LB. DOWNHOLE HAMMER (SLIP JAR

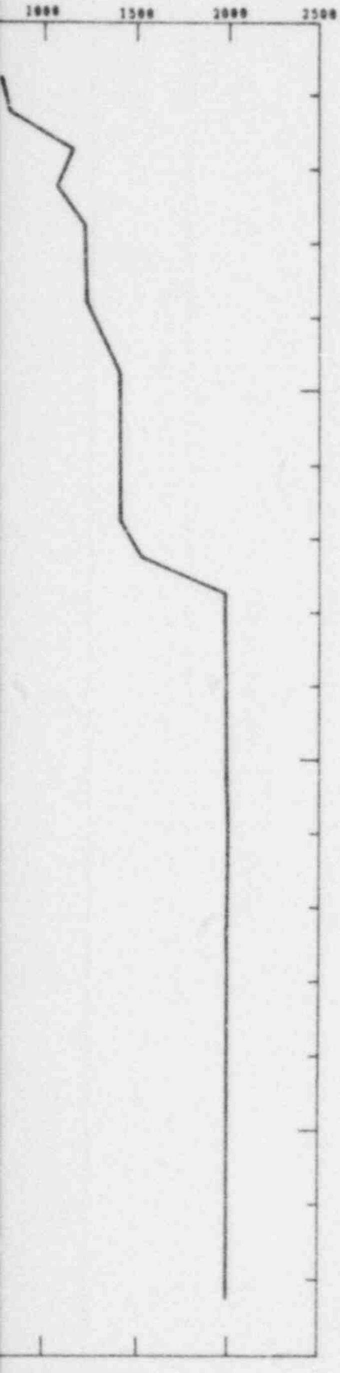
7) DETAILED RESULTS OF THE DOWNHOLE GEOPHYSICAL TESTI
APPENDIX B.

8) LABORATORY RESONANT COLUMN AND CYCLIC TRIAXIAL TES
TO Gmax (Gmax = $V_s^2 \rho$) AS DETERMINED FROM DOWNHOLE G
WAVE VELOCITY MEASUREMENTS.

9) NORMALIZED LABORATORY MODULI ARE UNCORRECTED FOR P
DISTURBANCE.

POOR ORIGINAL

VE VELOCITY '-V_s (fps)



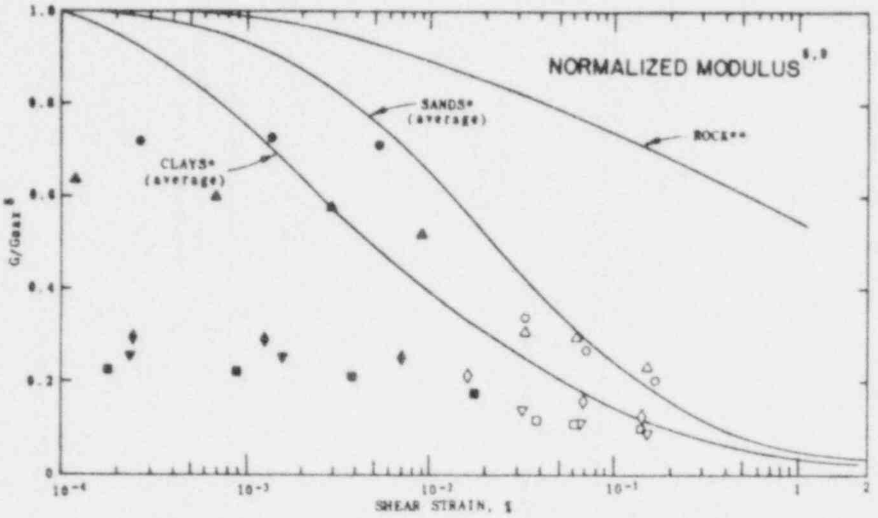
O.D. SPLIT SPOON

DROPPED 18 INCHES
ARE PRESENTED IN

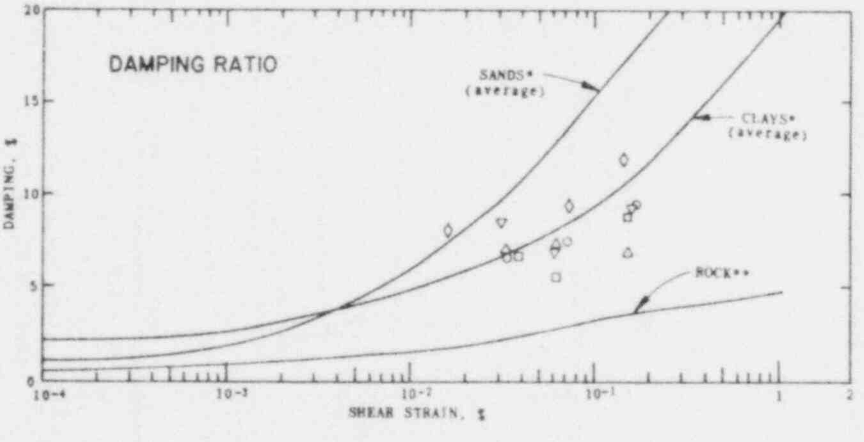
ATA ARE NORMALIZED
HYSICAL SHEAR

BLE SAMPLE

DYNAMIC PROPERTIES OF SUBSURFACE MATERIALS



RESONANT COLUMN	CYCLIC TRIAXIAL	SAMPLE DEPTH, FEET	Gmax 8 psi	V_s 8 fps
●	○	80	42,600	.30
▲	△	130	52,600	1420
■	□	190	107,800	2000
◆	◇	305	111,000	2000
▼	▽	347	111,000	2000



* FROM SW-AJA (1972)
** FROM SCHNABEL, et al. (1971).

BORING LOG AND
SUMMARY OF TEST RESULTS
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21-6

Section 22

Noranda Aluminum Plant
New Madrid, Missouri

SECTION 22

NORANDA ALUMINUM PLANT, NEW MADRID, MISSOURI

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SECTION 22

NORANDA ALUMINUM PLANT, NEW MADRID, MISSOURI

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SECTION 22

NORANDA ALUMINUM PLANT

NEW MADRID, MISSOURI

22.1 STATION DESCRIPTION

22.1.1 Location and Building

New Madrid is a town situated on the west bank of the Mississippi River in southeastern Missouri. The town is located in New Madrid County, about 150 miles south of St. Louis.

The Noranda Aluminum Plant lies 5.5 miles south-southwest of New Madrid, on the west bank of the Mississippi. The accelerograph station at the plant is located in the western portion of the complex in the Rectifier/Control Building (Fig. 22-1). This building contains electrical switching equipment used to control power to the plant.

The Rectifier/Control Building is a one-story structure built on grade (Fig. 22-2). The building is rectangular in plan, with dimensions of 32 by 72 feet. Exterior walls and interior partitions of the building are constructed of 8-inch. reinforced concrete block. The building foundations consist of concrete strip footings. Finished floor elevation in the building is 297 ft. MSL. The structure was completed in 1970.

22.1.2 Instrumentation and Earthquake Recordings

The accelerograph station at the Noranda Aluminum Plant is owned and operated by the USGS and is identified as station number 2420 in their strong motion instrument network. This station is part of an array of instruments being installed by the USGS to study spectral characteristics and attenuation of strong ground motion in the New Madrid seismic zone (USGS, 1977a and b). When completed, this network will consist of over 35 instruments located in two mutually perpendicular arrays. In one array, the instruments will be spaced at 15-mile intervals along a line extending from Cape Girardeau, Missouri, to Marked Tree, Arkansas. The other array will contain instruments at 5- to 10-mile spacings along a line extending from Poplar Bluff, Missouri, to Obion, Tennessee.

The Rectifier/Control Building is instrumented with an accelerograph and a seismoscope (S/N 231). The station was initially instrumented on February 29, 1972, with an SMA-1 accelerograph (S/N 317), which remains in service at the station today. This accelerograph was in continuous service at the station except for the period from October 23, 1977, to July 14, 1978, when the instrument was removed for internal modifications. The instrument has the following orientations for pendulum motion (USGS, unpub.): Longitudinal - West; Vertical - Down; and Transverse - South.

Both the accelerograph and the seismoscope are located in the southwest corner of the Rectifier/Control Building (Fig. 22-2). A plan of the accelerograph room and a photo of the current instrumentation are shown in Fig. 22-3. Both the accelerograph and the seismoscope are bolted directly to the concrete floor slab (ground level).

Two earthquakes have been recorded by the SMA-1 accelerograph in the Rectifier/Control Building. Details of the records are presented in Appendix A. Summary data is given below.

Date (Mo-Da-Yr)	Magnitude (Richter)	Maximum Intensity (MM)	Peak Acceleration (g)
06-13-75	4.3	VI	0.07
03-24-76	5.0	VI	0.01

Only the record of the 1975 event is of significance in earthquake engineering since it has a peak acceleration greater than 0.05g. Additionally, this record is of particular significance since it has the highest ground acceleration recorded in the eastern and midwestern United States. Both the 1975 and 1976 records have been digitized and processed by St. Louis University (Herrmann, 1977). Time histories of ground motion for both records are presented in Appendix A.

22.2 GEOLOGY AND SEISMICITY

22.2.1 Regional Geology

A geologic map of the New Madrid region is presented in Fig. 22-4. The New Madrid region, as defined for this report, includes the area within about 60 kilometers (37 miles) of the Noranda Aluminum Plant near New Madrid, Missouri. The geology indicated on the map was obtained from the data sources cited in Fig. 22-4. In the following discussions the symbols in parentheses refer to geologic units on the map.

The Noranda Aluminum Plant is situated near the northern end of the Mississippi embayment, a broad arm of the Gulf Coastal Plain which extends up the valley of the Mississippi River from about the 32nd parallel to southeastern Missiouri and southern Illinois. This wedge-shaped region, as a whole, is a broad, flat plain with a gentle slope to the south.

The deposits of the Mississippi embayment are composed of sediments of Mesozoic (pT) and Cenozoic age (QT and Q). These sediments were deposited in a downwarped trough, or syncline, which plunges to the south and whose axis generally parallels the Mississippi River. Deposition in this trough began in Jurassic time and has continued into the Quaternary (Cushing, et al., 1964). These sediments, which are composed of gravel, sand, silt, clay, lignite, marl, chalk, and limestone, range in thickness from a trace to several thousand feet. In Pleistocene and Holocene times, erosion and deposition produced lowlands and thick alluvial deposits (Q). Also, in the Pleistocene, a thick blanket of loess (QT) was spread over the upland areas.

22.2.2 Local Geology

The local geology in the vicinity of the Noranda Aluminum Plant (New Madrid) is depicted in Geologic Cross-Section V-V' of Fig. 22-5. This easterly-trending section passes about 5 miles north of the Noranda Aluminum Plant and just south of the town of New Madrid.

As indicated in the section, Cretaceous and Tertiary sediments overlie undifferentiated basement rocks of Paleozoic age in the vicinity of the plant. The Paleozoic rocks (Pu) are mostly dolomite and limestone, and minor amounts of sandstone and shale (Groshskoph, 1955). Cretaceous sediments (Ku) unconformably overlie the basement rocks. They are mostly of marine origin, largely calcareous, and range from sand to clay. Tertiary units are represented by mostly unconsolidated sand and clay of the Paleocene Midway Group (Tm), the Eocene Wilcox Group (Tw), and a sequence of undifferentiated late Tertiary sediments (Tu).

Quaternary deposits occupy much of the lowland areas. Loess deposits (QT) cover much of the area east of the Mississippi River alluvial plain and also cap prominent topographic highs west of the river. The Mississippi River alluvial plain is underlain by Quaternary alluvial deposits (Q) of gravel, sand, silt, and clay ranging up to 200 feet in thickness.

22.2.3 Structure and Seismicity

The structural geology of the New Madrid region is illustrated on the Geologic Map and in Cross-Section V-V' in Figs. 22-4 and 22-5, respectively.

The predominant structure in the region is a southerly-trending, downwarped trough or syncline, whose axis generally parallels the Mississippi River. This synclinal structure is indicated in Cross-Section V-V' (Fig. 22-5). Dips in the sedimentary units across the syncline range from 25 to 35 feet per mile. Many faults on the geologic map and on the section are inferred, based upon interpretation of subsurface data, or on exceptionally strong lineaments (Heyl and McKeown, 1978).

One of the major fault systems in the Central United States is the northeast-trending New Madrid fault system. The New Madrid fault system, which is greater than 40 miles wide, is complexly associated with the easterly-trending Cottage Grove-Shawneetown-Rough Creek fault zone and Hicks Dome, both about 50 miles northeast of New Madrid, and the east-southeasterly-trending Ste. Genevieve fault zone, which is about 35 miles north of New Madrid (Heyl and McKeown, 1978). The New Madrid fault system is best recognized approximately 75 miles northeast of the Noranda Aluminum Plant in Kentucky and Illinois. Evidence as to the character of the fault system and its continuity southwestward past New Madrid into the Mississippi River embayment is inconclusive (Heyl and McKeown, 1978).

New Madrid is located in one of the most seismically active regions in the Central and Eastern United States (Sykes, 1978; Spall, 1979). This active region is centered along the Mississippi River in southeastern Missouri, and in the adjoining parts of Arkansas, Illinois, Kentucky, and Tennessee. The region has exhibited continuing activity throughout historic time and accounts for about a third of the earthquakes in the Central United States. Data from seismograph networks of St. Louis University, which have been operating in the region since 1974, indicate narrow zones of high activity parallel to the Mississippi embayment as well as a zone at right angles to it. This line of seismic activity parallels the line of epicenters determined by Fuller for the New Madrid earthquakes of 1811-12 (Spall, 1979).

The more significant historic earthquakes (those of Modified Mercalli Intensity VI or greater) that have occurred in the New Madrid region are listed in Table 22-1 and their approximate epicentral locations are shown on Fig. 22-4. Of the 14 events listed, four had intensities of VII or greater. The largest of these was the New Madrid series of earthquakes in 1811 and 1812. Between December 16, 1811, and February 7, 1812, three earthquakes of intensity XII occurred in the New Madrid region, about 6 miles north-northwest of the Noranda Aluminum Plant site (Fig. 22-4). These earthquakes produced topographic changes over an area of 30,000 to 50,000 square miles, including the creation of Reelfoot Lake, approximately 10 miles southeast of the plant site, Lake St. Francis and Tiptonville Dome (Coffman and Von Hake, 1973). The New Madrid earthquakes of 1811-12 are the largest historic events that have occurred in the Central United States.

22.3 SITE CONDITIONS

Site conditions at the Noranda Aluminum Plant were studied with a site reconnaissance, deep boring, in situ geophysical measurements, and limited laboratory testing. A 329-foot deep boring was drilled at a location about 600 feet southwest of the Rectifier/Control Building to study the subsurface conditions. A downhole geophysical survey was performed for the full depth of the boring to obtain shear wave velocities of the soils. Soil samples retrieved from the boring were tested in the laboratory to determine their index properties. Detailed results of the field drilling and geophysical testing are presented in Appendix B, and detailed results of the laboratory tests are presented in Appendix C. Summary findings from the field and laboratory studies are discussed below.

22.3.1 Surface Features

The Noranda Aluminum Plant is located on the alluvial Mississippi embayment, less than 3000 feet from the Mississippi River (Fig. 22-1). The ground surface in the vicinity of the plant is relatively flat, with an average elevation of about 295 ft. MSL.

22.3.2 Subsurface Conditions

The 329-foot deep boring at the Noranda Aluminum Plant encountered 190 feet of alluvial sediments overlying unconsolidated sands and clays of the Wilcox Group. Rock was not encountered in the boring. These soil strata are generalized in the boring log of Fig. 22-6 and are briefly discussed below.

The 190 feet of alluvium encountered in the boring consisted of clean to silty, fine to medium sand with some gravelly zones. The density of the sand increased with depth, ranging from loose in the upper 15 feet, to medium dense to dense between depths of 15 and 85 feet, and to very dense below 85 feet. Water content values of the sand generally ranged between 10 and 20 percent. The shear wave velocity determined for the sand increased from 500 fps near the ground surface to 1100 fps at the base of the alluvium.

Materials of the Wilcox Group, consisting of a hard, silty clay with zones of sand and gravel as much as 10 feet thick, were encountered below a depth of 190 feet to the base of the boring at 329 feet. Only one sample was taken in this zone due to difficulties in operating the drilling equipment. The hole was logged for this depth interval primarily from drilling action and cutting returns. The shear wave velocity increased in this zone to a constant value of 1650 fps below a depth of 240 feet.

The water table was measured at a depth of 11 feet in the boring. The water table at the site should be largely controlled by the level of the Mississippi River.

22.3.3 Dynamic Soil Properties

Because only drive samples were retrived from the boring, laboratory testing was not conducted to determine the dynamic properties of the subsurface soils.

TABLE 22-1

SIGNIFICANT EARTHQUAKES IN THE NEW MADRID REGION[1]

Source[2]	Year	Date Mo. Day	Time (CST)	Latitude[3] North (°)	Longitude[3] West (°)	Magnitude[4] (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral[5] Distance (miles)
A	1811	12 - 16	02:00	36.6	89.6	-	XII	-	6 NNW
A	1812	1 - 23	-						
A	1812	2 - 7	-						
A	1865	8 - 17	09:00	36.5	89.5	-	VII	-	4 E
A	1883	1 - 11	01:12	37.0	89.2	-	VI	-	39 NNE
A	1883	4 - 12	02:30	37.0	89.2	-	VI-VII	-	39 NNE
A	1895	10 - 31	05:08	37.0	89.4	-	VIII	-	32 NNE
A	1916	12 - 18	23:42	36.6	89.3	-	VI-VII	-	16 ENE
A	1927	5 - 7	02:28	36.5	89.0	-	VII	-	31 E
A	1952	7 - 16	17:48	36.2	89.6	-	VI	-	21 S
A	1955	3 - 29	03:03	36.0	89.5	-	VI	-	35 S
B	1962	2 - 2	00:43	36.3	89.4	-	VI	16	17 SE
A	1962	7 - 23	00:05	36.1	89.8	-	VI	-	31 SSW
A	1963	3 - 3	11:30	36.7	90.1	4.5	VI	-	32 WNW
B	1974	5 - 13	00:52	36.71	89.39	4.1 (SLM)	VI	1	17 NE
B	1975	6 - 13	16:40	36.54	89.68	4.3 (SLM)	VI	1	7 WNW

Notes:

1. Earthquakes selected for this tabulation have maximum intensities of VI or greater and have occurred within about 60 km (37 miles) of New Madrid (Noranda Aluminum Plant). The intent of this table is to provide a general indication of the seismicity in the region; it is not a complete list of all earthquakes.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Von Hake (1973)

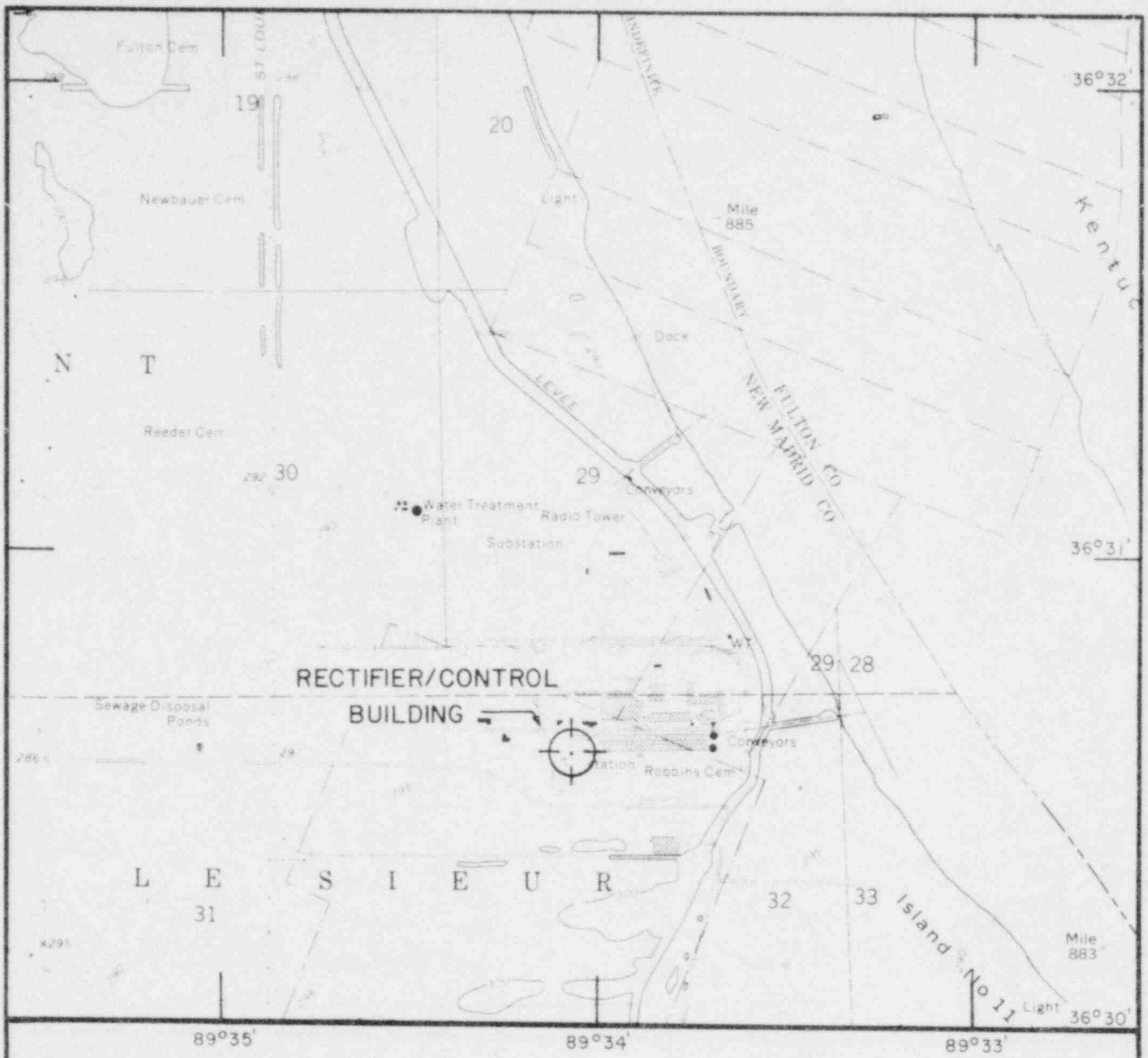
   B. United States Earthquakes

3. The range of uncertainty for epicentral locations may be taken as ± 0.5° for earthquakes prior to 1960 and as about ± 0.2° for those since 1960.

4. Magnitudes designated as SLM were computed by Saint Louis University, Saint Louis, MO.

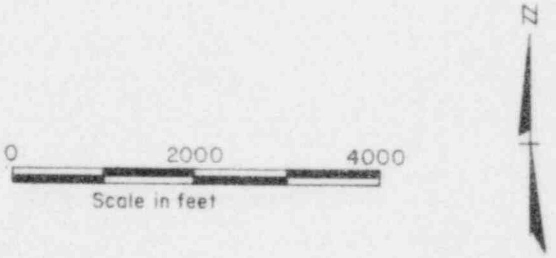
5. All distances have been scaled relative to the accelerograph station at the Noranda Aluminum Plant.

POOR ORIGINAL



NORANDA ALUMINUM PLANT
RECTIFIER/CONTROL BUILDING

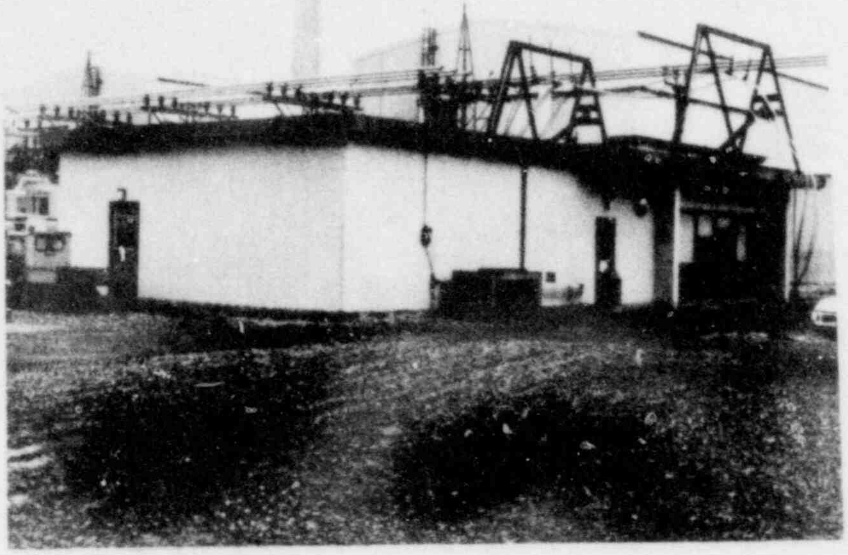
USGS Station No.:	**2420**
County:	**New Madrid**
USGS Topographic Quadrangle:	**New Madrid, Missouri**
Coordinates:	**36°30'35"N. 89°34'04"W.**
Location:	**5.5 miles south-southwest of New Madrid, Missouri**
Building:	**One-story at grade; reinforced concrete block construction.**



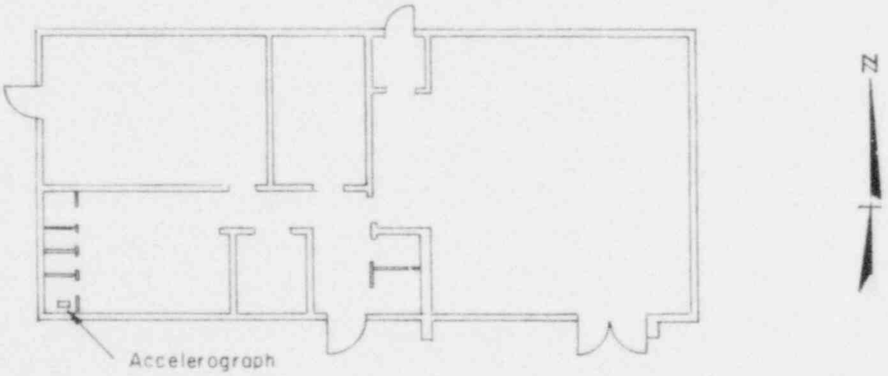
STATION LOCATION
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

POOR ORIGINAL

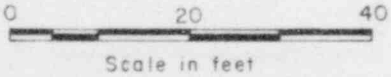
FIG.22-1



Rectifier/Control Building
View-Northeast



Rectifier/Control Building
Floor Plan

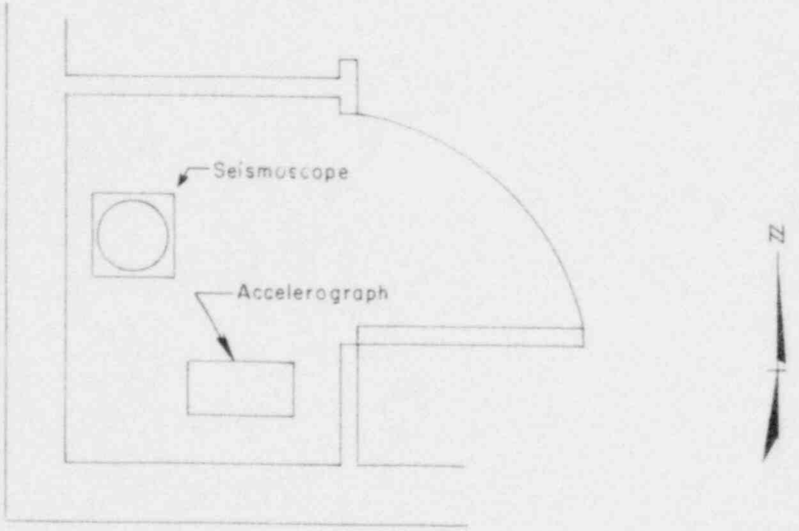


BUILDING PLAN
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

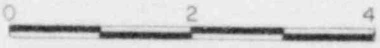
POOR ORIGINAL

FIG.22-2

SMA-1 Accelerograph
Rectifier/Control Building



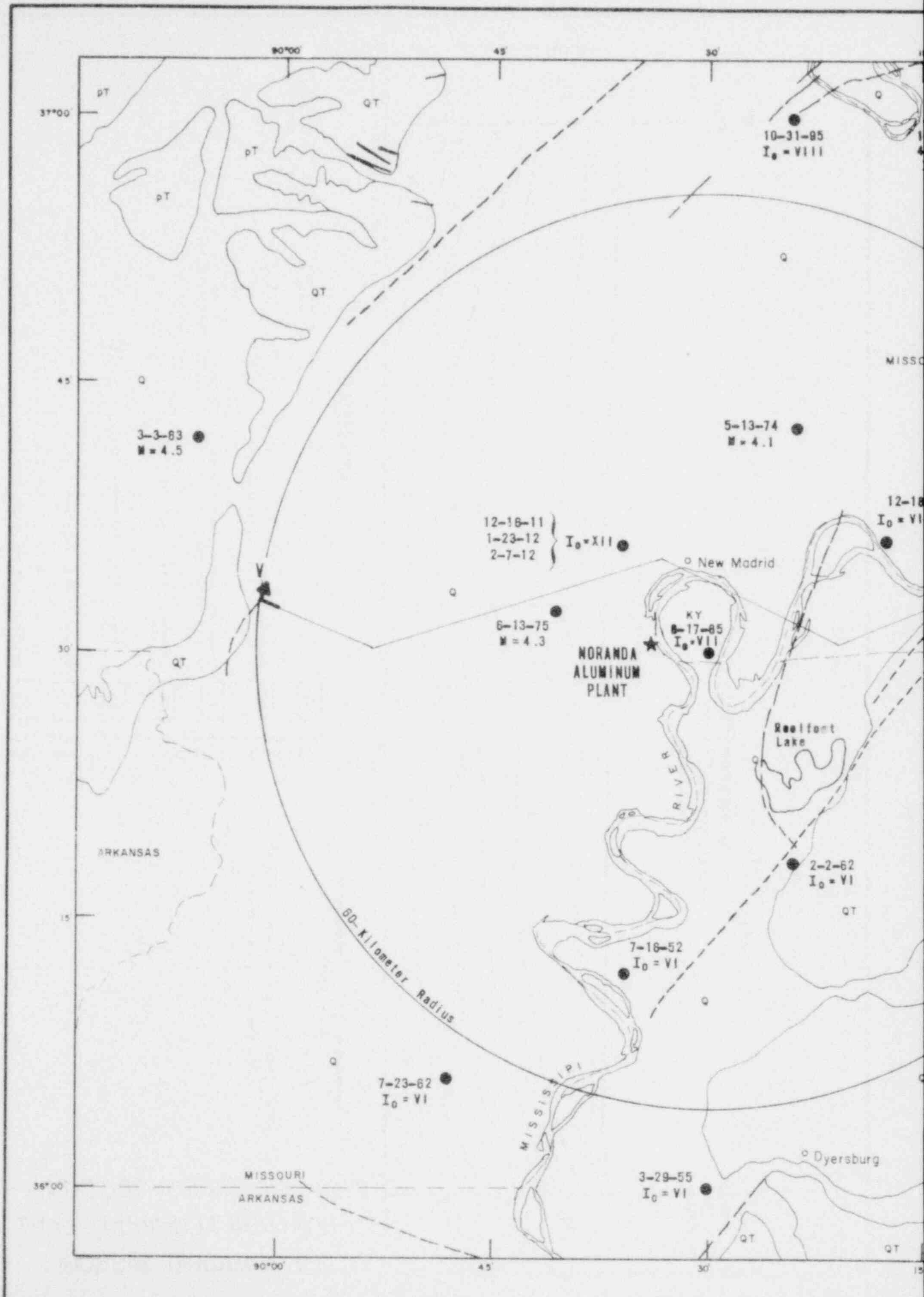
Accelerograph Room Plan



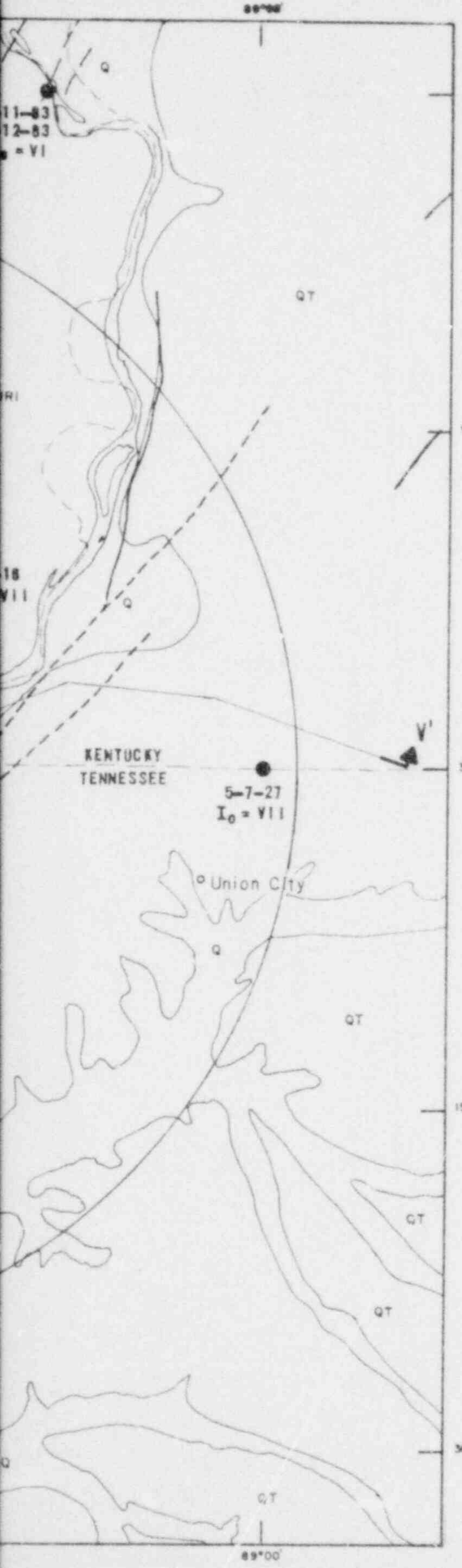
Scale in feet

STATION INSTRUMENTATION
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG.22-3



POOR ORIGINAL



EXPLANATION

Q	Quaternary Alluvium
QT	Quaternary and Tertiary sedimentary rocks. Includes Pleistocene loess deposits.
pT	Pre-tertiary sedimentary rocks.

★ Accelerograph Station location.

● Epicentral locations of selected historic earthquakes listed in Table 22-1.

8-13-75 - Date of occurrence (month-day-year)

$I_0 = V$ — Maximum Intensity (MM)

M = 4.3 — Magnitude (Richter)

Cross-section location.

Contact

Fault — Solid line where known or approximately located; long dash where uncertain; short dash were inferred from exceptionally strong lineaments on aerial photos.

NOTES: 1) Geology and fault information after Heyl and McKeown (1978).

2) All faults shown on map are of pre-Tertiary age (Heyl and McKeown, 1978).

3) Cross-Section V-V' is shown on Fig. 22-5.

0 5 10 15

Scale in miles

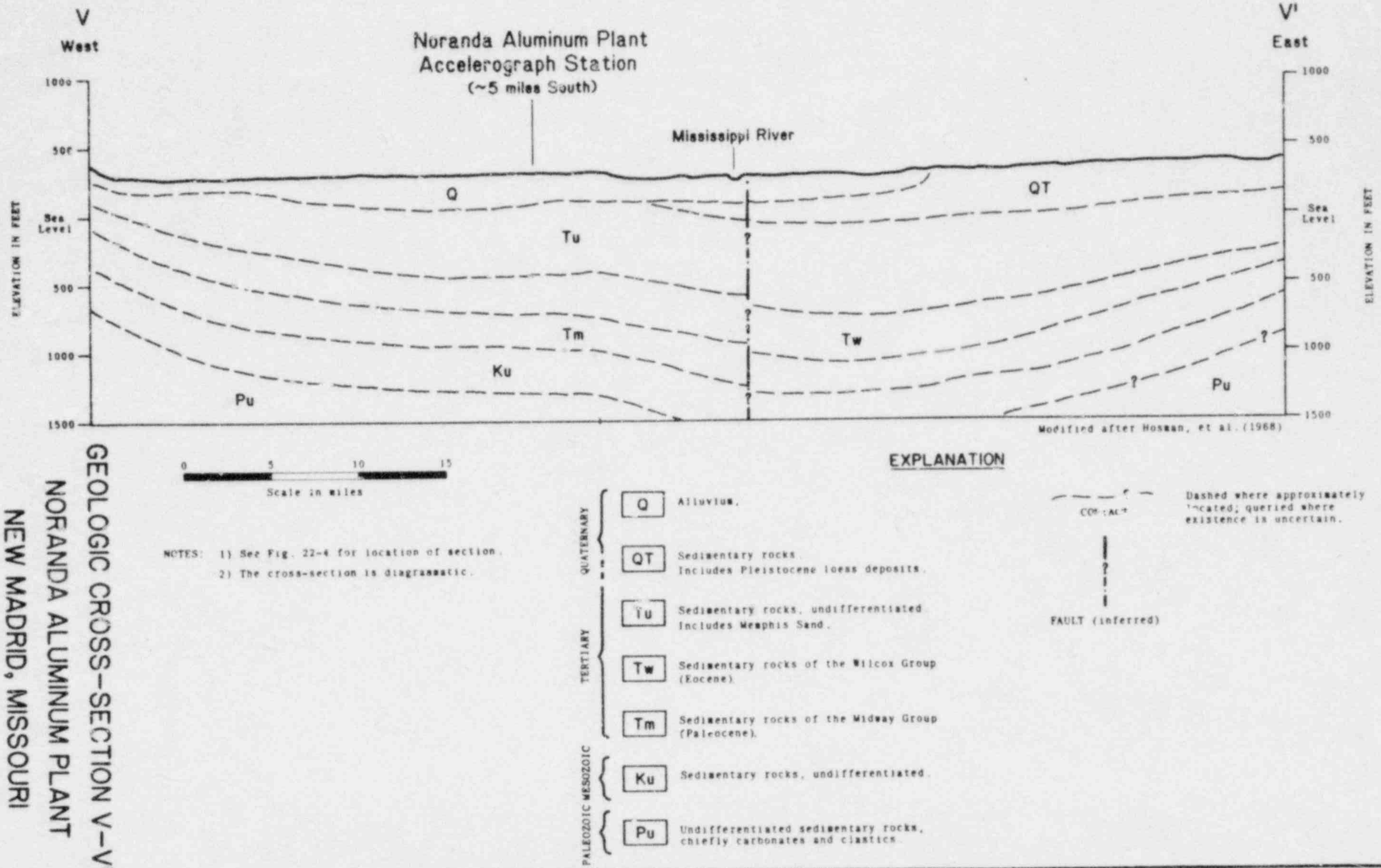
0 5 10 15

Scale in kilometers

Location of Geologic Map

GEOLOGIC MAP
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG. 22-4



Modified after Hosman, et al. (1968)

NOTES: 1) See Fig. 22-4 for location of section.
2) The cross-section is diagrammatic.

EXPLANATION

Q	Alluvium.
QT	Sedimentary rocks. Includes Pleistocene loess deposits.
Tu	Sedimentary rocks, undifferentiated Includes Memphis Sand.
Tw	Sedimentary rocks of the Wilcox Group (Eocene).
Tm	Sedimentary rocks of the Midway Group (Paleocene).
Ku	Sedimentary rocks, undifferentiated.
Pu	Undifferentiated sedimentary rocks, chiefly carbonates and clastics.

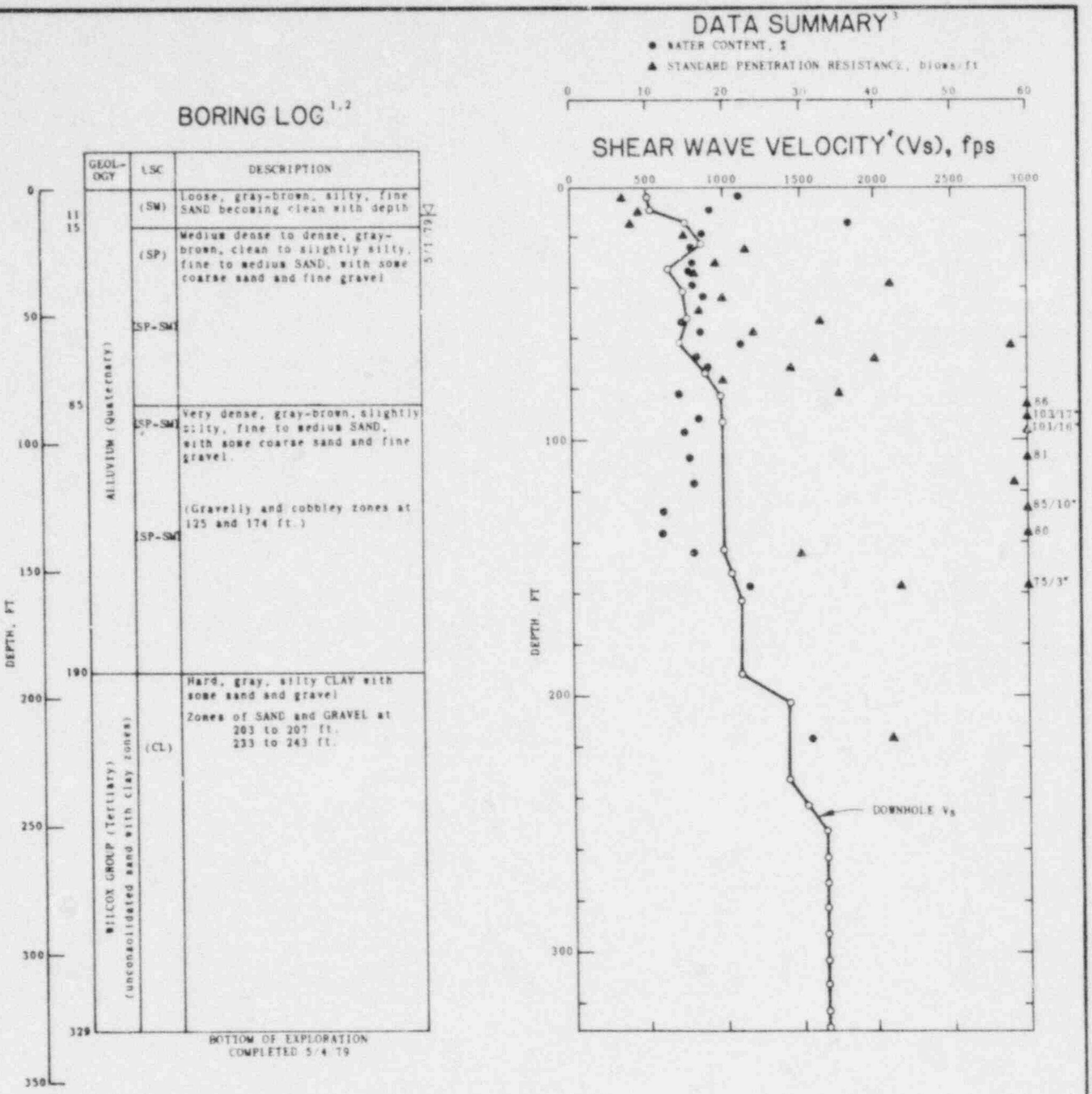
CONTACT: Dashed where approximately located; queried where existence is uncertain.

FAULT (inferred)

GEOLOGIC CROSS-SECTION V-V'
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG. 22-5

POOR ORIGINAL



NOTES: 1) THE BORING IS LOCATED ABOUT 600 FT. SOUTHWEST OF THE RECTIFIER/CONTROL BUILDING, WHICH CONTAINS THE ACCELEROGRAPH THE STRATIFICATION LINES IN THE BORING LOG REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES, AND THE TRANSITION MAY BE GRADUAL.

2) THE BORING ELEVATION OF 297 FT. MSL WAS OBTAINED BY HAND LEVELING FROM A NEARBY BENCH MARK.

3) LIMITED LABORATORY TESTING WAS PERFORMED SINCE ONLY SPT DRIVE SAMPLES WERE TAKEN IN THE BORING. LABORATORY TEST RESULTS ARE PRESENTED IN APPENDIX C.

4) DETAILED RESULTS OF THE DOWNHOLE GEOPHYSICAL TESTING ARE PRESENTED IN APPENDIX B.

POOR ORIGINAL

BORING LOG AND
SUMMARY OF TEST RESULTS
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG. 22-6

APPENDIX A

EARTHQUAKE RECORDS

APPENDIX A
EARTHQUAKE RECORDS

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APPENDIX A
EARTHQUAKE RECORDS

INTRODUCTION

Organization

This appendix contains detailed information about the earthquakes which were recorded at the accelerograph stations. This information is presented in the form of tables of station records and plots of ground motion time histories and response spectra. The general format of this data is discussed below; however, specific items may not apply to all stations. Data for the individual accelerograph stations is presented in the five sections which follow (Sections 18A-22A).

Instrumentation

An accelerograph, similarly termed by others as a strong motion seismograph, is an instrument for recording earthquake ground accelerations. In contrast to an observatory seismograph which operates constantly, an accelerograph remains on standby until triggered by a seismic vibration. Since it is designed to record strong ground motion, the accelerograph has a sensitivity several orders of magnitude lower than a seismograph. Typical magnifications of a seismograph may be up to a million, whereas an accelerograph would have a magnification in the order to 30 to 150.

All of the accelerograph stations mentioned in this appendix belong to the USGS Strong Motion Instrumentation Network. This network consists of instruments mainly located in the United States, although some instruments are located in other countries. Instruments in the network may be owned and maintained by the USGS or other agencies. For instance, several of the accelerograph stations mentioned in this appendix are owned by the California Division of Mines and Geology (CDMG) under their Strong Motion Instrumentation Program (CDMG, 1974). Under this arrangement, the CDMG owns and maintains the station and the USGS processes all station records.

Characteristics of some of the instruments in the USGS network are indicated in Table A-1. More detailed instrument descriptions are presented in Brazee, 1974. The orientations listed in Table A-1 are for pendulum motion;i.e., the direction of displacement of the instrument pendulum to produce a positive trace (upward) on the accelerograph record. The USGS is discontinuing the practice of reporting pendulum motions and instead will report all instrument orientations in the case motion convention. The case motion system is based on displacement of the accelerograph case; consequently, it is 180 degrees out of phase with the orientation for pendulum motion. However, only pendulum motion bearings are cited in this report.

TABLE OF STATION RECORDS

Station Data

The tables of station records contain basic information on the accelerograph stations including location, buildings and instrumentation. This information was primarily obtained from the files of the USGS (unpub.) and the CDMG (unpub.); however, a site reconnaissance was made at each station to check or correct this data. Presently, select station data may be acquired through the USGS computerized Strong Motion tion Retrieval System (verse, 1978).

Earthquakes

Earthquakes recorded at the stations are listed in the tables in chronological order. Local times are given for the events as Alaska Standard Time (AST), Pacific Standard Time (PST), or Central Standard Time (CST). The tables also include the sources that were used in obtaining earthquake information, since disagreement on earthquake location and size is common. Earthquake epicenters listed in the tables may be regarded as having a range of uncertainty of about ± 0.5 degrees for events prior to 1960 and as about ± 0.2 degrees for later events. Epicentral distances in the tables have all been scaled relative to the accelerograph station.

Earthquake magnitudes given in the tables have been computed by various organizations. Magnitudes followed by a letter designation have been determined by a specific authority. Where the method of magnitude determination was not clear in the source data, designations were omitted from the events. The following designations were used to indicate the various authorities:

B - University of California at Berkeley
P - California Institute of Technology in Pasadena
SLM - St. Louis University, St. Louis, Missouri
M_b - Magnitude computed from body waves on a seismogram (C&GS/USGS).

Records

Peak values of acceleration are reported in the tables for the uncorrected accelerograms and, where processed, the corrected accelerograms. In most cases, accelerations cited for the uncorrected accelerograms were obtained from the annual publication United States Earthquakes. Accelerations of the processed records are indicated immediately below the uncorrected values. Record processing has been performed by the California Institute of Technology (Hudson, et al., 1971-1975a), the USGS (Brady and Perez, 1979), and St. Louis University (Herrmann, 1977). Accelerograms that have been processed by the California Institute of Technology (CIT) are indicated in the tables with their CIT record identification number.

Acceleration values are commonly reported in either g's or cm/sec^2. Exact conversion of the latter to g's is to divide by 980; however, for practical purposes, it is common to convert to g's by dividing by 1000. To minimize confusion, the acceleration values in the tables are reported in g's to either two or three decimal places to signify the nature of the source data. Accelerations reported to two decimal places have been obtained from sources which report directly in g's. Values reported to three decimal places have been converted from source data expressed in cm/sec^2 (divided by 1000).

Uncorrected and corrected earthquake records are available from several sources. The CIT report series on strong motion records for the February 9, 1971 San Fernando, California, earthquake and significant earlier events is available from the National Technical Information Service (NTIS). Digitized earthquake data from the CIT report series is available from the Environmental Data and

Information Service (EDIS) and from the National Information Service for Earthquake Engineering (NISEE). The above reports and other earthquake data may be obtained from the following agencies:

1. EDIS/NOAA
   National Geophysical and Solar Terrestrial Data Center
   Code D62
   Boulder, Colorado 80302

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

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

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

5. National Technical Information Service
   U.S. Department of Commerce
   Springfield, Virginia 22151

GROUND MOTION TIME HISTORIES

Ground motion time history plots are presented for earthquake records that have been digitized and processed by others. Plots appearing in this appendix have been taken from reports by the CIT (Hudson, et al, 1971-1975a), USGS (Brady and Perez, 1979) and St. Louis University (Herrmann, 1977). The format of these figures consists of the baseline-corrected, time history of acceleration and corresponding curves of integrated ground velocity and displacement. Separate figures are presented for each of the three component directions of the accelerograph that recorded the earthquake.

RESPONSE SPECTRA

Response spectra plots are presented for earthquake records that have been digitized and processed by others. Plots appearing in this appendix have been taken from reports by the CIT (Hudson, et al., 1971-1975b) and USGS (Brady and Perez, 1979). The format of these figures consists of tripartite plots of response spectra that have been calculated at 0, 2, 5, 10 and 20% damping. Separate figures are presented for each of the three component directions of the accelerograph that recorded the earthquake.

TABLE A-1

ACCELEROGRAPH MODELS IN THE USGS STRONG MOTION NETWORK

Instrument	Sensitivity cm/g	Period Sec.	Recording Medium	Orientation[1]	Manufacturer
C&GS Standard	6-17	0.04-0.08	6 or 12 inch photo paper	L - Toward V - Up T - Left	Coast and Geodetic Survey
AR-240	7.5	0.05-0.06	12 inch photo paper	L - Away V - Down T - Left	Teledyne Geotech
RFT-250	1.9	0.05	70-mm film	L - Away V - Down T - Left	Teledyne Geotech
MO-2	1.5 (hor.) 2.2 (vert.)	0.03	35-mm film	L - 45° Left V - Up T - 45° Right	Victoria Engineering, New Zealand
SMA-1	1.9	0.04	70-mm film	L - Toward V - Down T - Right	Kinemetrics

Notes:

1. Orientation is the direction of displacement of the accelerograph pendulum for a trace up on the record.

   L, V and T refer to the longitudinal, vertical and transverse components of acceleration.

Section 18A

UA Duckering Hall
Fairbanks, Alaska

SECTION 18A
EARTHQUAKE RECORDS
UA DUCKERING HALL
FAIRBANKS, ALASKA

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SECTION 18A
EARTHQUAKE RECORDS
UA DUCKERING HALL
FAIRBANKS, ALASKA

STATION RECORDS

The only earthquake recorded at Duckering Hall was the event of June 21, 1967 (Table 18A-1). Although the accelerograph was triggered by the shock at 08:05 AST, it continued to run without time marks after this event and recorded three additional shocks. It was during one of these later shocks that the maxiumum ground accelertion of 0.14g was recorded (Jordan, et al., 1968).

Although the accelerogram of the June 21, 1967 earthquake has not been processed, details of the event have been reported by Jordan, et al. (1968). The uncorrected accelerogram of the 08:05 shock, showing all three components of the recorded ground motion, is presented in Fig. 18A-1. Velocity and displacement response spectra calculated for this event by Jordan, et al. (1968) are presented in Figs. 18A-2 through 18A-7.

TABLE 18A-1

STATION RECORDS

UA DUCKERING HALL

FAIRBANKS, ALASKA

USGS NO.	:	2721
Location	:	University of Alaska (Fairbanks, Campus) southeast portion of campus
Property Owner	:	University of Alaska
Building	:	Three stories with a daylight basement, steel framing and reinforced concrete construction.
Instrument Location	:	Basement room U-5; approx. 5 ft. below exterior grade.
Present Instrumentation	:	SMA-1 accelerograph (S/N 1926) and seismoscope (S/N 3072).
Station Installation Date	:	July 29, 1965

Borough : Fairbanks North Star
Quadrangle : Fairbanks D-2 SW, Alaska
Township 1S; Range 1W; Section 6
Coordinates : 64.857°N; 147.816°W

Source[1]	Year	Date Mo. Day	Time (AST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (miles)	Max. Acceleration (g's)[2] South	Down	East	Record[3]
A	1967	6 - 21	08:05 08:13 08:25	64.8	147.4	5.4 5.6 (m_b) 5.4	VII	--	13 ESE	0.06	0.06	0.06	C&GS[3]
										0.07	0.03	0.03	
										0.14	0.08	0.09	
										0.08	0.04	0.04	

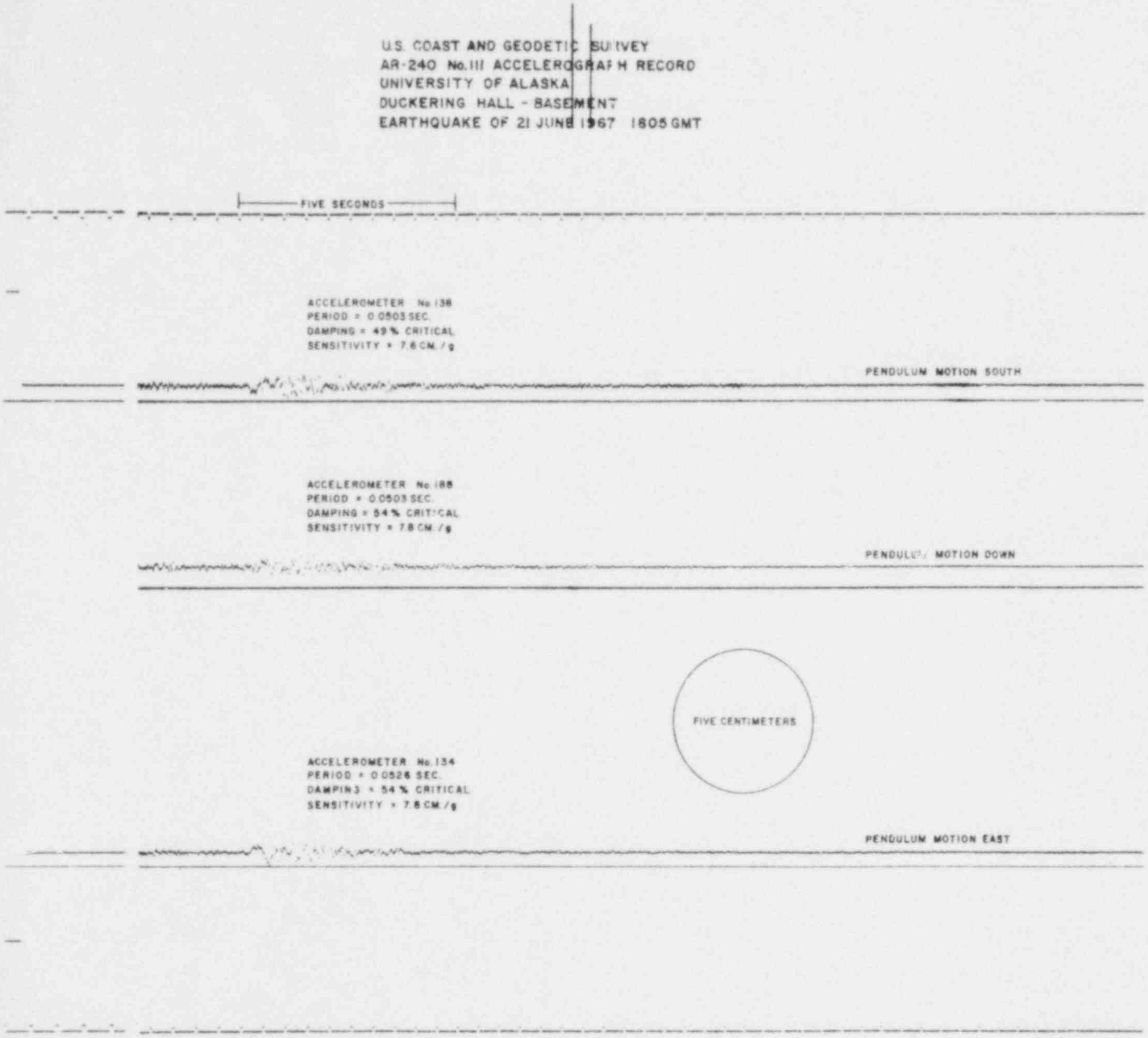
Notes:

1. Jordan, et al. (1968), source A, was used for compiling data on the 1967 earthquake. Station records were checked with the listings of Brazee (1974), Morris, et al. (1977), and the USGS (unpub.).

2. All recoreings were made on an AR-240 accelerograph (S/N 111) with the indicated bearings for pendulum motion. The initial shock of 08:05 triggered the accelerograph. Three subsequent shocks were also recorded the same day, but the time of these events is uncertain.

3. Response spectra were calculated for the 08:05 shock (Jordan, et al., 1968).

POOR ORIGINAL



POOR ORIGINAL

FIG. 18A-1

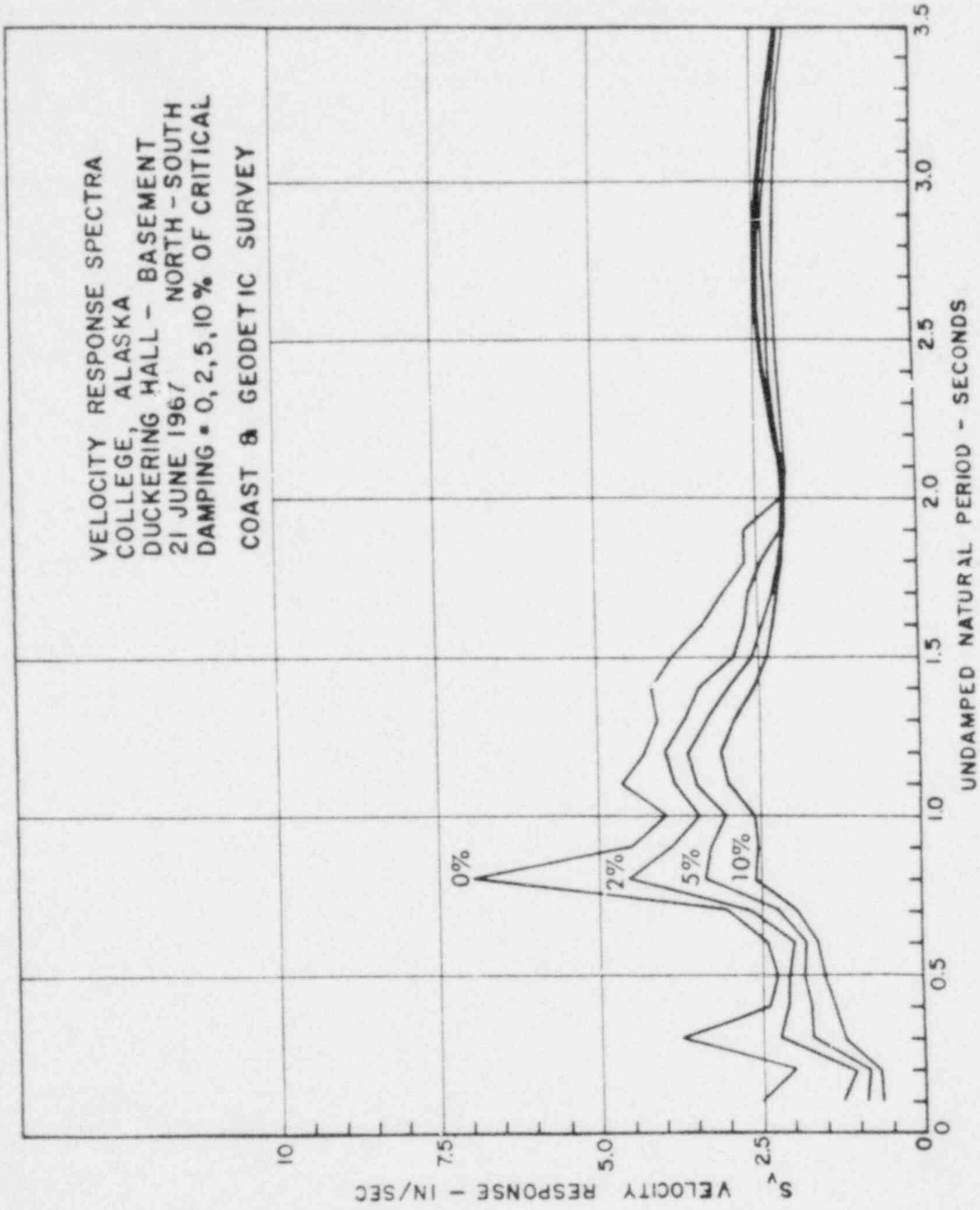

VELOCITY RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 NORTH - SOUTH
DAMPING = 0, 2, 5, 10 % OF CRITICAL
COAST & GEODETIC SURVEY
0%
2%
5%
10%
S_v VELOCITY RESPONSE - IN/SEC
0
2.5
5.0
7.5
10
UNDAMPED NATURAL PERIOD - SECONDS
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

FIG. 18A-2

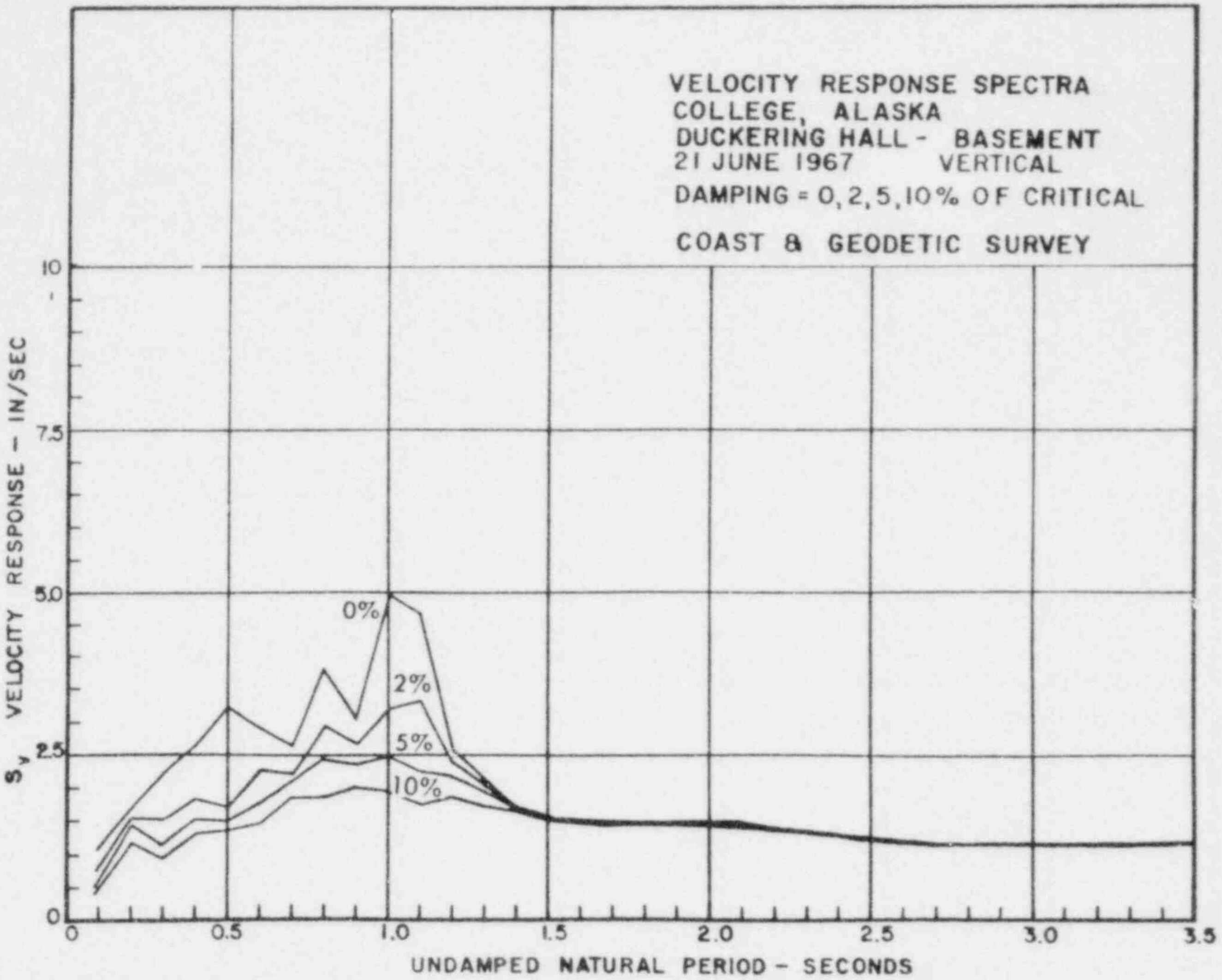

VELOCITY RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 VERTICAL
DAMPING = 0, 2, 5, 10% OF CRITICAL
COAST & GEODETIC SURVEY
S_v VELOCITY RESPONSE - IN/SEC
10
7.5
5.0
2.5
0
0%
2%
5%
10%
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
UNDAMPED NATURAL PERIOD - SECONDS

FIG. 18A-3

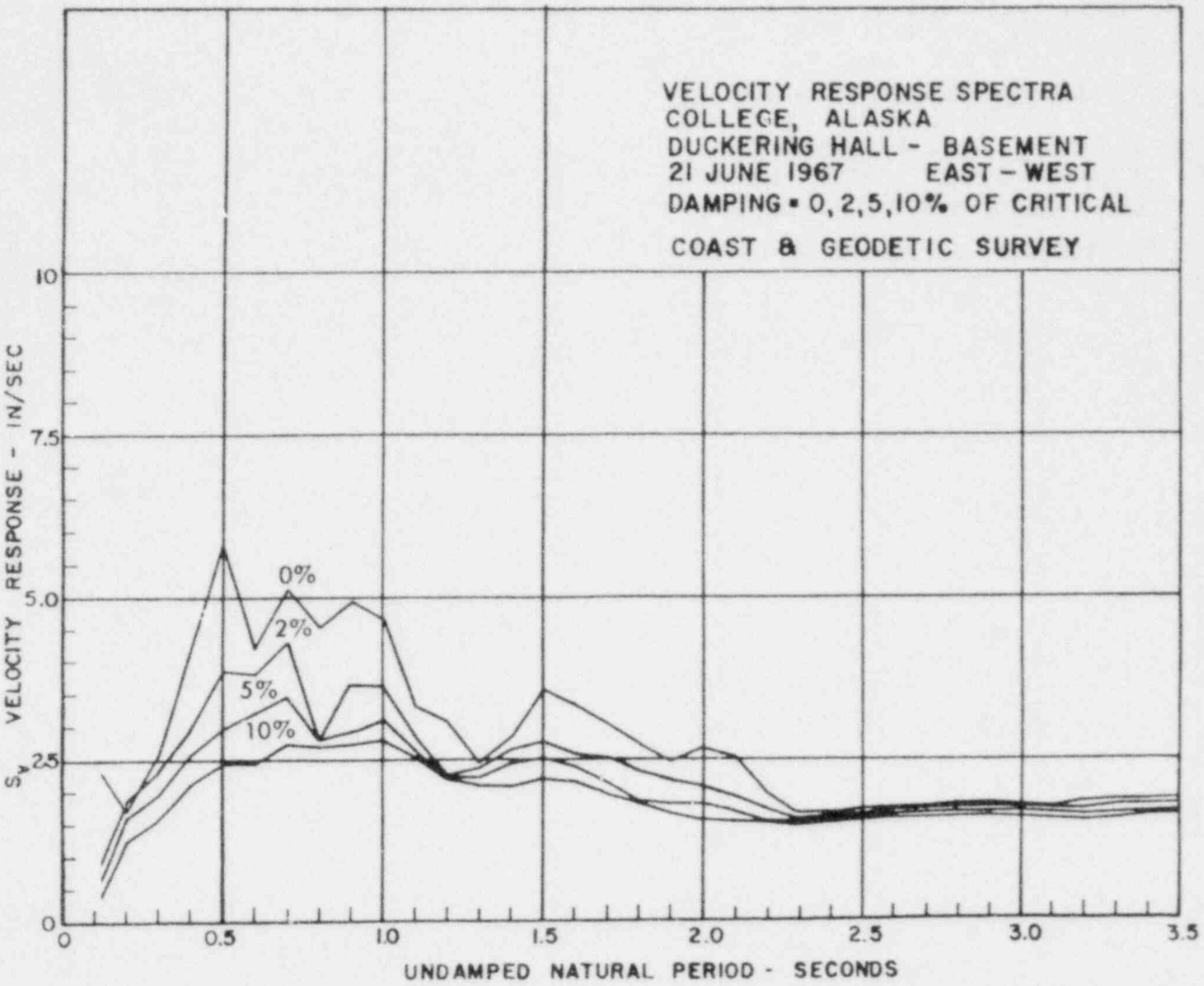

VELOCITY RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 EAST - WEST
DAMPING = 0, 2, 5, 10% OF CRITICAL
COAST & GEODETIC SURVEY
0%
2%
5%
10%
10
7.5
5.0
2.5
0
S_v
VELOCITY RESPONSE - IN/SEC
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
UNDAMPED NATURAL PERIOD - SECONDS

FIG. 18A-4

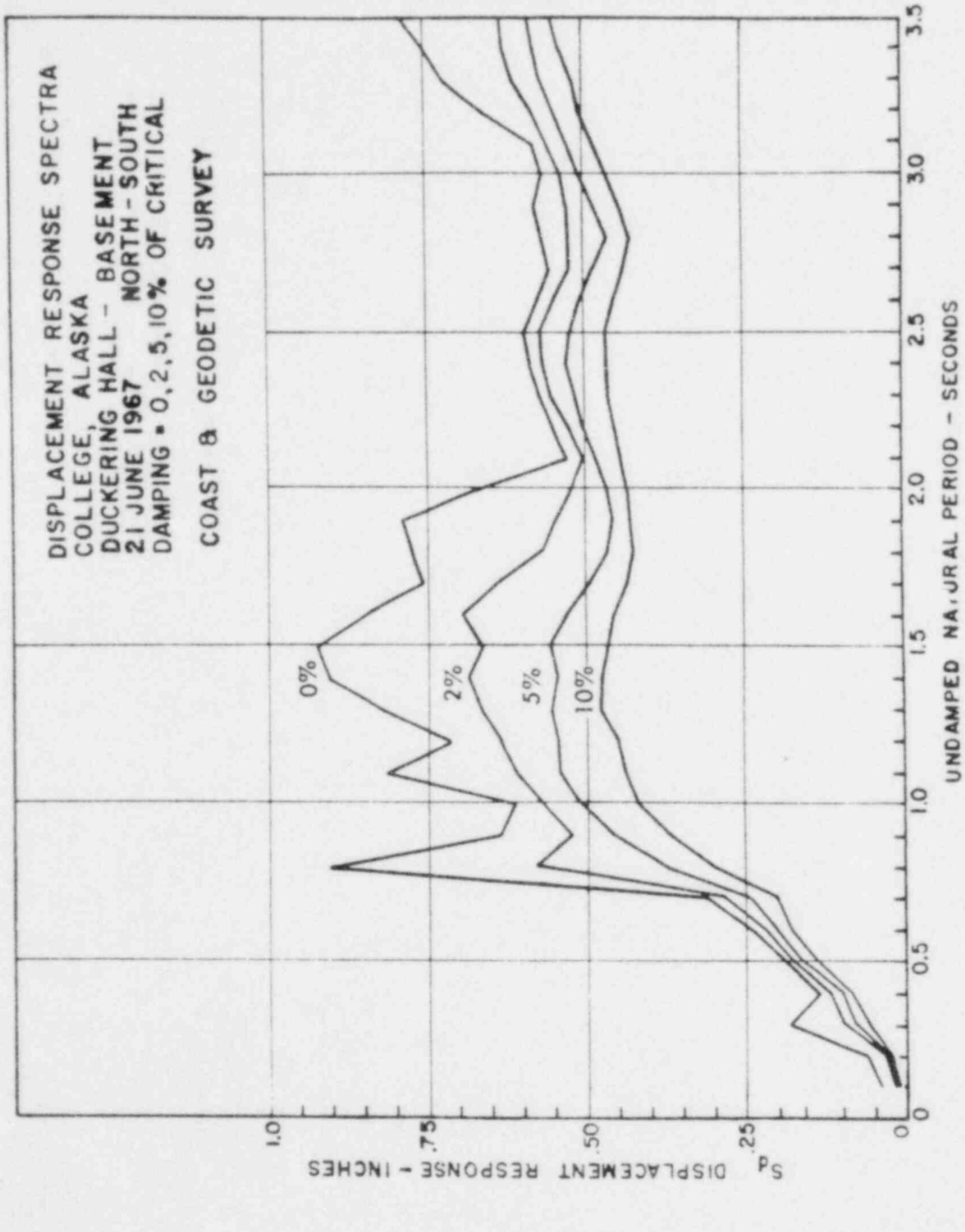

DISPLACEMENT RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 NORTH - SOUTH
DAMPING = 0,2,5,10% OF CRITICAL
COAST & GEODETIC SURVEY
0%
2%
5%
10%
S_d DISPLACEMENT RESPONSE - INCHES
1.0
.75
.50
.25
0
UNDAMPED NATURAL PERIOD - SECONDS
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

FIG. 18A-5

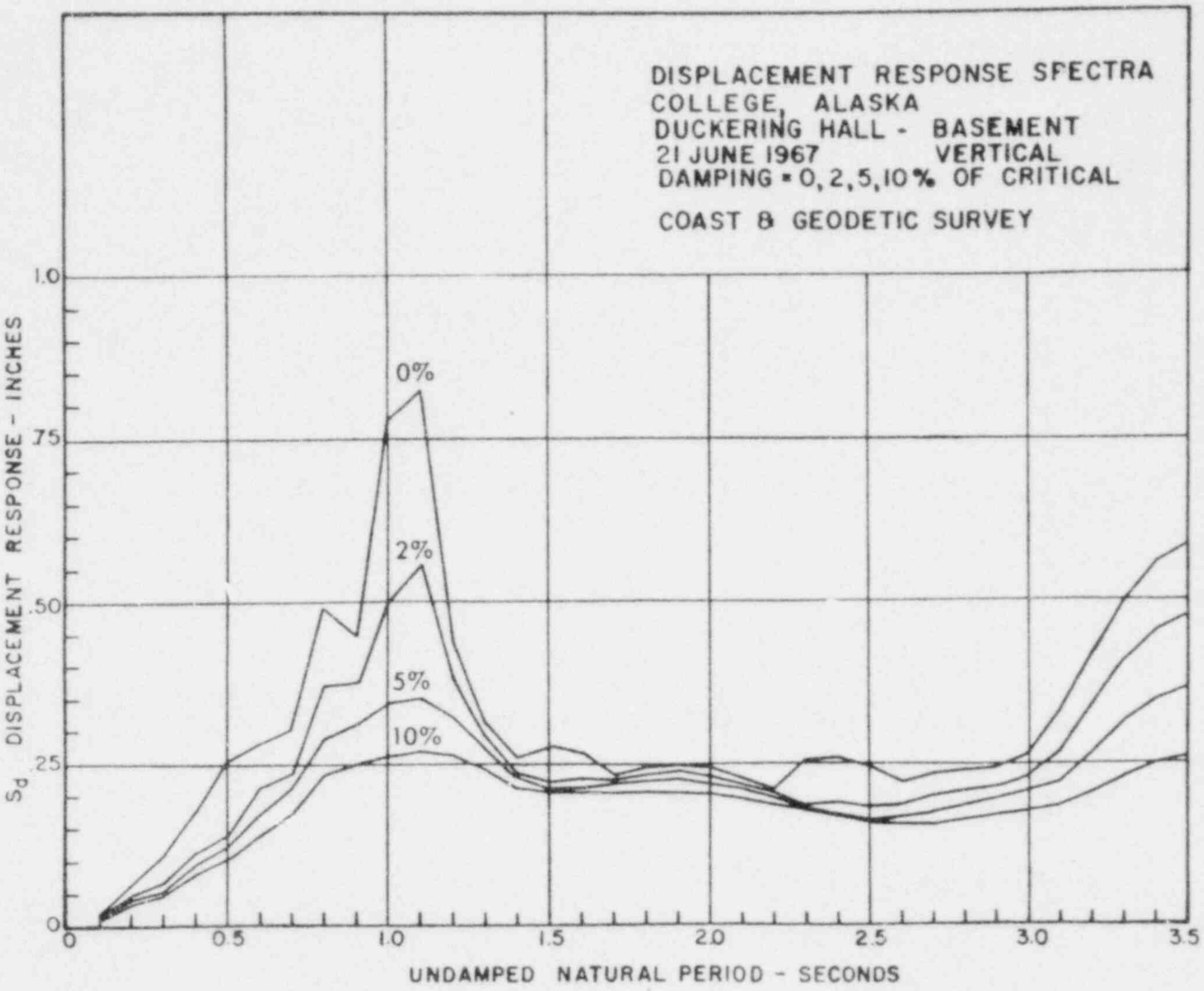

DISPLACEMENT RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 VERTICAL
DAMPING = 0, 2, 5, 10 % OF CRITICAL
COAST & GEODETIC SURVEY
0%
2%
5%
10%
S_d DISPLACEMENT RESPONSE - INCHES
1.0
.75
.50
.25
0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
UNDAMPED NATURAL PERIOD - SECONDS

FIG. 18A-6

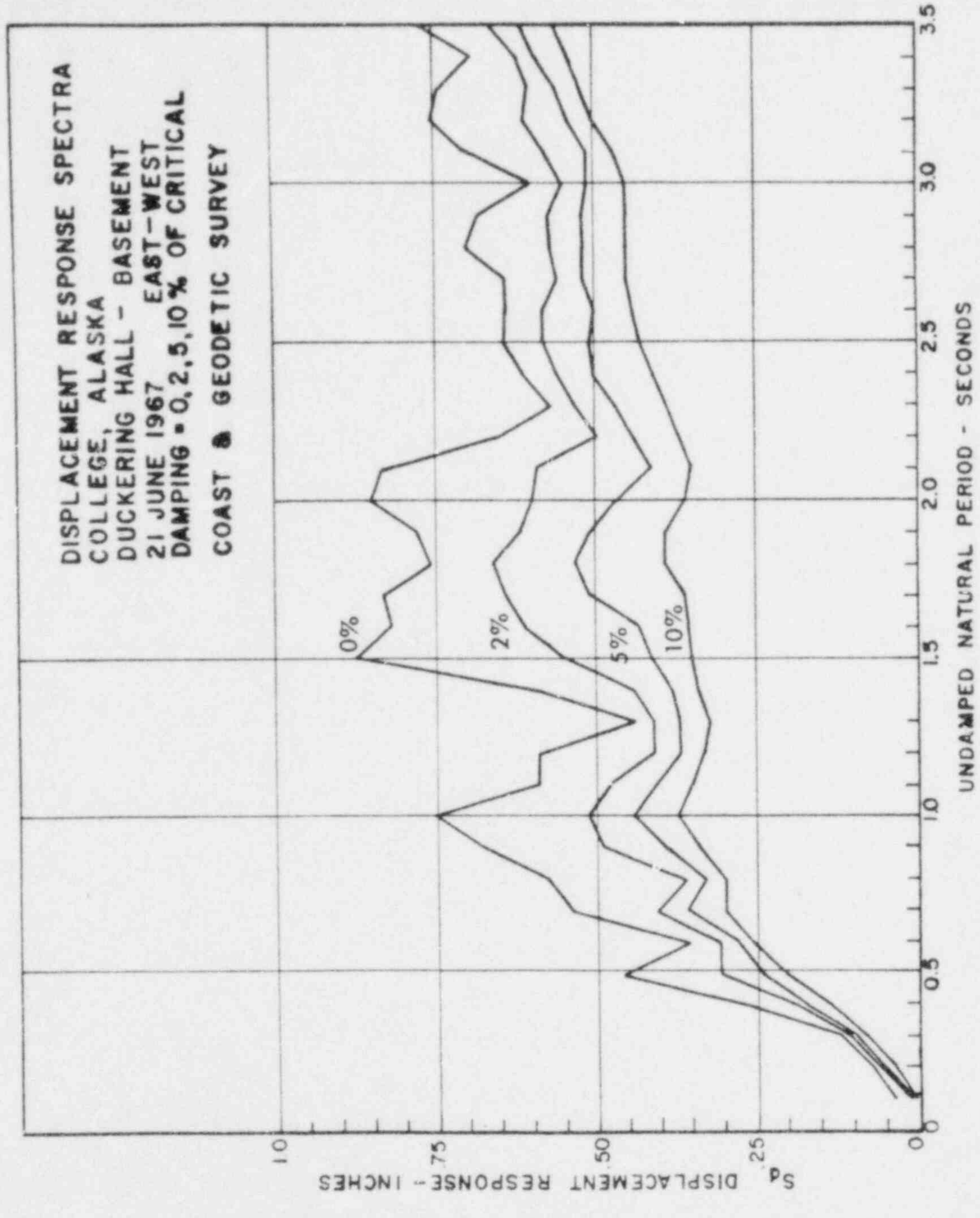

DISPLACEMENT RESPONSE SPECTRA
COLLEGE, ALASKA
DUCKERING HALL - BASEMENT
21 JUNE 1967 EAST-WEST
DAMPING = 0,2,5,10% OF CRITICAL
COAST & GEODETIC SURVEY
0%
2%
5%
10%
S_d DISPLACEMENT RESPONSE - INCHES
1.0
.75
.50
.25
0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
UNDAMPED NATURAL PERIOD - SECONDS

FIG. 18A-7

Section 19A

General Store
Petrolia, California

SECTION 19A
EARTHQUAKE RECORDS
GENERAL STORE
PETROLIA, CALIFORNIA

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TABLE 19A-1

STATION RECORDS

GENERAL STORE

PETROLIA, CALIFORNIA

USGS No. : 1398
CDMG No. : 156
Location : Mattole Road, Petrolia, Calif.
Property Owner : Petrolia Volunteer Fire District
Building : Small, fiberglass instrument shelter
Instrument Location : Ground level
Present Instrumentation : SMA-1 accelerograph (S/N 1815)
Station Installation Date : Aug. 11, 1974

County : Humbolt
Quadrangle : Petrolia, Calif. (7.5')
Township 2S; Range 2W; Section 3
Coordinates : 40.325°N; 124.286°W

Source[1]	Year	Date Mo. Day	Time (PST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (miles)	Max. Acceleration (g's)[2] N75E	Down	N15W	Record
A	1975	1 - 11	17:37	40.22	124.26	4.4(B)	VI	1	7 SSE	0.19	0.04	0.13[3]	-
B										0.180	0.030	0.114[4]	USGS[4]
A	1975	6 - 7	00:46	40.57	124.14	5.2(B)	VII	13	18 NNE	0.19	0.03	0.13[3]	-
B										0.159	0.039	0.128[4]	USGS[4]
A	1975	11 - 14	01:30	40.62	124.31	4.8(B)	VI	14	21 N	0.10	0.02	0.08[3]	-

Notes:

1. The following sources were used in compiling the earthquake data:

   A. *United States Earthquakes*

   B. Brady and Perez (1979)

   Station records were checked with the listings of Morris, et al. (1977) and the USGS (unpub.).

2. All recordings were made on a SMA-1 accelerograph (S/N 1684) with the indicated bearings for pendulum motion (USGS, unpub.). The reported horizontal bearings may be in error by 16° - see text for details.

3. Accelerations from unprocessed records (*United States Earthquakes*).

4. Accelerations from digitized and baseline corrected records that have been processed by the USGS (Brady and Perez, 1979).

POOR ORIGINAL

CORRECTED ACCELERATION.VELOCITY.DISPLACEMENT
CAPE MENDOCINO EARTHOUAKE OF JANUARY 11.1975.1737PST
PETROLIA.CALIFORNIA.GENERAL STORE.N75E COMP
ACCELEPOGRAM IS BAND PASS FILTERED BETWEEN .350 - .500 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-179.7 CM/SEC/SEC.VELOCITY=5.869 CM/SEC.DISPL=-.244 CM

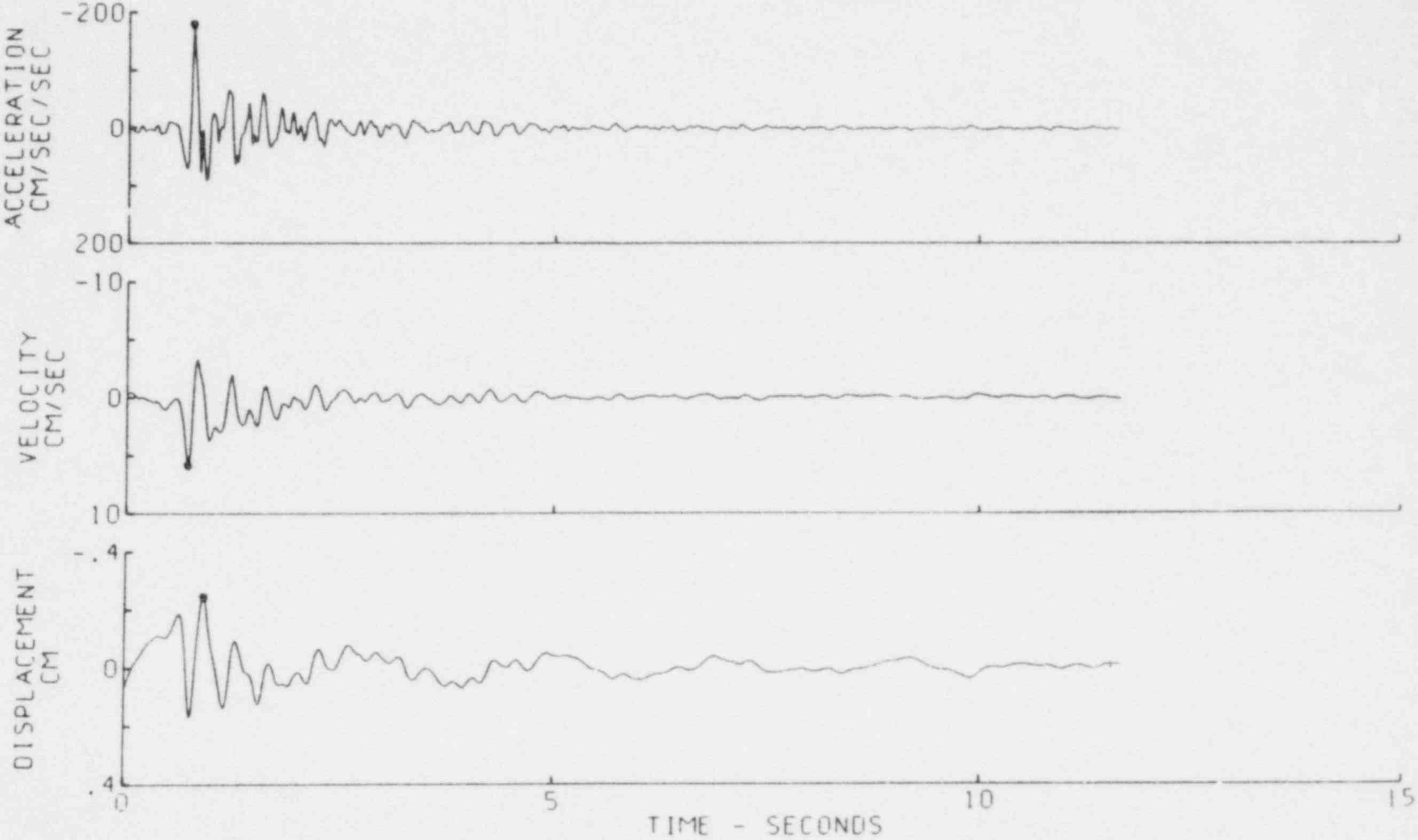


FIG. 19A-1

POOR ORIGINAL

CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
CAPE MENDOCINO EARTHQUAKE OF JANUARY 11, 1975, 1737PST
PETROLIA, CALIFORNIA, GENERAL STORE, DOWN COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .350 - .500 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=30.50 CM/SEC/SEC, VELOCITY=1.440 CM/SEC, DISPL=-.082 CM

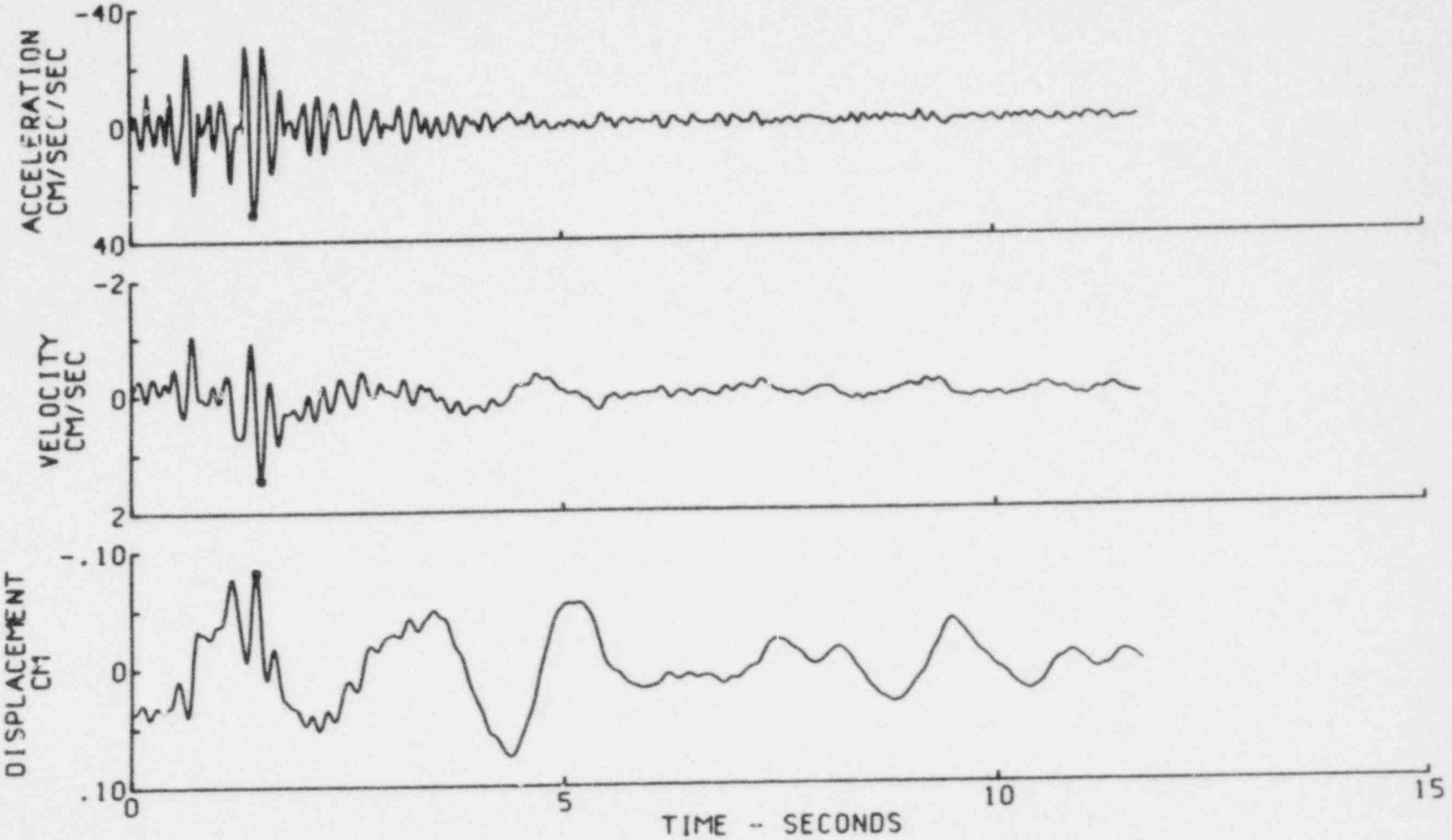


FIG. 19A-2

CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
CAPE MENDOCINO EARTHQUAKE OF JANUARY 11, 1975, 1737PST
PETROLIA, CALIFORNIA, GENERAL STORE, N15W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .350 - .500 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL = -113.7 CM/SEC/SEC, VELOCITY = 2.564 CM/SEC, DISPL = .119 CM

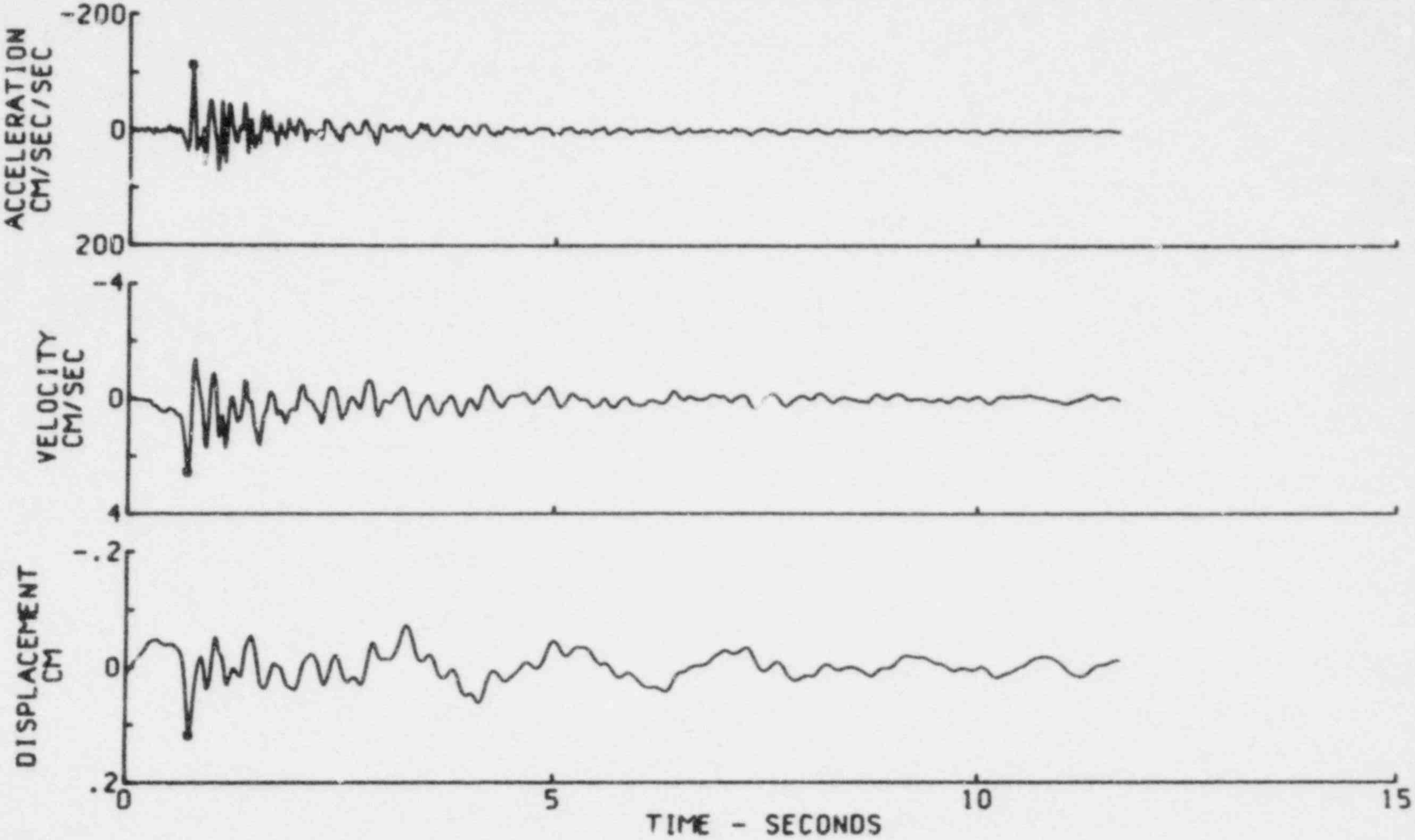


FIG. 19A-3

CORRECTED ACCELERATION.VELOCITY.DISPLACEMENT
HUMBOLDT COUNTY EARTHQUAKE OF JUNE 7.1975.0846GMT
PETROLIA.CALIFORNIA.GENERAL STORE.N75E COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .170 - .250 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-158.5 CM/SEC/SEC.VELOCITY=-8.720 CM/SEC.DISPL=1.540 CM

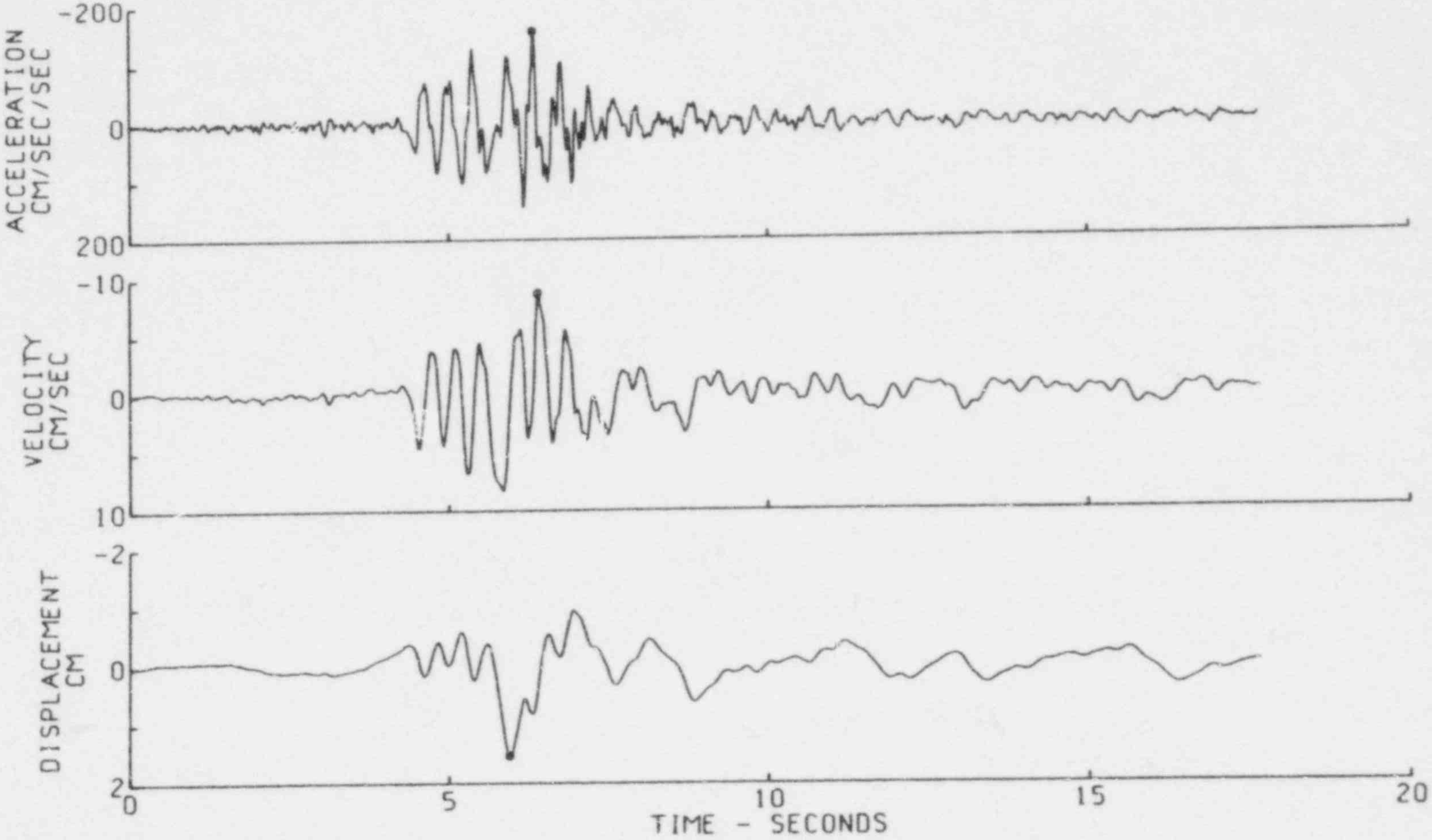


FIG. 19A-4

CORRECTED ACCELERATION.VELOCITY.DISPLACEMENT
HUMBOLDT COUNTY EARTHQUAKE OF JUNE 7.1975.0846GMT
PETROLIA.CALIFORNIA.GENERAL STORE.DOWN COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .170 - .250 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=38.71 CM/SEC/SEC.VELOCITY=-1.580 CM/SEC.DISPL=-.380 CM

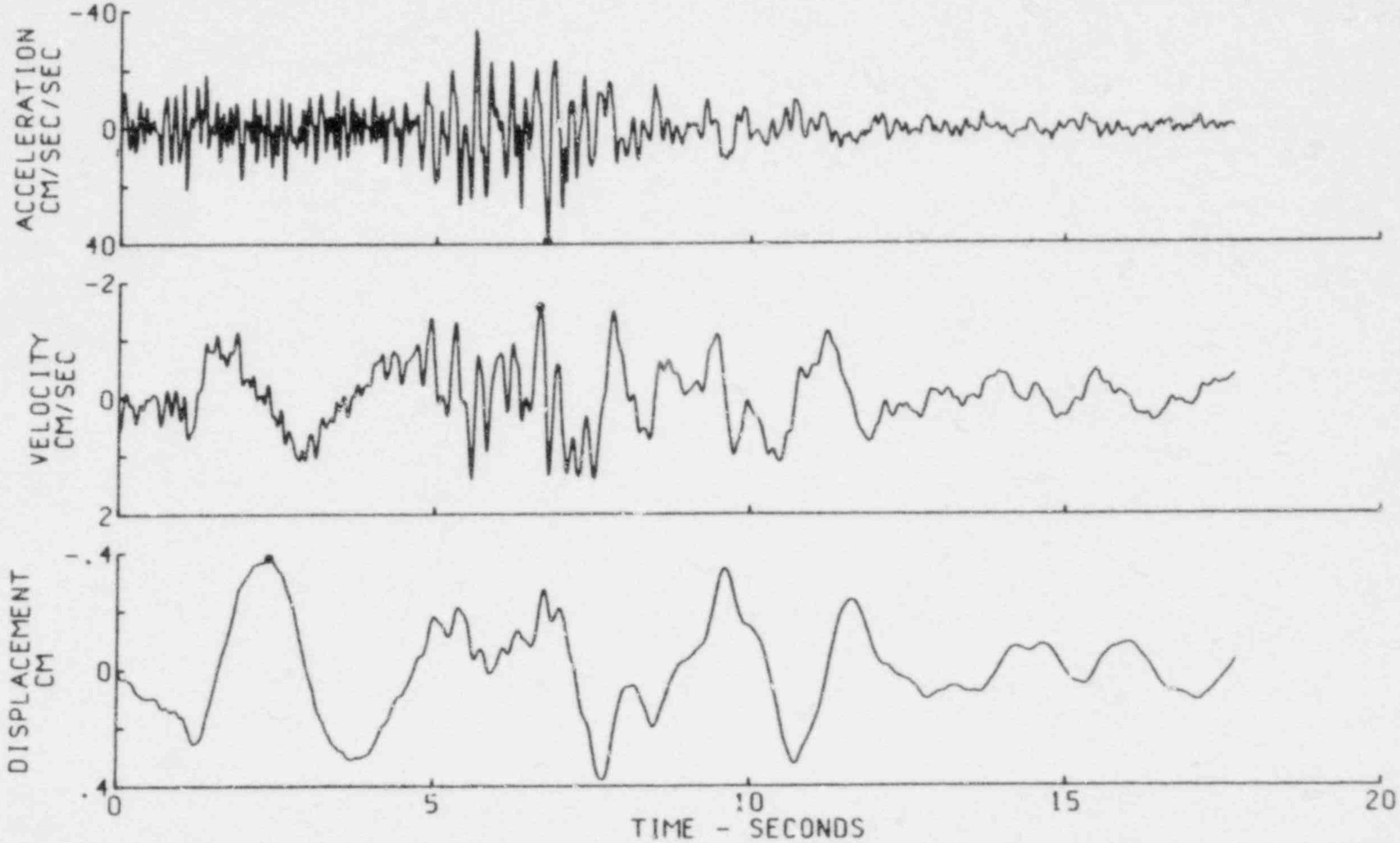


FIG. 19A-5

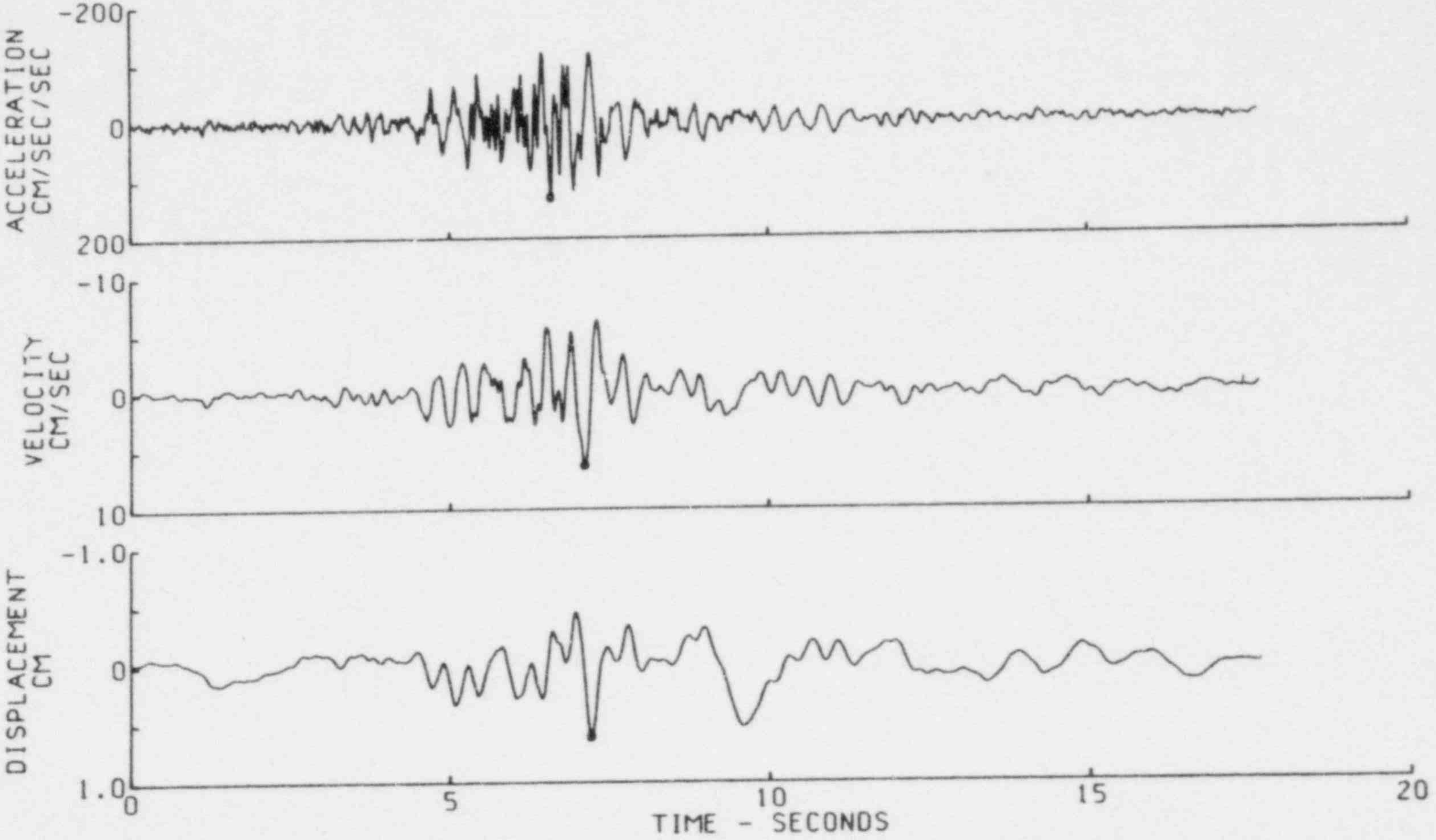

CORRECTED ACCELERATION.VELOCITY.DISPLACEMENT
HUMBOLDT COUNTY EARTHQUAKE OF JUNE 7.1975.0846GMT
PETROLIA.CALIFORNIA.GENERAL STORE.N15W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .170 - .250 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=128.1 CM/SEC/SEC.VELOCITY=6.330 CM/SEC.DISPL=.610 CM

FIG. 19A-6

RESPONSE SPECTRA
PETROLIA,CALIF,GEN. STORE,01/11/75,N75E
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

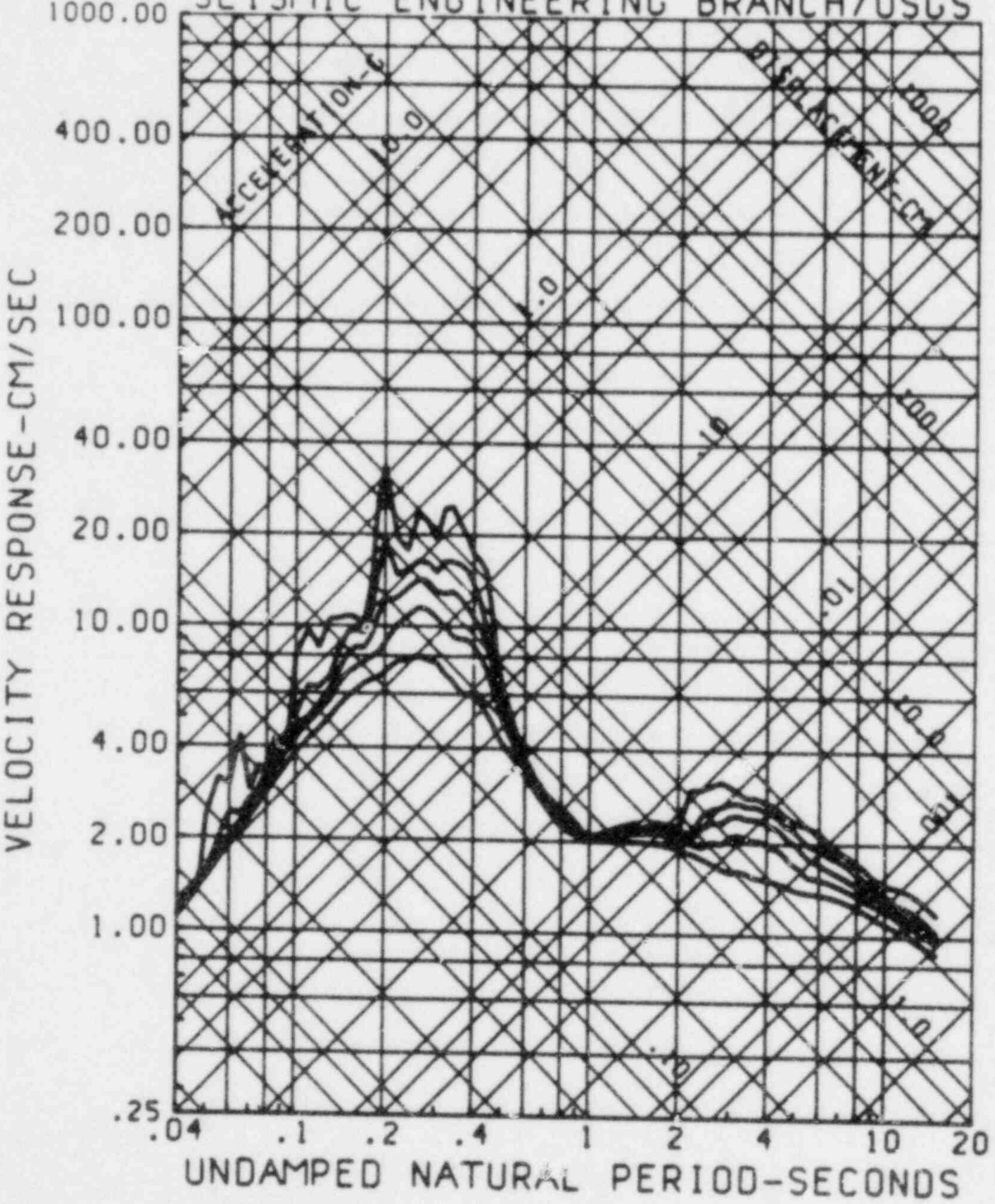


FIG. 19A-7

RESPONSE SPECTRA
PETROLIA.CALIF.GEN. STORE.01/11/75.DOWN
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

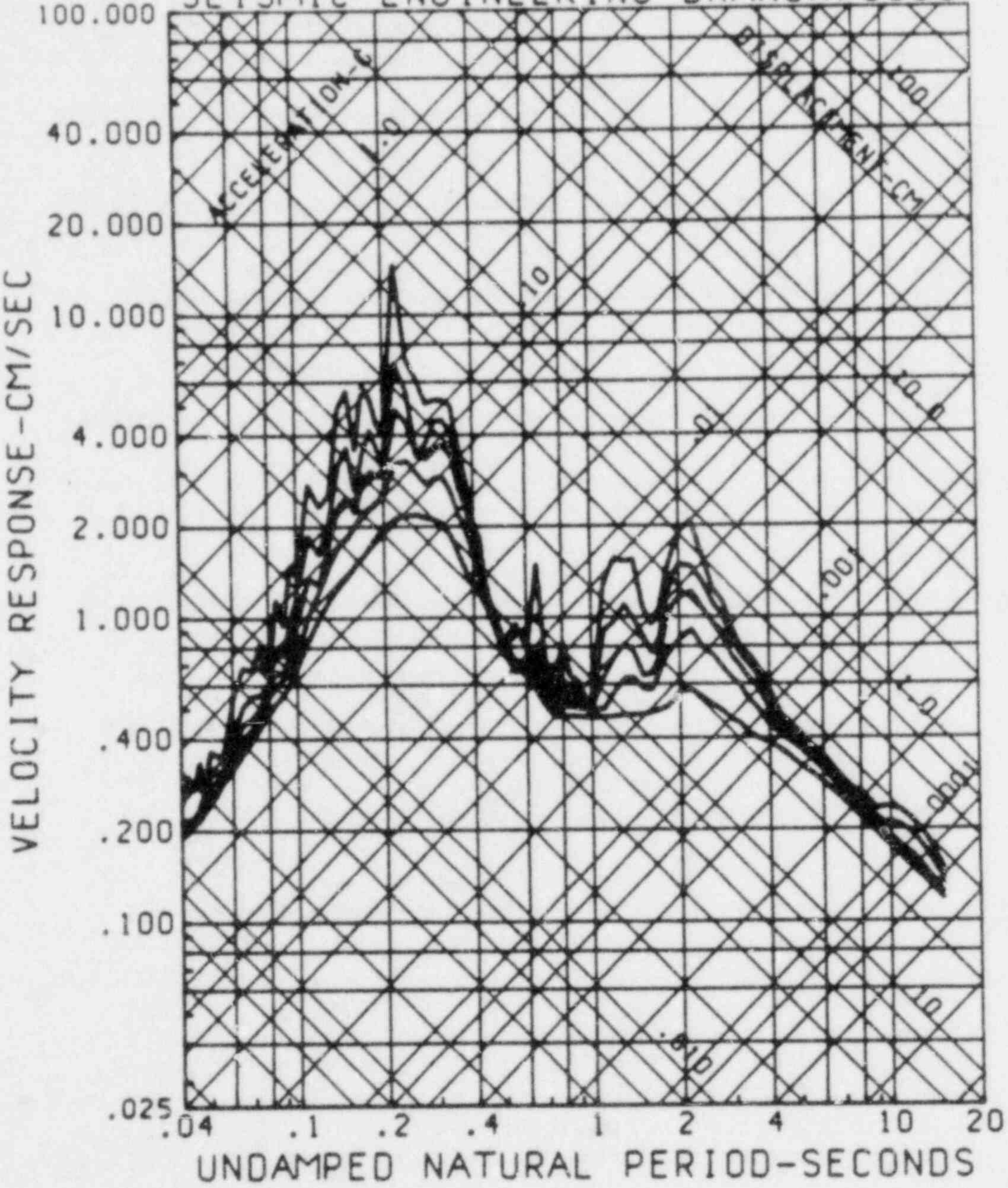


FIG. 19A-8

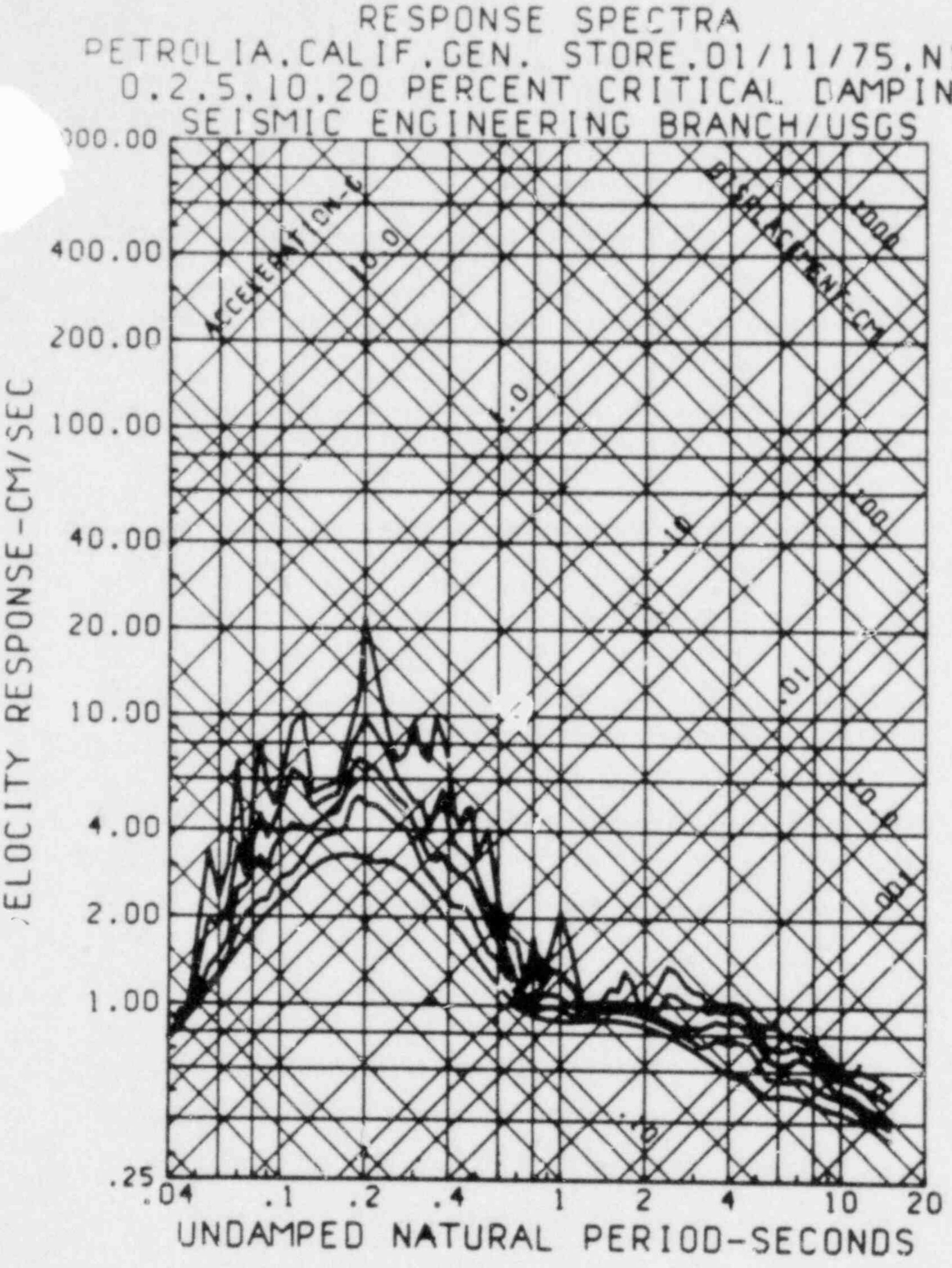
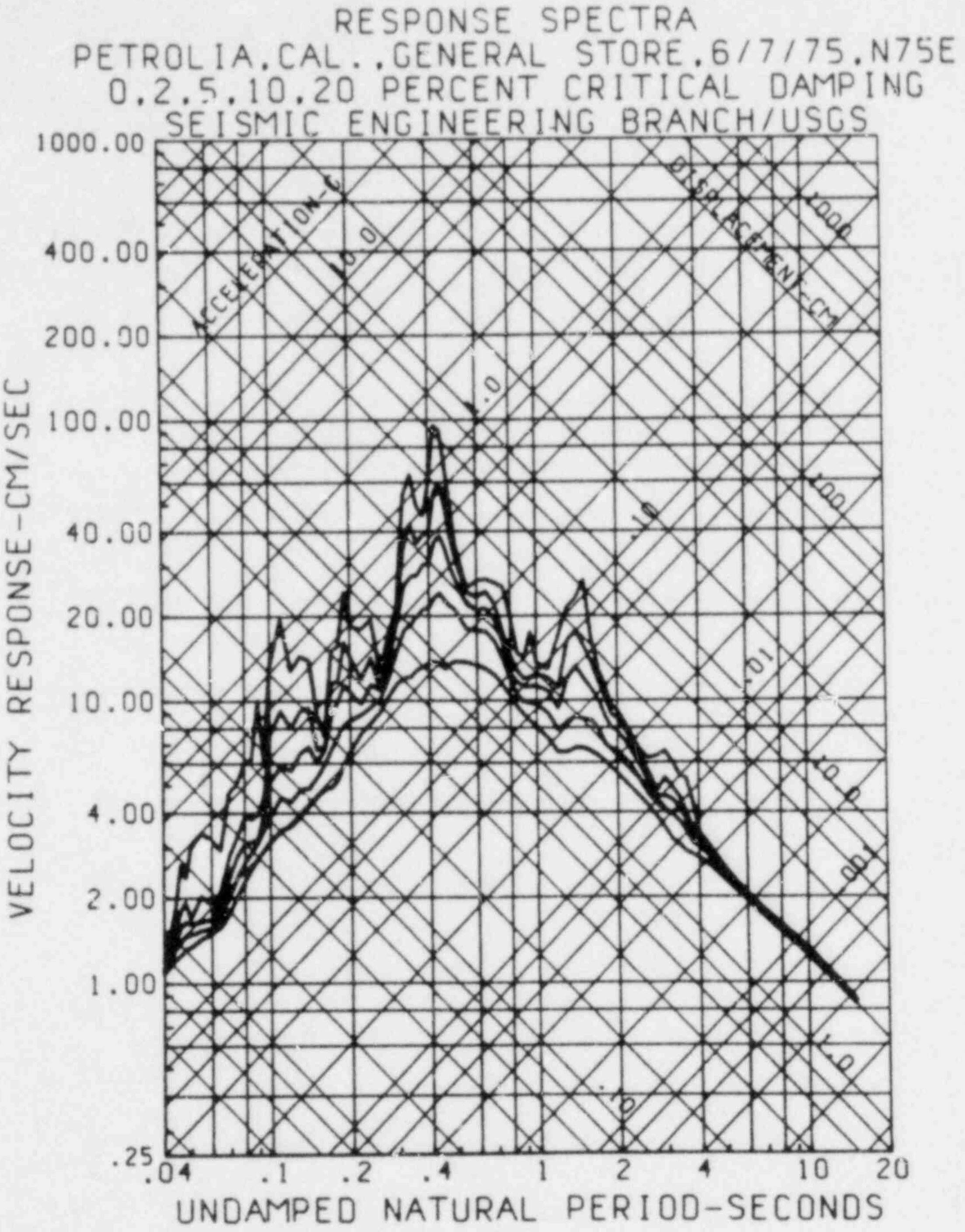
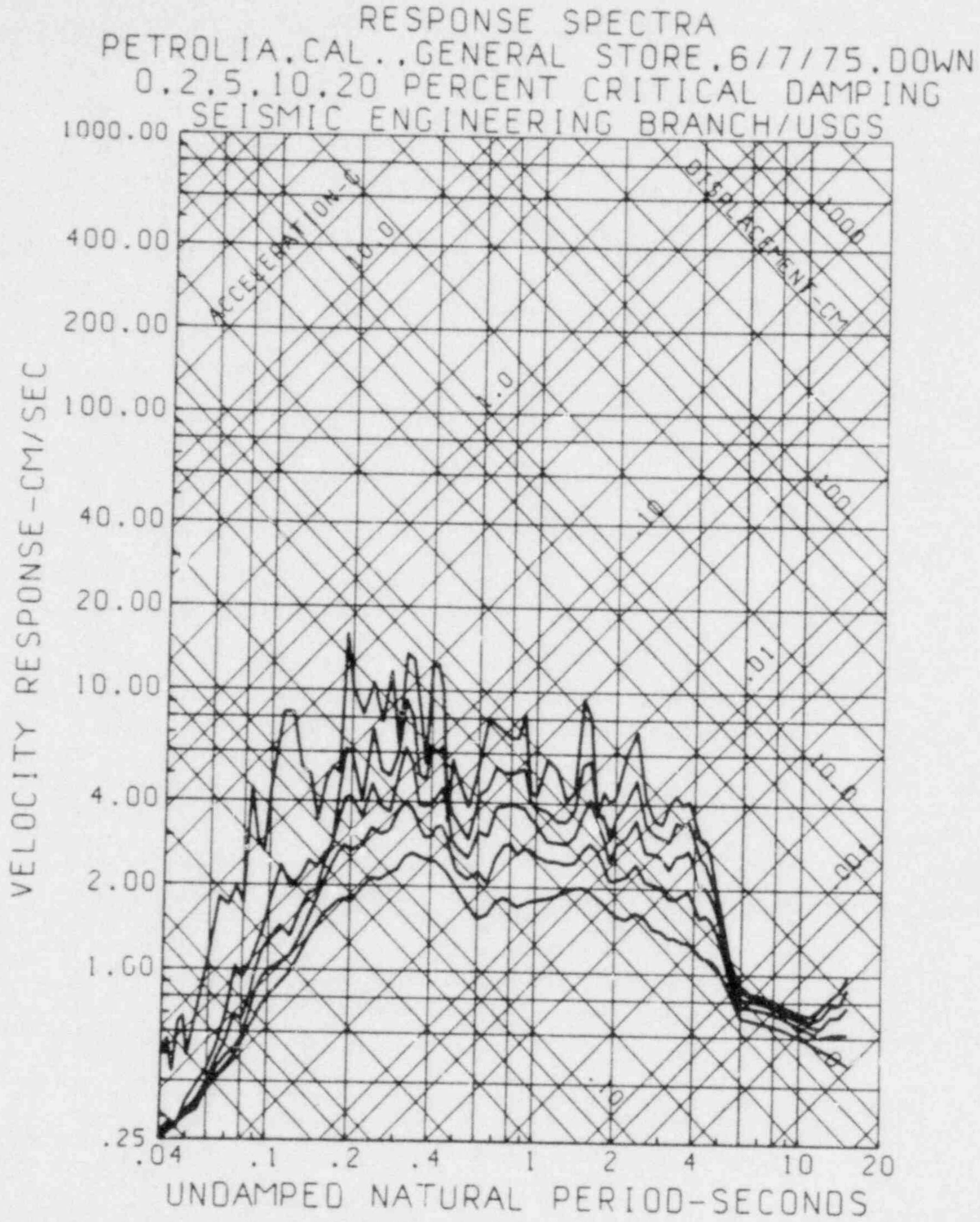

RESPONSE SPECTRA
PETROLIA,CALIF,GEN. STORE,01/11/75,N15W
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-CM-G
10.0
1.0
.10
.01
DISPLACEMENT-CM
1000
100
10.0
.001

FIG. 19A-9



RESPONSE SPECTRA
PETROLIA,CAL.,GENERAL STORE,6/7/75,N75E
0,2,5,10,20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

FIG. 19A-10



RESPONSE SPECTRA
PETROLIA.CAL..GENERAL STORE.6/7/75.DOWN
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

FIG. 19A-11

RESPONSE SPECTRA
PETROLIA.CAL..GENERAL STORE.6/7/75.N15W
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS

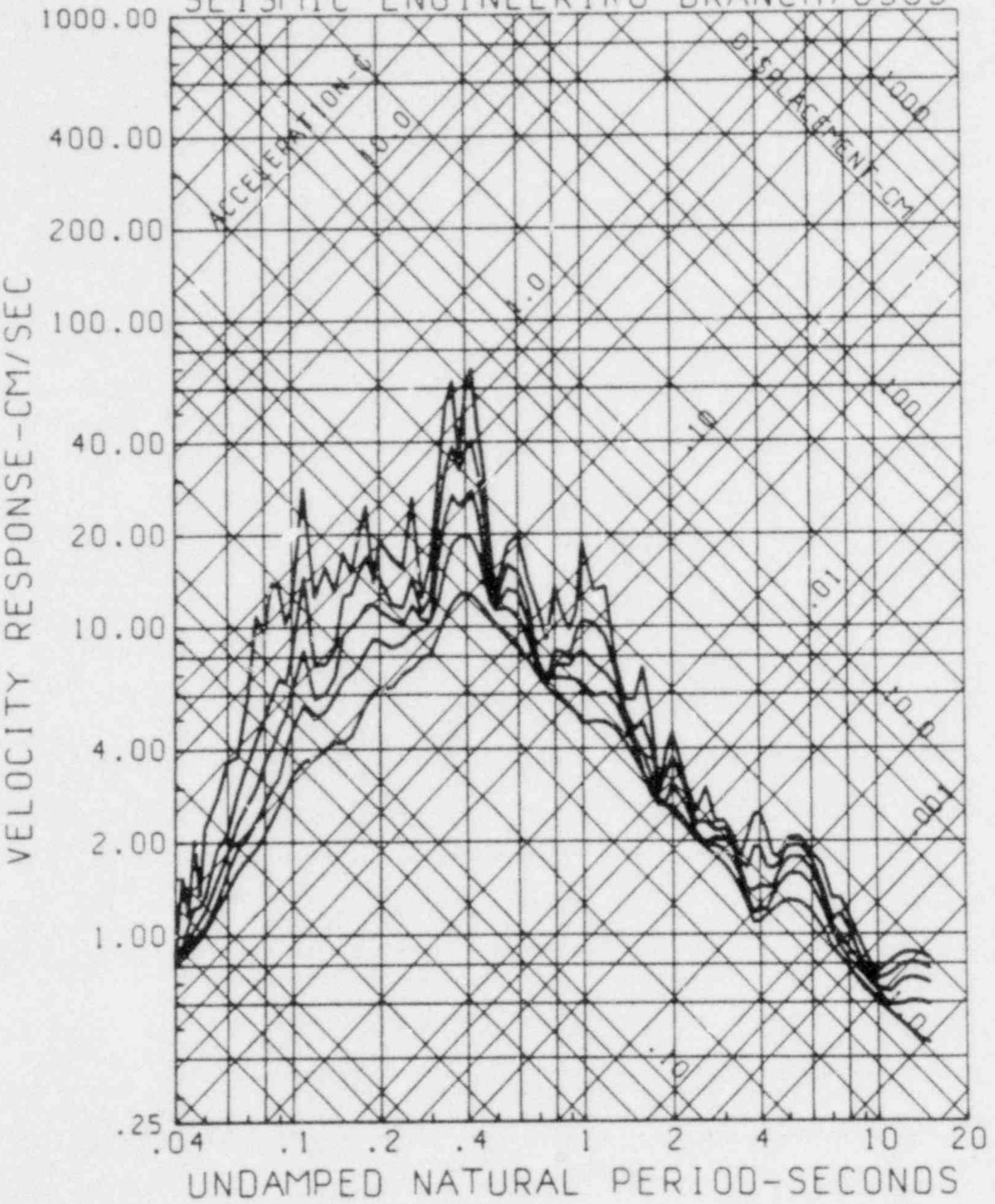


FIG. 19A-12

Section 20A

City Hall
Hollister, California

SECTION 20A
EARTHQUAKE RECORDS
CITY HALL
HOLLISTER, CALIFORNIA

LIST OF TABLES

LIST OF FIGURES

TABLE 20A-1

STATION RECORDS[1]

CITY HALL

HOLLISTER, CALIFORNIA

USGS No. : 1028
Location : 375 Fifth St., approx. 300 ft. east of the intersection of Fifth and San Benito Sts.
Property Owner : City of Hollister
Building : One story with a daylight basement, reinforced concrete construction
Instrument Location : Basement; approx. 3 ft. below exterior grade
Present Instrumentation : C&GS Standard 12" accelerograph (S/N 24) and a seismoscope (S/N 1607)
Station Installation Date : February 11, 1947

County : San Benito
Quadrangle : Hollister, Calif. (7.5')
Township 12S; Range 5E; Section 34A
Coordinates : 36.851°N; 121.402°W

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (miles)	Max. Acceleration (g's)[3] S01W	Up	N89W	Record[7]
A,B	1949	3 - 9	04:29	37.0	121.5	5.3	VII	-	12 NNW	0.120	0.075	0.191[4]	-
C										0.119	0.070	0.194[6]	U301
A,B	1954	4 - 25	12:33	36.9	121.7	5.25	VIII	-	17 W	0.054	0.024	0.058[4]	-
C										0.050	0.023	0.052[6]	U305
A,B	1955	9 - 4	18:01	37.4	121.8	5.8	VII	-	44 NNW	0.047	0.013	0.043[4]	-
A,B	1960	1 - 19	19:26	36.8	121.4	5.1	VI	-	4 S	0.023	0.024	0.063[4]	-
C										0.035	0.024	0.056[6]	U307
A,B	1961	4 - 8	23:23	36.7	121.3	5.6	VII	-	13 SSE	0.059	0.031	0.157[4]	-
C										0.061	0.049	0.176[6]	A018
A,B	1961	4 - 8	23:26	36.7	121.3	5.6	VII	-	13 SSE	0.066	0.048	0.083[4,5]	-
C										0.075	0.060	0.169[6]	U309
B	1974	11 - 28	15:01	36.91	121.50	5.2(B)	VI	6	6 NW	0.10	0.07	0.17[4]	-
D										0.089	0.066	0.163[6]	USGS

Notes:

1. Earthquake records selected for this tabulation generally have maximum accelerations of 0.05 g or greater. There are over 70 accelerograph records for the station at the City Hall.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Von Hake (1973)
   B. *United States Earthquakes*
   C. Hudson, et al. (1971-1975a)
   D. Brady and Perez (1979)

   Sources A and B were used for earthquake location, time and size. Sources B, C and D were used for earthquake acceleration information. Station records were checked with the listings of Brazee (1974), Morris, et al. (1977) and the USGS (unpub.).

3. All recordings were made on C&GS standard accelerographs oriented at the indicated bearings for pendulum motion. The 1949 event was made on recorder S/N 27, all other events were made on recorder S/N 24.

4. Accelerations from unprocessed records.

5. The record at 23:26 had one acceleration excursion of about 0.16 g as indicated in the raw accelerogram of the N89W component.

6. Accelerations from digitized and baseline corrected records.

7. Records with a letter and number designation have been processed by the California Institute of Technology (Hudson, et al., 1971-1975a and b). The 1974 record was processed by the USGS (Brady and Perez, 1979).

POOR ORIGINAL

NORTHERN CALIFORNIA EARTHQUAKE MAR 9, 1949 - 0429 PST

IIU301 49.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W

⊕ PEAK VALUES : ACCEL = 119.4 CM/SEC/SEC VELOCITY = -8.3 CM/SEC DISPL = 1.7 CM

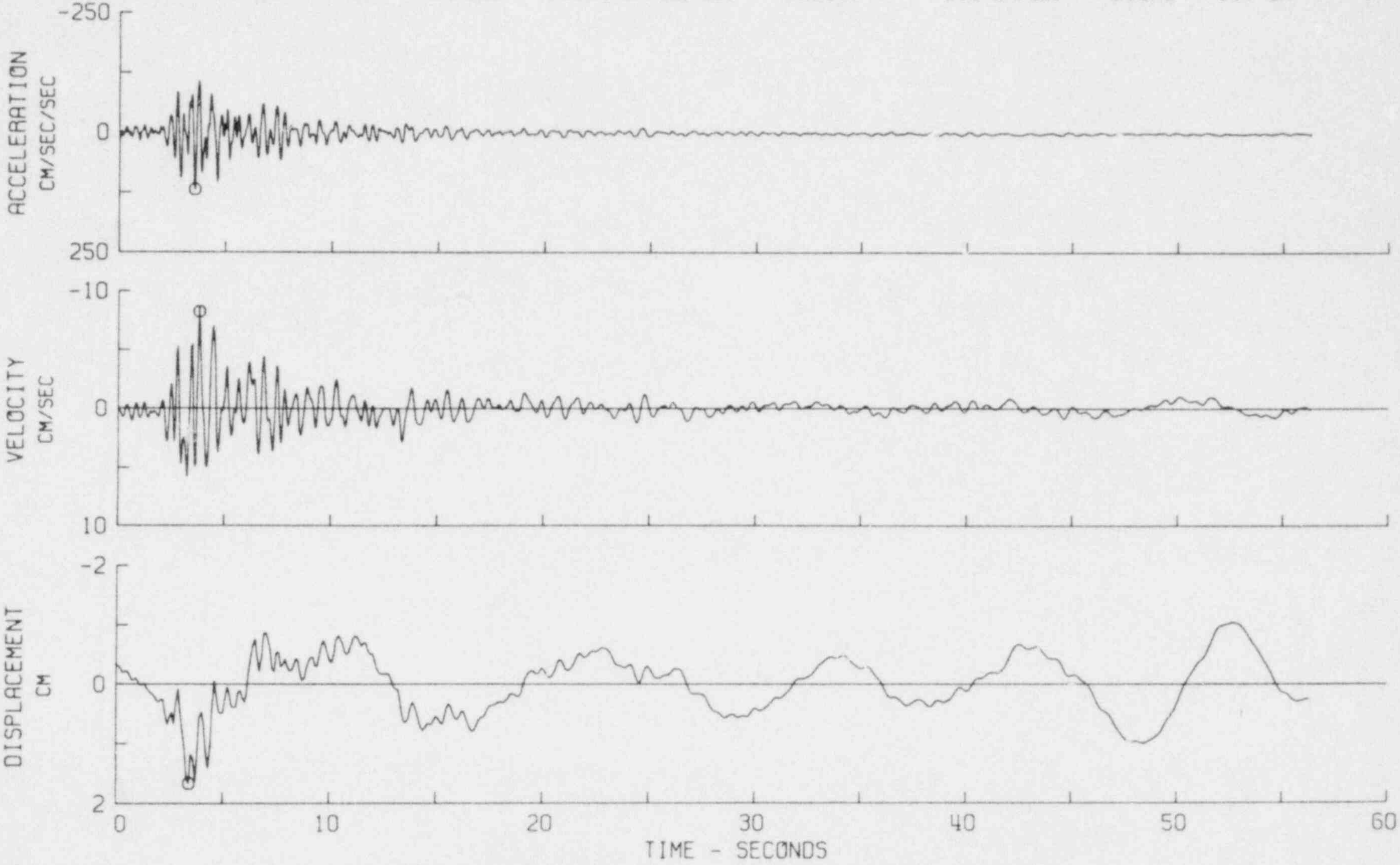
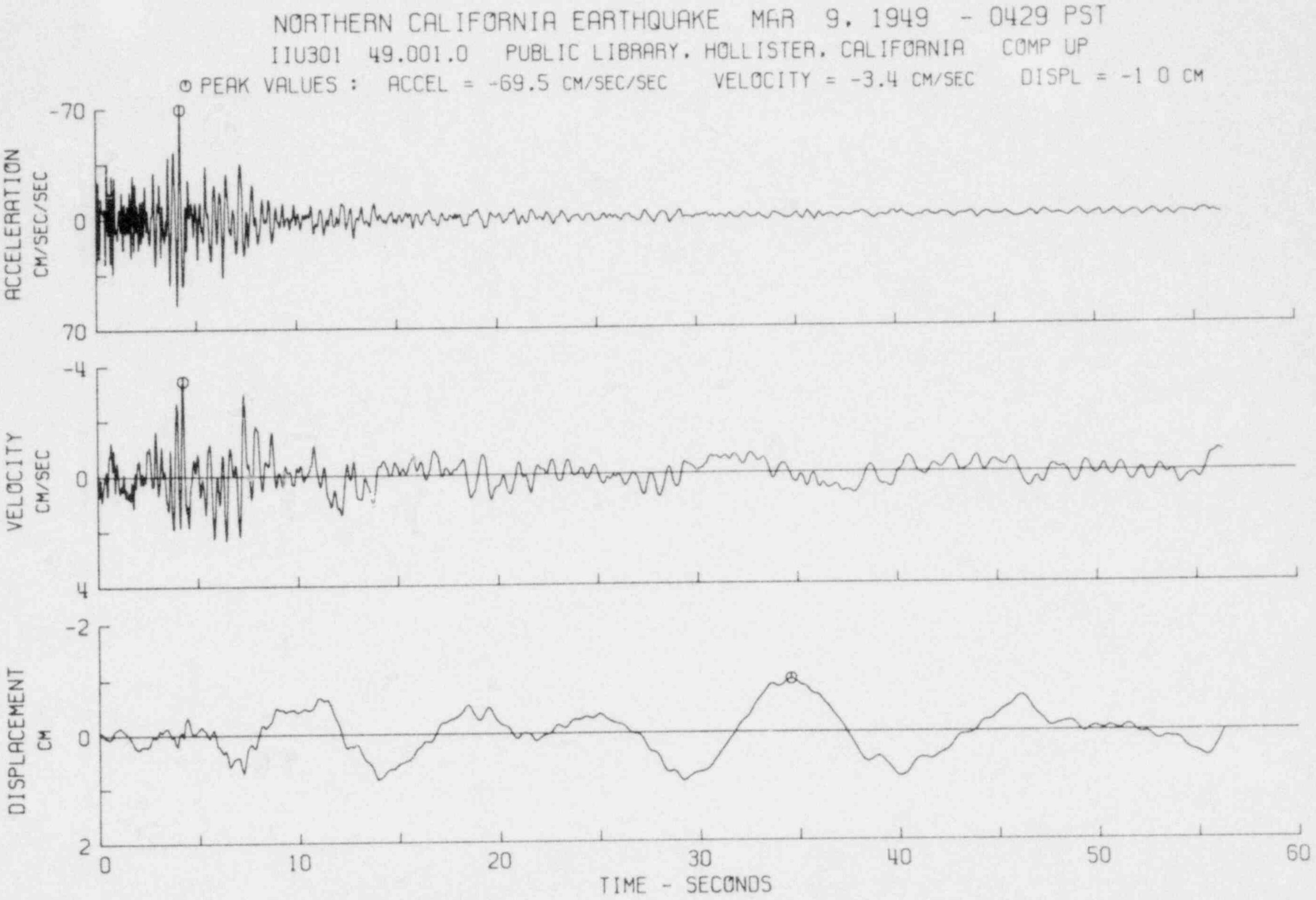


FIG. 20A-1


NORTHERN CALIFORNIA EARTHQUAKE MAR 9. 1949 - 0429 PST

IIU301 49.001.0 PUBLIC LIBRARY. HOLLISTER. CALIFORNIA COMP UP

⊙ PEAK VALUES : ACCEL = -69.5 CM/SEC/SEC VELOCITY = -3.4 CM/SEC DISPL = -1.0 CM

FIG. 20A-2

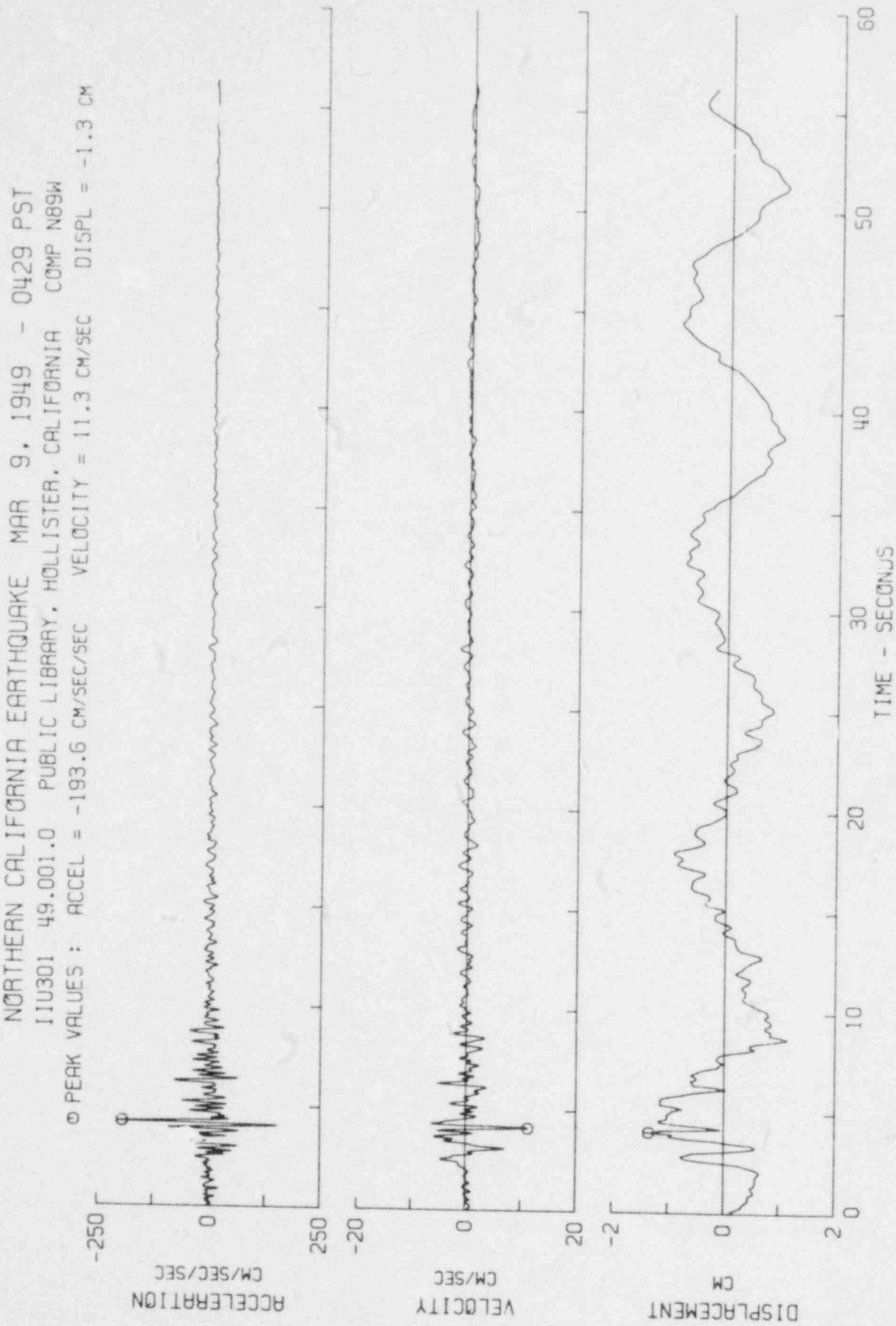

NORTHERN CALIFORNIA EARTHQUAKE MAR 9, 1949 - 0429 PST
IIU301 49.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W
⊙ PEAK VALUES : ACCEL = -193.6 CM/SEC/SEC VELOCITY = 11.3 CM/SEC DISPL = -1.3 CM
ACCELERATION CM/SEC/SEC
-250
0
250
VELOCITY CM/SEC
-20
0
20
DISPLACEMENT CM
-2
0
2
0
10
20
30
40
50
60
TIME - SECONDS

FIG. 20A-3

CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST
IIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W
⊙ PEAK VALUES : ACCEL = 48.9 CM/SEC/SEC VELOCITY = 4.4 CM/SEC DISPL = 1.4 CM

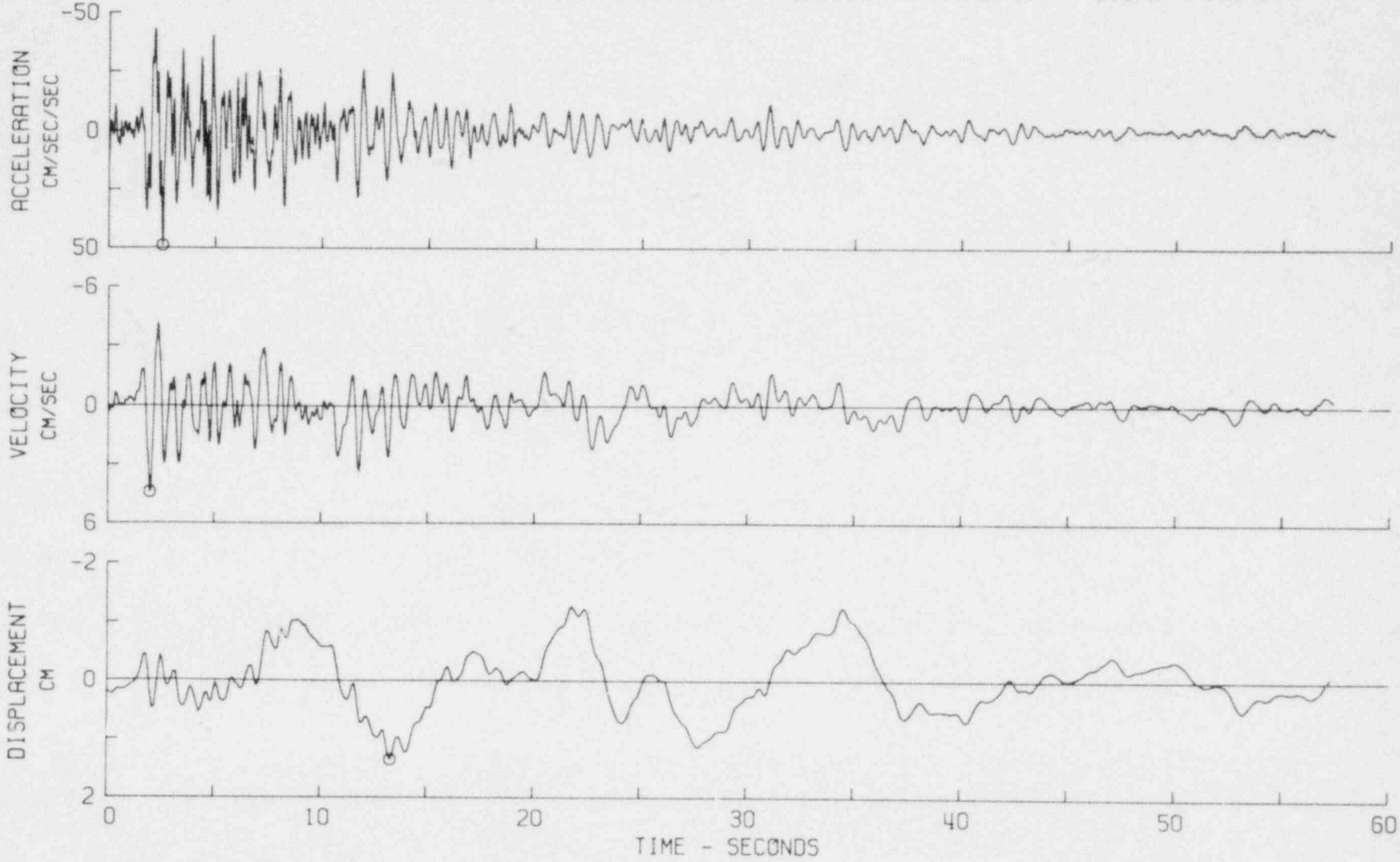


FIG. 20A-4

CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST

IIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP

⊙ PEAK VALUES : ACCEL = -23.1 CM/SEC/SEC VELOCITY = 1.9 CM/SEC DISPL = 1.1 CM

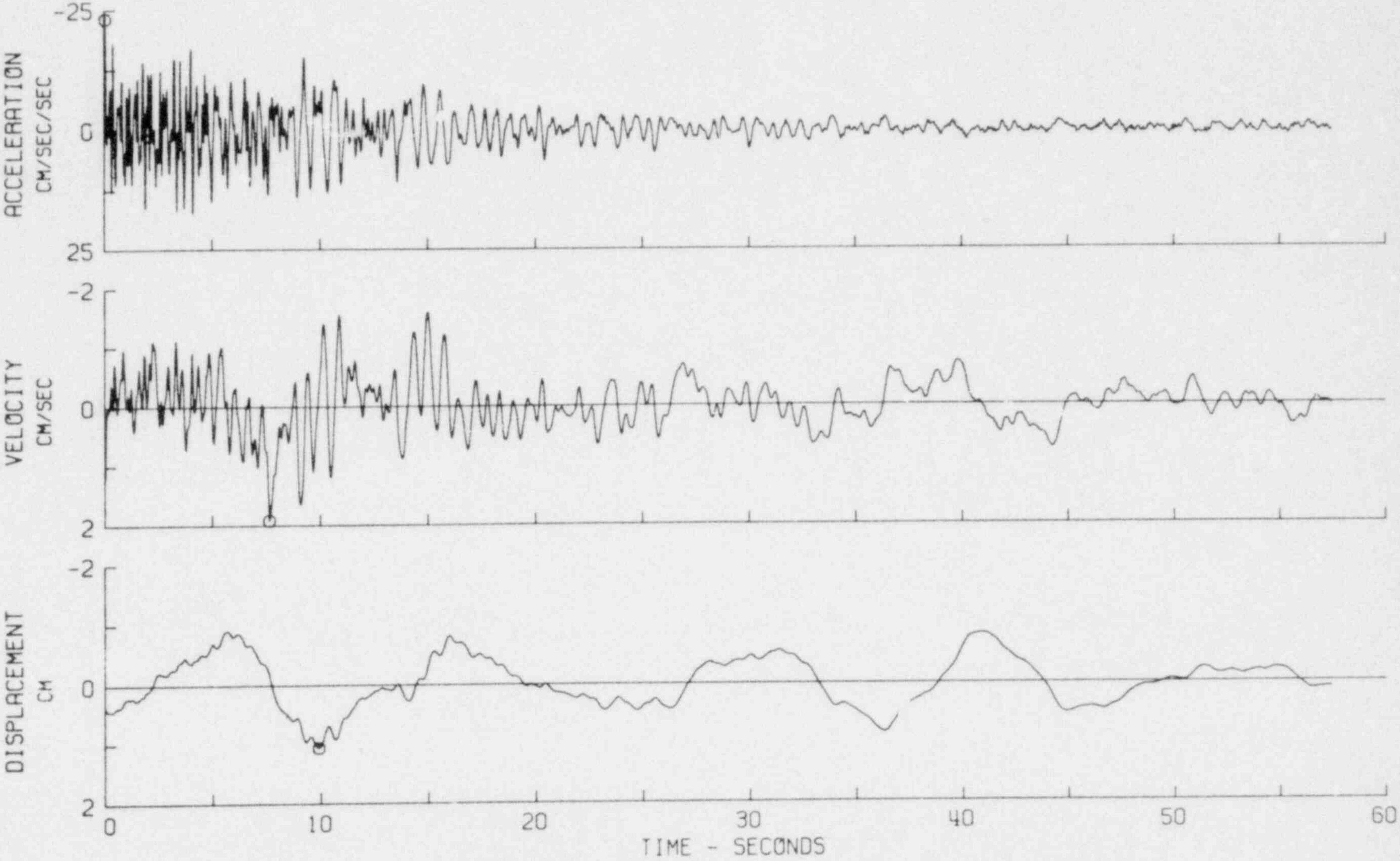
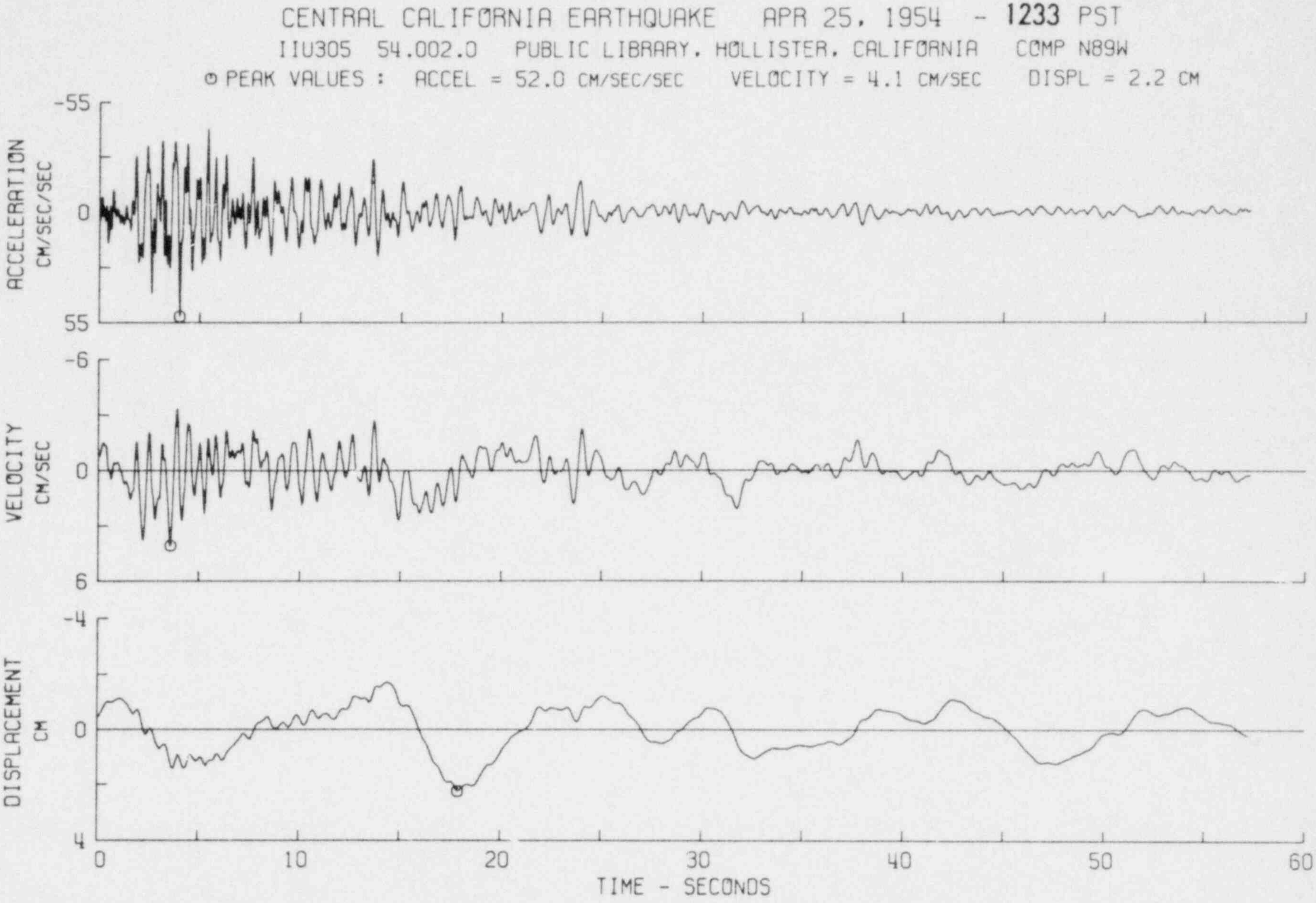


FIG. 20A-5


CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST

IIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W

⊙ PEAK VALUES : ACCEL = 52.0 CM/SEC/SEC VELOCITY = 4.1 CM/SEC DISPL = 2.2 CM

FIG. 20A-6

CENTRAL CALIFORNIA EARTHQUAKE JAN 19, 1960 - 1926 PST
IIU307 60.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W
⊕ PEAK VALUES : ACCEL = -35.3 CM/SEC/SEC VELOCITY = -3.6 CM/SEC DISPL = -1.2 CM

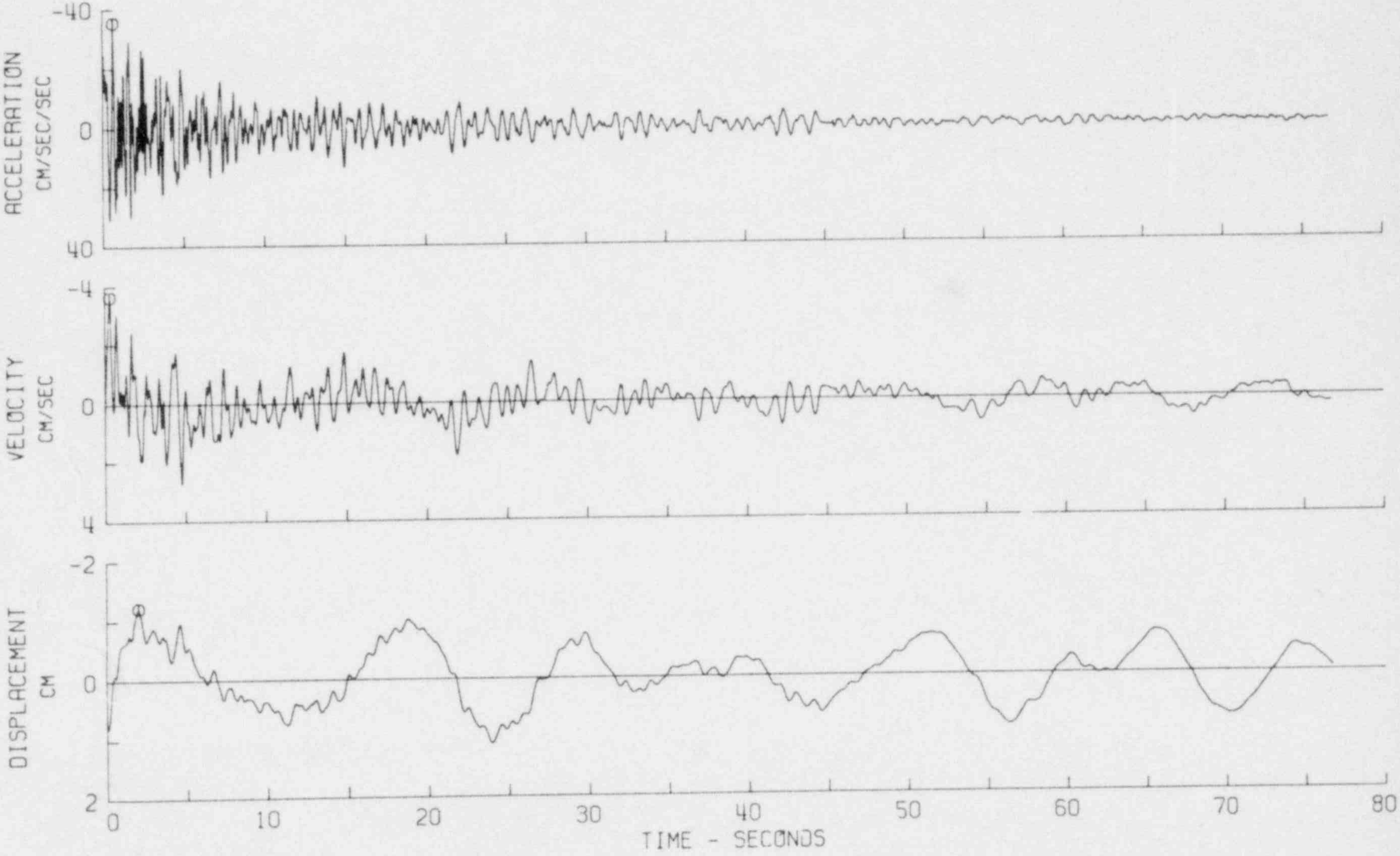


FIG. 20A-7

CENTRAL CALIFORNIA EARTHQUAKE JAN 19, 1960 - 1926 PST
IIU307 60.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP
⊙ PEAK VALUES : ACCEL = 23.6 CM/SEC/SEC VELOCITY = -2.1 CM/SEC DISPL = 1.1 CM

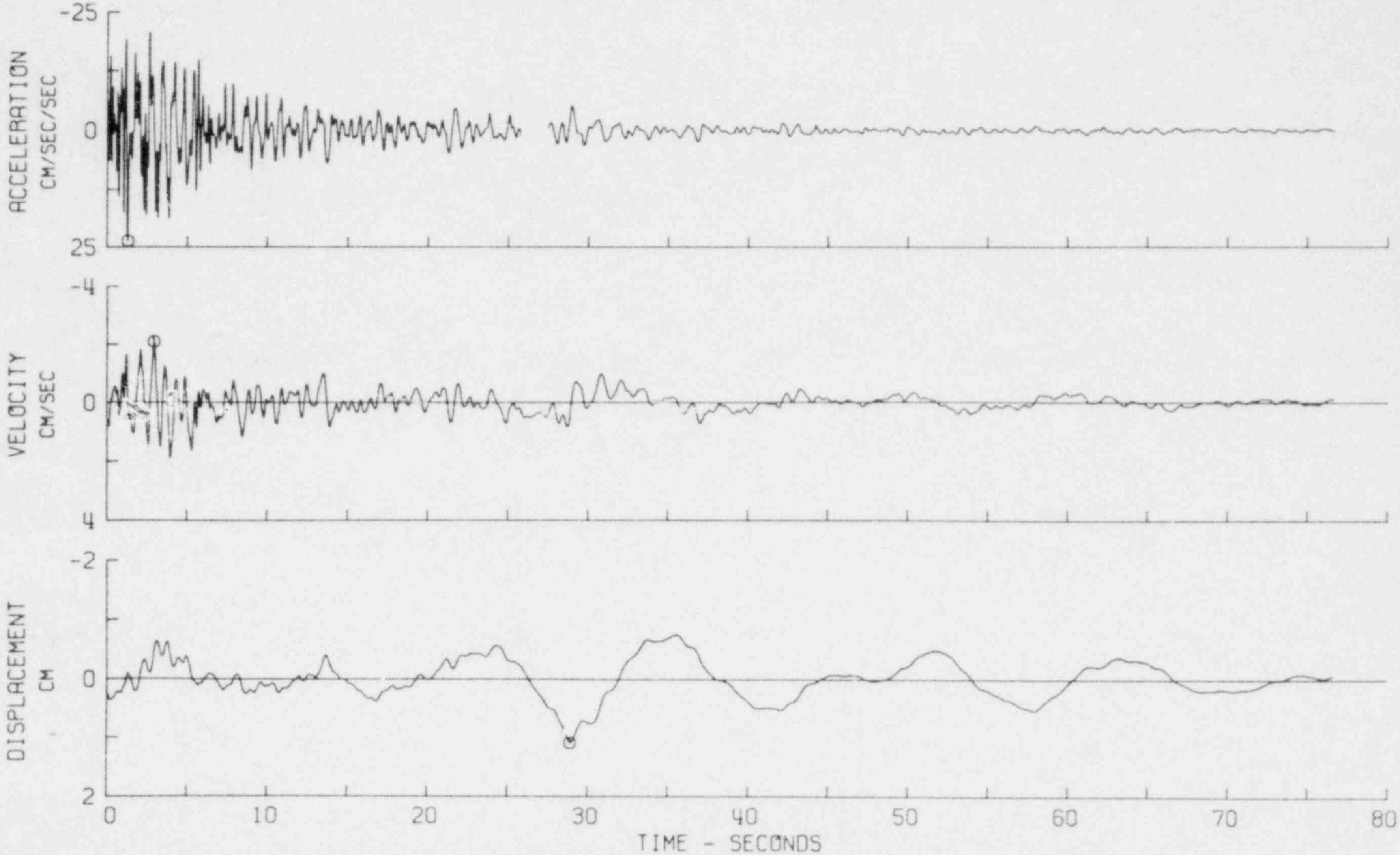
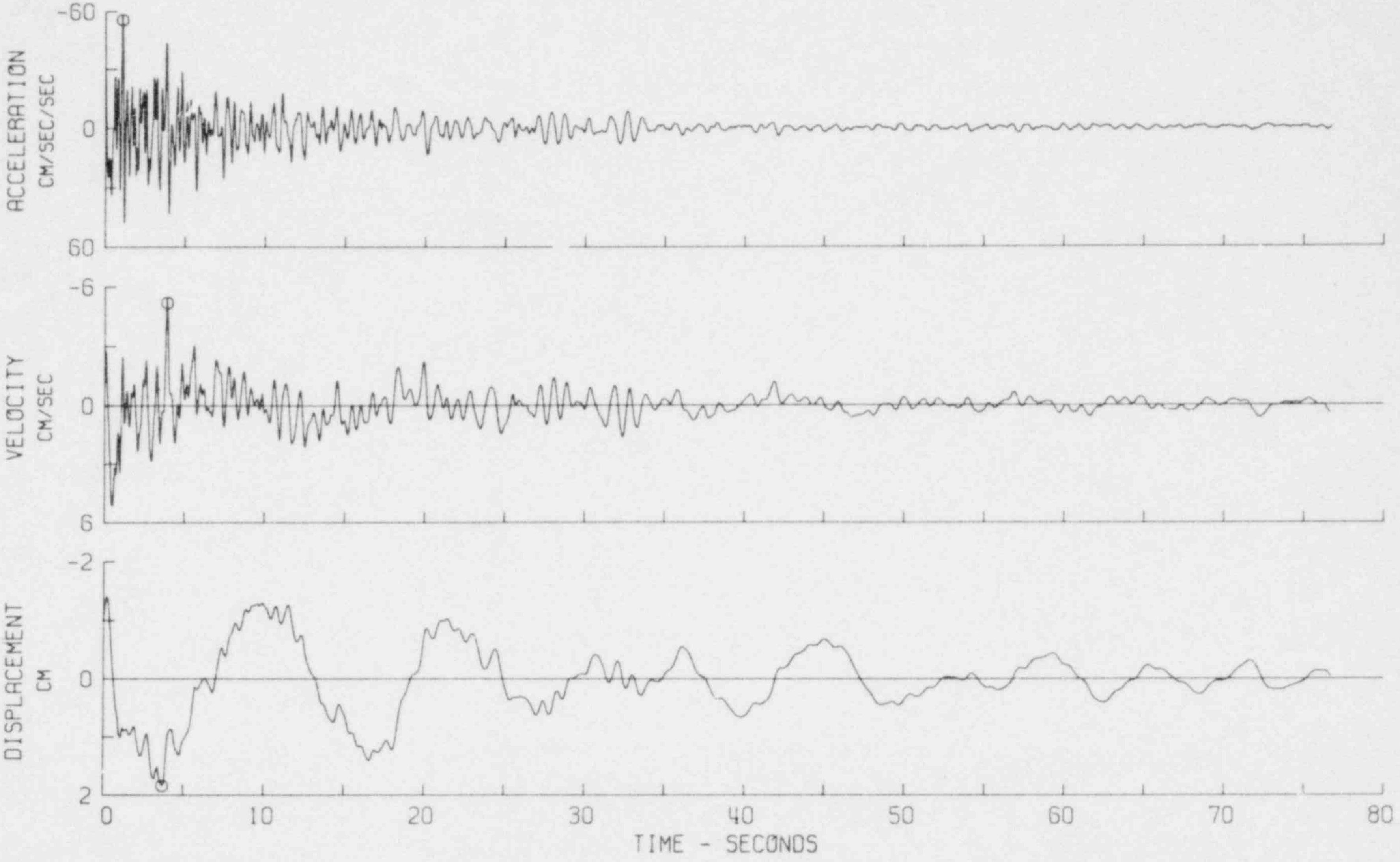
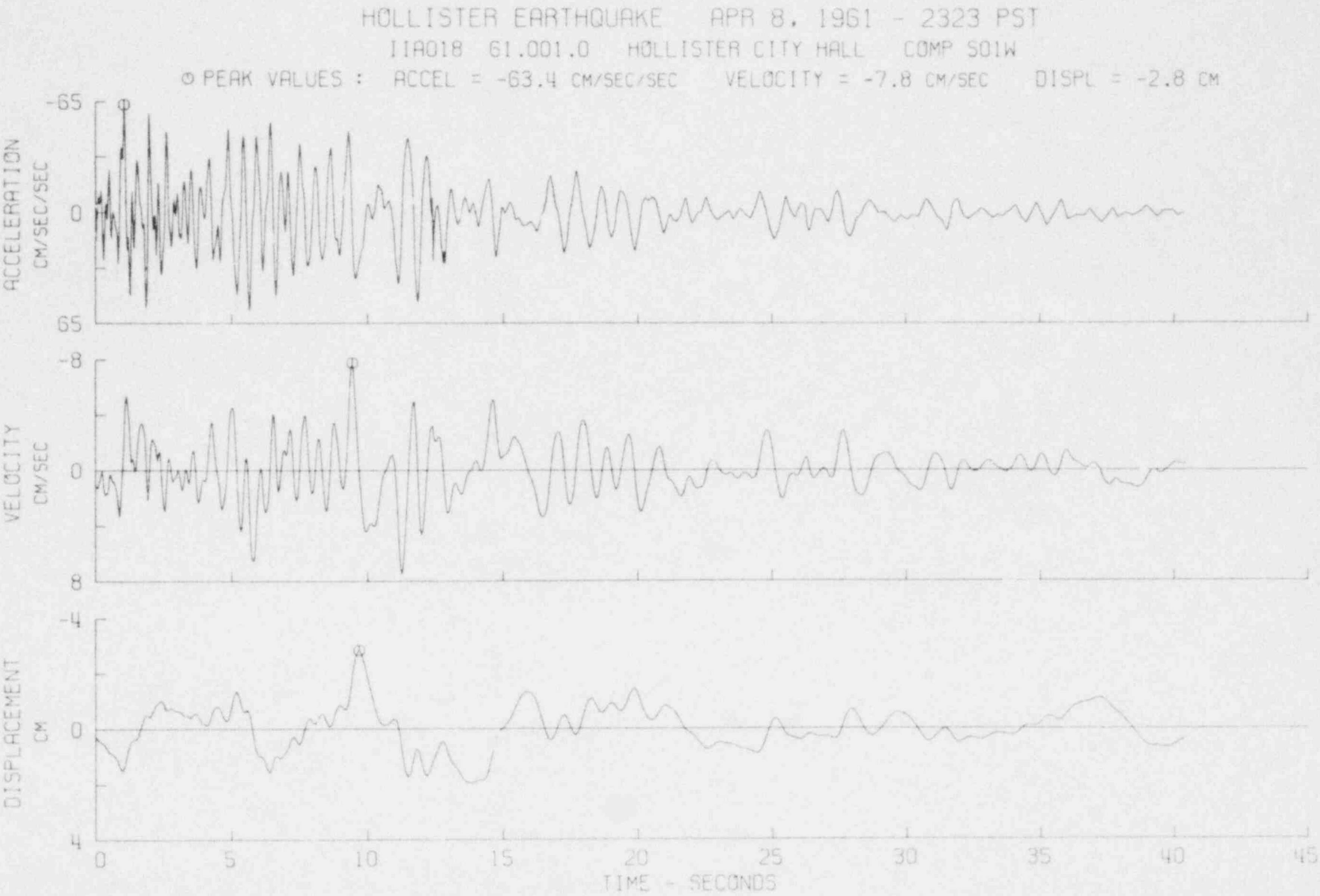


FIG. 20A-8



CENTRAL CALIFORNIA EARTHQUAKE JAN 19. 1960 - 1926 PST
IIU307 60.001.0 PUBLIC LIBRARY. HOLLISTER. CALIFORNIA COMP N89W
⊙ PEAK VALUES : ACCEL = -55.5 CM/SEC/SEC VELOCITY = -5.2 CM/SEC DISPL = 1.8 CM

FIG. 20A-9



HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST

IIA018 61.001.0 HOLLISTER CITY HALL COMP S01W

⊕ PEAK VALUES : ACCEL = -63.4 CM/SEC/SEC VELOCITY = -7.8 CM/SEC DISPL = -2.8 CM

FIG. 20A-10

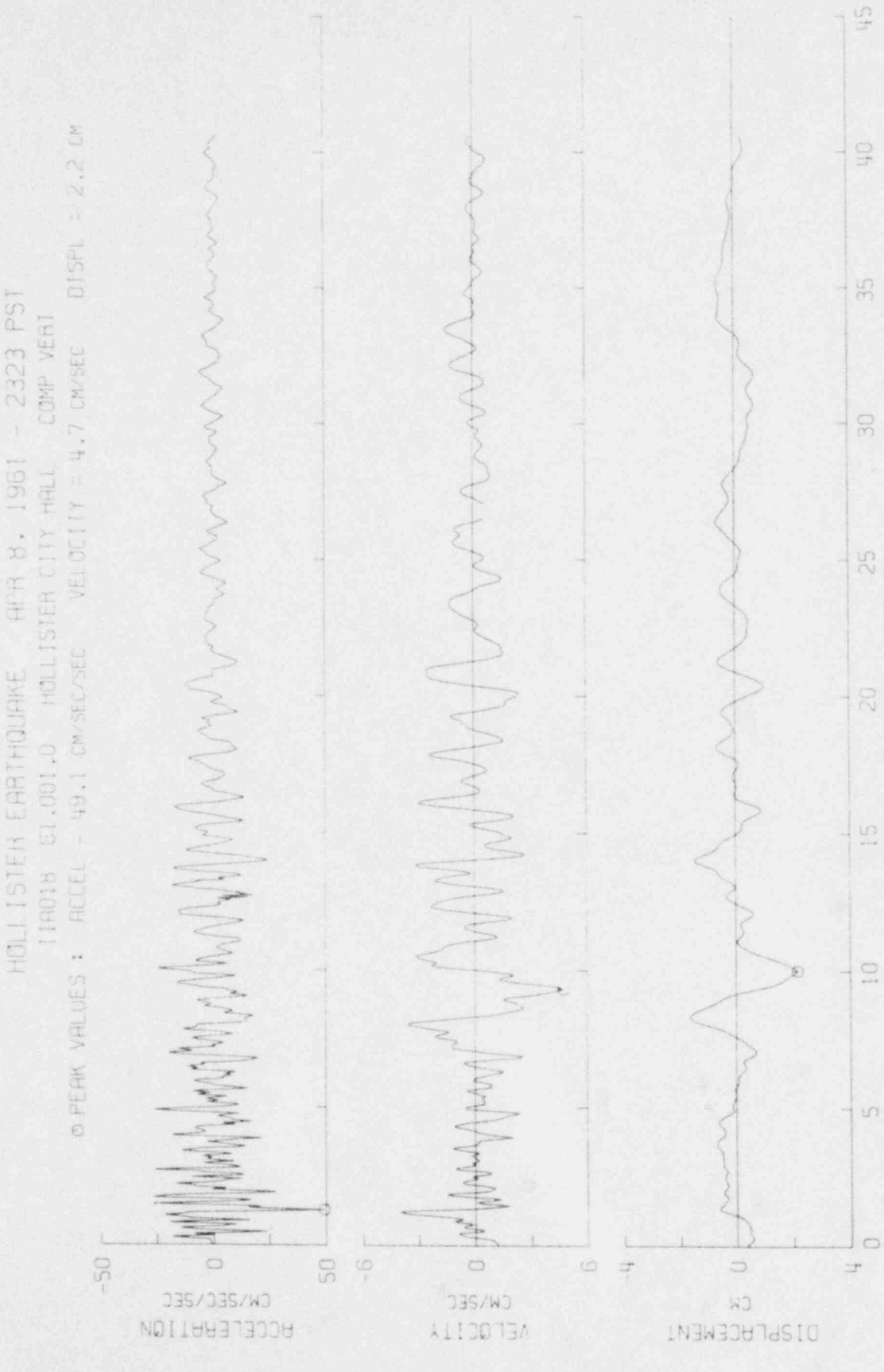

HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST
IIA018 61.001.0 HOLLISTER CITY HALL COMP VERT
⊙ PEAK VALUES : ACCEL = 49.1 CM/SEC/SEC VELOCITY = 4.7 CM/SEC DISPL = 2.2 CM
ACCELERATION
CM/SEC/SEC
-50
0
50
VELOCITY
CM/SEC
-6
0
6
DISPLACEMENT
CM
-4
0
4
0
5
10
15
20
25
30
35
40
45
TIME - SECONDS

FIG. 20A-11

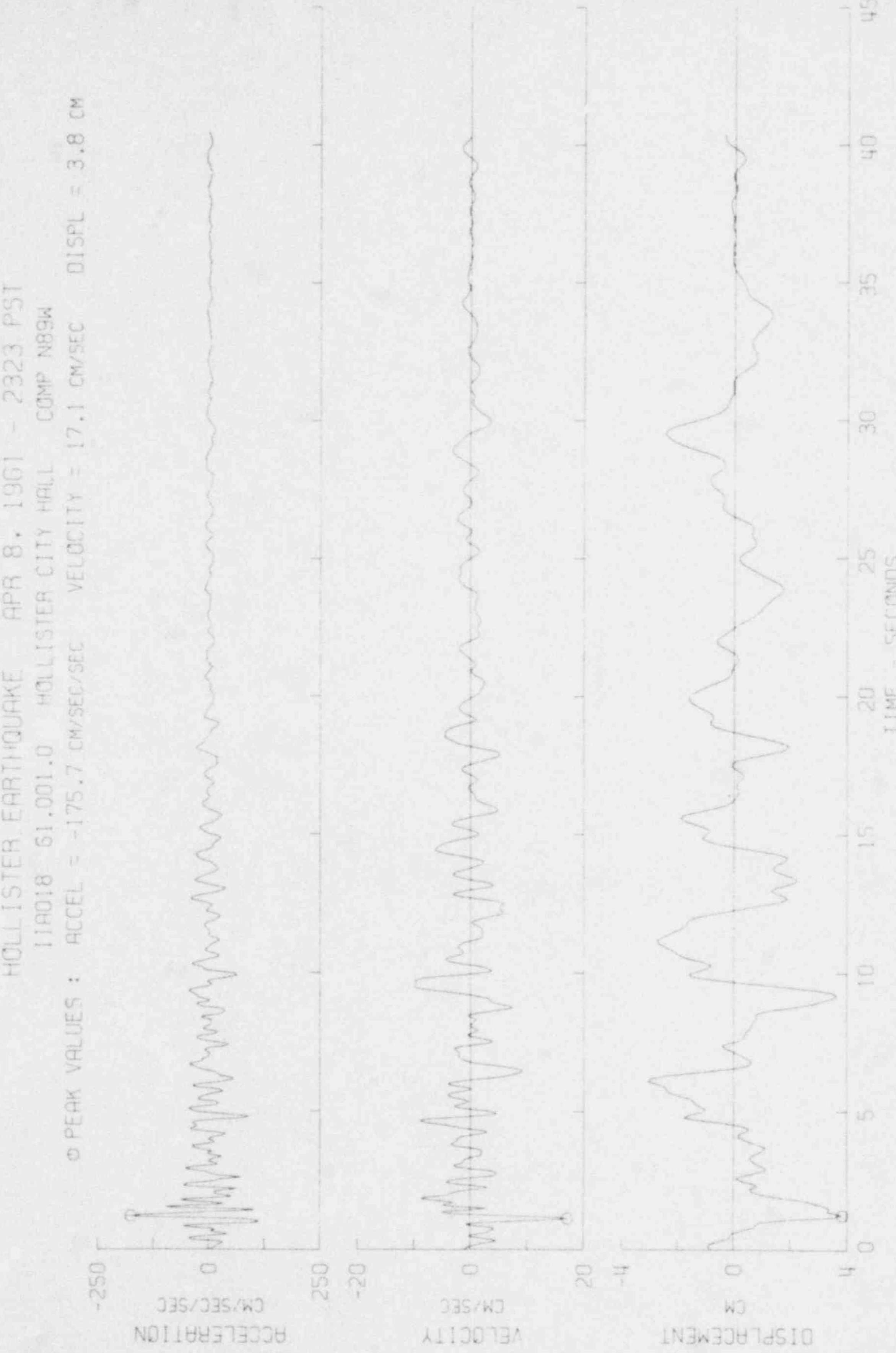

HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST
IIA018 61.001.0 HOLLISTER CITY HALL COMP N89W
⊙ PEAK VALUES : ACCEL = -175.7 CM/SEC/SEC VELOCITY = 17.1 CM/SEC DISPL = 3.8 CM
ACCELERATION
CM/SEC/SEC
-250
0
250
VELOCITY
CM/SEC
-20
0
20
DISPLACEMENT
CM
-4
0
4
0
5
10
15
20
25
30
35
40
45
TIME - SECONDS

FIG. 20A-12

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8, 1961 - **2326** PST
IIU309 61.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W
⊕ PEAK VALUES : ACCEL = -74.9 CM/SEC/SEC VELOCITY = -6.3 CM/SEC DISPL = -1.8 CM

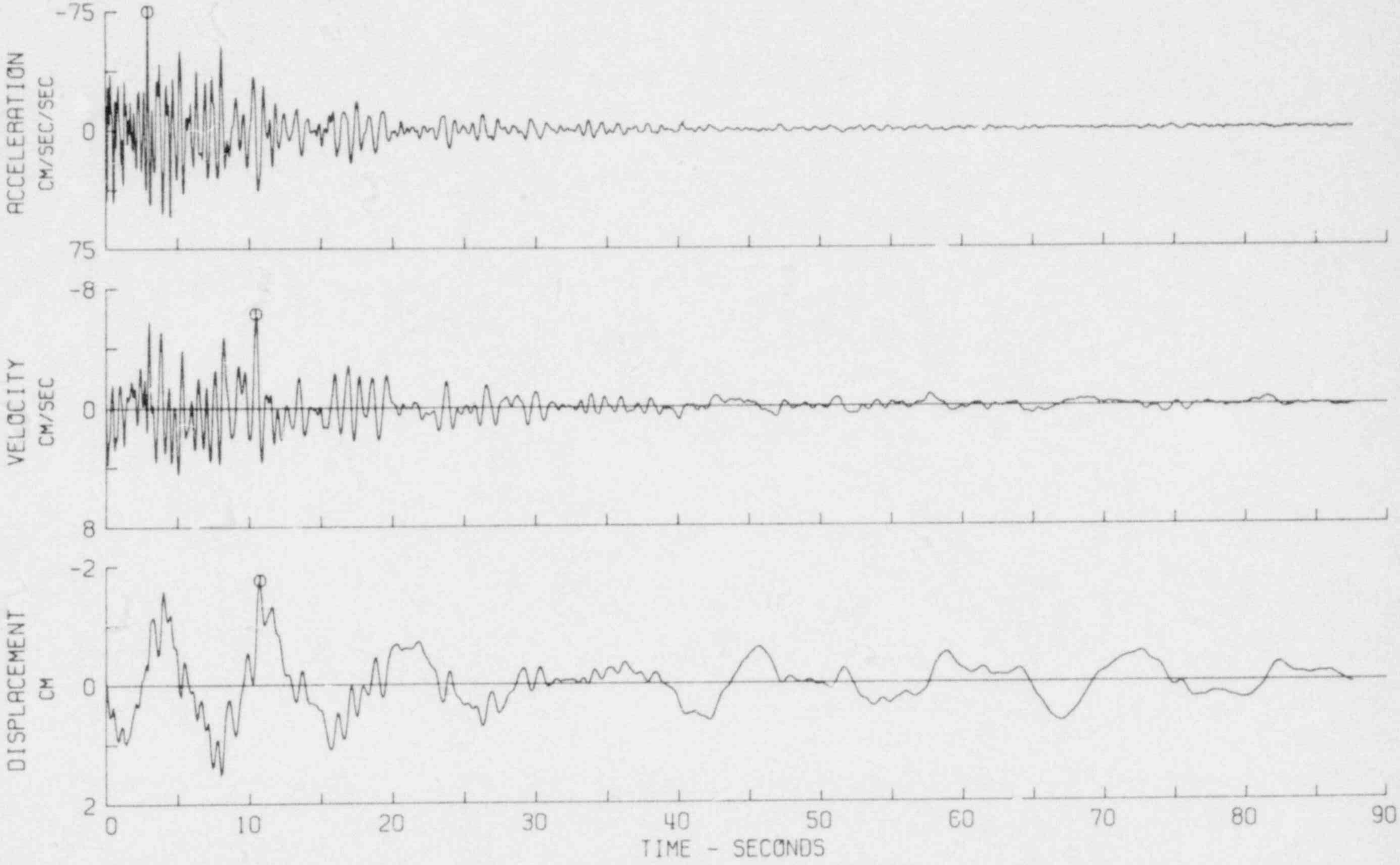


FIG. 20A-13

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8. 1961 - **2326** PST
IIU309 61.002.0 PUBLIC LIBRARY. HOLLISTER. CALIFORNIA COMP UP
⊙ PEAK VALUES : ACCEL = -60.2 CM/SEC/SEC VELOCITY = -4.1 CM/SEC DISPL = 2.0 CM

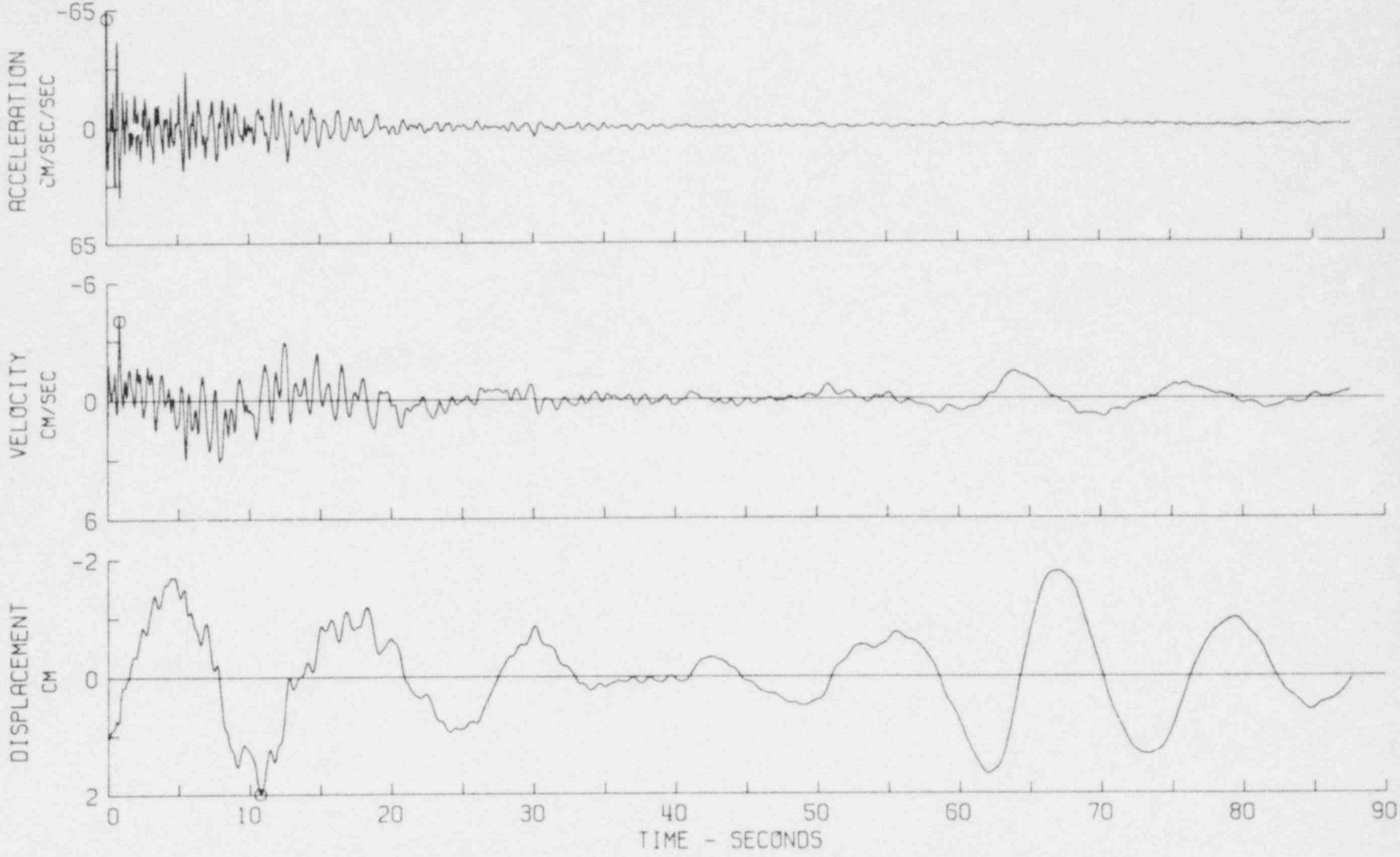


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FIG. 20A-14

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8, 1961 - **2326** PST
IIU309 61.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W
⊙ PEAK VALUES : ACCEL = 168.6 CM/SEC/SEC VELOCITY = -10.8 CM/SEC DISPL = 3.0 CM

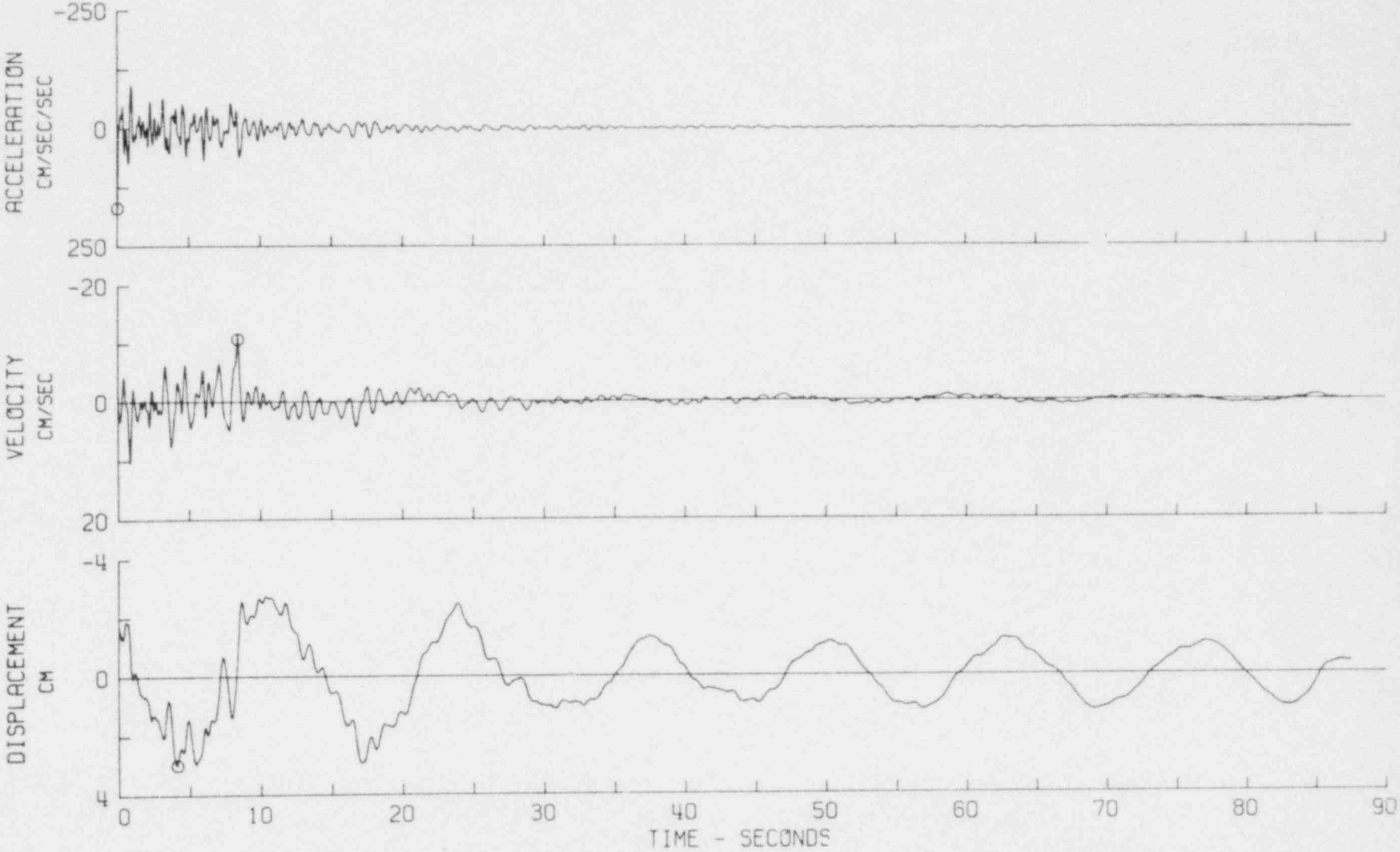


FIG. 20A-15

CORRECTED ACCELERATION, VELOCITY, DISPLACEMENT
HOLLISTER EARTHQUAKE OF NOVEMBER 28, 1974, 2301GMT
HOLLISTER, CALIFORNIA, CITY HALL, S01W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-89.17 CM/SEC/SEC, VELOCITY=5.555 CM/SEC, DISPL=-.854 CM

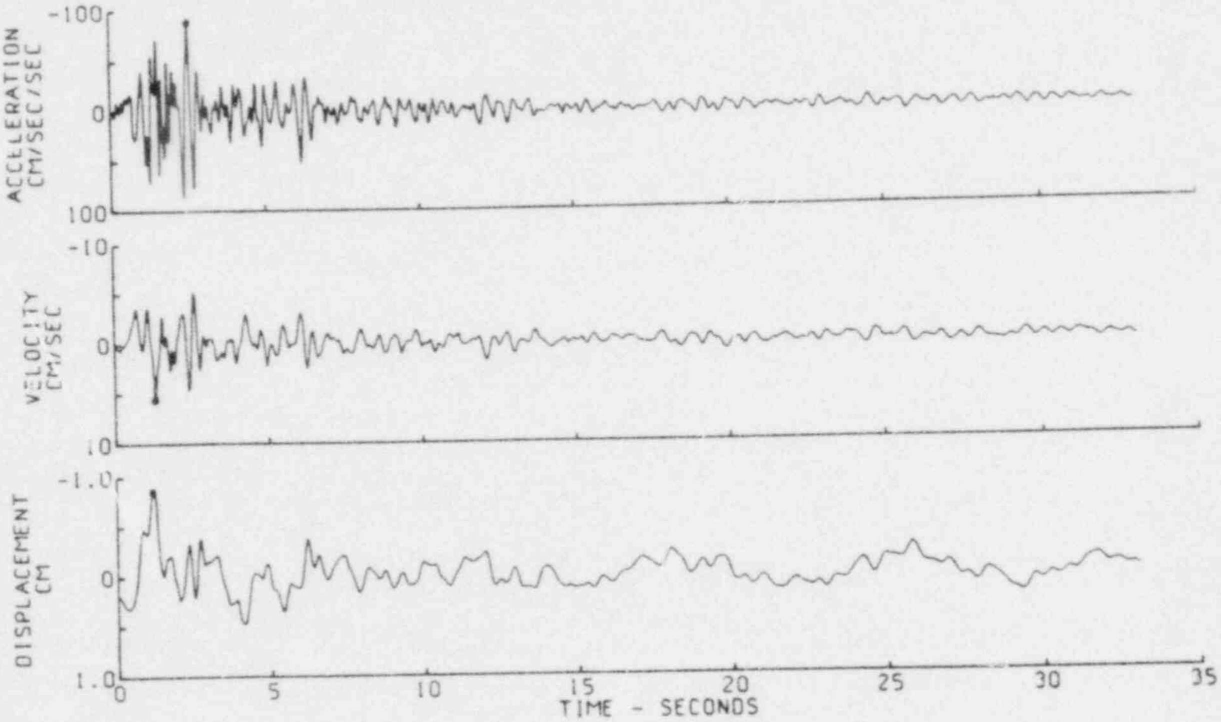
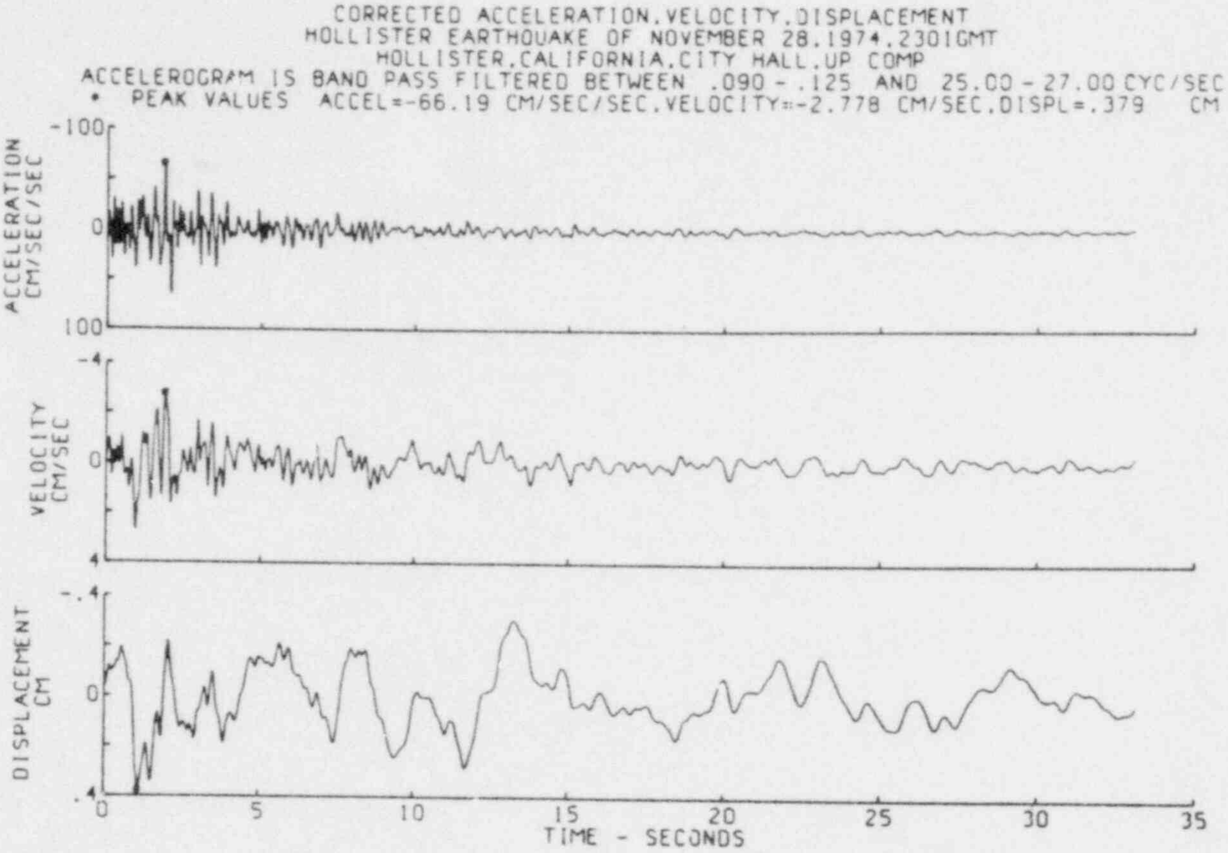
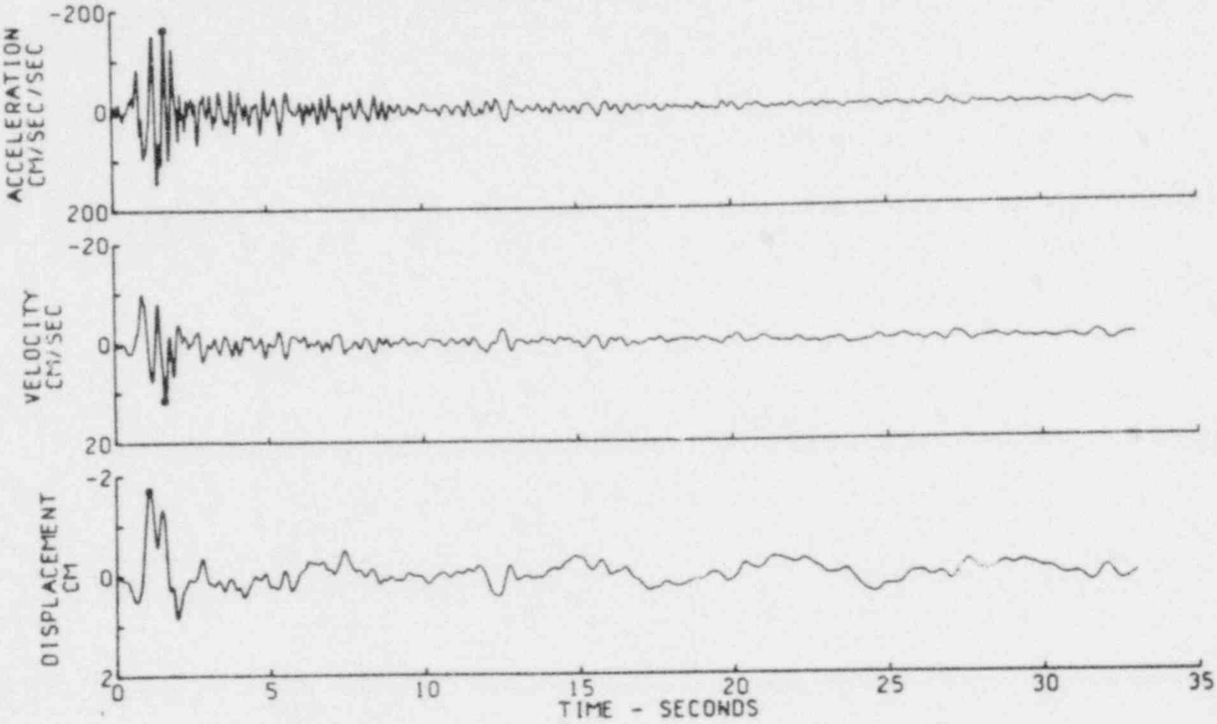


FIG. 20A-16



CORRECTED ACCELERATION,VELOCITY,DISPLACEMENT
HOLLISTER EARTHQUAKE OF NOVEMBER 28,1974,2301GMT
HOLLISTER,CALIFORNIA,CITY HALL,UP COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-66.19 CM/SEC/SEC,VELOCITY=-2.778 CM/SEC,DISPL=.379 CM

FIG. 20A-17



CORRECTED ACCELERATION,VELOCITY,DISPLACEMENT
HOLLISTER EARTHQUAKE OF NOVEMBER 28,1974,2301GMT
HOLLISTER,CALIFORNIA,CITY HALL,N89W COMP
ACCELEROGRAM IS BAND PASS FILTERED BETWEEN .090 - .125 AND 25.00 - 27.00 CYC/SEC
• PEAK VALUES ACCEL=-162.8 CM/SEC/SEC,VELOCITY=11.49 CM/SEC,DISPL=-1.708 CM

FIG. 20A-18

RESPONSE SPECTRUM

NORTHERN CALIFORNIA EARTHQUAKE MAR 9, 1949 - 0429 PST

IIIU301 49.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

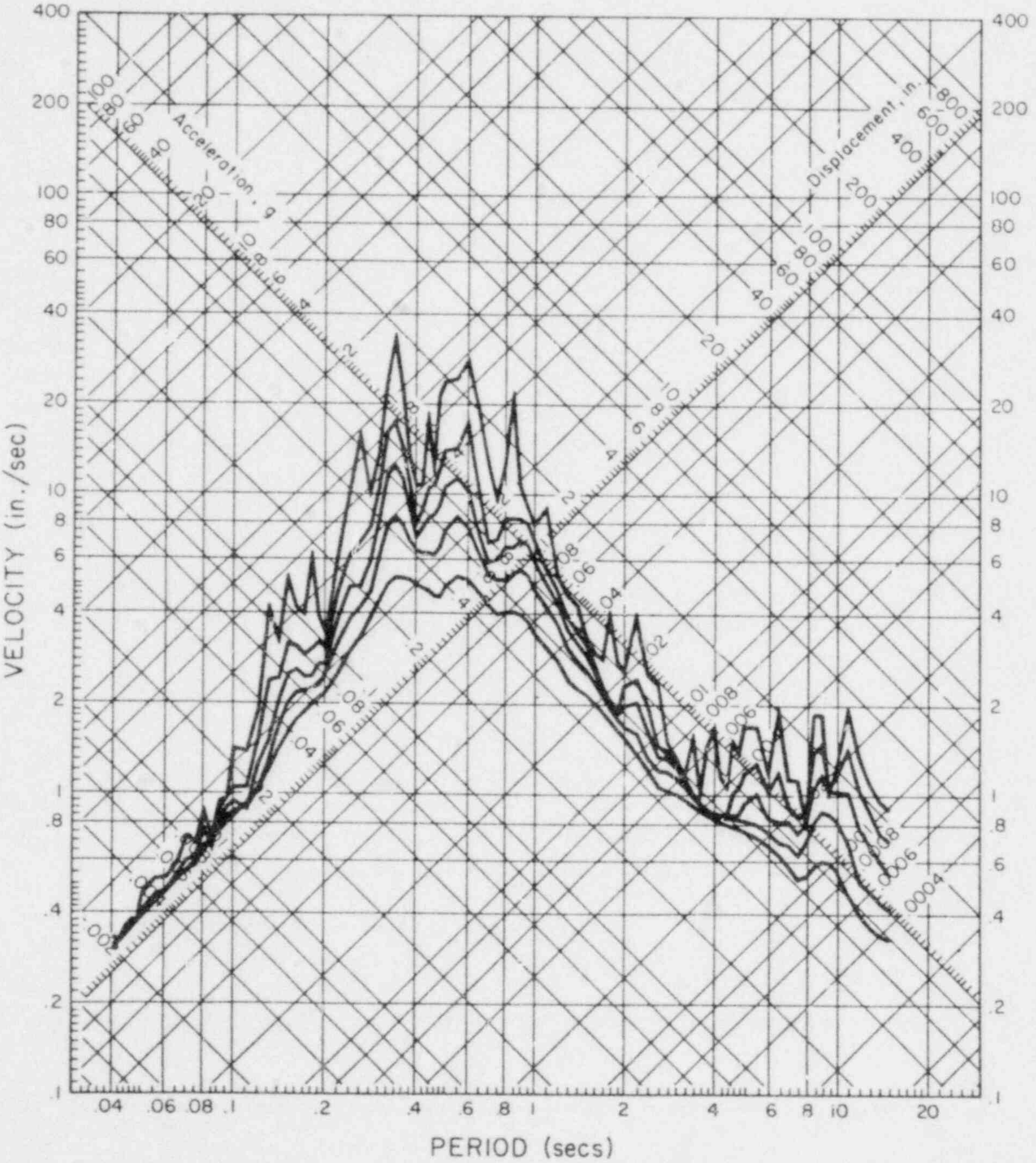


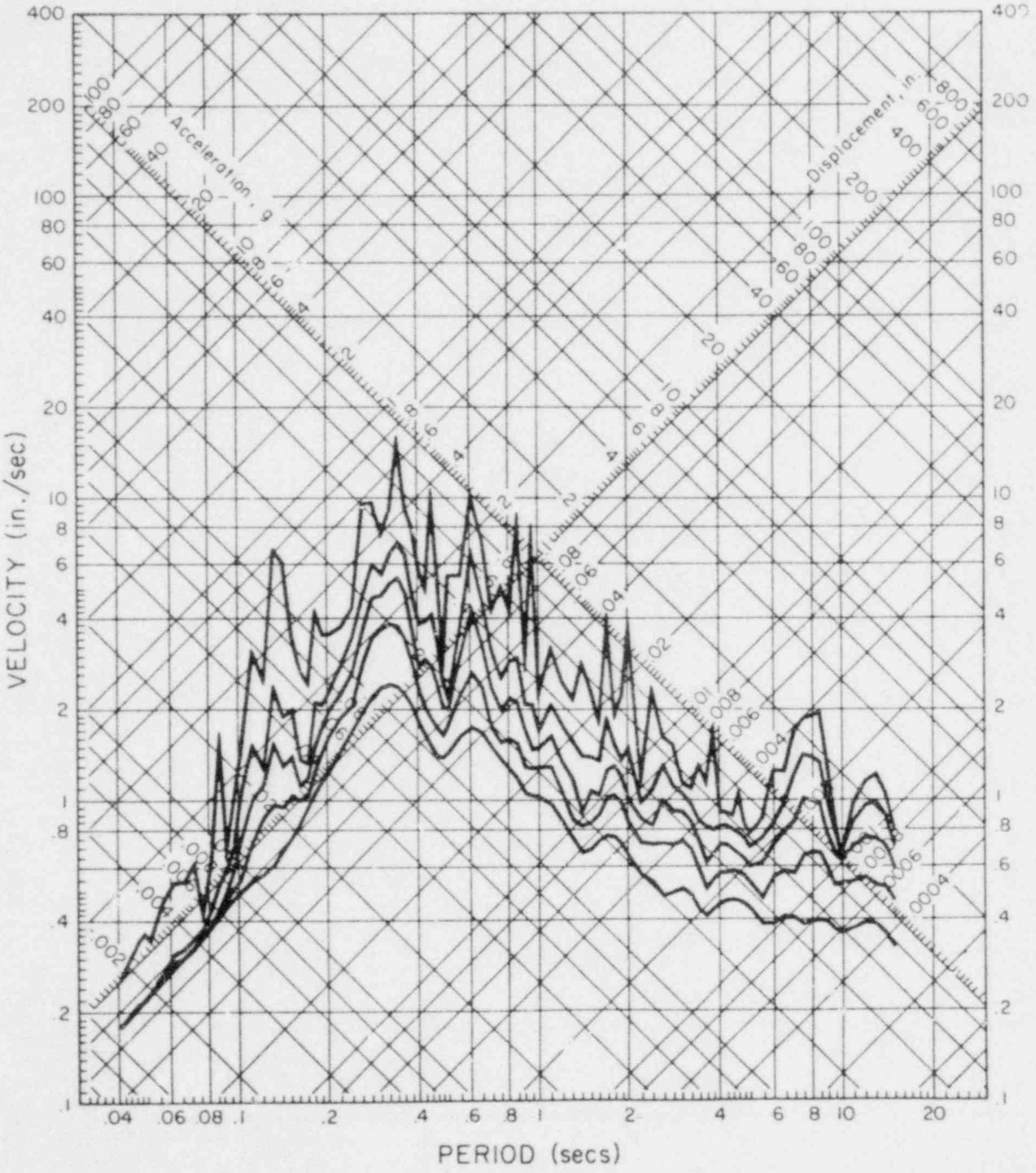
FIG. 20A-19

RESPONSE SPECTRUM

NORTHERN CALIFORNIA EARTHQUAKE MAR 9, 1949 - 0429 PST

IIIU301 49.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL



RESPONSE SPECTRUM

NORTHERN CALIFORNIA EARTHQUAKE MAR 9, 1949 - 0429 PST

IIIU301 49.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

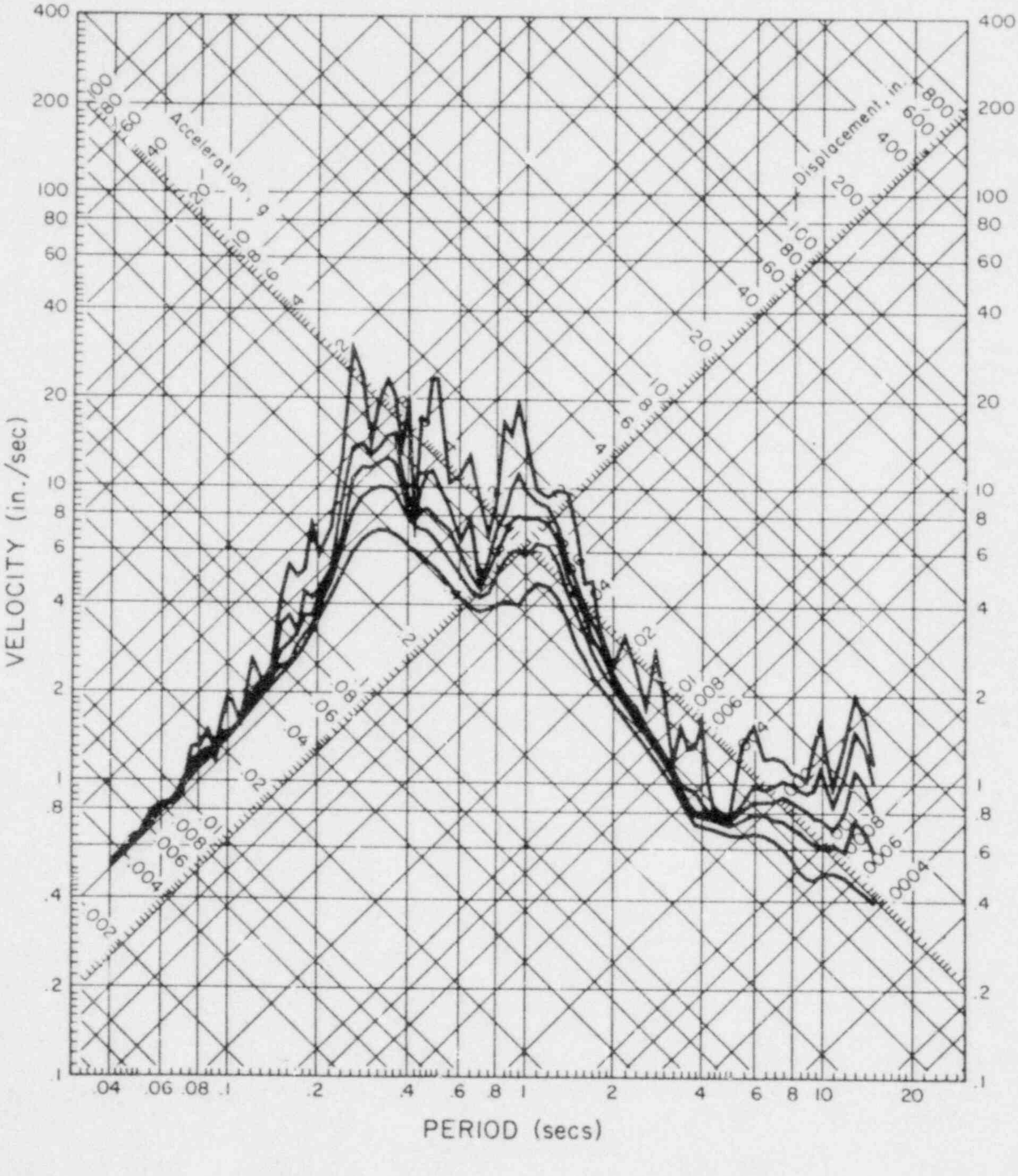
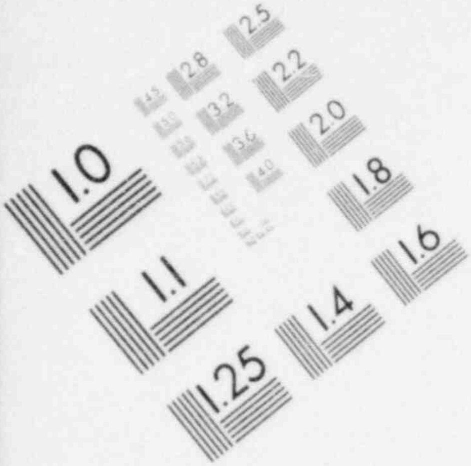


FIG. 20A-21



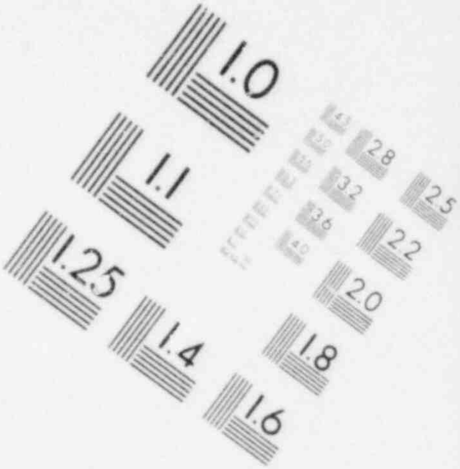
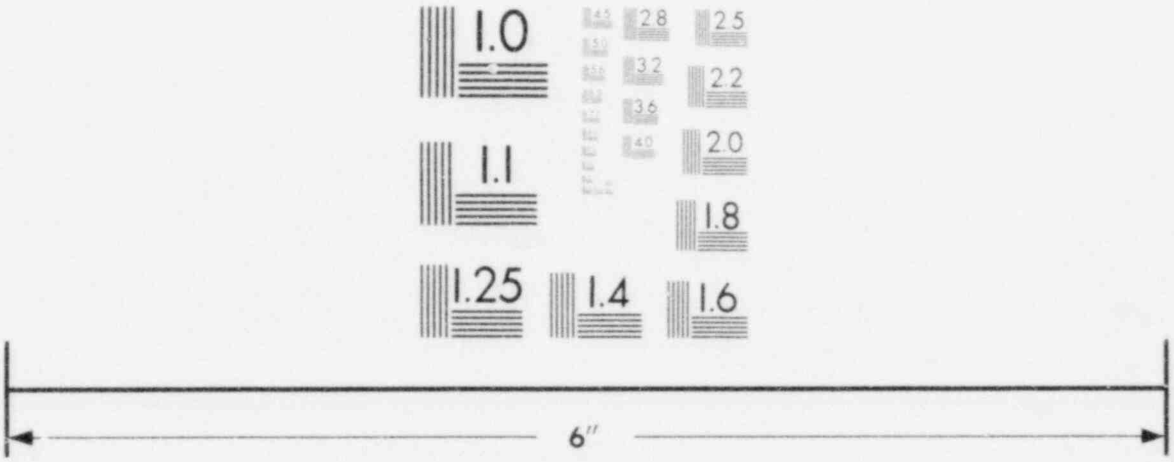
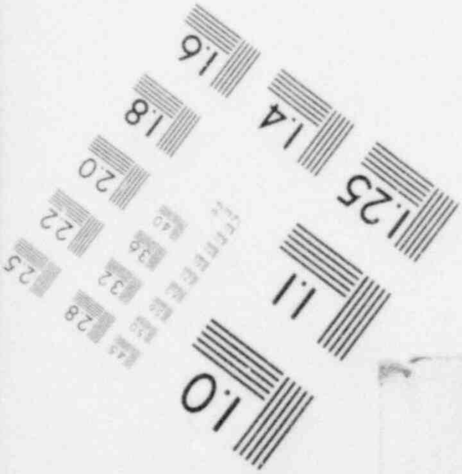
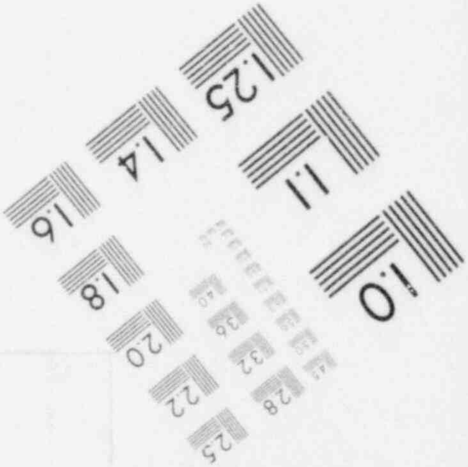


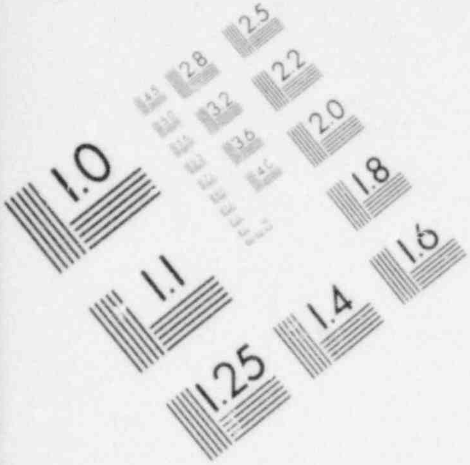
IMAGE EVALUATION
TEST TARGET (MT-3)



MICROCOPY RESOLUTION TEST CHART







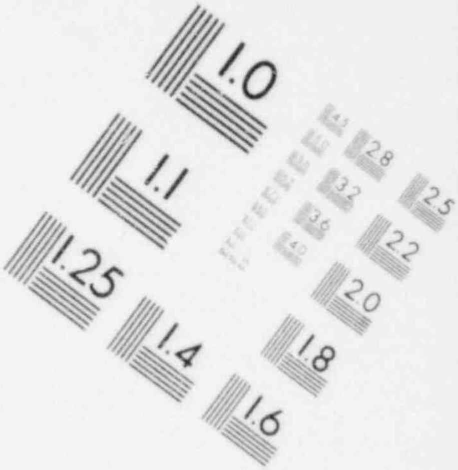
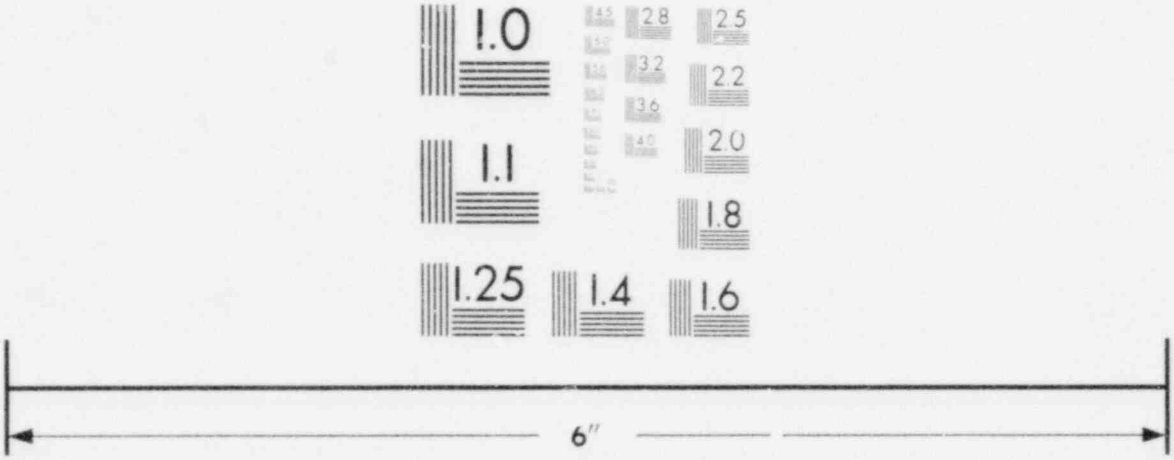
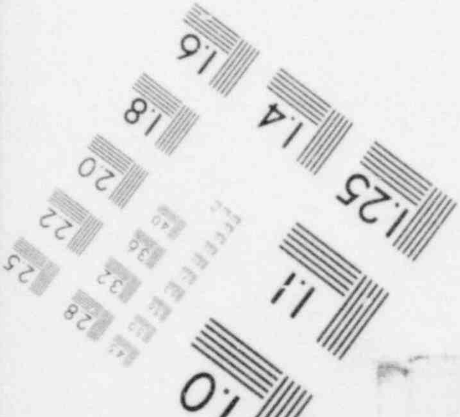
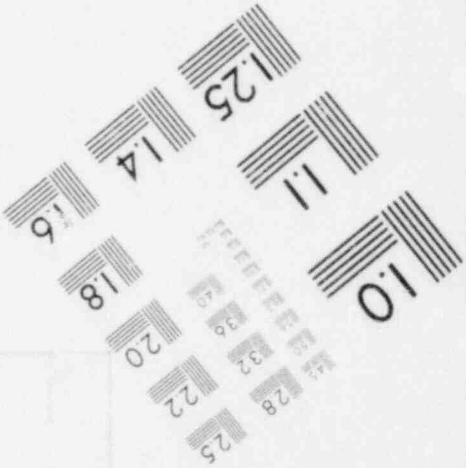


IMAGE EVALUATION
TEST TARGET (MT-3)



MICROCOPY RESOLUTION TEST CHART





RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST

IIIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

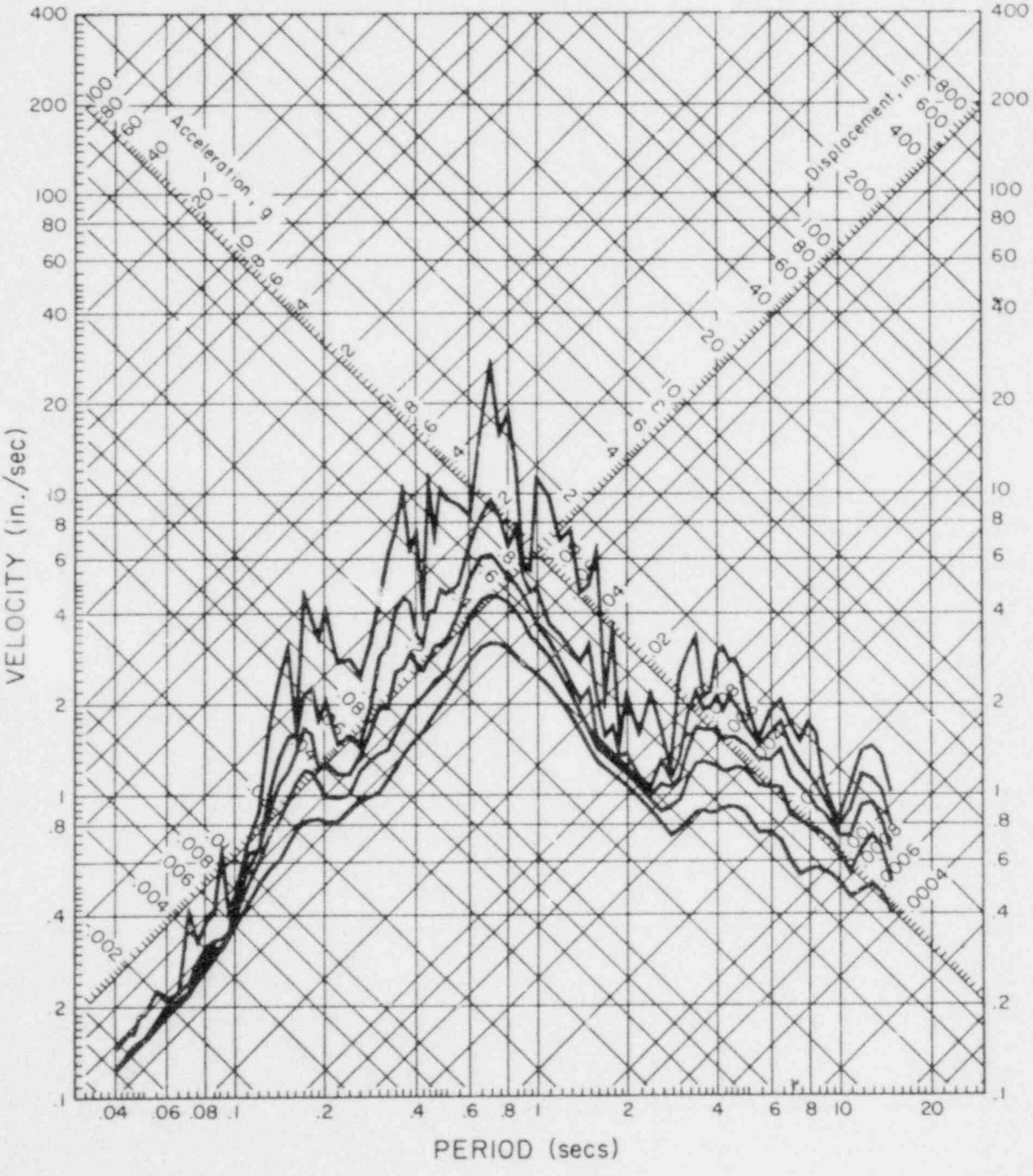


FIG. 20A-22

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST

IIIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

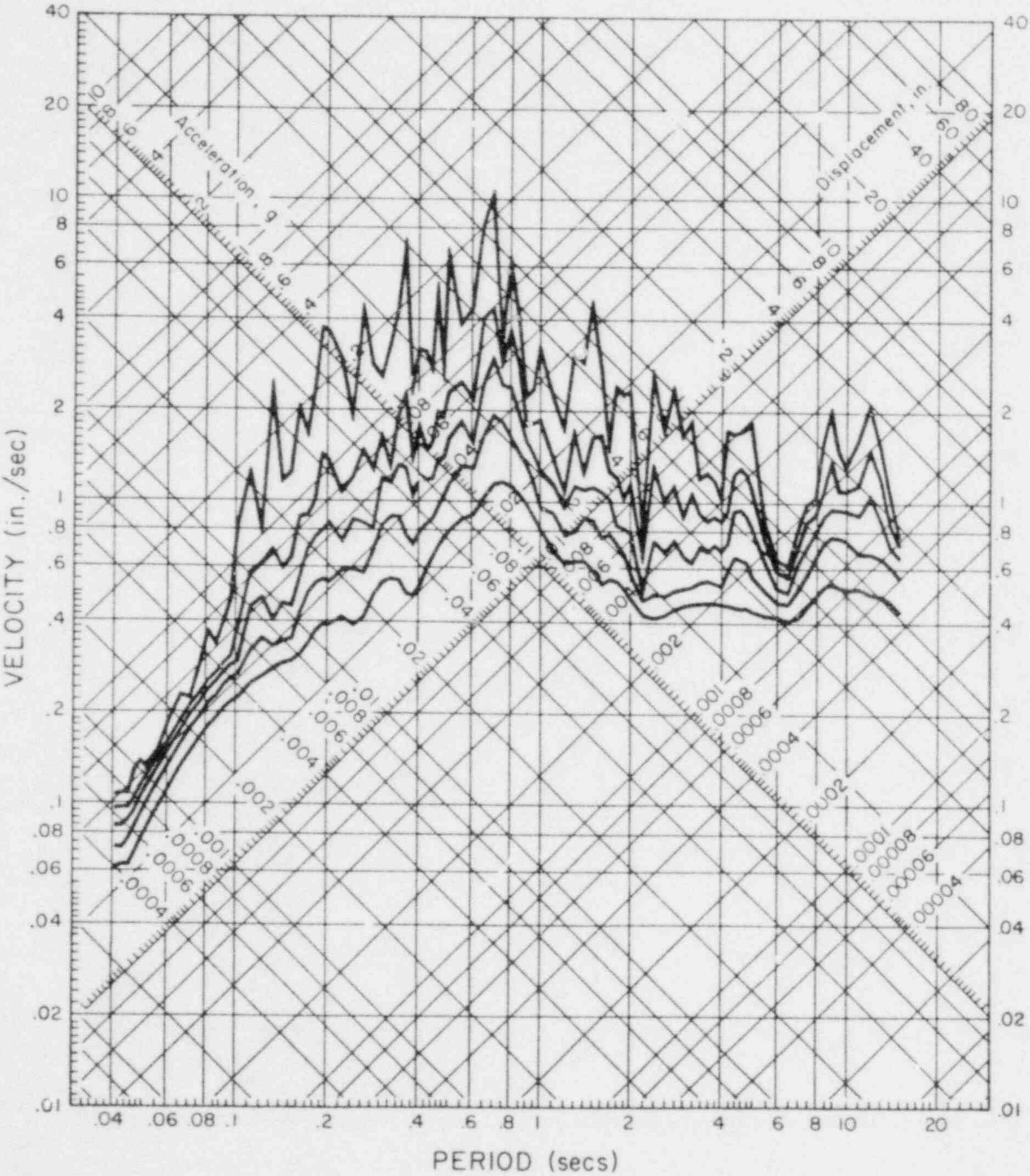


FIG. 20A-23

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE APR 25, 1954 - 1233 PST

IIIU305 54.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

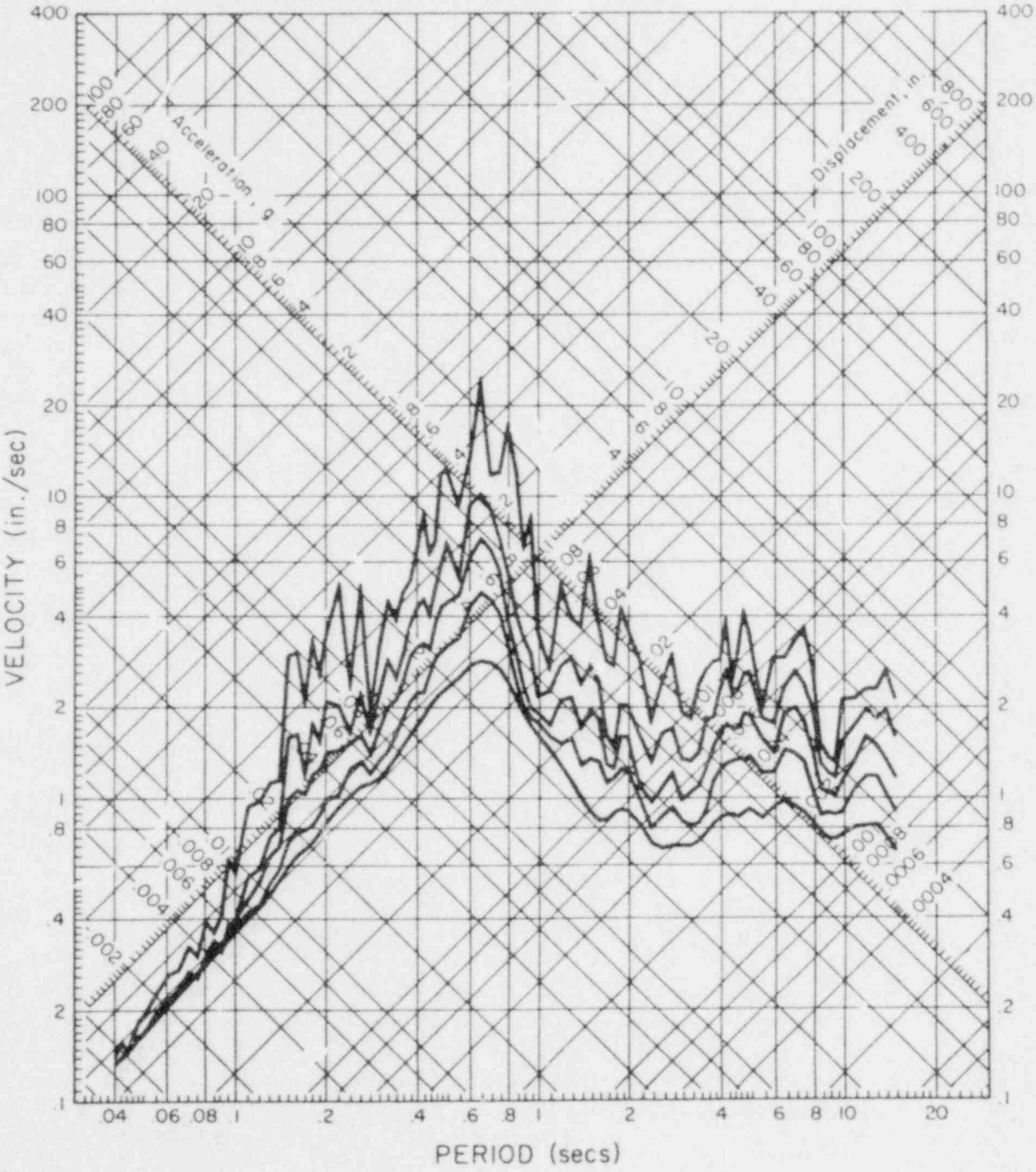


FIG. 20A-24

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE JAN 19, 1960 - 1926 PST

IIIU307 60.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

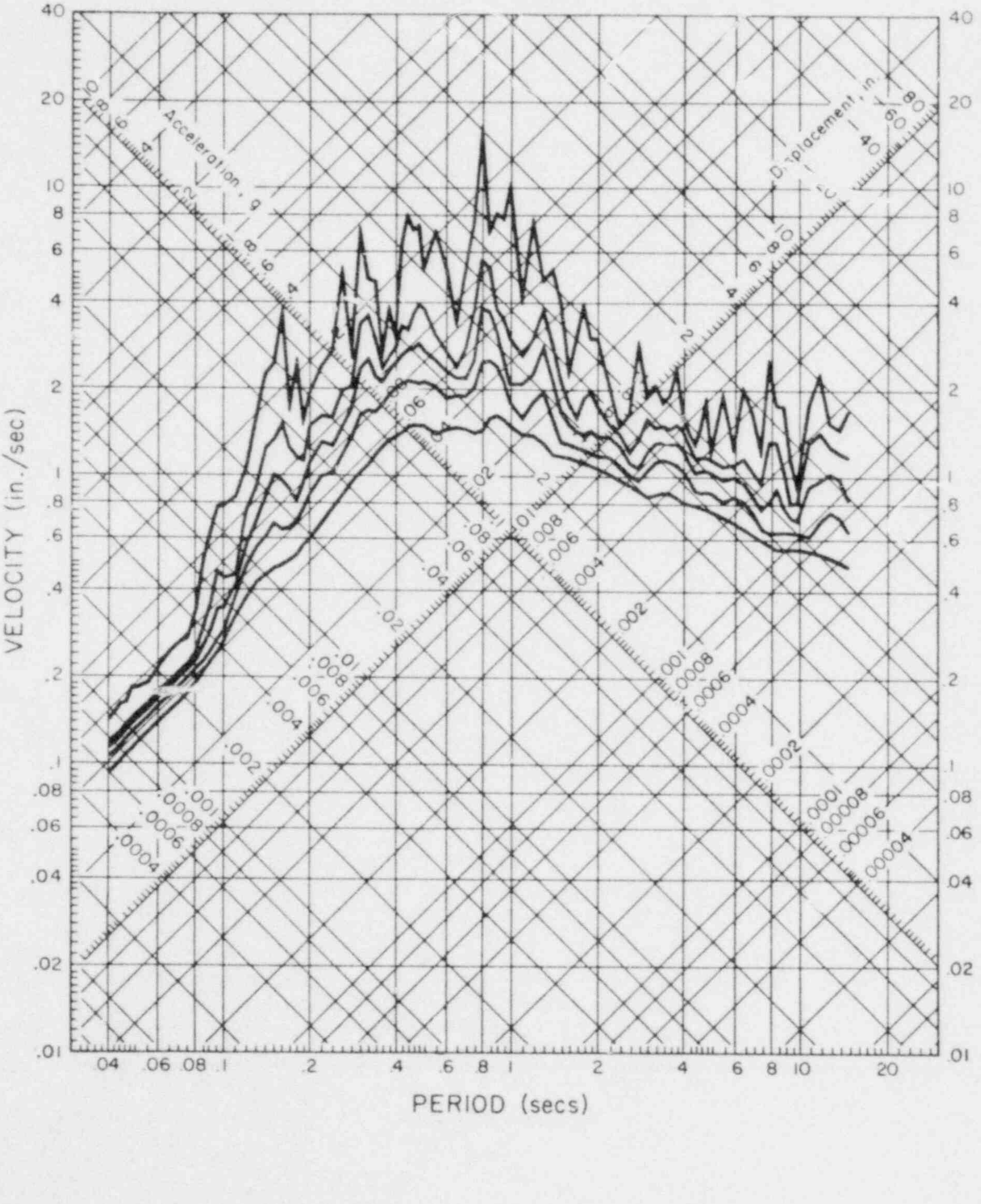


FIG. 20A-25

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE JAN 19, 1960 - 1926 PST

IIIU307 60.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

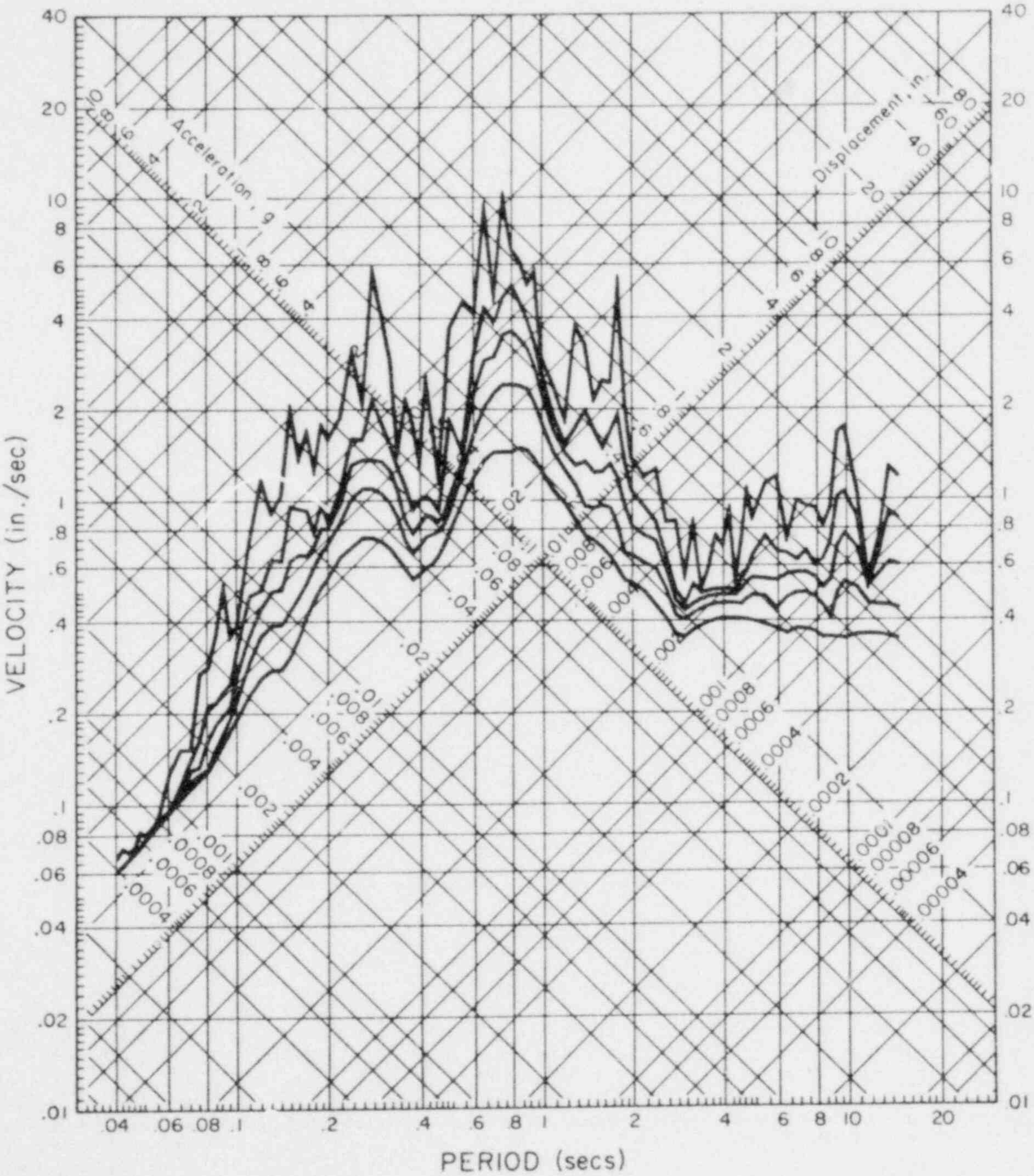


FIG. 20A-26

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EARTHQUAKE JAN 19, 1960 - 1926 PST

IIIU307 60.001.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

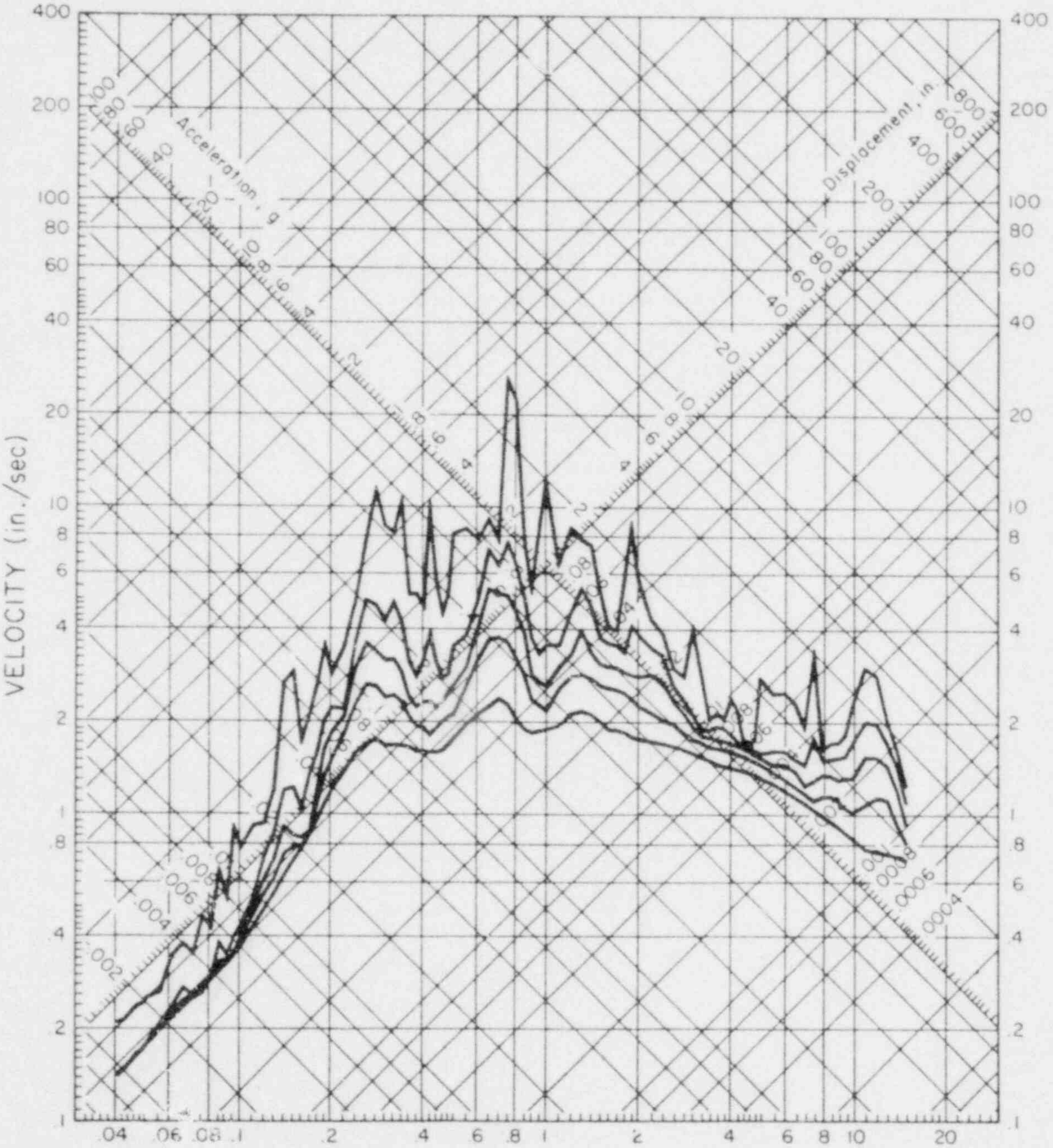


FIG. 20A-27

RESPONSE SPECTRUM

HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST

IIIA018 61.001.0 HOLLISTER CITY HALL COMP S01W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

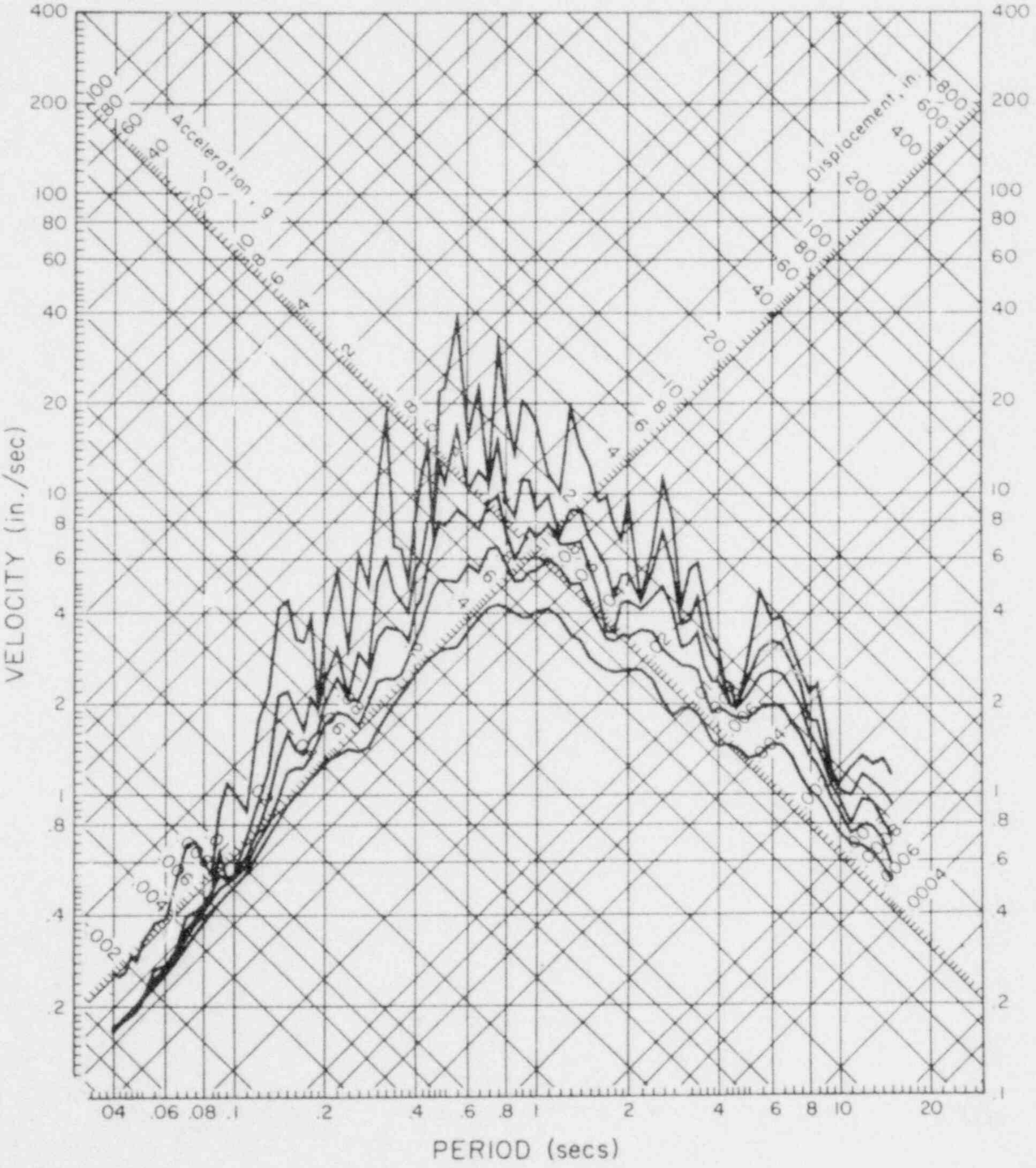


FIG. 20A-28

RESPONSE SPECTRUM

HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST

IIIA018 61.001.0 HOLLISTER CITY HALL COMP VERT

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

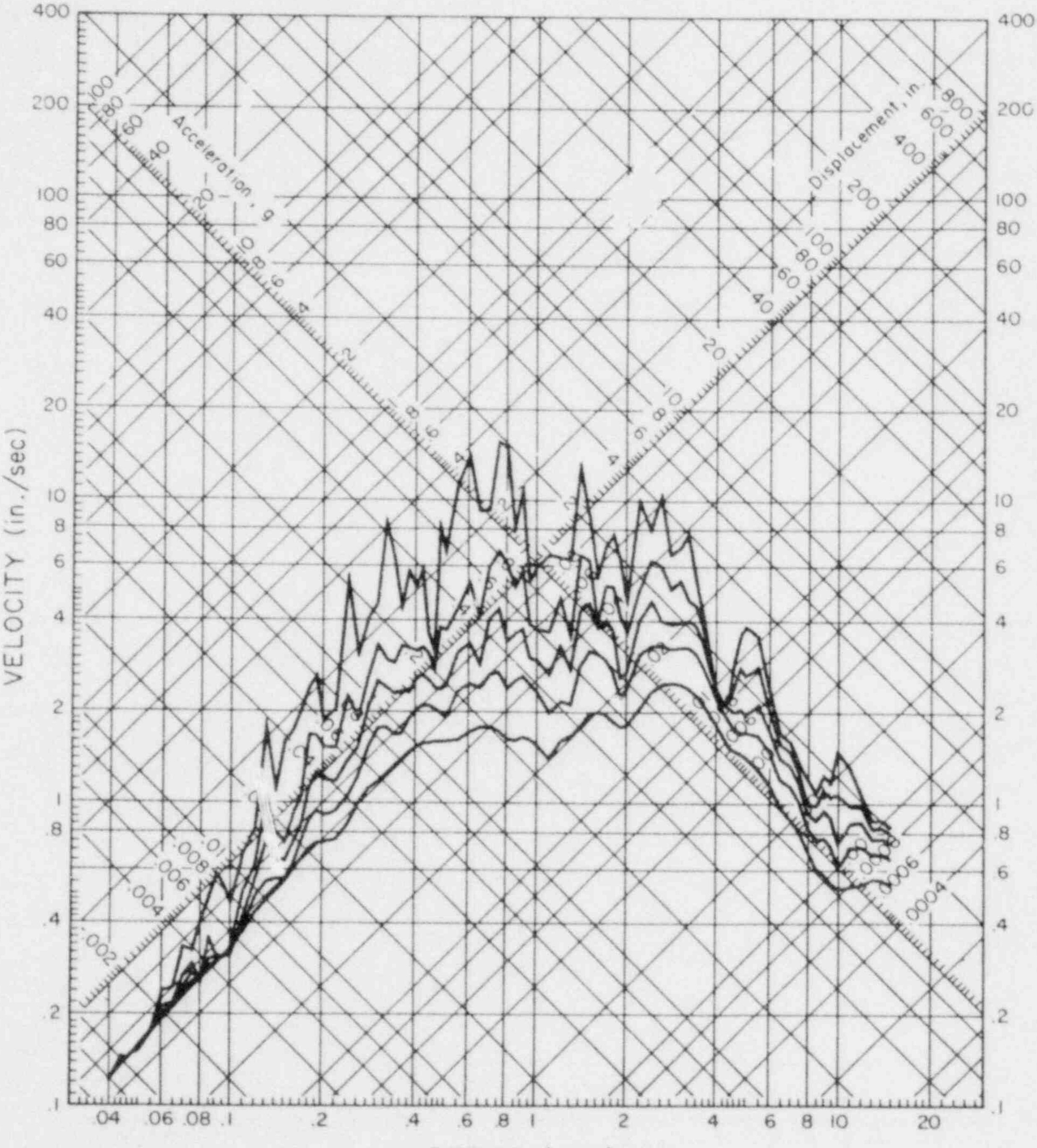


FIG. 20A-29

RESPONSE SPECTRUM

HOLLISTER EARTHQUAKE APR 8, 1961 - 2323 PST

IIIA018 61.001.0 HOLLISTER CITY HALL COMP N89W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

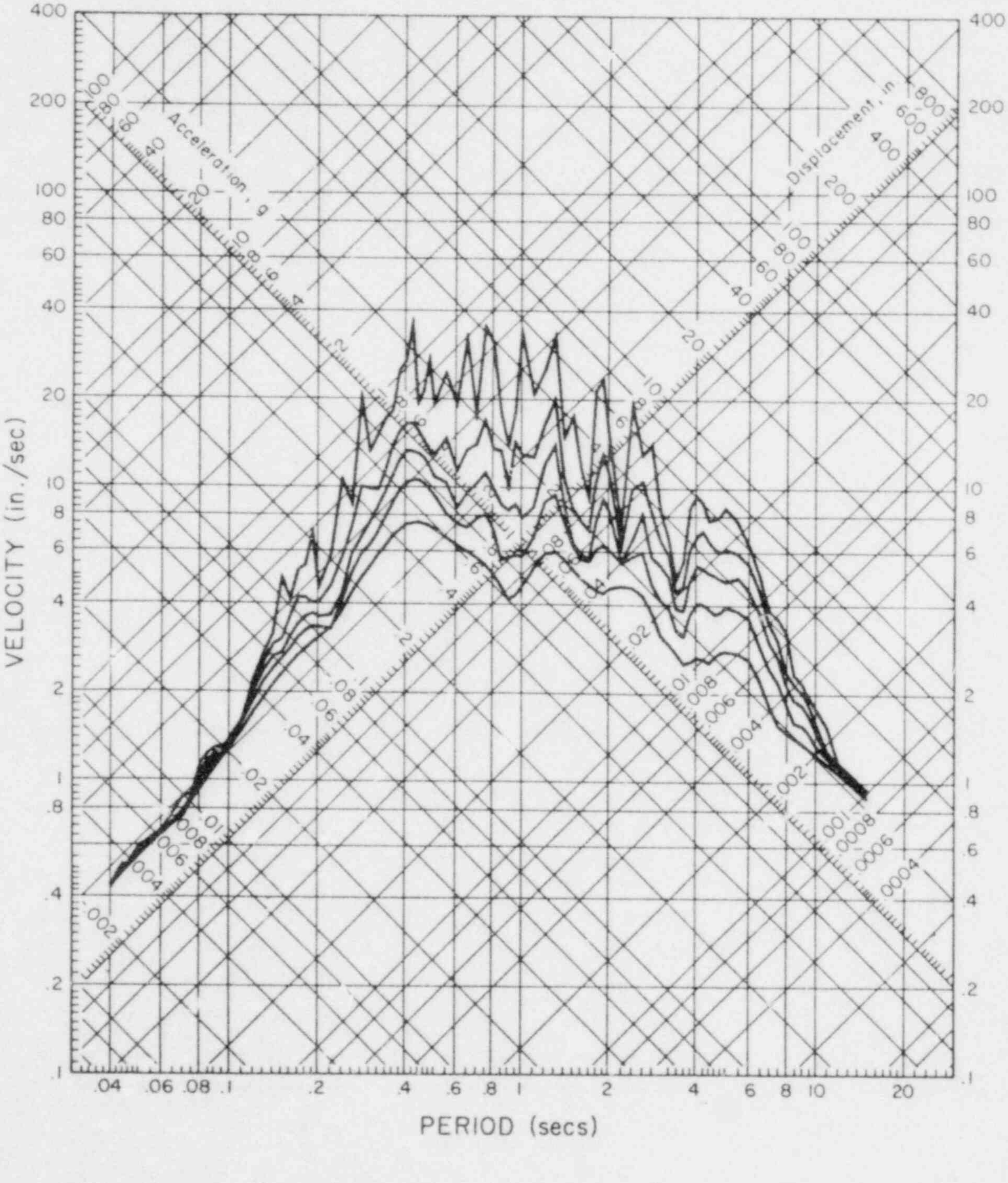


FIG. 20A-30

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8, 1961 - 2336 PST

IIIU309 61.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP S01W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

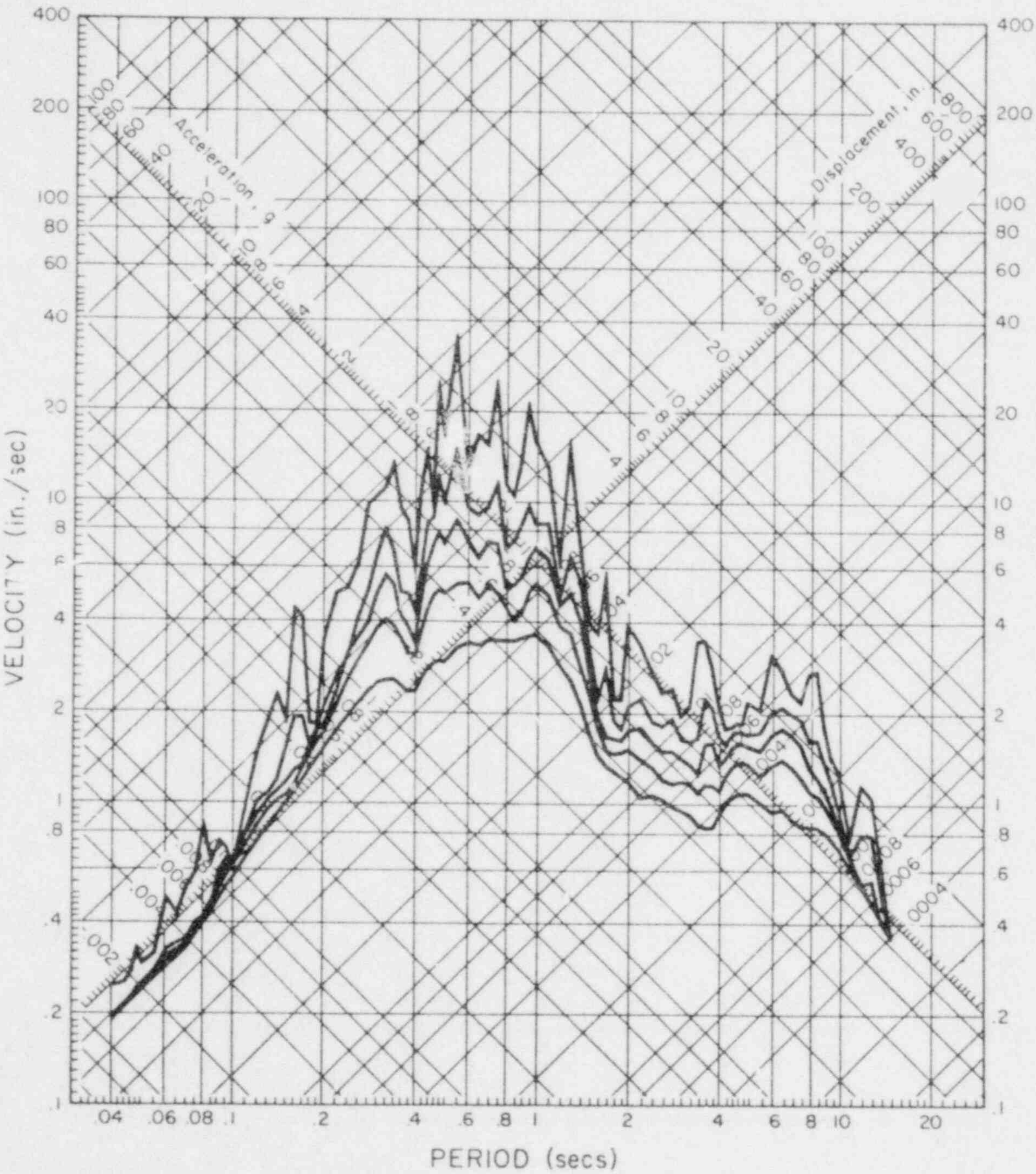


FIG. 20A-31

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8, 1961 - 2326 PST

IIIU309 61.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

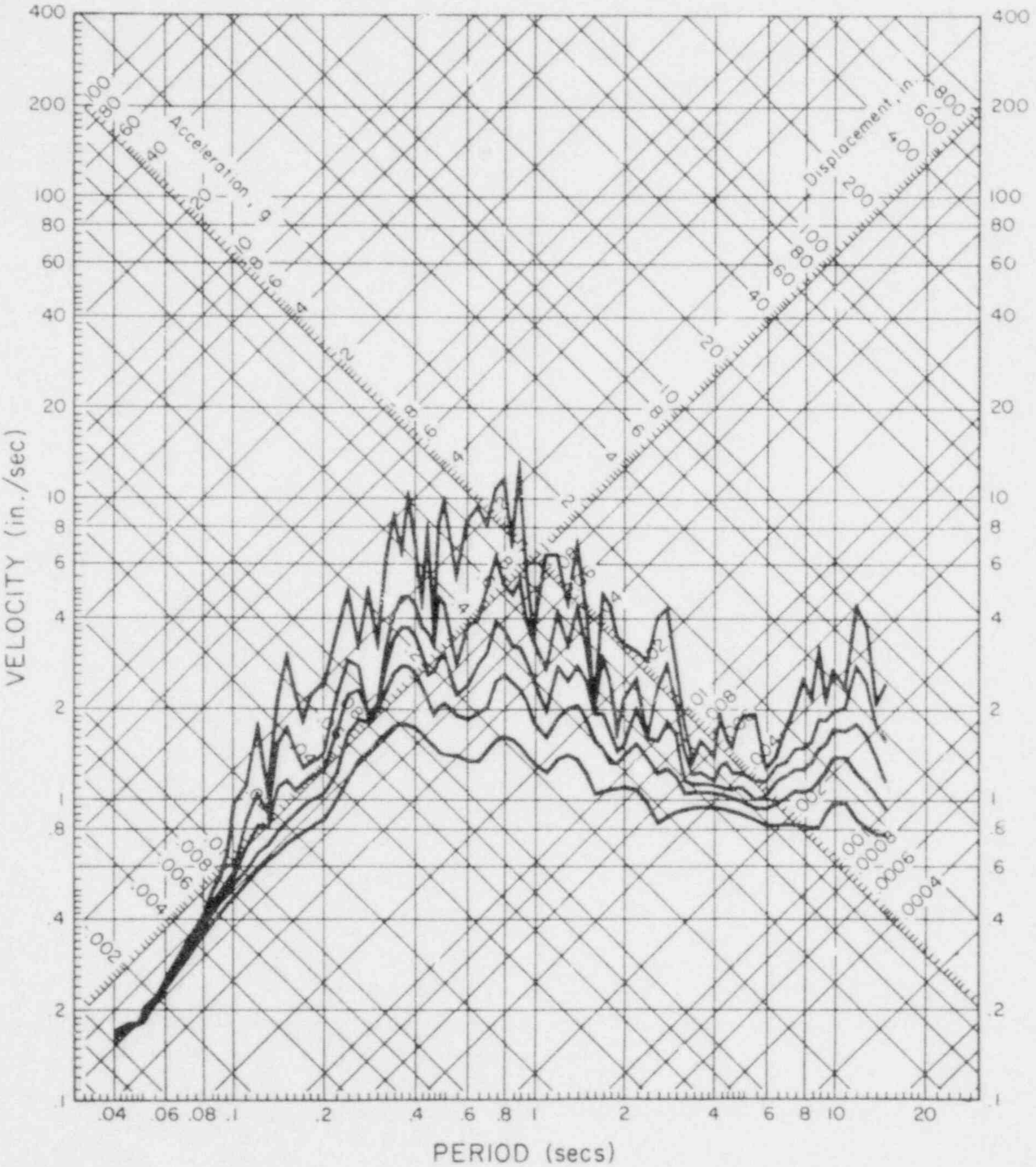


FIG. 20A-32

RESPONSE SPECTRUM

CENTRAL CALIFORNIA EQ. AFTERSHOCK APR 8, 1961 - 2326 PST

IIIU309 61.002.0 PUBLIC LIBRARY, HOLLISTER, CALIFORNIA COMP N89W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

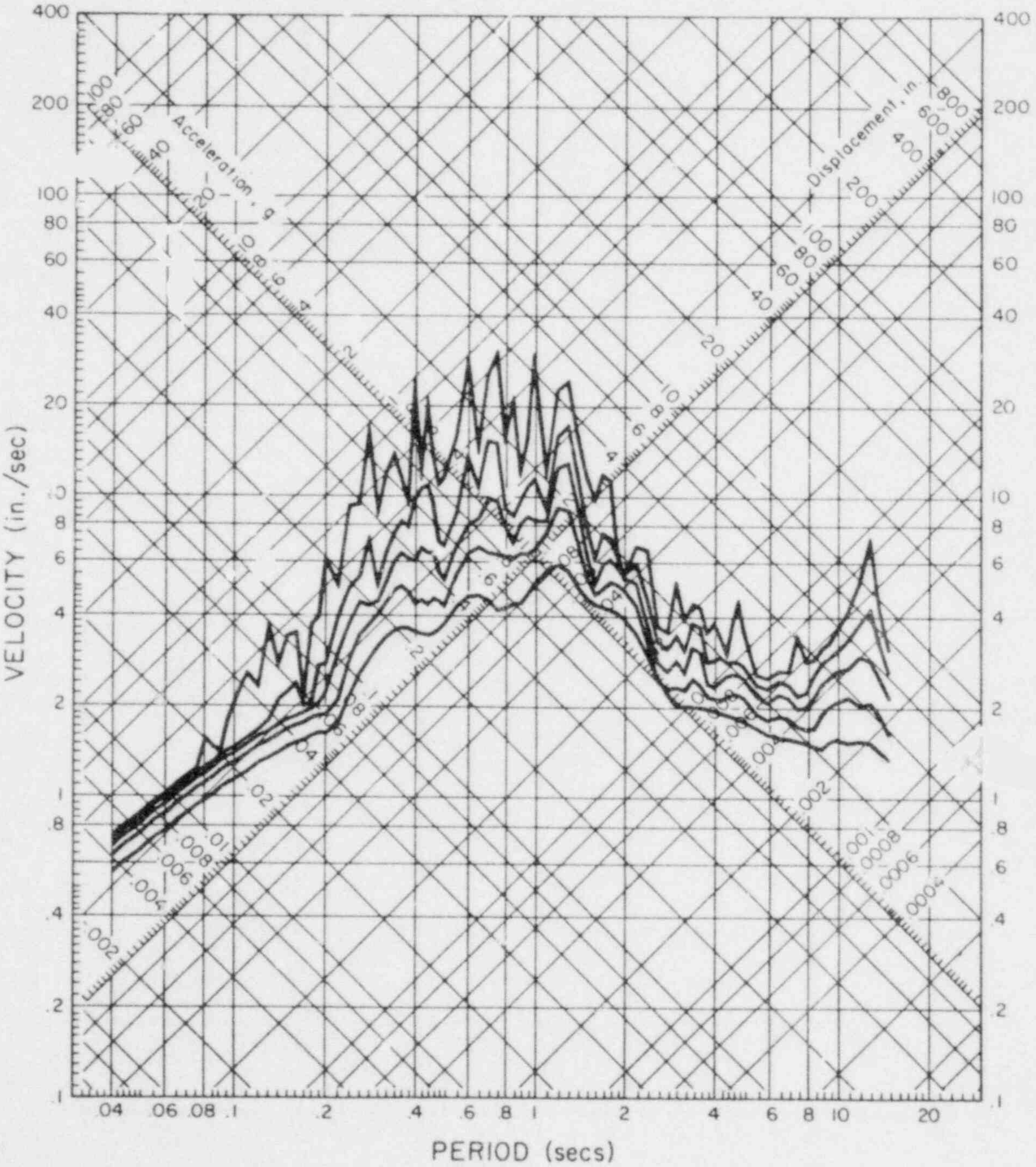


FIG. 20A-33

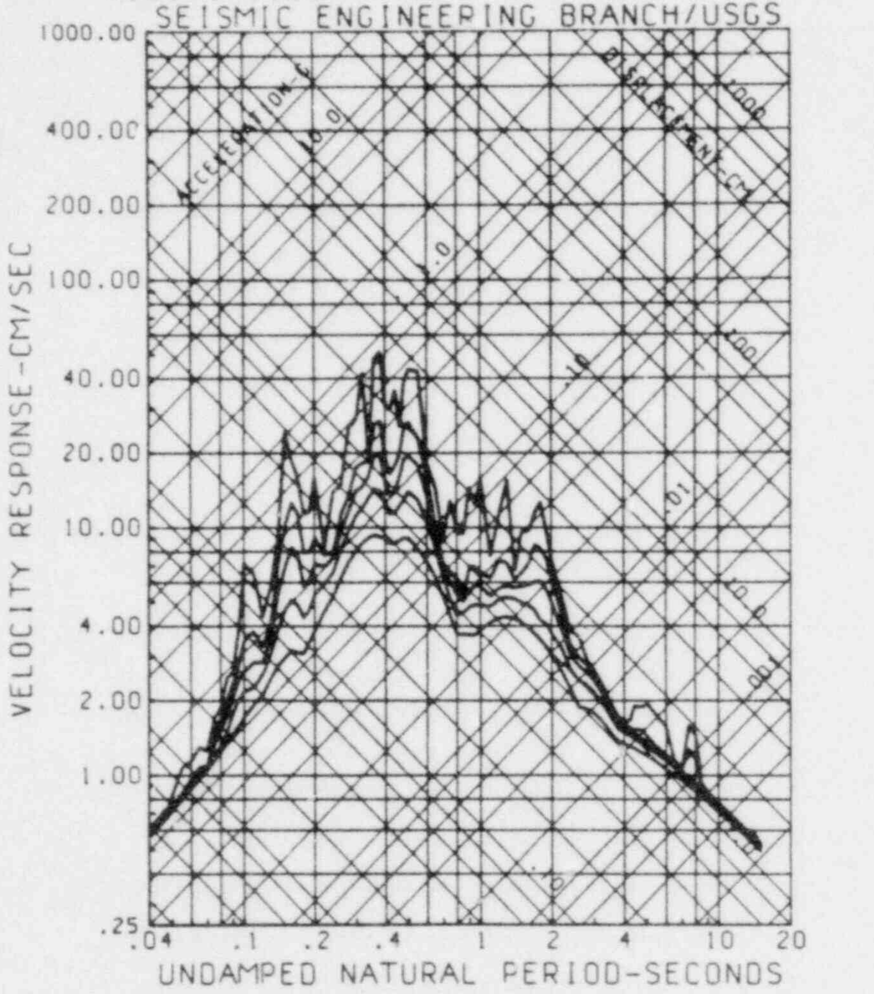

RESPONSE SPECTRA
HOLLISTER.CALIF.CITY HALL.11/28/74.S01W
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10
10.0
.001
.10

FIG. 20A-34

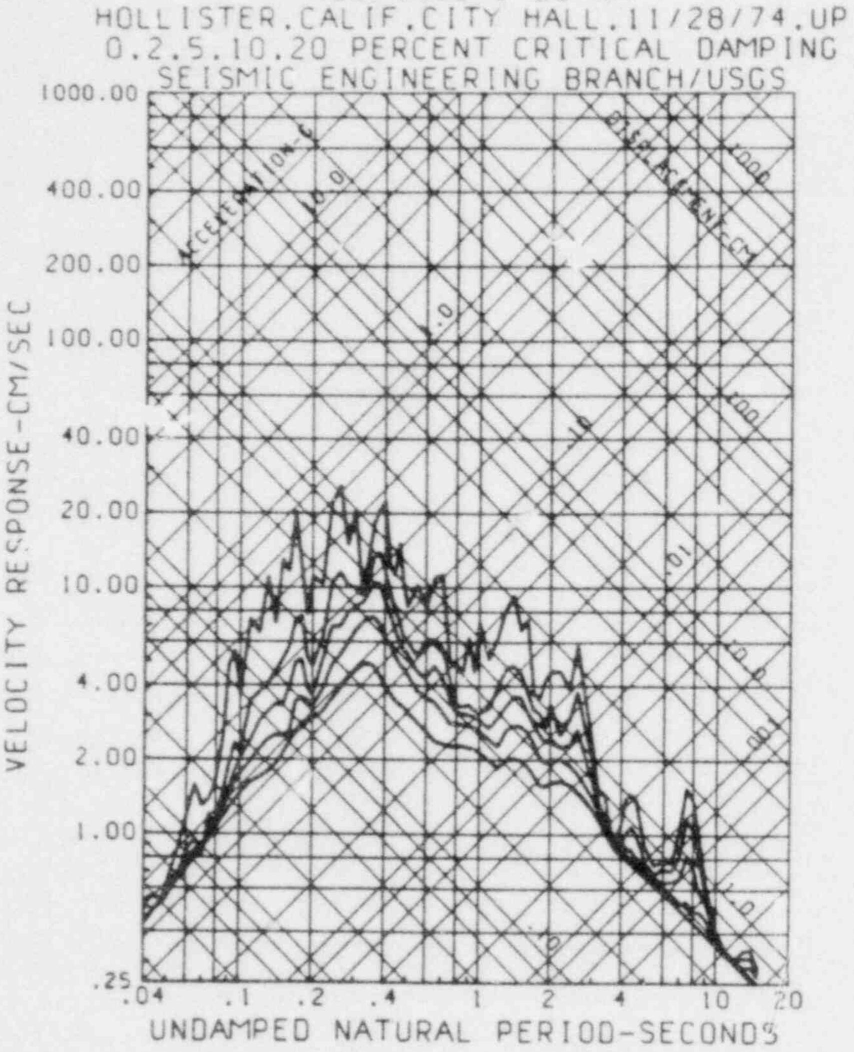

RESPONSE SPECTRA
HOLLISTER.CALIF.CITY HALL.11/28/74.UP
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
ACCELERATION-G
10.0
1.0
.10
.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0
.10
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

FIG. 20A-35

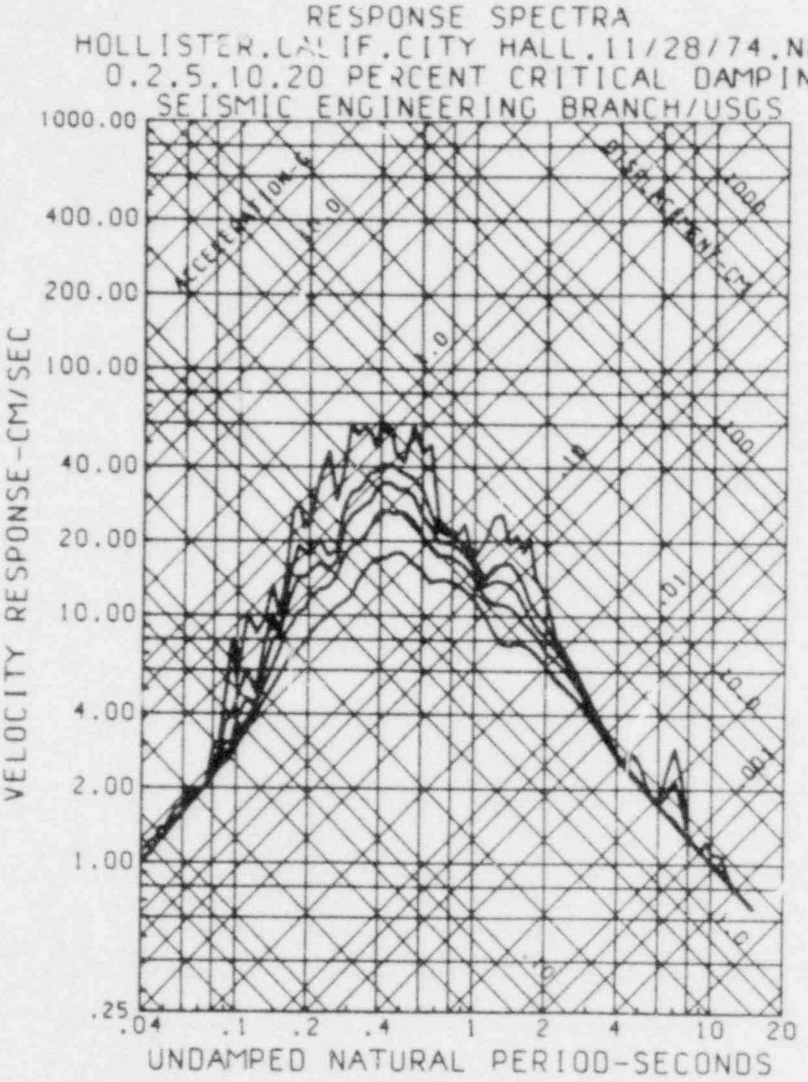

RESPONSE SPECTRA
HOLLISTER.CALIF.CITY HALL.11/28/74.N89W
0.2.5.10.20 PERCENT CRITICAL DAMPING
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1000
100
10
1.0
.1
.01
.001

FIG. 20A-36

Section 21A

Hollywood Storage Building
Los Angeles, California

SECTION 21A
EARTHQUAKE RECORDS
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

LIST OF TABLES

LIST OF FIGURES

Figure Number — Page

- BASEMENT INSTRUMENT -

- PARKING LOT INSTRUMENT -

TABLE 2IA-1

STATION RECORDS[1]

HOLLYWOOD STORAGE BUILDING (BASEMENT)

LOS ANGELES, CALIFORNIA

USGS No. : 133
CDMG No. : 236
Location : 1025 N. Highland Ave.; approx 300 ft. south of the intersection of Highland Ave. and Santa Monica Blvd.
Property Owner : Bekins Storage Co.
Building : 14 stories with a basement, reinforced concrete construction
Instrument Location : Basement, approx. 12 ft. below exterior grade
Present Instrumentation : CRA-1 accelerograph (S/N 124)
Station Installation Date : June 27, 1933

County : Los Angeles
Quadrangle : Hollywood, Calif. (7.5')
Township 1S; Range 14W; Section 15
Coordinates : 34.090°N; 118.338°W

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (miles)	Max. Acceleration (g's)[3] East	Up	South	Record
A,B	1933	10 - 2	01:10	33.8	118.1	5.4	VI	-	24 SE	——	0.038[4]	——	-
C										0.026	0.011	0.032[5]	B023[5]
A,B	1952	7 - 21	03:52	35.0	119.0	7.7	XI	-	75 NW	0.029	0.014	0.036[4]	-
C										0.044	0.023	0.054[5]	A006[5]
B	1971	2 - 9	06:01	34.4	118.4	6.4(P)	XI	5	22 N	0.15	0.06	0.11[4]	-
C										0.148	0.050	0.104[5]	0057[5]

Notes:

1. Earthquake records selected for this tabulation generally have maximum accelerations of 0.05 or greater. There are over 40 accelerograph records for the instrument in the basement of the Hollywood Storage Building.

2. The following sources were used in compiling the earthquake data:

   A. Coffman and Von Hake (1973)

   B. <u>United States Earthquakes</u>

   C. Hudson, et al. (1971-1975a)

   Sources A and B were used for earthquake location, time and size. Sources B and C were used for earthquake acceleration information. Station records were checked with the listings of Brazee (1974), Morris, et al. (1977) and the USGS (unpub.).

3. All recordings were made on C&GS standard accelerographs oriented at the indicated bearings for pendulum motion. The 1933 event was made on recorder S/N 21; the other two events were made on recorder S/N 22.

4. Accelerations from unprocessed records.

5. Accelerations from digitized and baseline corrected records in the CIT series (Hudson, et al. (1971-1975a).

POOR ORIGINAL

TABLE 21A-2

STATION RECORDS[1]

HOLLYWOOD STORAGE BUILDING (PARKING LOT)

LOS ANGELES, CALIFORNIA

USGS No. : 135
CDMG No. : 303
Location : Approx. 80 ft. west of the southwest corner of the Hollywood Storage Building at 1025 N. Highland Ave,
Property Owner : Bekins Storage Co.
Building : Small, fiberglass instrument shelter
Instrument Location : Ground level
Present Instrumentation : RFT-250 accelerograph (S/N 371)
Station Installation Date : December, 1934

County : Los Angeles
Quadrangle : Hollywood, Calif. (7.5')
Township 1S; Range 14W; Section 15
Coordinates : 34.090°N 118.338°W

Source[2]	Year	Date Mo. Day	Time (PST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (mile)	Max. Acceleration (g's)[3]			Record
										East	Up	South	
A,B	1952	7 1	03:52	35.0	119.0	7.7	XI	-	75 NW	0.041	0.013	0.042[4]	-
C										0.041	0.020	0.058[5]	A007[5]
B	1971	2 - 9	06:01	34.4	118.4	6.4(P)	XI	5	22 N	0.22	0.12	0.19[4]	-
C										0.207	0.087	0.167[5]	D058[5]

Notes:

1. Earthquake records selected for this tabulation generally have maximum accelerations of 0.05g or greater. There are over 40 accelerograph records for the instrument in the parking lot of the Hollywood Storage Building.

2. The following sources were used in compiling the earthquake data.

   A. Coffman and Von Hake (1973)

   B. <u>United States Earthquakes</u>

   C. Hudson et al. (1971-1975a)

   Sources A and B were used for earthquake location, time and size. Sources B and C were used for earthquake acceleration information. Station records were checked with the listings of Brazee (1974), Morris, et al. (1977) and the USGS (unpub.).

3. All recordings were made on a C&GS standard accelerograph (S/N 1) with the indicated bearings for pendulum motion.

4. Accelerations from unprocessed records.

5. Accelerations from digitized, baseline corrected records in the CIT series (Hudson et al. 1971-1975a).

POOR ORIGINAL

SOUTHERN CALIFORNIA EARTHQUAKE OCT 2, 1933 - 0110 PST

IIB023 33.007.0 HOLLYWOOD STORAGE BLDG BASEMENT COMP S90E

⊙ PEAK VALUES : ACCEL = -26.4 CM/SEC/SEC VELOCITY = -2.2 CM/SEC DISPL = 0.4 CM

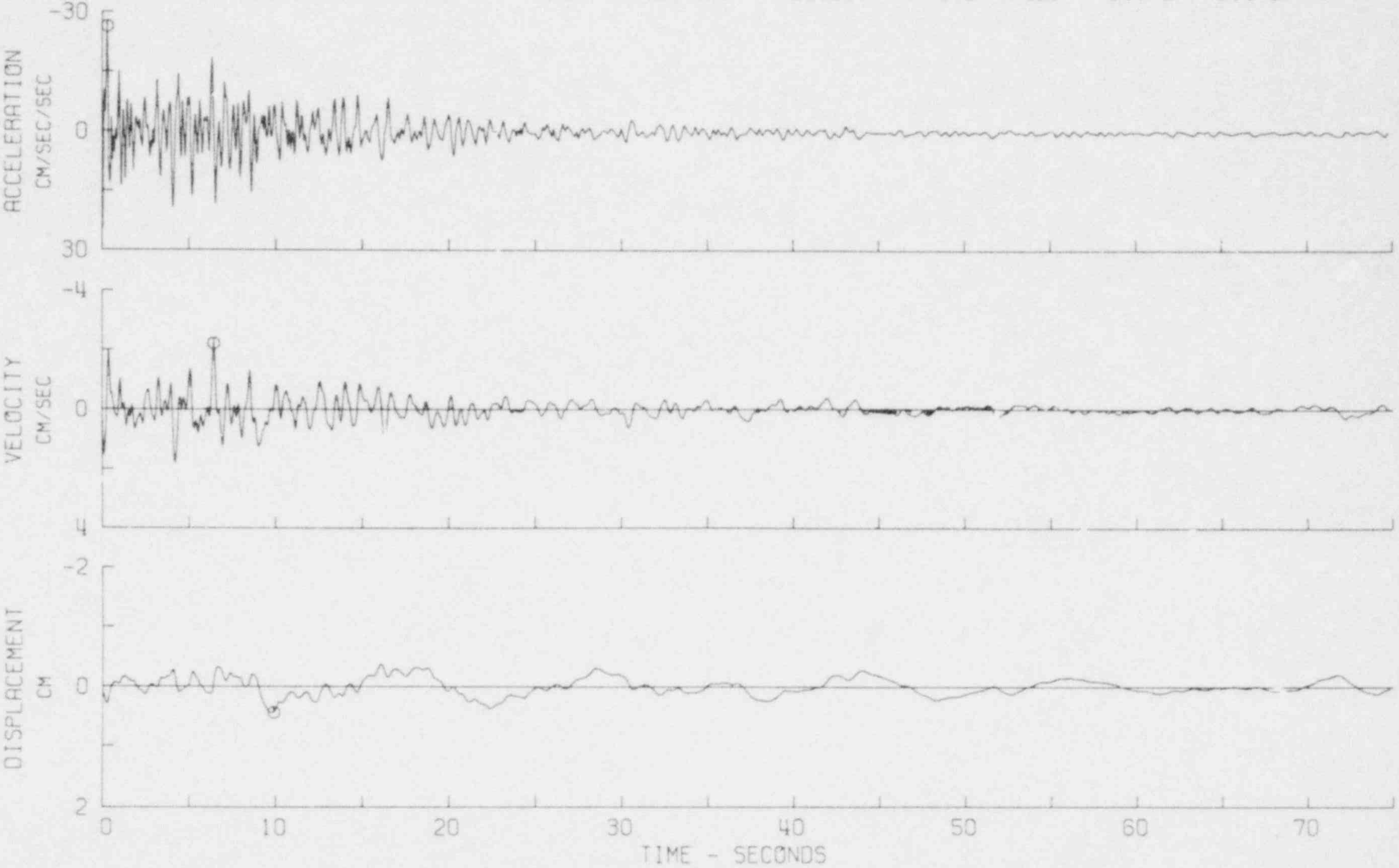


FIG. 21A-1

SOUTHERN CALIFORNIA EARTHQUAKE OCT 2, 1933 - 0110 PST

IIB023 33.007.0 HOLLYWOOD STORAGE BLDG BASEMENT COMP Up

○ PEAK VALUES : ACCEL = 10.7 CM/SEC/SEC VELOCITY = 0.9 CM/SEC DISPL = -0.5 CM

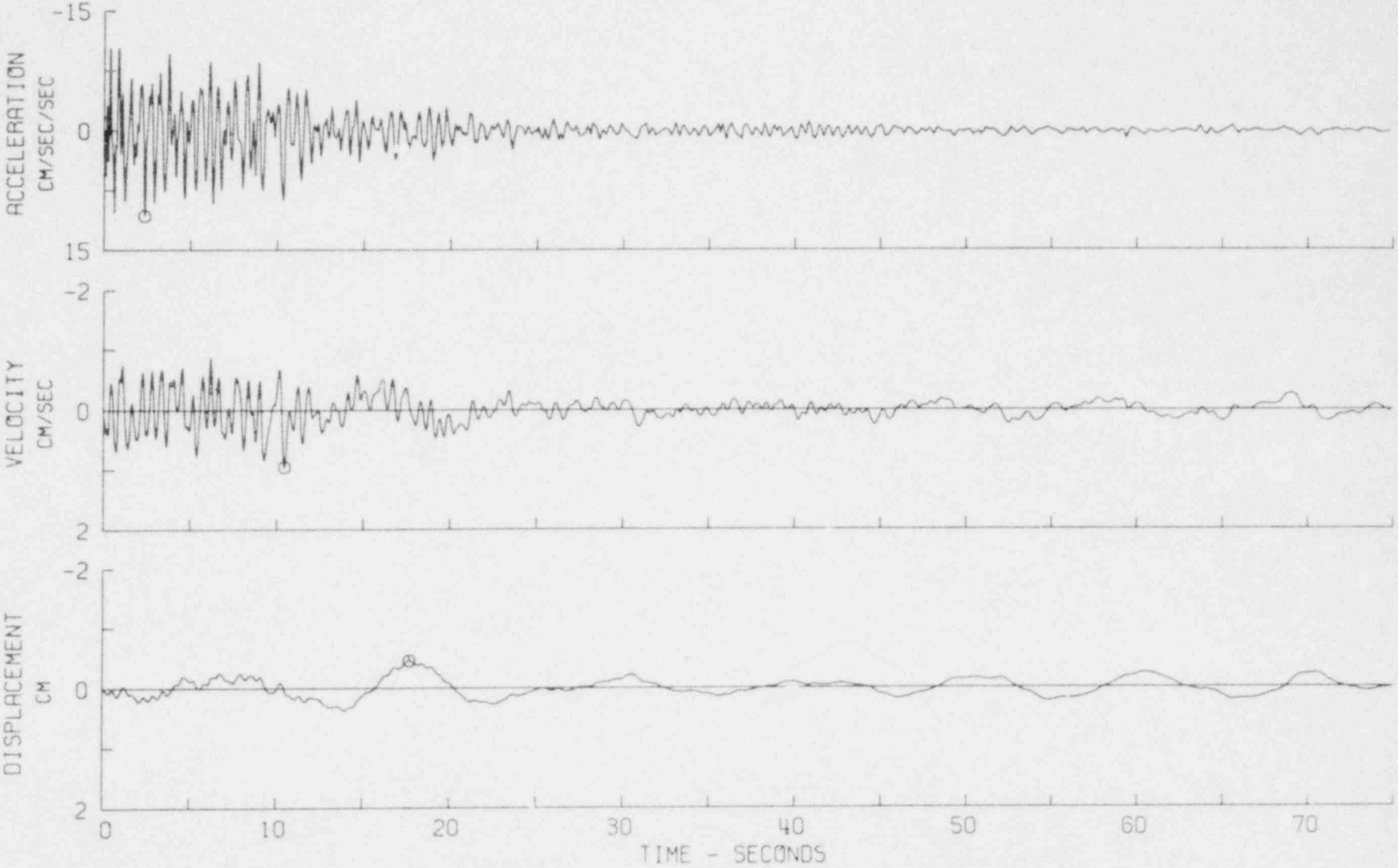


FIG. 21A-2

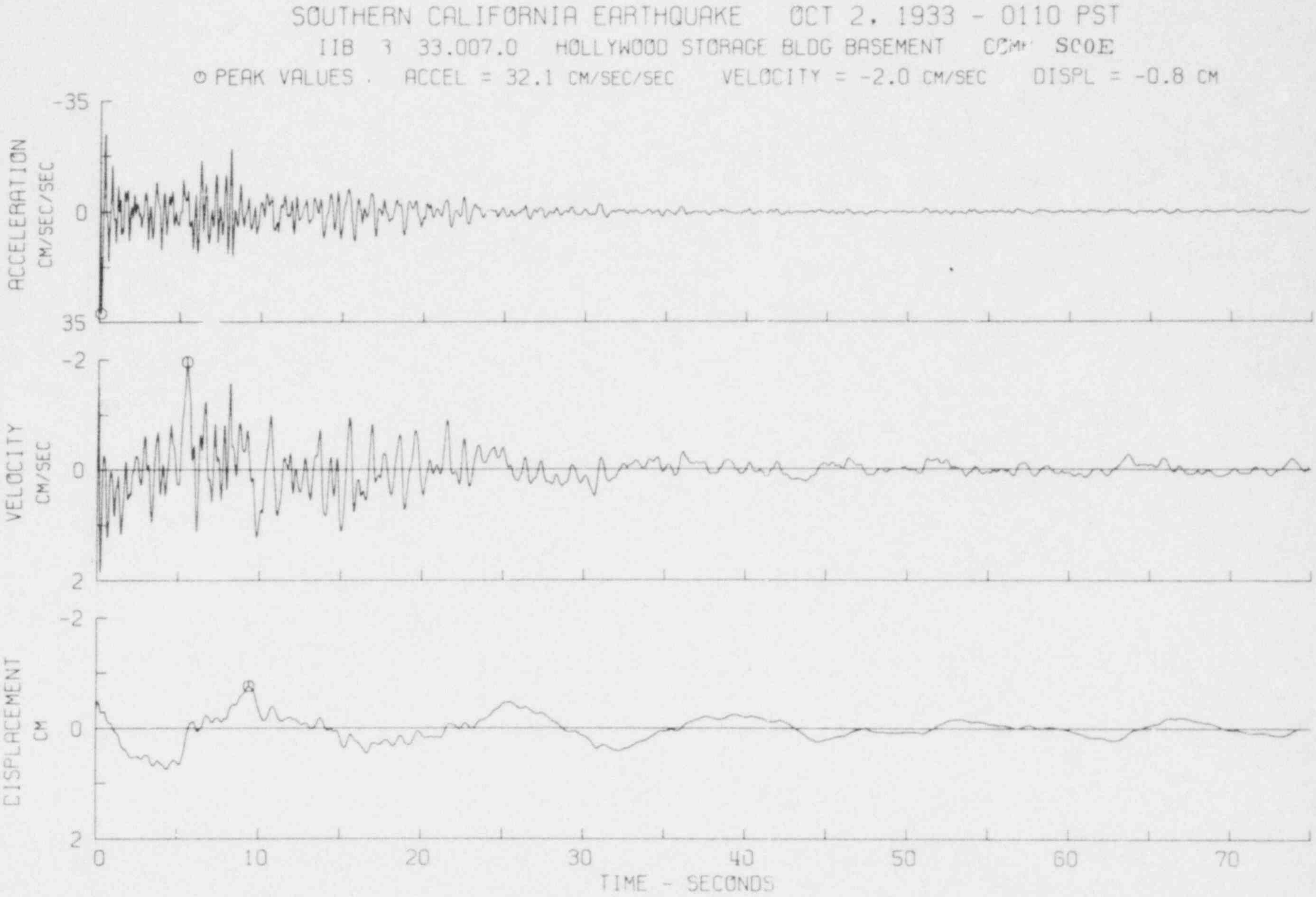

SOUTHERN CALIFORNIA EARTHQUAKE OCT 2. 1933 - 0110 PST
IIB 3 33.007.0 HOLLYWOOD STORAGE BLDG BASEMENT COMP S00E
⊕ PEAK VALUES . ACCEL = 32.1 CM/SEC/SEC VELOCITY = -2.0 CM/SEC DISPL = -0.8 CM
ACCELERATION CM/SEC/SEC
-35
0
35
VELOCITY CM/SEC
-2
0
2
DISPLACEMENT CM
-2
0
2
0
10
20
30
40
50
60
70
TIME - SECONDS

FIG. 21A-3

KERN COUNTY. CALIFORNIA EARTHQUAKE JULY 21. 1952 - 0452 PDT
IIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP N90E
⊙ PEAK VALUES : ACCEL = 43.5 CM/SEC/SEC VELOCITY = 9.4 CM/SEC DISPL = -5.9 CM

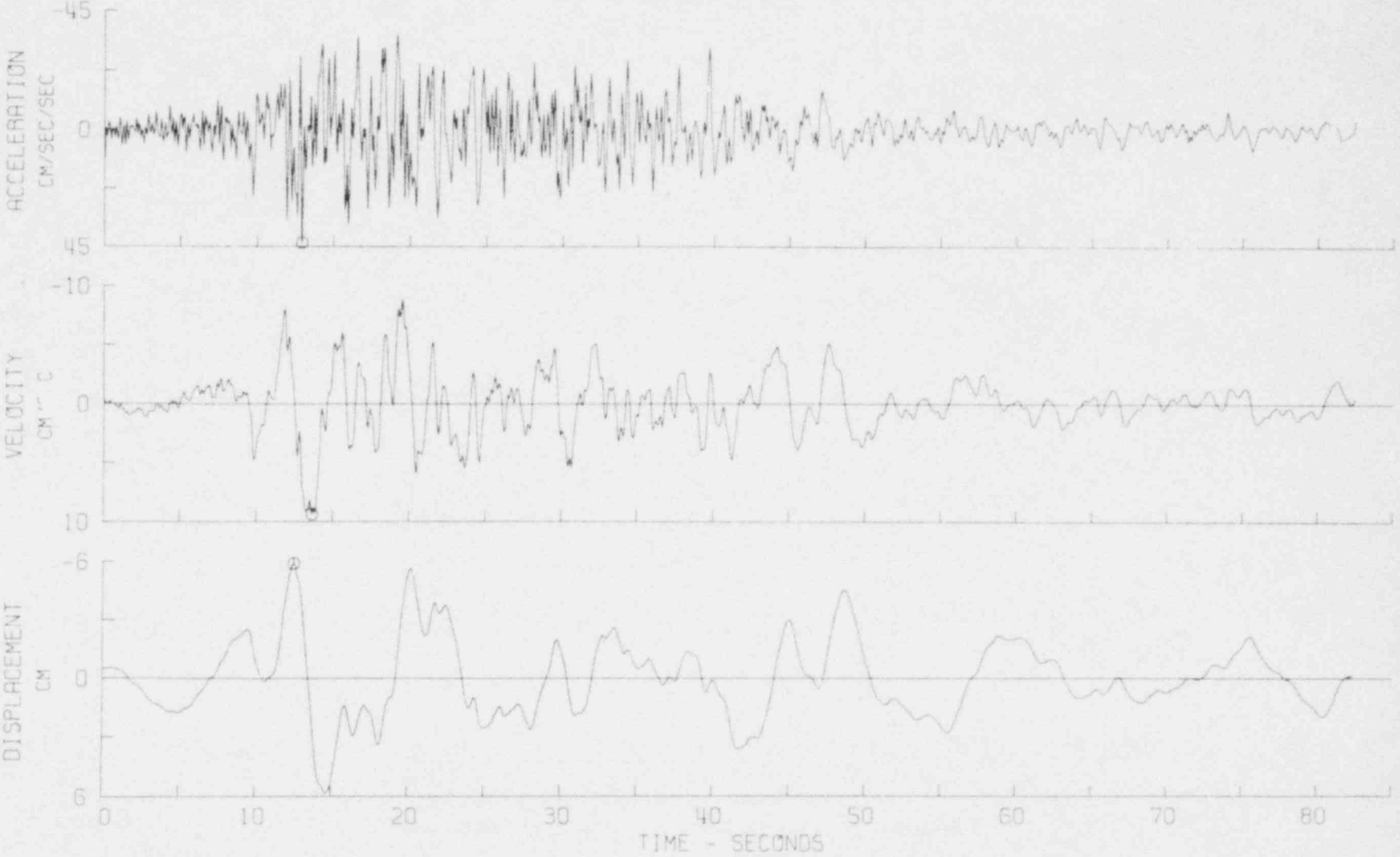


FIG. 21A-4

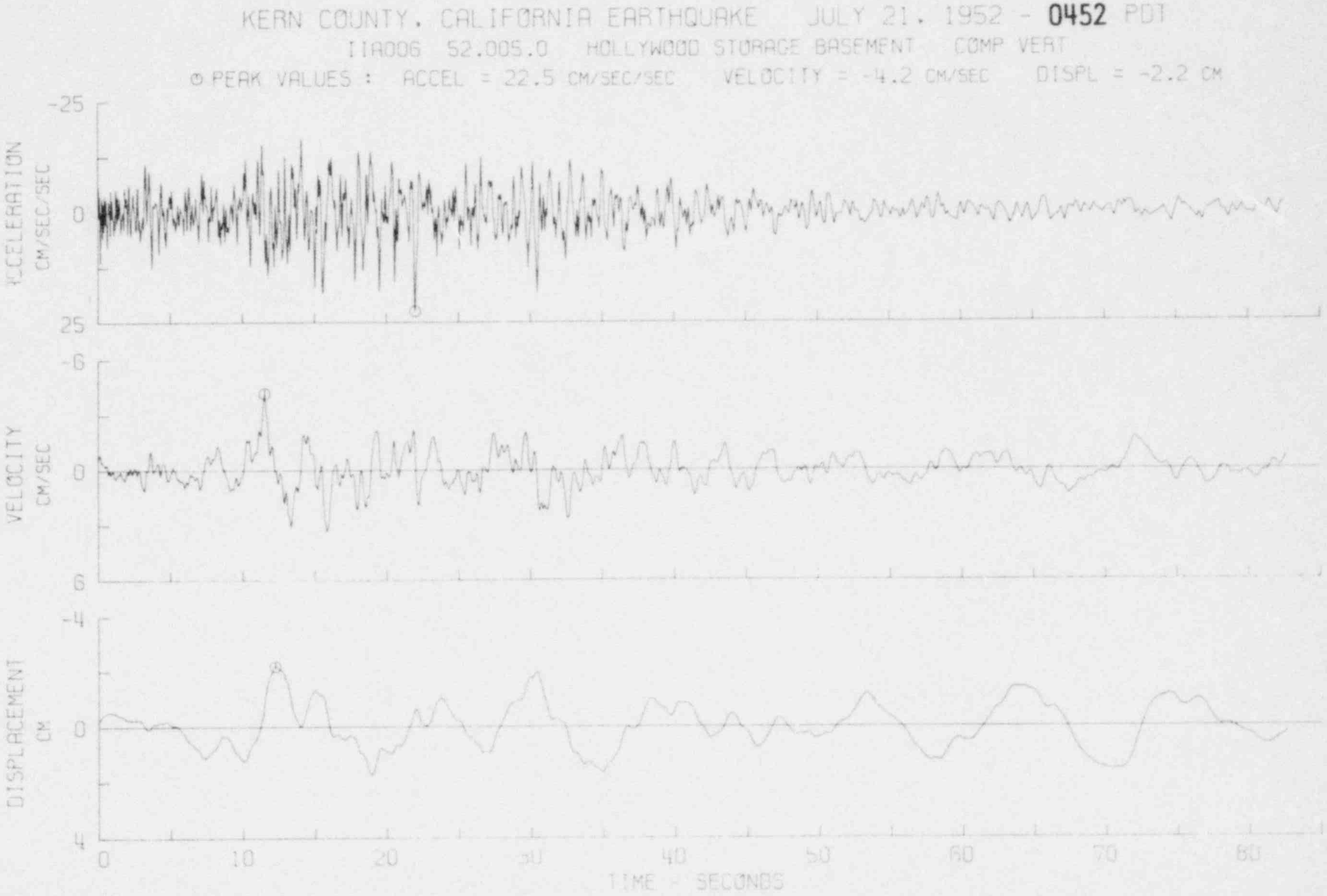

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT
IIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP VERT
⊙ PEAK VALUES : ACCEL = 22.5 CM/SEC/SEC VELOCITY = -4.2 CM/SEC DISPL = -2.2 CM
ACCELERATION CM/SEC/SEC
-25
0
25
VELOCITY CM/SEC
-6
0
6
DISPLACEMENT CM
-4
0
4
0
10
20
30
40
50
60
70
80
TIME - SECONDS

FIG. 21A-5

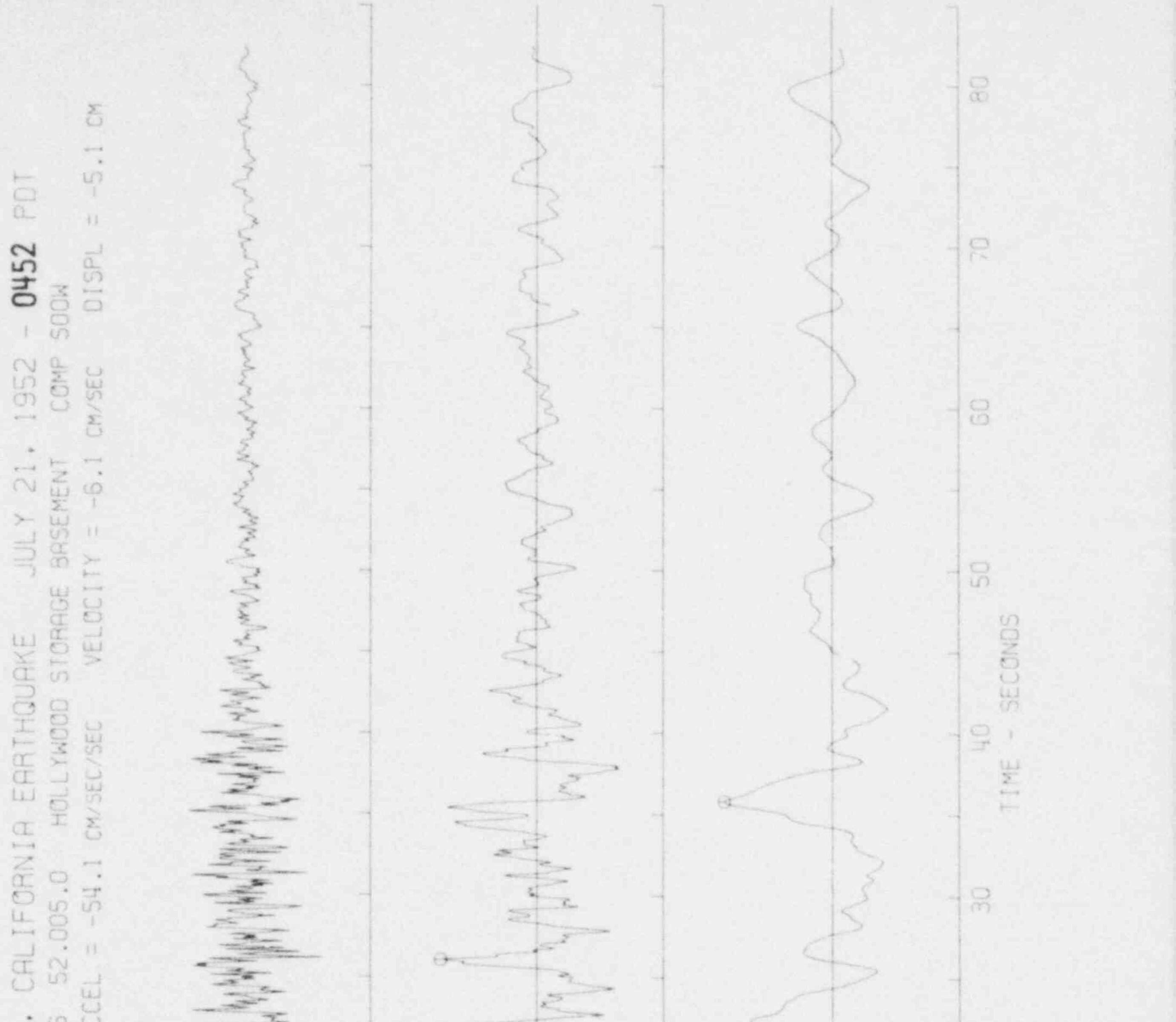

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT
IIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP S00W
⊙ PEAK VALUES : ACCEL = -54.1 CM/SEC/SEC VELOCITY = -6.1 CM/SEC DISPL = -5.1 CM
ACCELERATION
CM/SEC/SEC
-55
0
55
VELOCITY
CM/SEC
-8
0
8
DISPLACEMENT
CM
-6
0
6
0
10
20
30
40
50
60
70
80
TIME - SECONDS

FIG. 21A-6

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - **0601** PST
IID057 71.156.0 HOLLYWOOD STORAGE BSMT. LOS ANGELES, CAL COMP N90E
⊙ PEAK VALUES : ACCEL = 148.2 CM/SEC/SEC VELOCITY = -19.4 CM/SEC DISPL = -13.1 CM

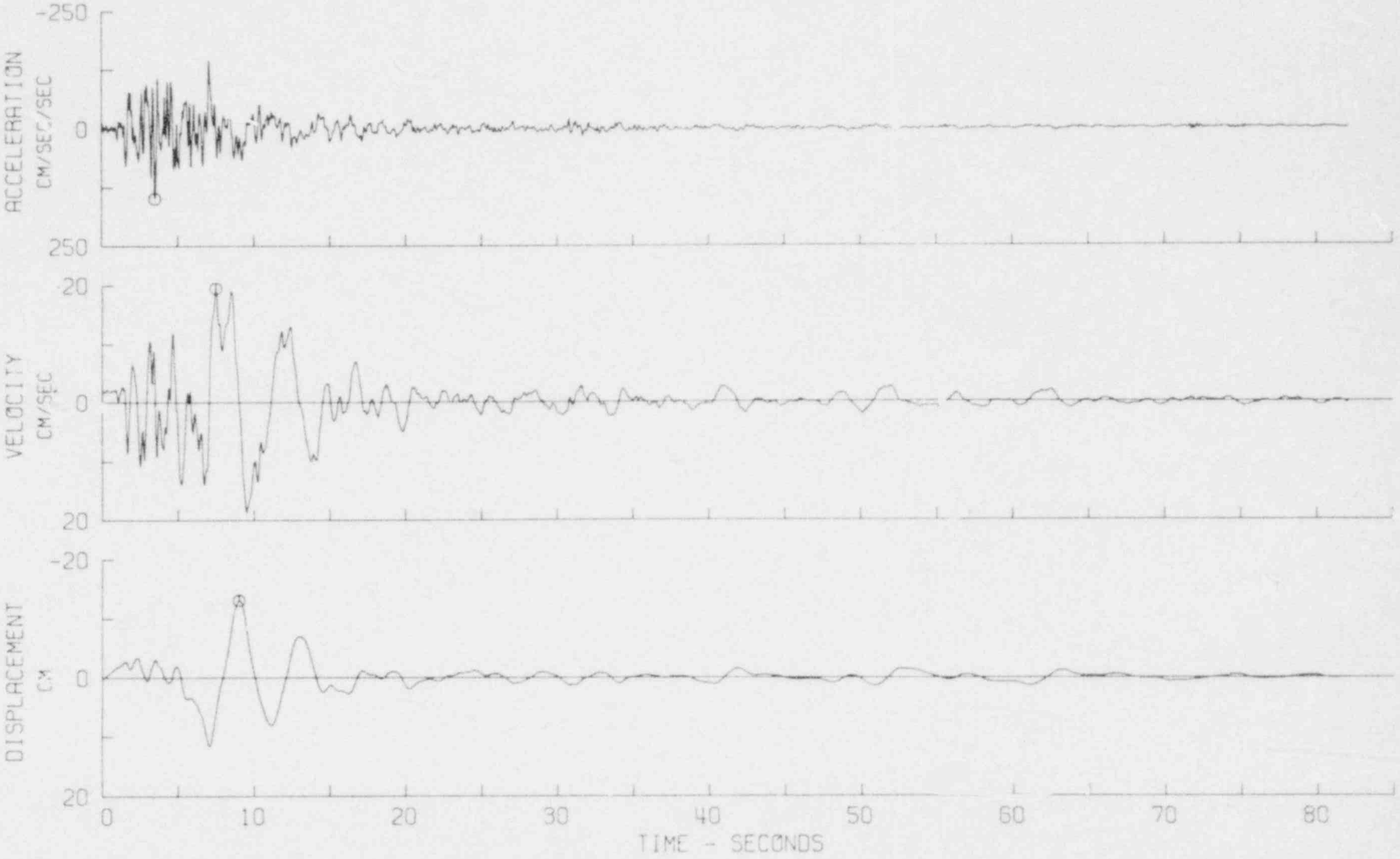


FIG. 21A-7

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IID057 71.156.0 HOLLYWOOD STORAGE BSMT, LOS ANGELES, CAL COMP UP

⊕ PEAK VALUES : ACCEL = -49.8 CM/SEC/SEC VELOCITY = 6.0 CM/SEC DISPL = -3.8 CM

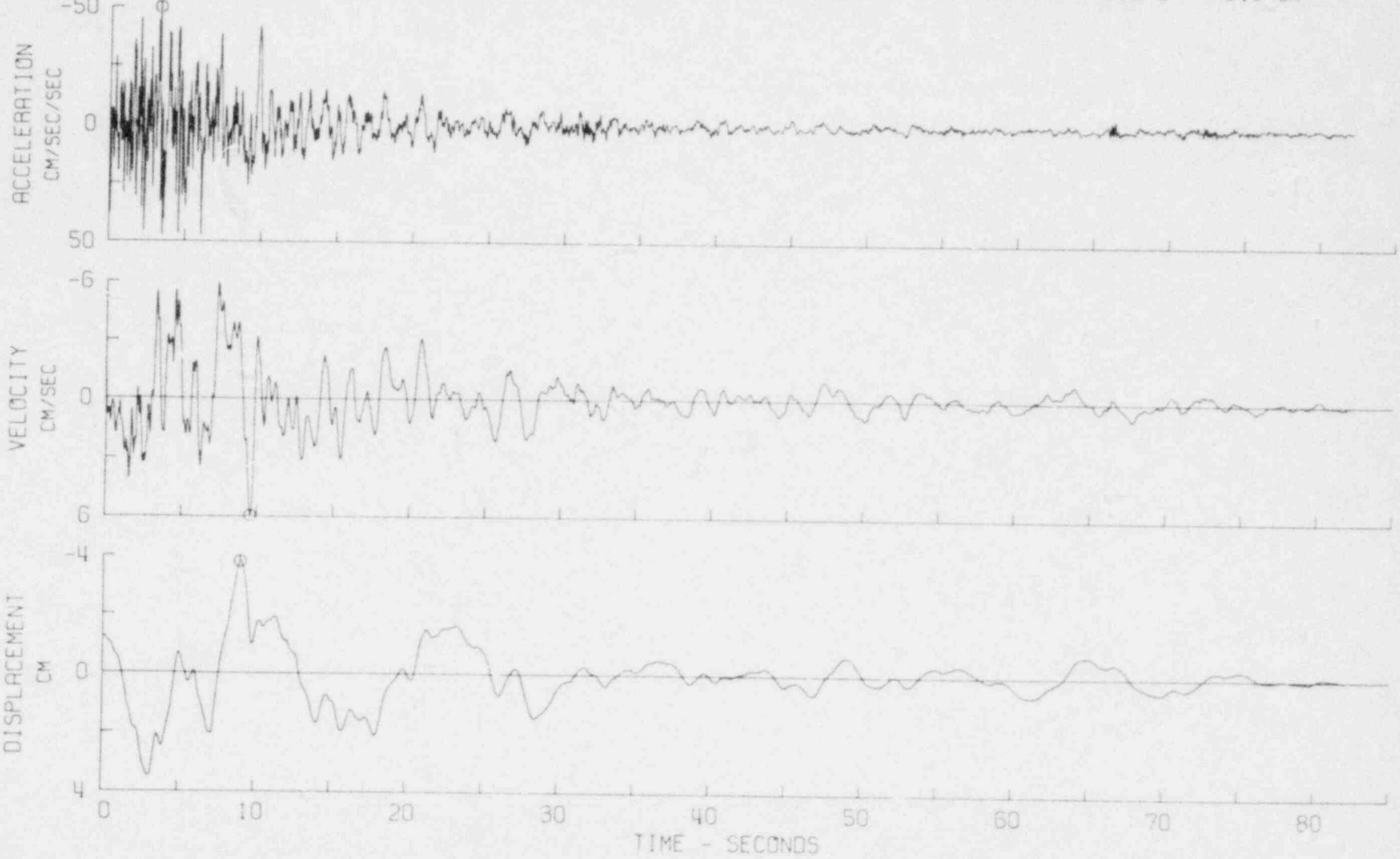


FIG. 21A-8

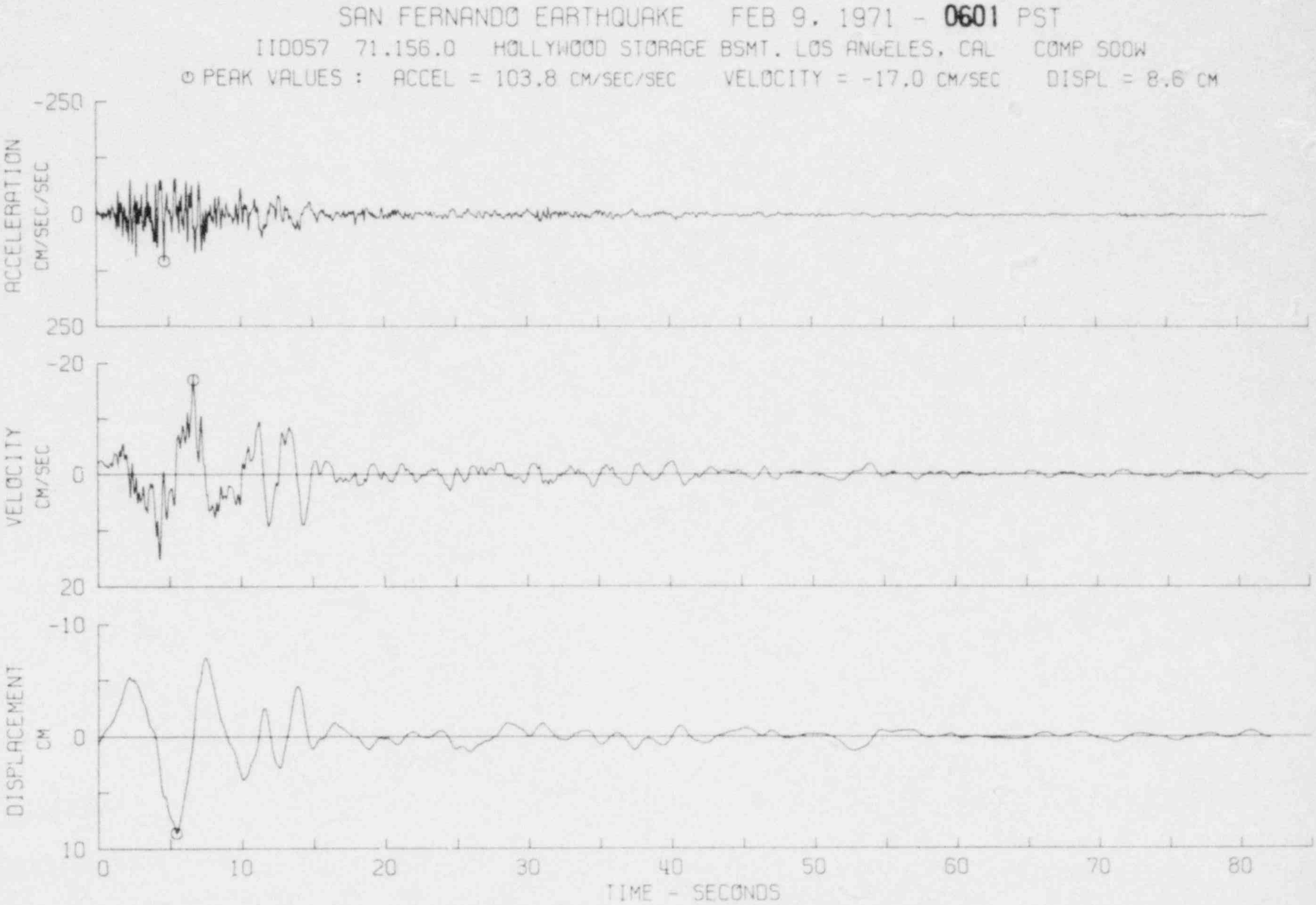

SAN FERNANDO EARTHQUAKE FEB 9. 1971 - 0601 PST
IID057 71.156.0 HOLLYWOOD STORAGE BSMT. LOS ANGELES, CAL COMP S00W
⊙ PEAK VALUES : ACCEL = 103.8 CM/SEC/SEC VELOCITY = -17.0 CM/SEC DISPL = 8.6 CM
ACCELERATION
CM/SEC/SEC
-250
0
250
VELOCITY
CM/SEC
-20
0
20
DISPLACEMENT
CM
-10
0
10
0
10
20
30
40
50
60
70
80
TIME - SECONDS

FIG. 21A-9

RESPONSE SPECTRUM

SOUTHERN CALIFORNIA EARTHQUAKE OCT 2, 1933 - 0110 PST

IIIB023 33.007.0 HOLLYWOOD STORAGE BLDG BASEMENT COMP N90E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

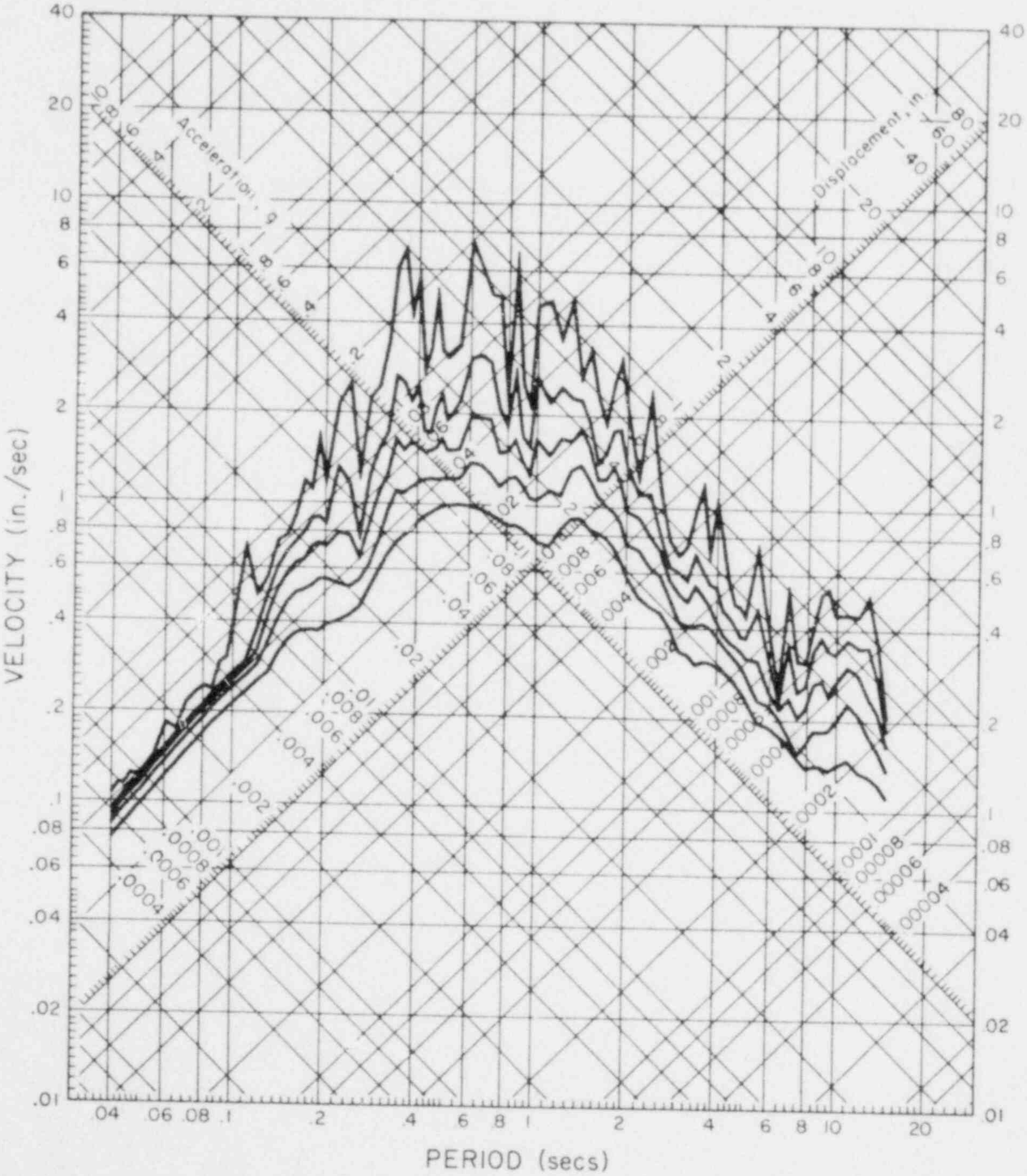


FIG. 21A-10

RESPONSE SPECTRUM

SOUTHERN CALIFORNIA EARTHQUAKE   OCT 2, 1933 - 0110 PST

IIIB023 33.007.0   HOLLYWOOD STORAGE BLDG BASEMENT   COMP Up

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

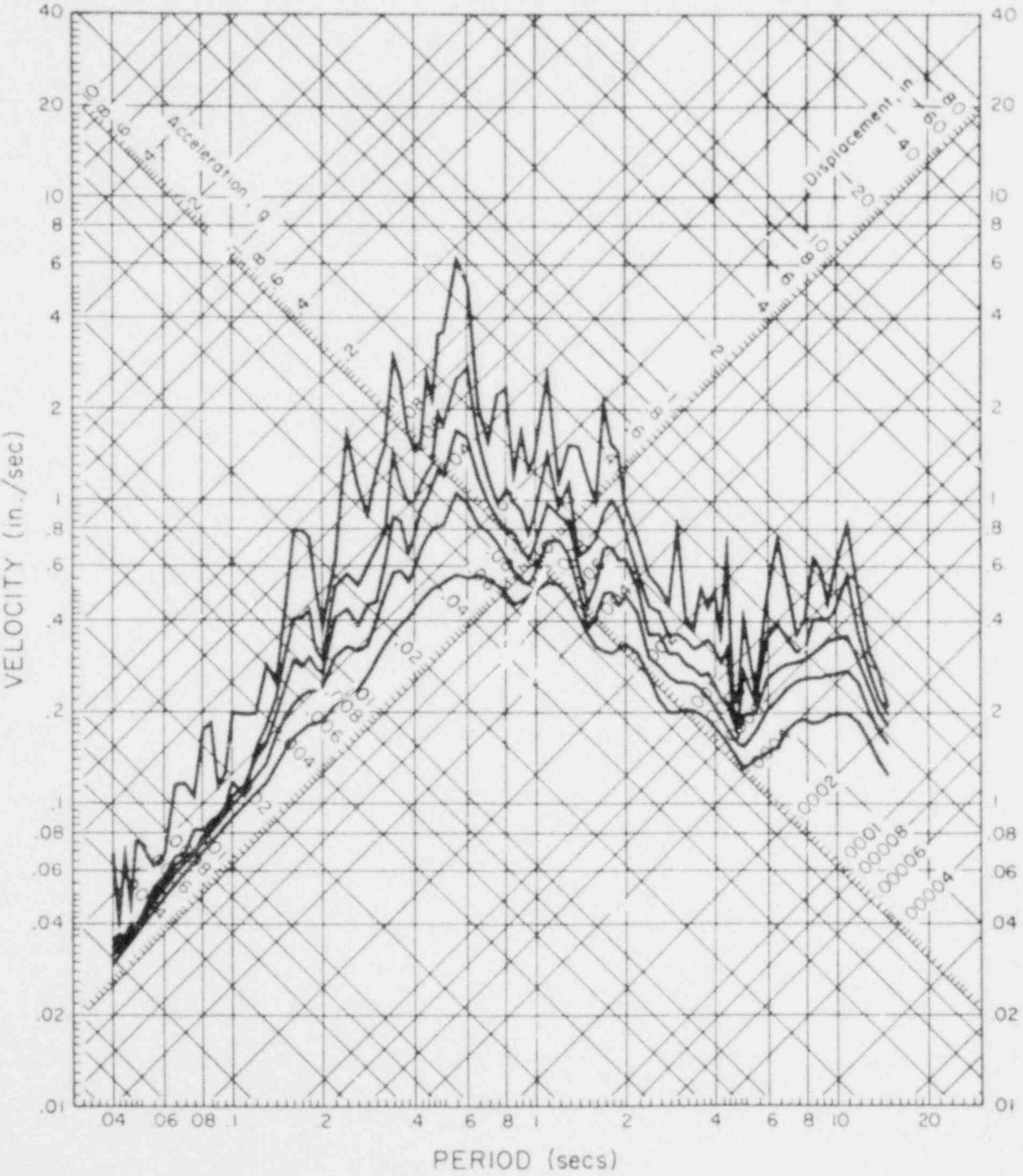


FIG. 21A-11

RESPONSE SPECTRUM

SOUTHERN CALIFORNIA EARTHQUAKE OCT 2, 1933 - 0110 PST

IIIB023 33.007.0 HOLLYWOOD STORAGE BLDG BASEMENT COMP S00E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

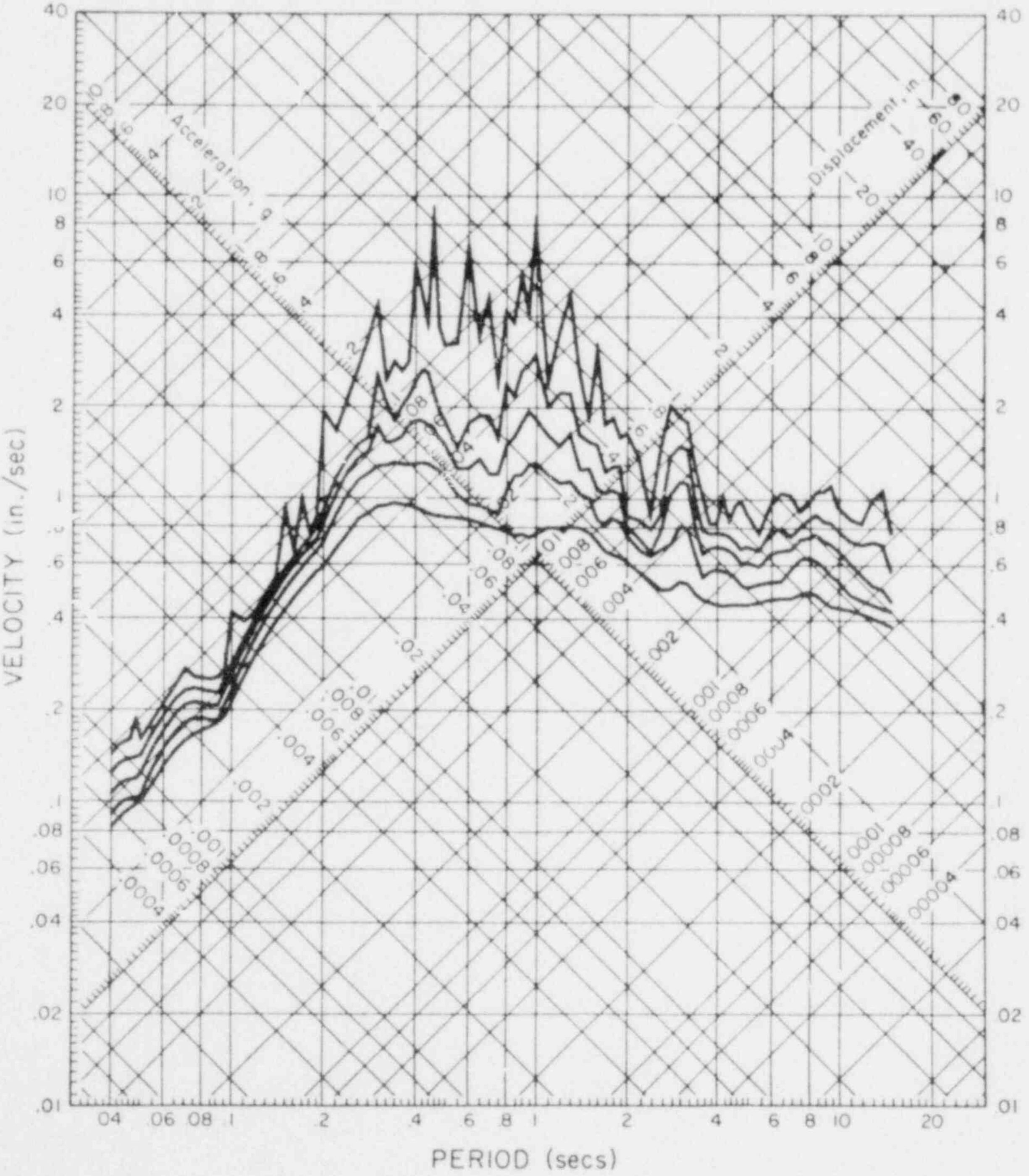


FIG. 21A-12

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT

IIIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP N90E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

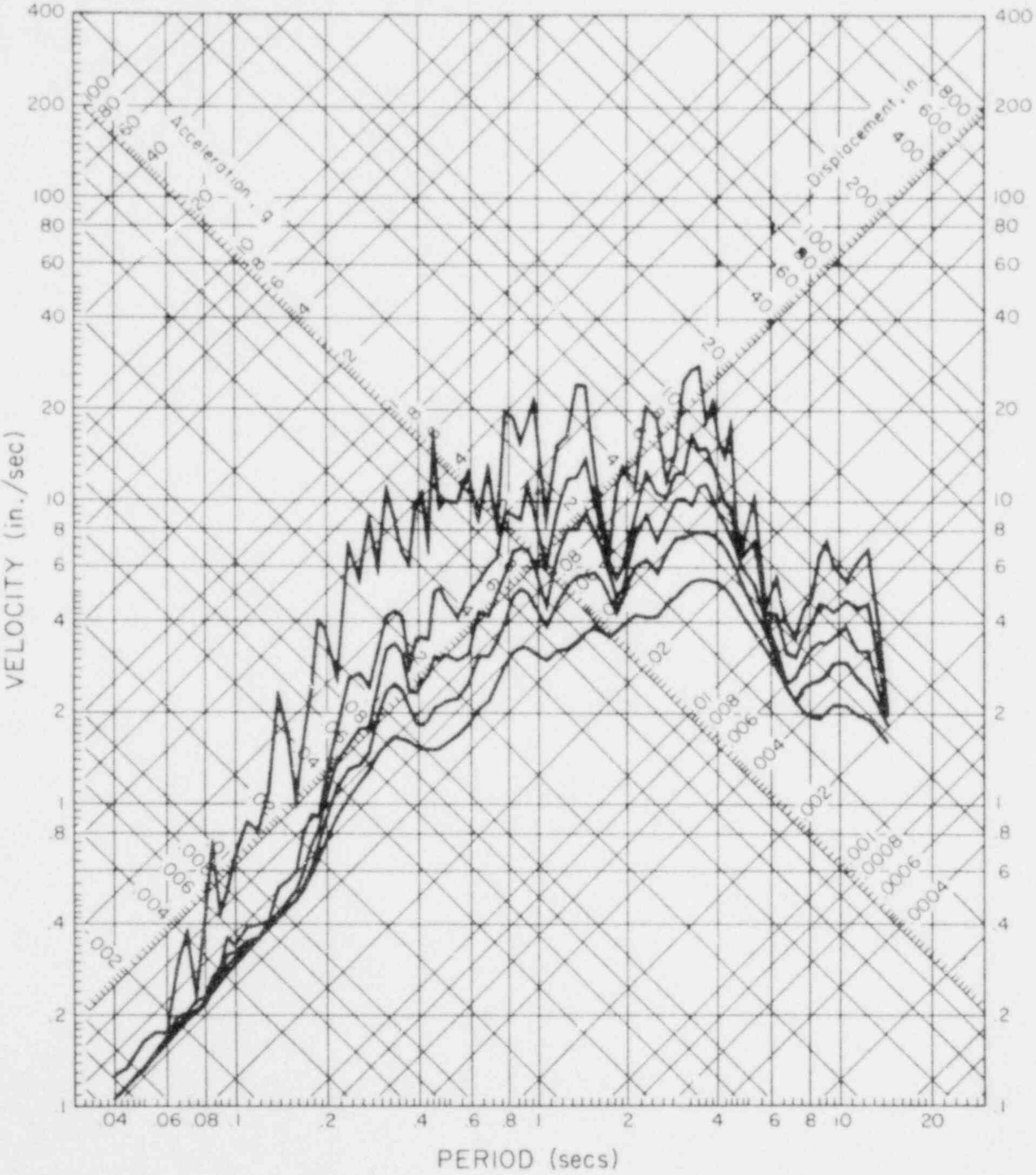


FIG. 21A-13

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - **0452** PDT

IIIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP VERT

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

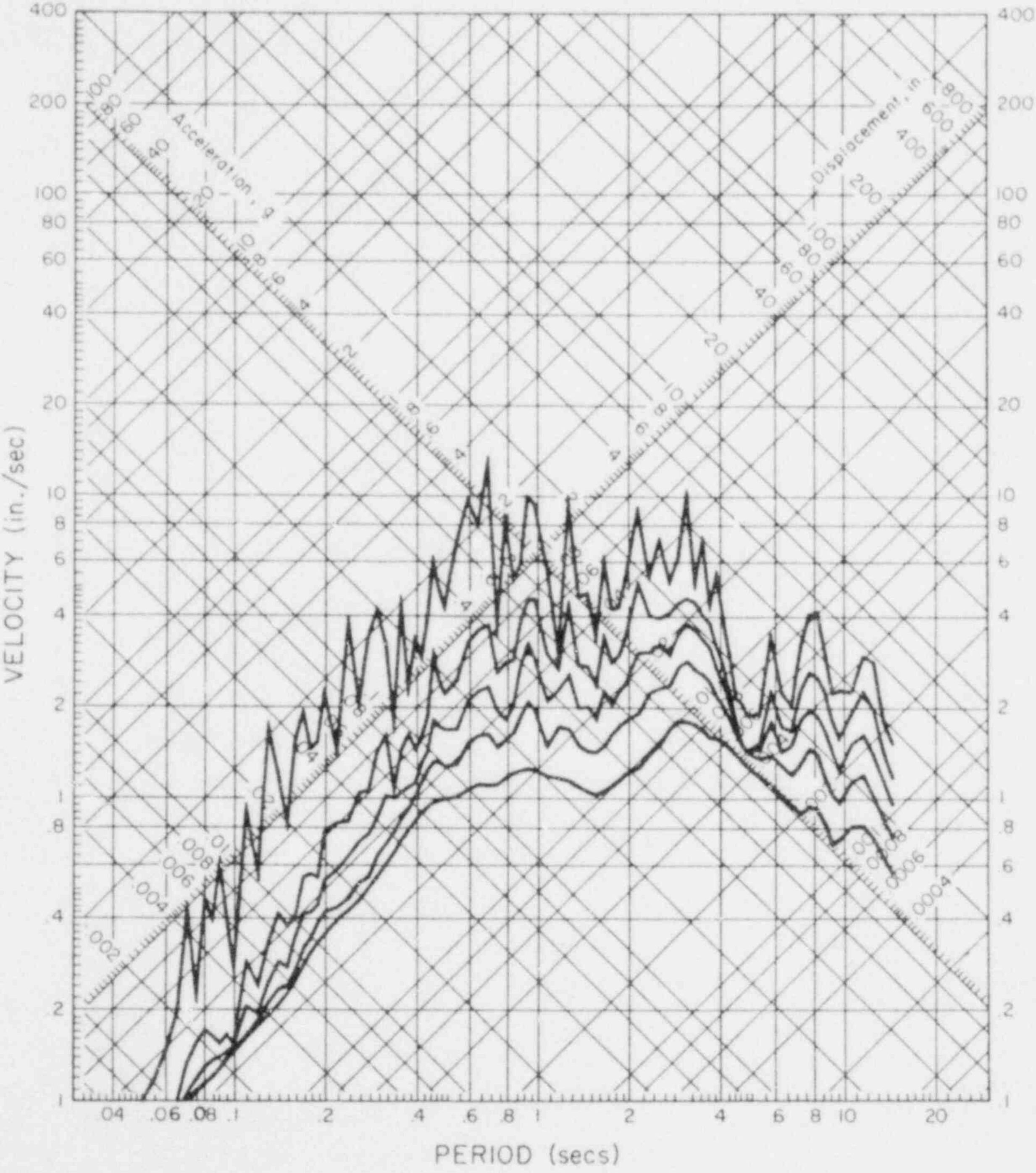


FIG. 21A-14

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT

IIIA006 52.005.0 HOLLYWOOD STORAGE BASEMENT COMP S00W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

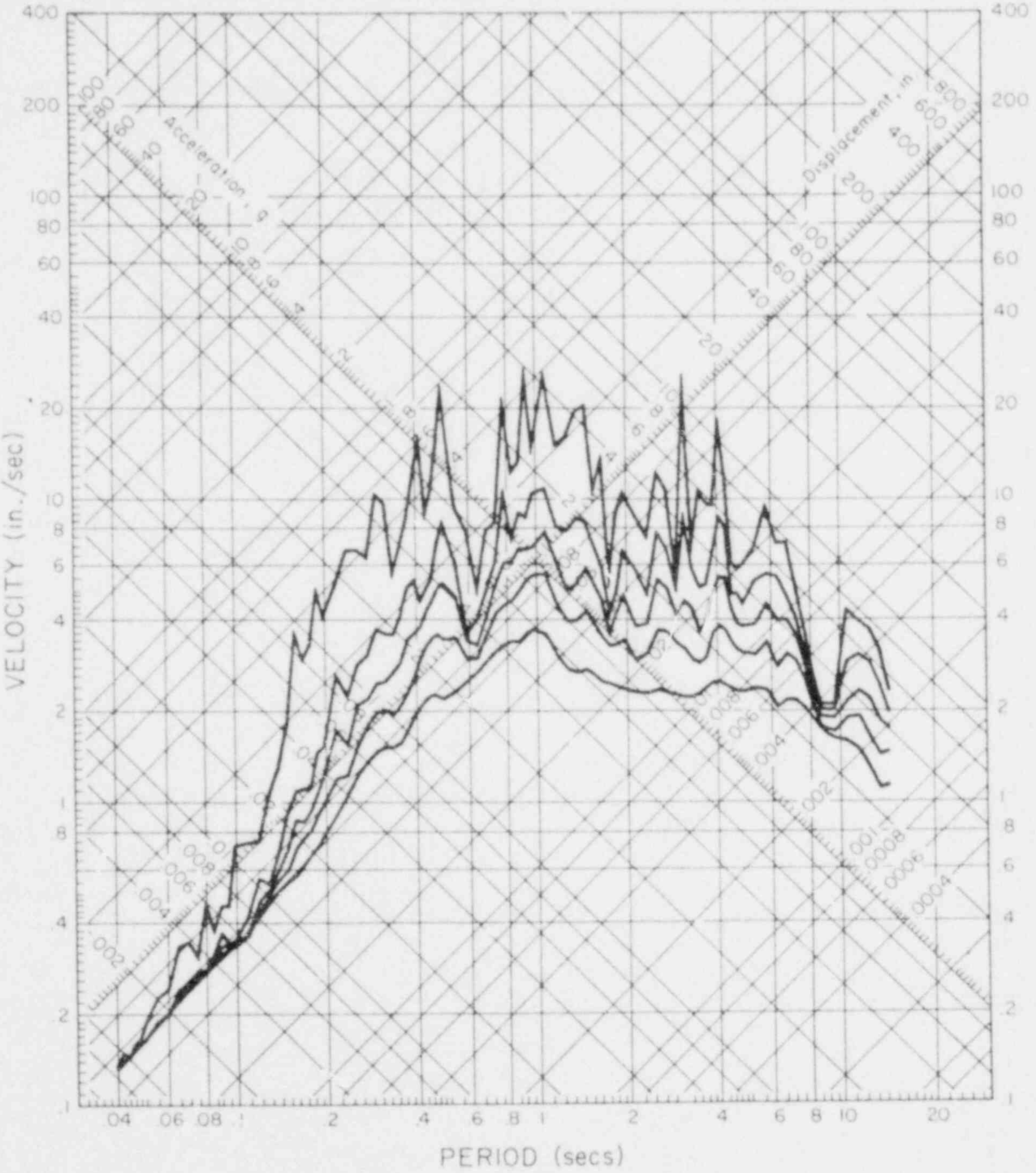


FIG. 21A-15

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IIID057 71.155.0 HOLLYWOOD STORAGE BSMT, LOS ANGELES, CAL COMP N90E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

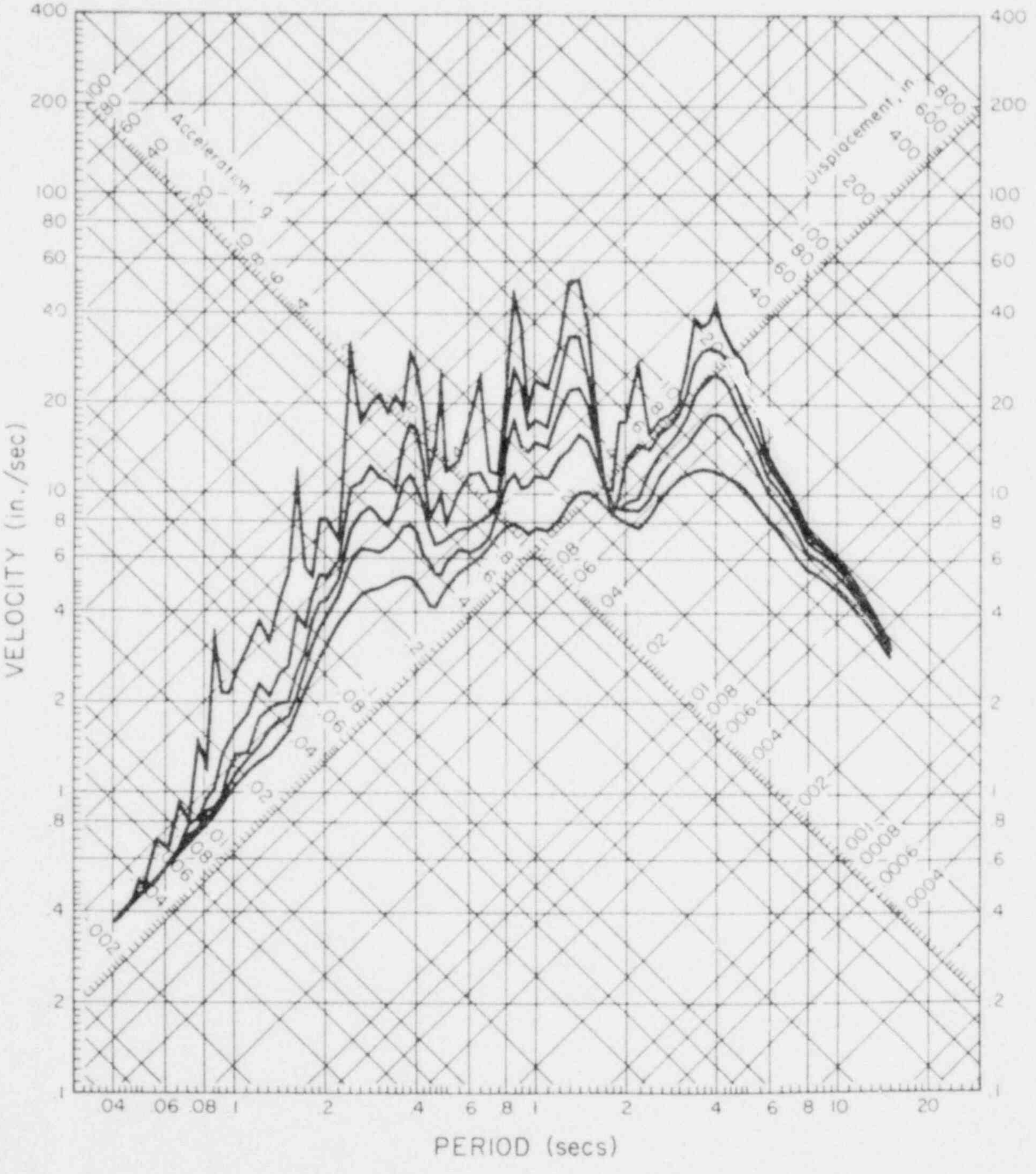


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FIG. 21A-16

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IIID057 71.156.0 HOLLYWOOD STORAGE BSMT. LOS ANGELES, CAL COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

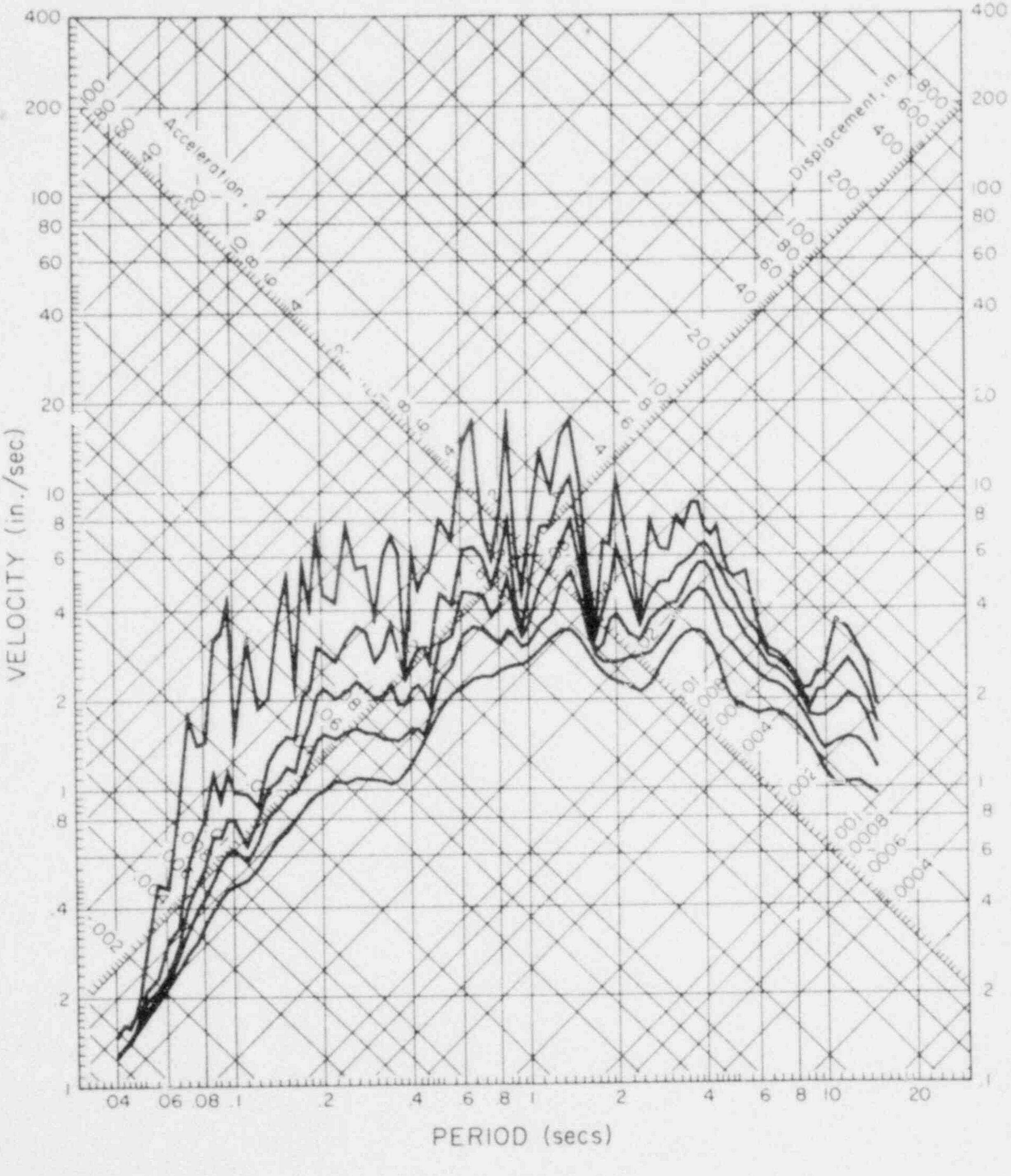

FIG. 21A-17

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - **0601** PST

III0057 71.156.0 HOLLYWOOD STORAGE BSMT. LOS ANGELES, CAL COMP S00W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

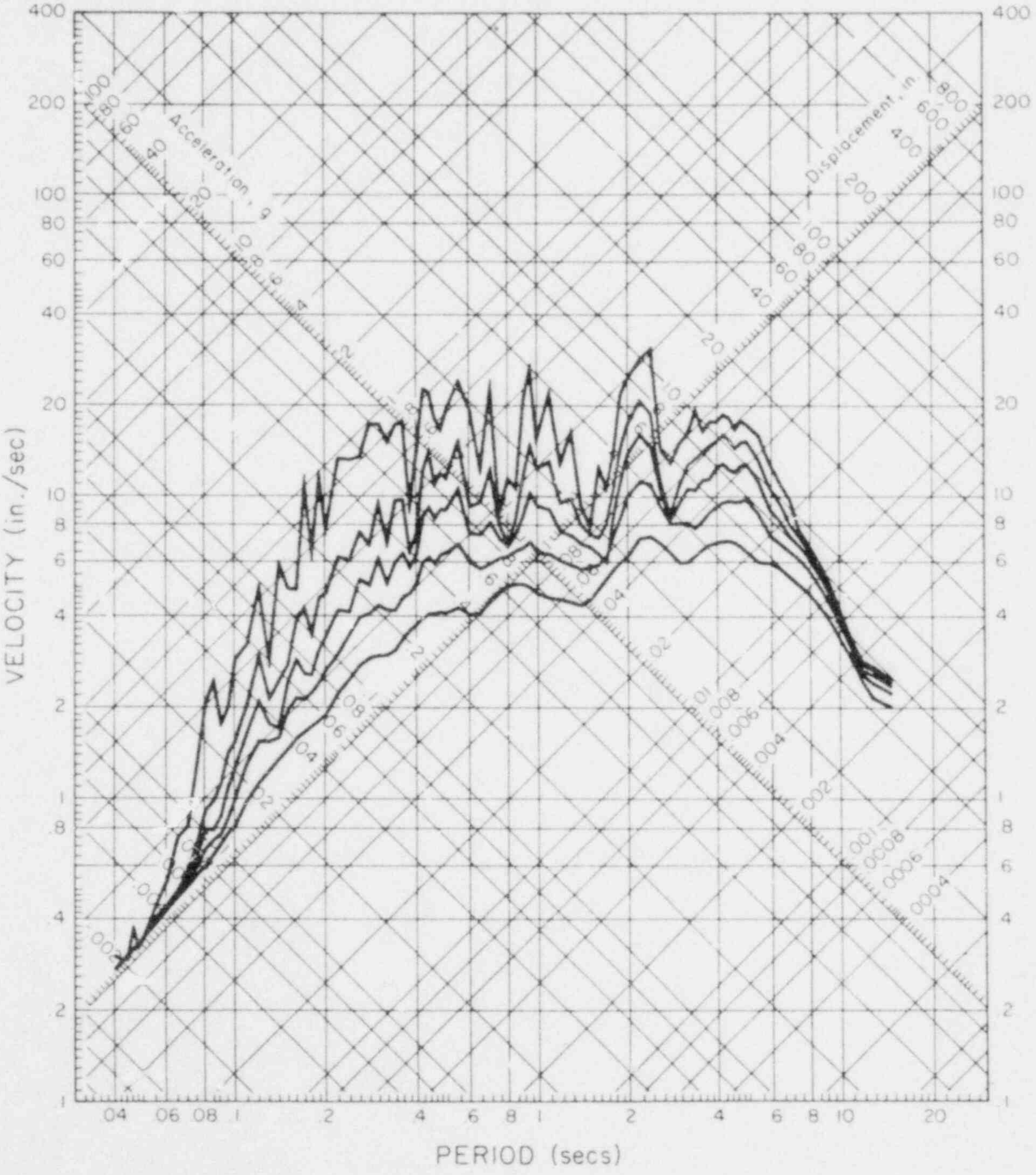

FIG. 21A-18

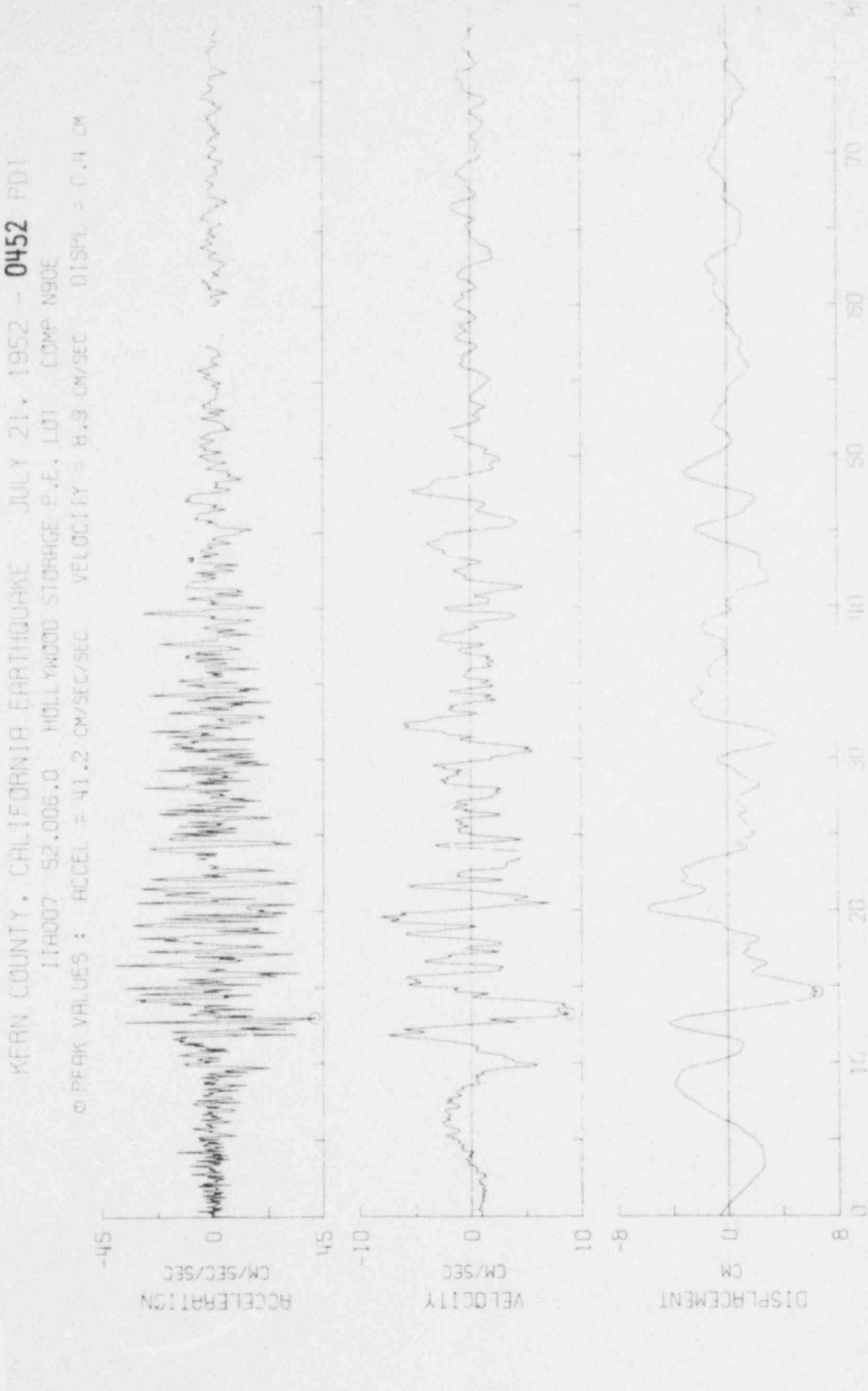
KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT
IIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP N90E
⊙ PEAK VALUES : ACCEL = 41.2 CM/SEC/SEC VELOCITY = 8.9 CM/SEC DISPL = 6.4 CM
ACCELERATION
CM/SEC/SEC
-45
0
45
VELOCITY
CM/SEC
-10
0
10
DISPLACEMENT
CM
-8
0
8
0
10
20
30
40
50
60
70
80
TIME - SECONDS

FIG. 21A-19

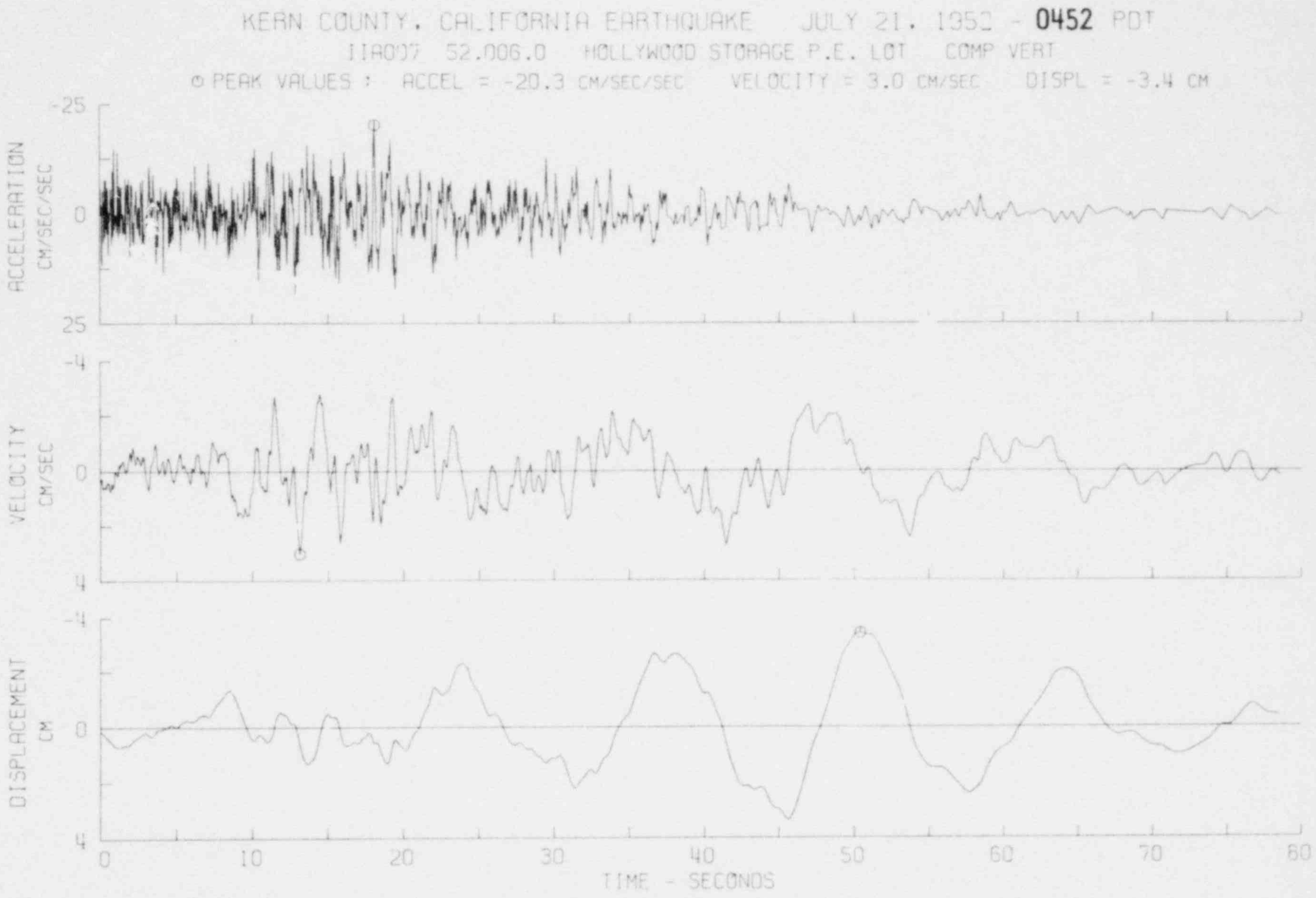
KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT
IIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP VERT
⊙ PEAK VALUES : ACCEL = -20.3 CM/SEC/SEC VELOCITY = 3.0 CM/SEC DISPL = -3.4 CM
ACCELERATION CM/SEC/SEC
-25
0
25
VELOCITY CM/SEC
-4
0
4
DISPLACEMENT CM
-4
0
4
0
10
20
30
40
50
60
70
80
TIME - SECONDS

FIG. 21A-20

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT
IIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP S00W
⊕ PEAK VALUES : ACCEL = -58.1 CM/SEC/SEC VELOCITY = -6.6 CM/SEC DISPL = -4.5 CM

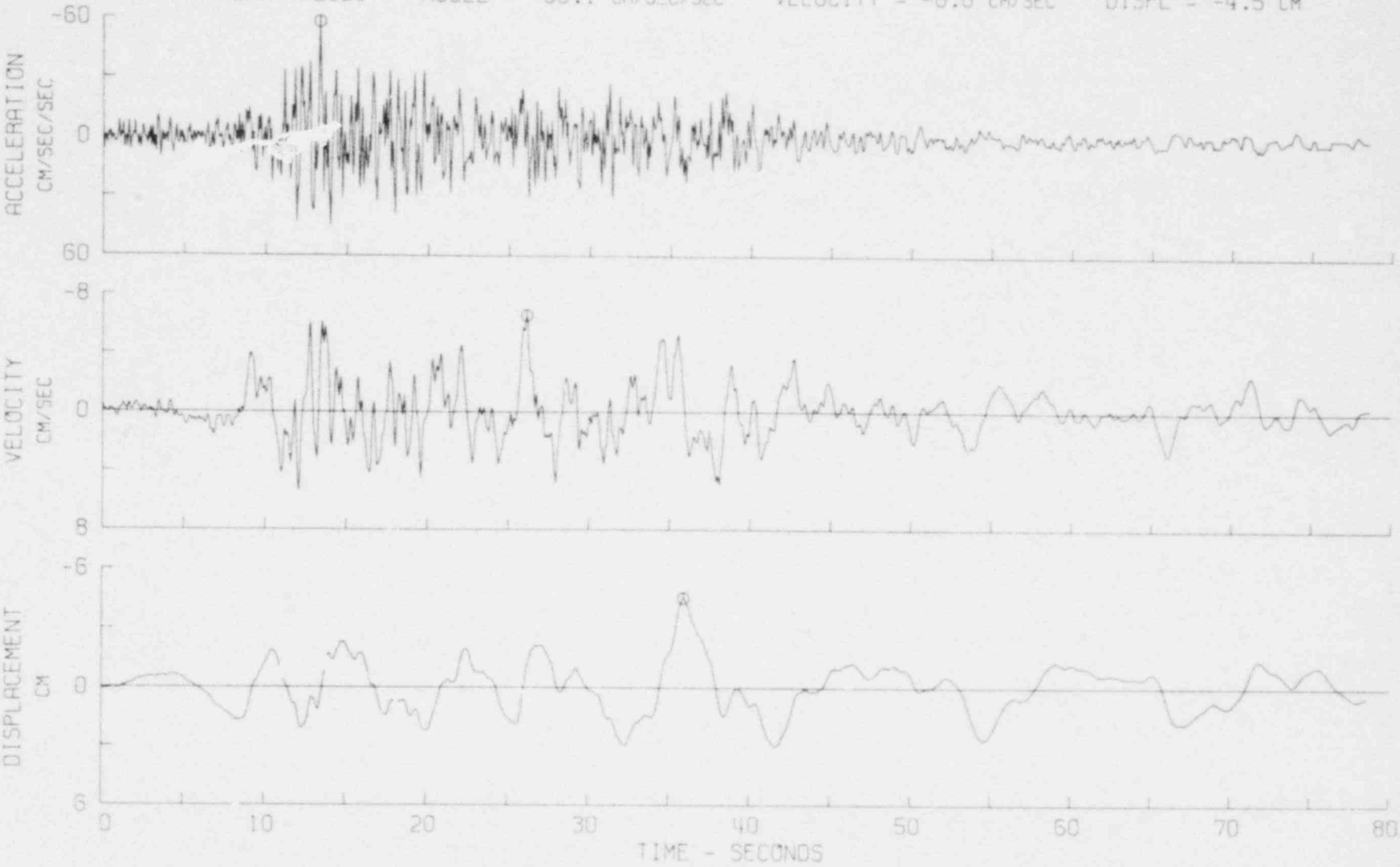

FIG. 21A-21

SAN FERNANDO EARTHQUAKE FEB 9. 1971 - 0601 PST

IID058 71.155.0 HOLLYWOOD STORAGE P.E. LOT. LOS ANGELES. CAL. COMP N90E

⊕ PEAK VALUES : ACCEL = -207.0 CM/SEC/SEC VELOCITY = -21.1 CM/SEC DISPL = -14.7 CM

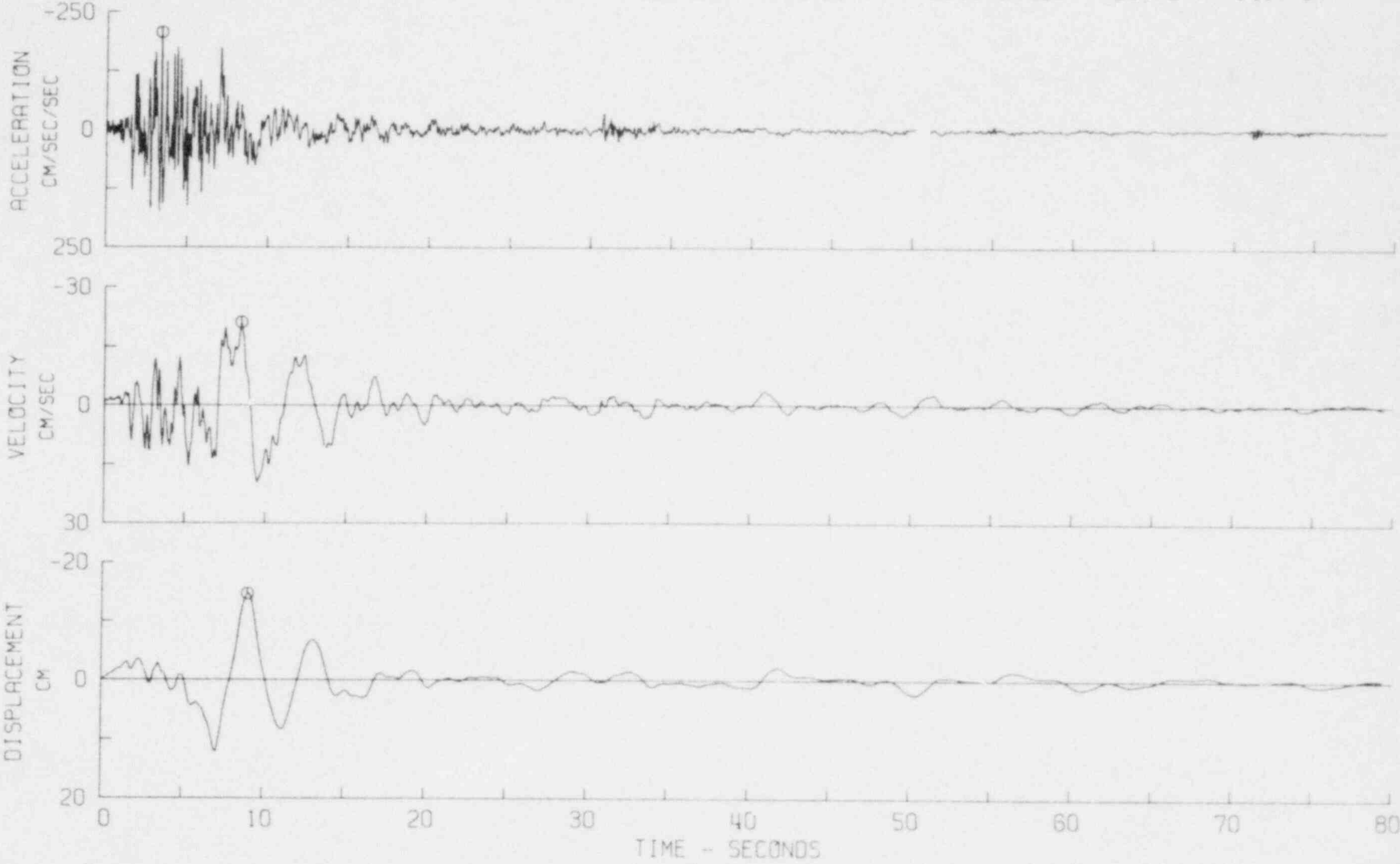

FIG. 21A-22

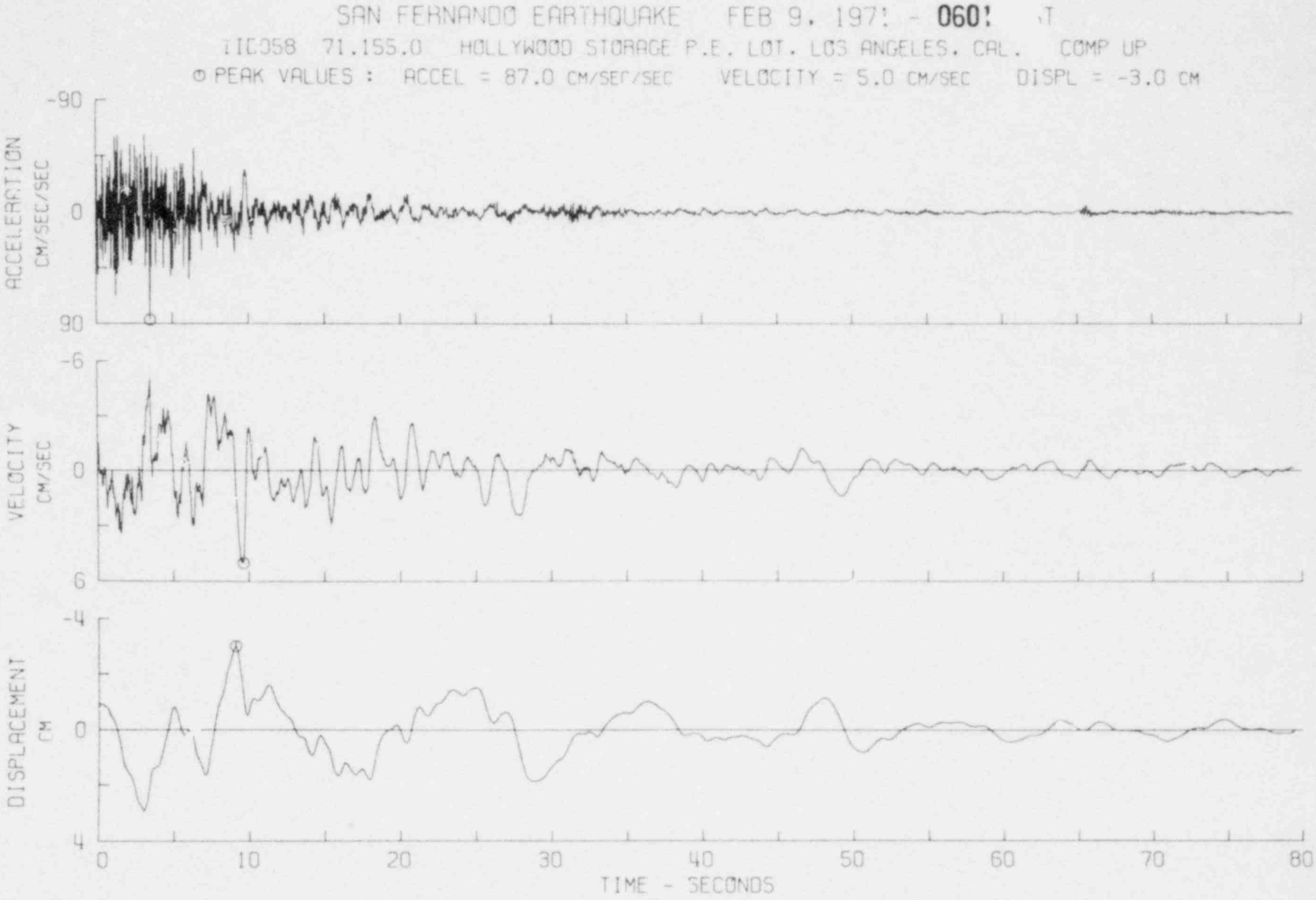
SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 060! T
IIC058 71.155.0 HOLLYWOOD STORAGE P.E. LOT, LOS ANGELES, CAL. COMP UP
⊙ PEAK VALUES : ACCEL = 87.0 CM/SEC/SEC VELOCITY = 5.0 CM/SEC DISPL = -3.0 CM

FIG. 21A-23

SAN FERNANDO EARTHQUAKE FEB 9. 1971 - **0601** PST

IID058 71.155.0 HOLLYWOOD STORAGE P.E. LOT. LOS ANGELES. CAL. COMP S00W

⊙ PEAK VALUES : ACCEL = 167.3 CM/SEC/SEC VELOCITY = -16.5 CM/SEC DISPL = 8.0 CM

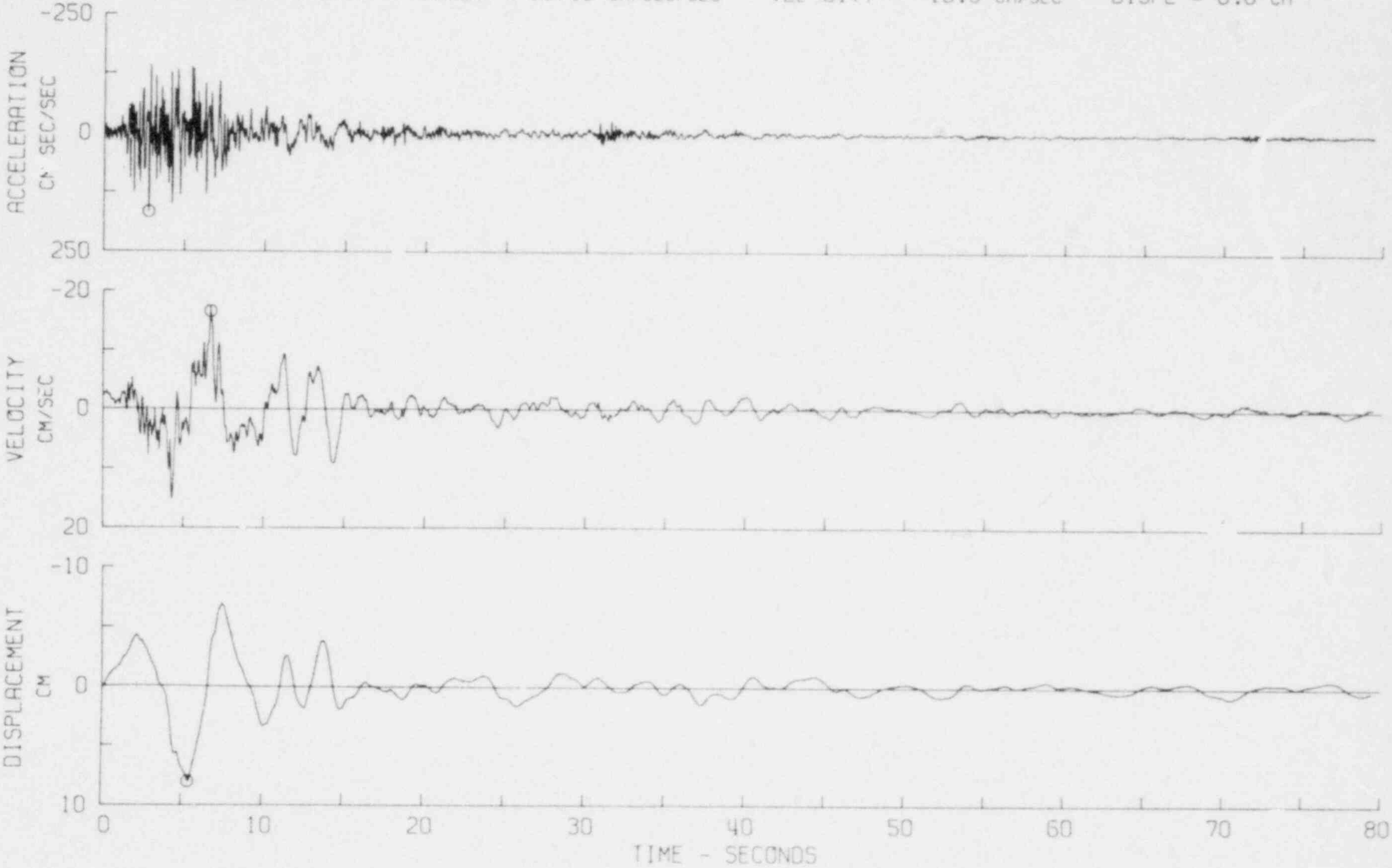

FIG. 21A-24

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT

IIIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP N90E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

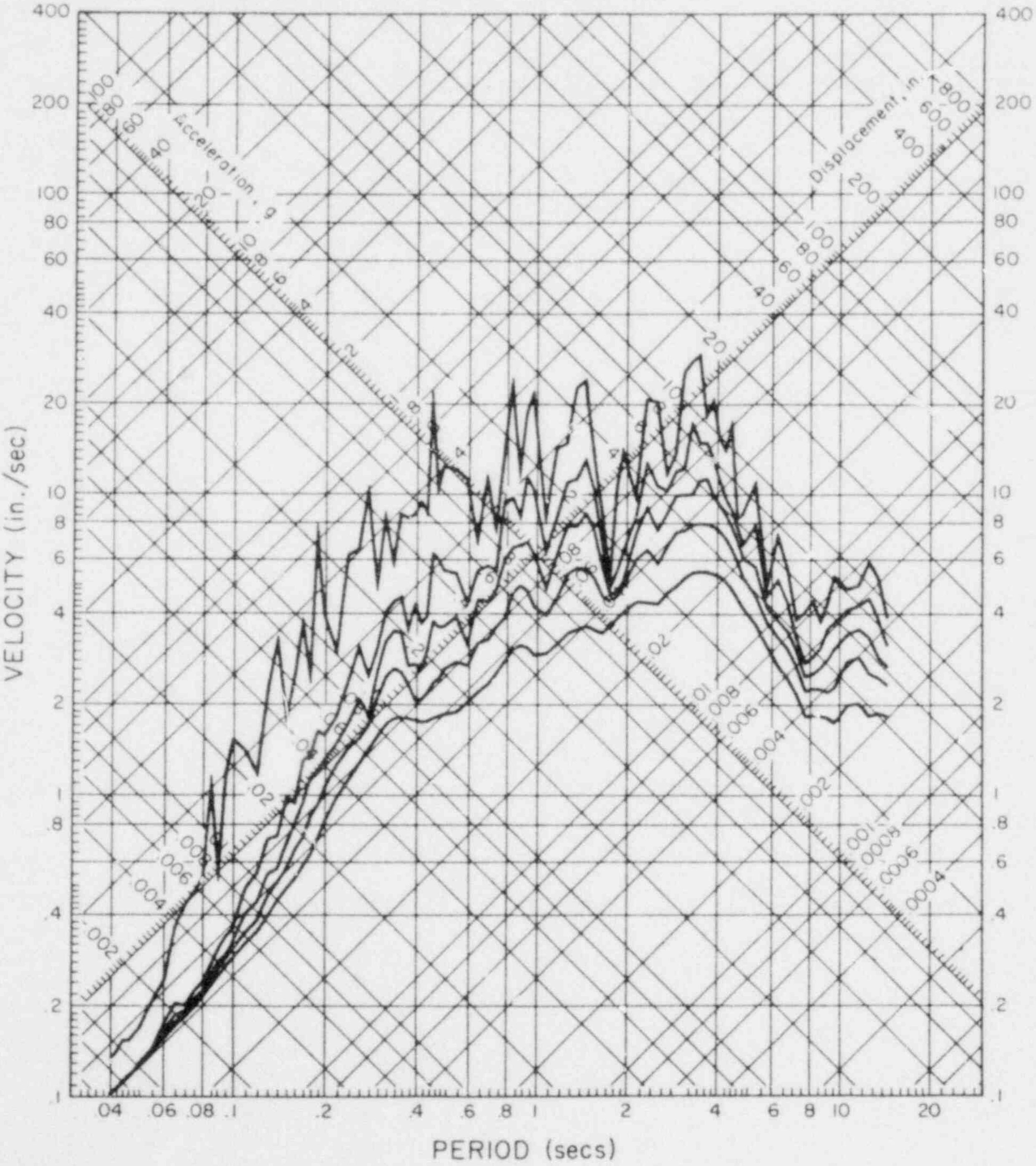

FIG. 21A-25

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT

IIIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP VERT

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

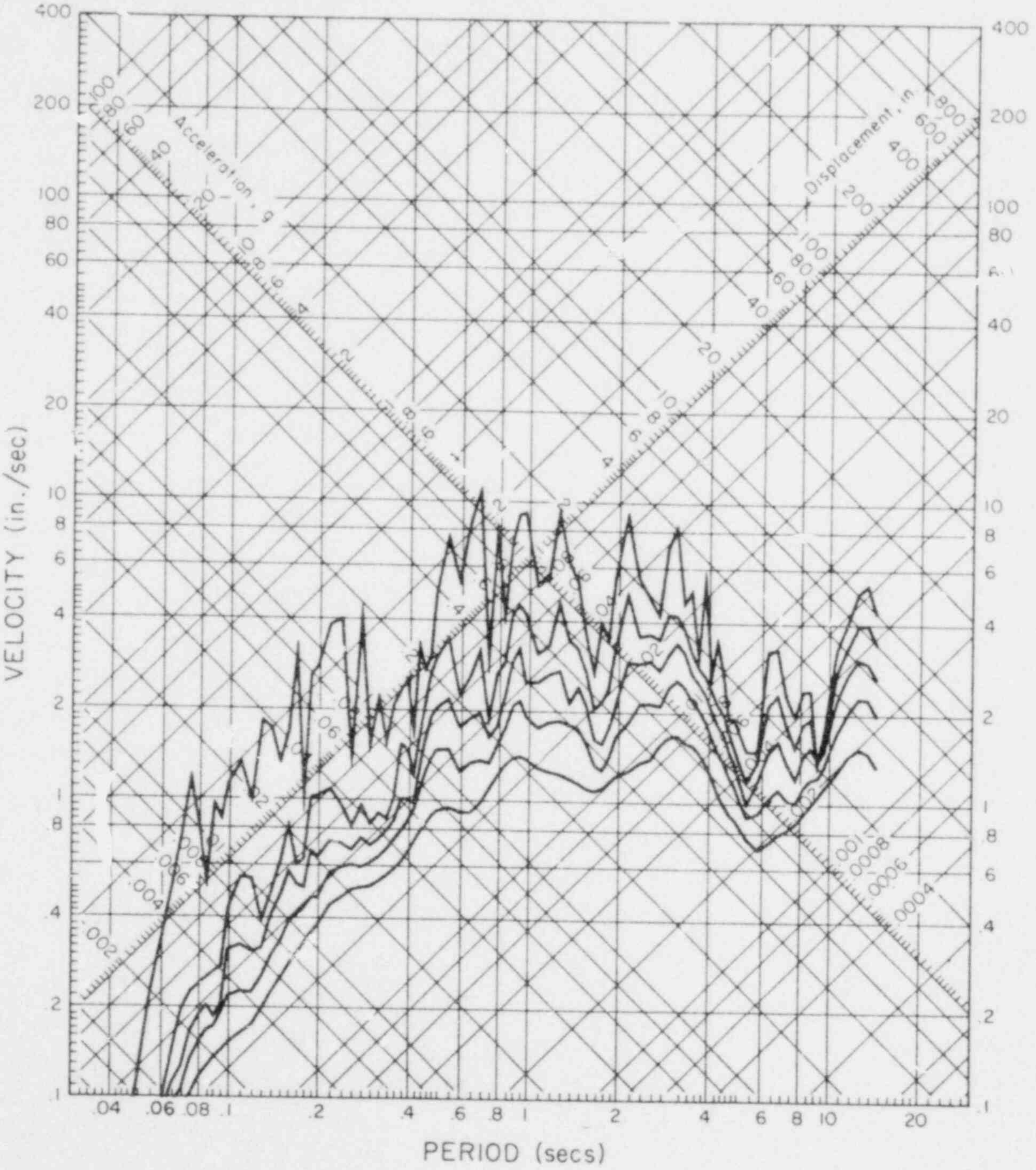

FIG. 21A-26

RESPONSE SPECTRUM

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0452 PDT

IIIA007 52.006.0 HOLLYWOOD STORAGE P.E. LOT COMP S00W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

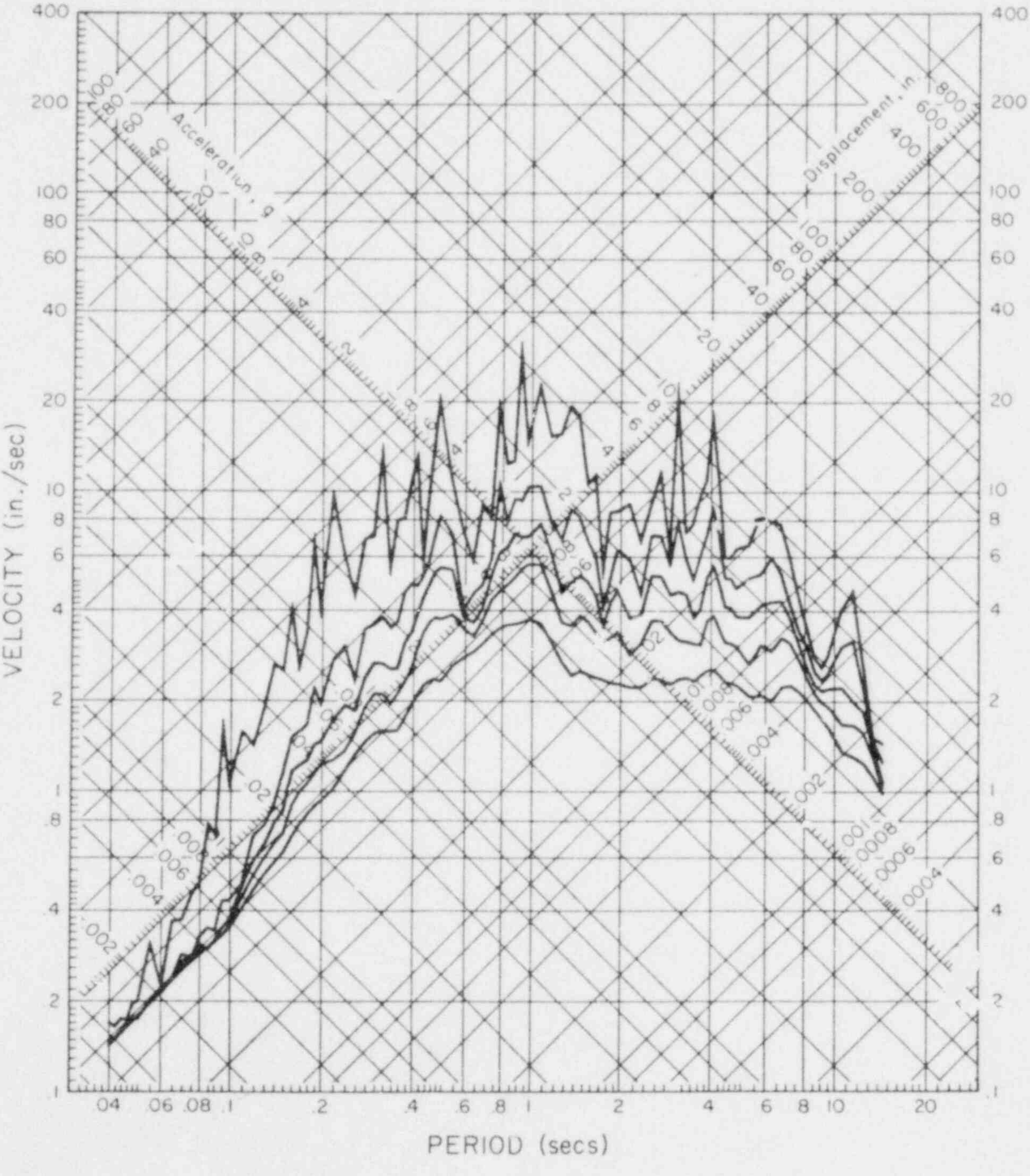

FIG. 21A-27

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IIID058 71.155.0 HOLLYWOOD STORAGE P.E. LOT, LOS ANGELES, CAL. COMP N90E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

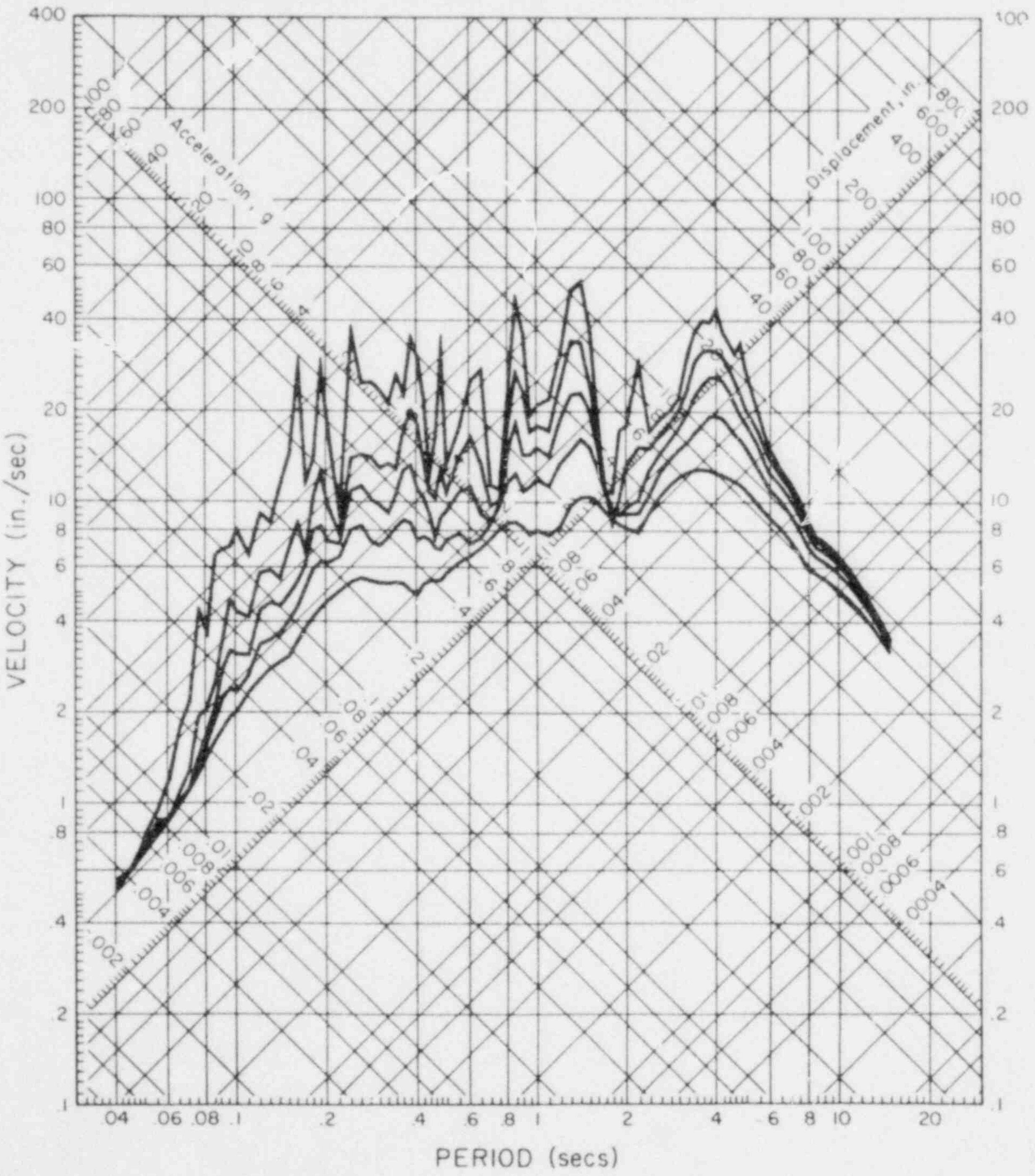

FIG. 21A-28

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IIID058 71.155.0 HOLLYWOOD STORAGE P.E. LOT, LOS ANGELES, CAL. COMP UP

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

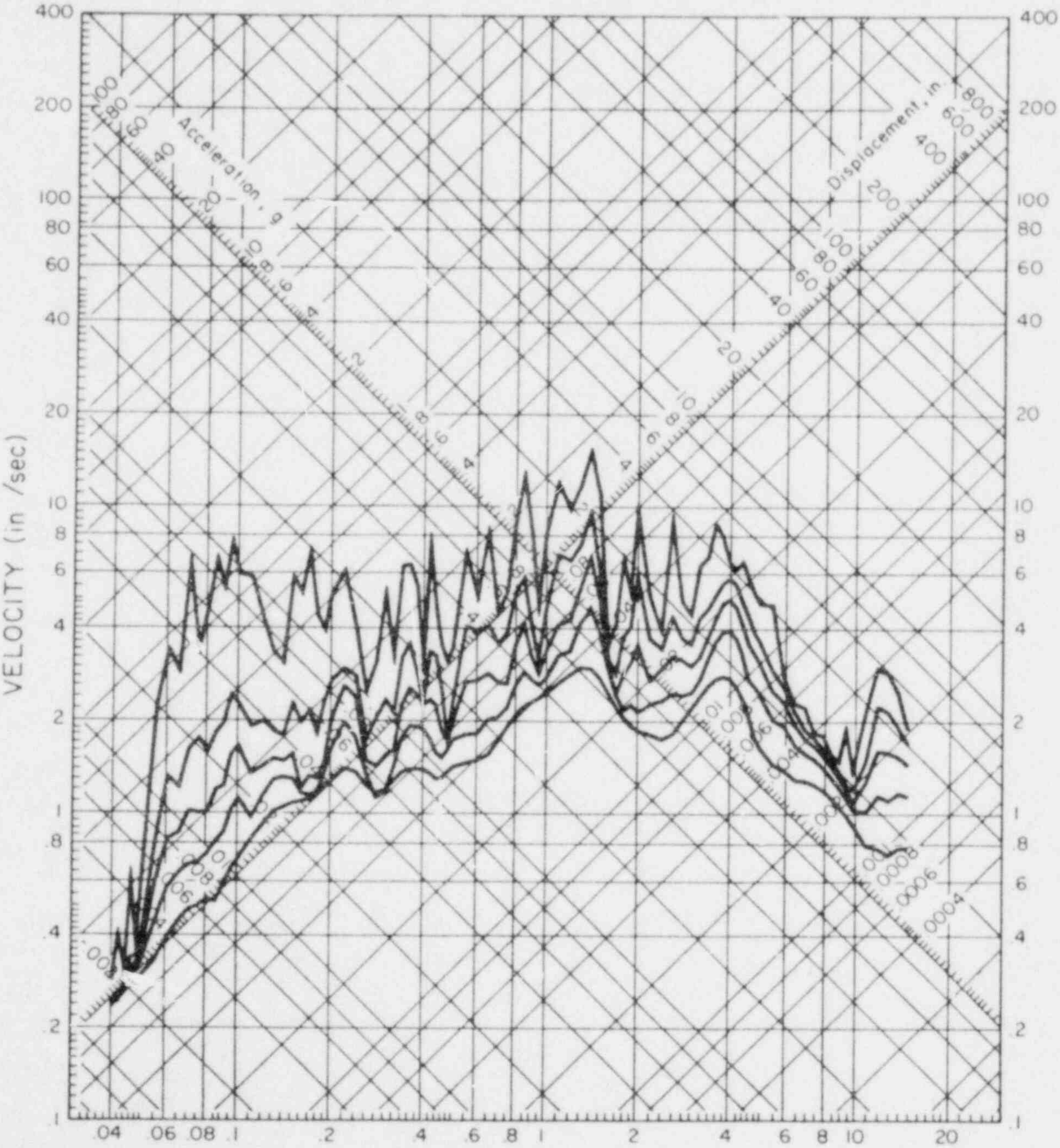

FIG. 21A-29

RESPONSE SPECTRUM

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0601 PST

IIID058 71.155.0 HOLLYWOOD STORAGE P.E. LOT, LOS ANGELES, CAL. COMP S00W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

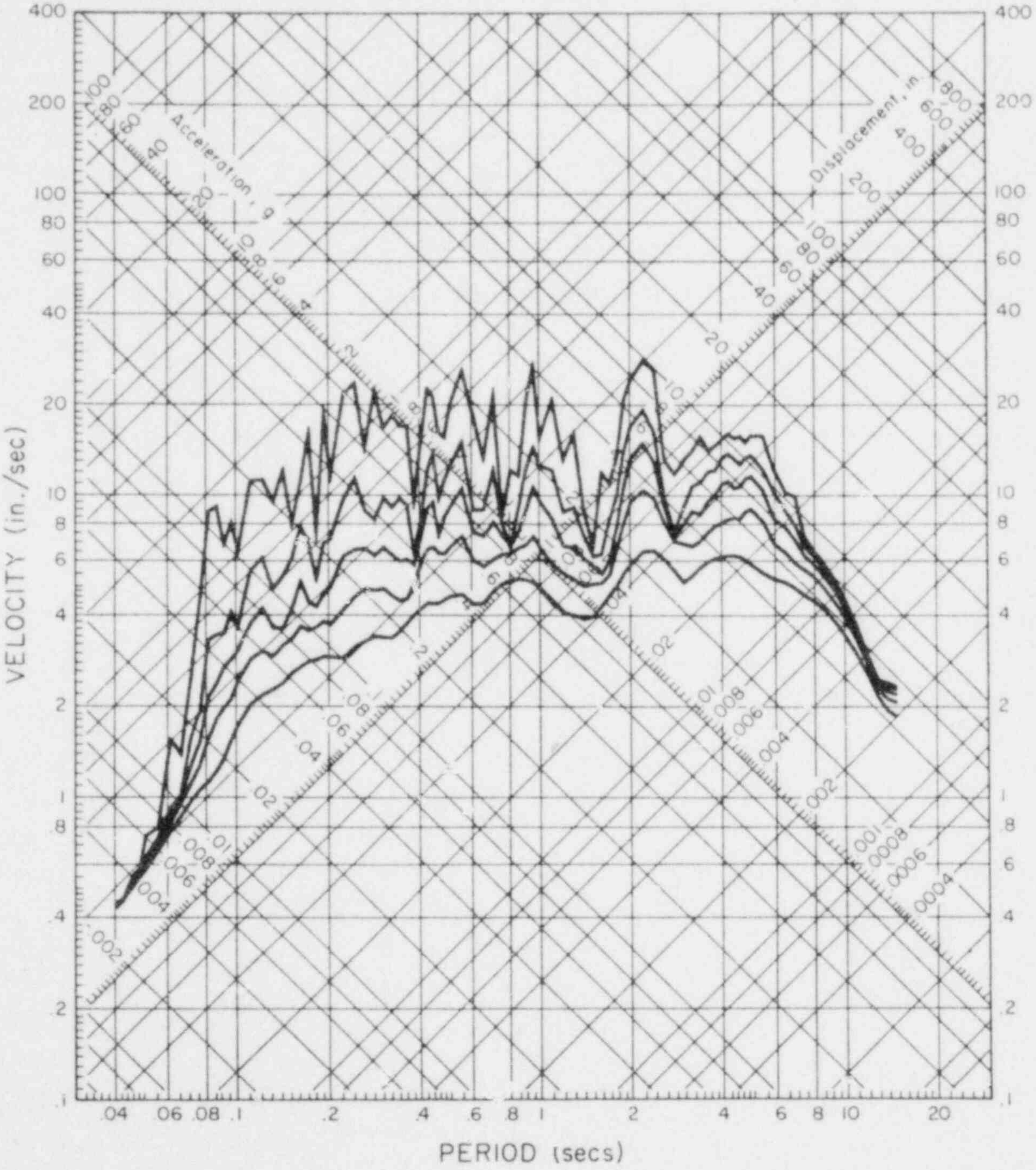

FIG. 21A-30

Section 22A

Noranda Aluminum Plant
New Madrid, Missouri

SECTION 22A

EARTHQUAKE RECORDS
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

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TABLE 22A-1

STATION RECORDS

NORANDA ALUMINUM PLANT

NEW MADRID, MISSOURI

USGS No. : 2420
Location : 5.5 miles SSW of New Madrid, Missouri
Noranda Aluminum Plant Rectifier/Control Building
Property Owner : Noranda Aluminum Co.
Building : One story at grade
reinforced concrete block construction
Instrument Location : Ground level
Present Instrumentation : SMA-1 accelerograph (S/N 317) and seismoscope (S/N 231)
Station Installation Date : February 29, 1972

County : New Madrid
Quadrangle : New Madrid, Mo - Ky (7.5')
Coordinates : 36.510°N; 89.568°W

Source[1]	Year	Date Mo. Day	Time (CST)	Latitude North(°)	Longitude West(°)	Magnitude (Richter)	Max. Intensity (MM)	Depth (miles)	Epicentral Distance (miles)	Max. Acceleration (g's) West	Down	South	Record
A	1975	6 - 13	16:40	36.54	89.68	4.3(SLM)	VI	1	7 WNW	0.06	0.04	0.07^2	-
B										0.043	0.031	0.064^4	SLM^4
A	1976	3 - 24	18:41	35.59	90.48	5.0(SLM)	VI	9	81 SW	———	$\leq 0.05^{2,3}$	———	-
B										0.013	0.010	0.011^4	SLM^4

Notes:

1. The following sources were used in compiling the earthquake data:

   A. United States Earthquakes

   B. Herrmann (1977)

   Station records were checked with the listings of Brazee (1974), Morris et al. (1977) and the USGS (unpub.).

2. Accelerations from unprocessed records.

3. Maximum acceleration recorded of any of the three components.

4. Accelerations from digitized and baseline corrected records that have been processed by Saint Louis University (Herrmann, 1977).

POOR ORIGINAL

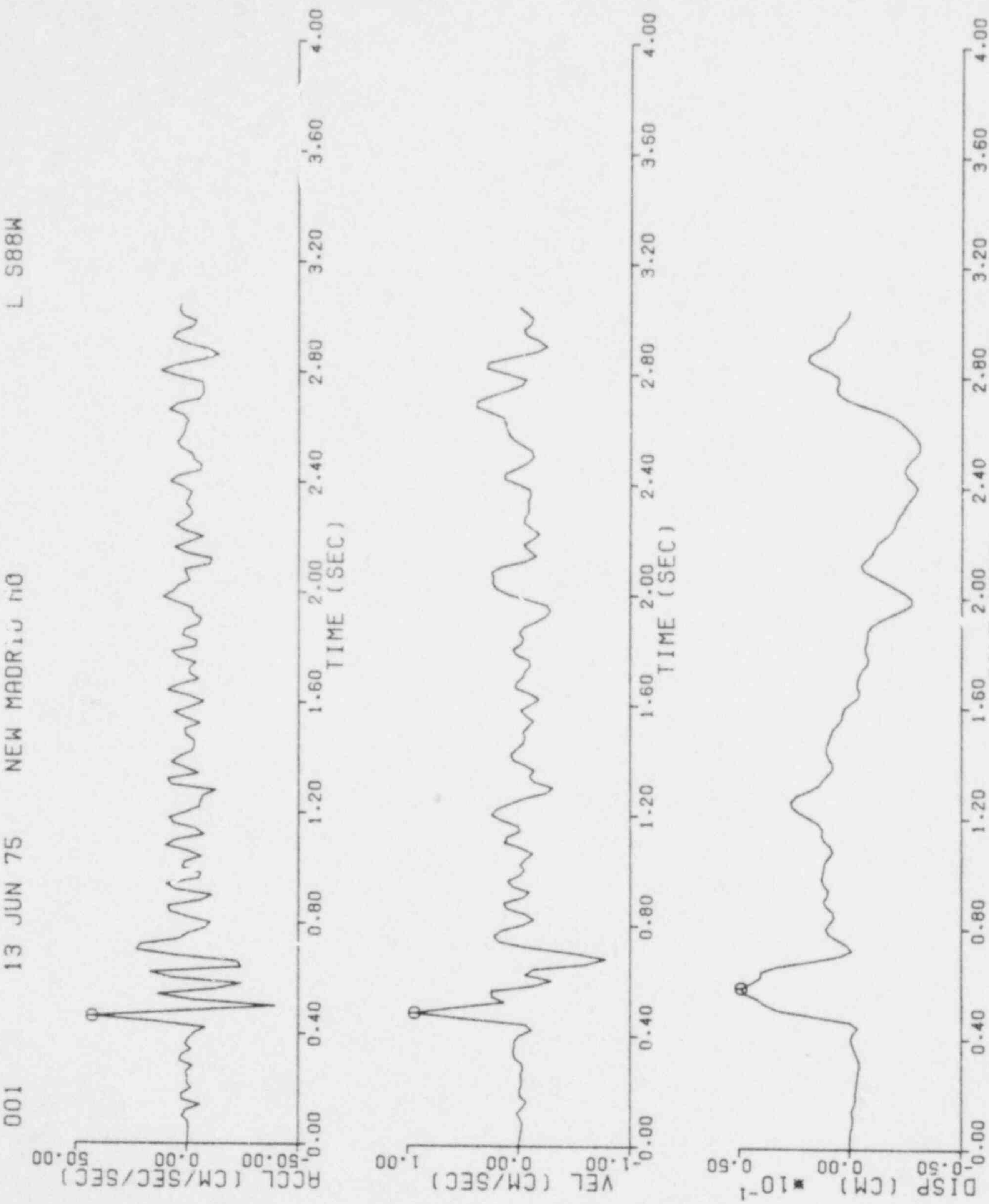
001 13 JUN 75 NEW MADRID MO L S88W
ACCL (CM/SEC/SEC)
50.00
0.00
-50.00
VEL (CM/SEC)
1.00
0.00
-1.00
DISP (CM) *10⁻¹
0.50
0.00
-0.50
TIME (SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00

FIG. 22A-1

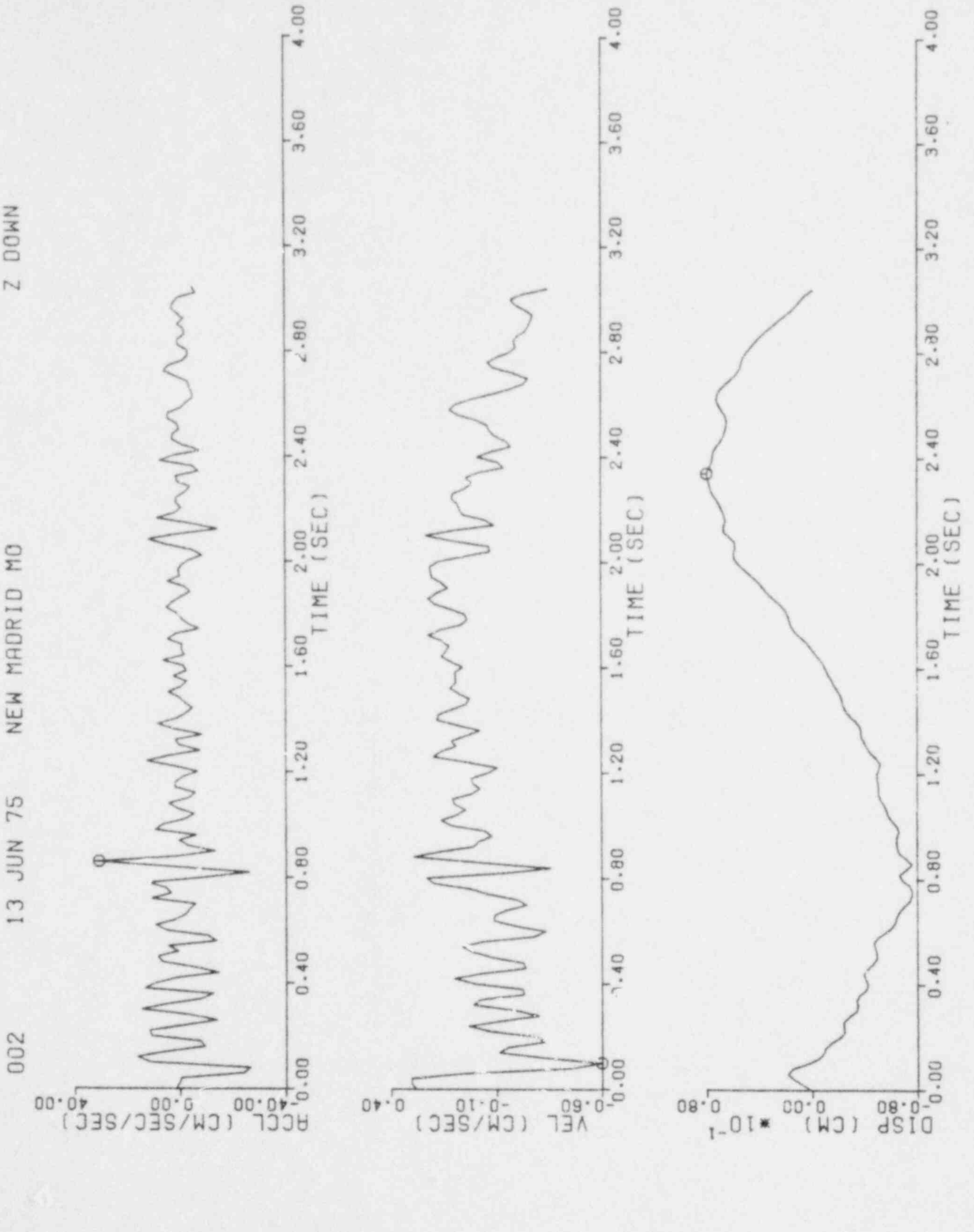
002
13 JUN 75
NEW MADRID MO
Z DOWN
ACCL (CM/SEC/SEC)
40.00
0.00
-40.00
VEL (CM/SEC)
0.40
-0.10
-0.60
DISP (CM) *10-1
0.80
0.00
-0.80
TIME (SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00

FIG. 22A-2

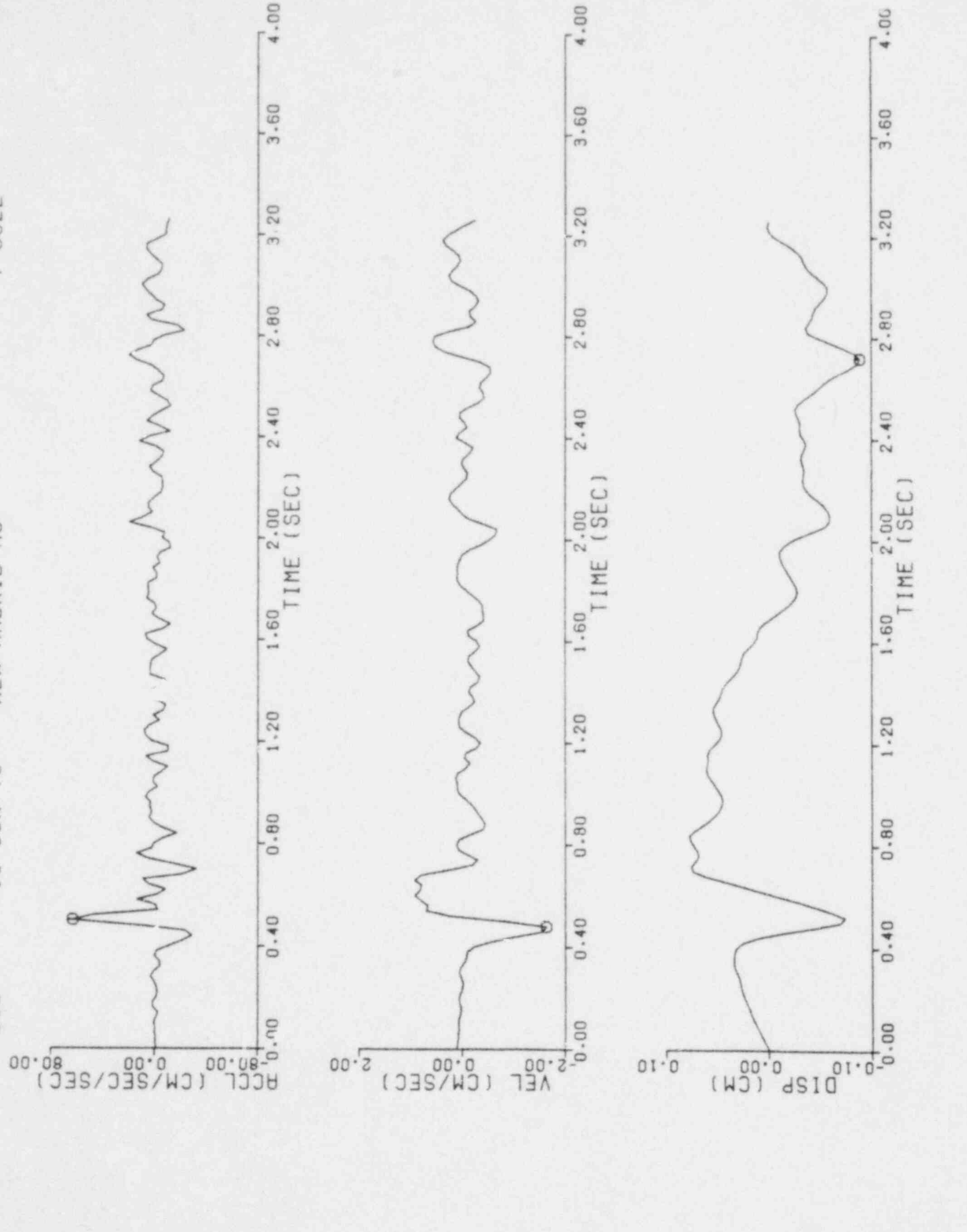
003
13 JUN 75
NEW MADRID MO
T S02E
ACCL (CM/SEC/SEC)
80.00
0.00
-80.00
VEL (CM/SEC)
2.00
0.00
-2.00
DISP (CM)
0.10
0.00
-0.10
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
TIME (SEC)

FIG. 22A-3

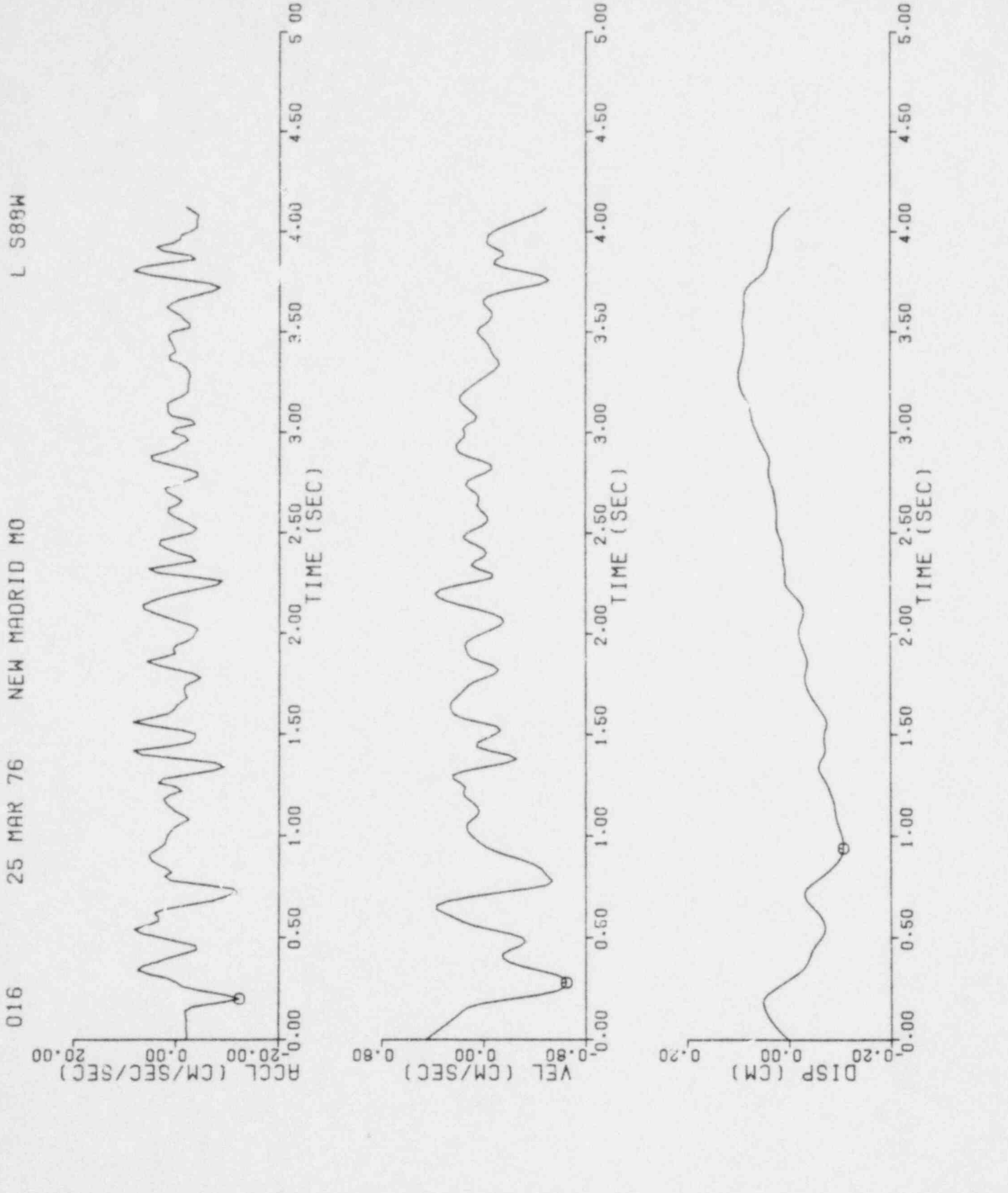
016
25 MAR 76
NEW MADRID MO
L S88W
ACCL (CM/SEC/SEC)
20.00
0.00
-20.00
VEL (CM/SEC)
0.80
0.00
-0.80
DISP (CM)
0.20
0.00
-0.20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
TIME (SEC)

FIG. 22A-4

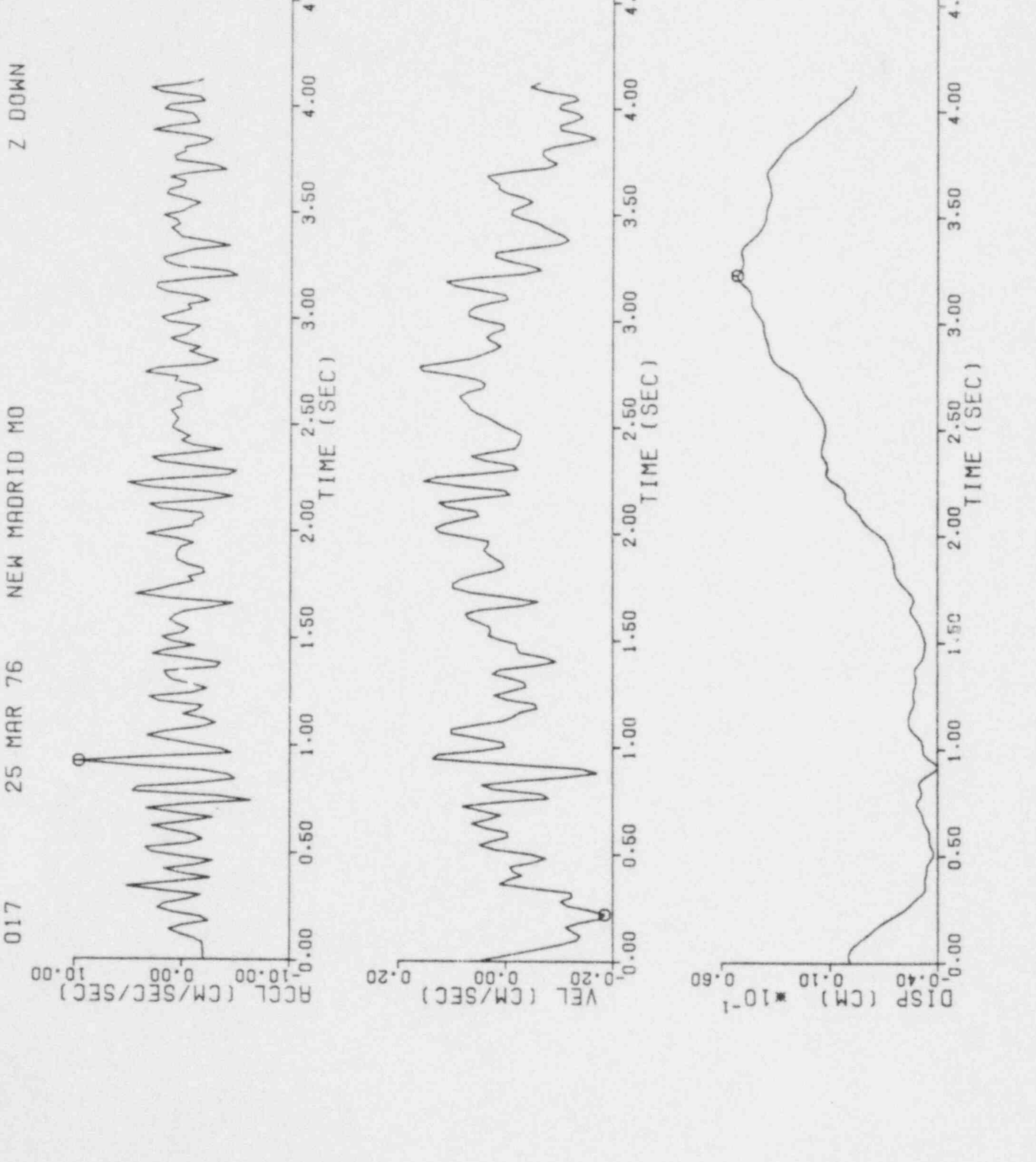
017
25 MAR 76
NEW MADRID MO
Z DOWN
ACCL (CM/SEC/SEC)
10.00
0.00
-10.00
VEL (CM/SEC)
0.20
0.00
-0.20
DISP (CM) *10⁻¹
0.60
0.10
-0.40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
TIME (SEC)

FIG. 22A-5

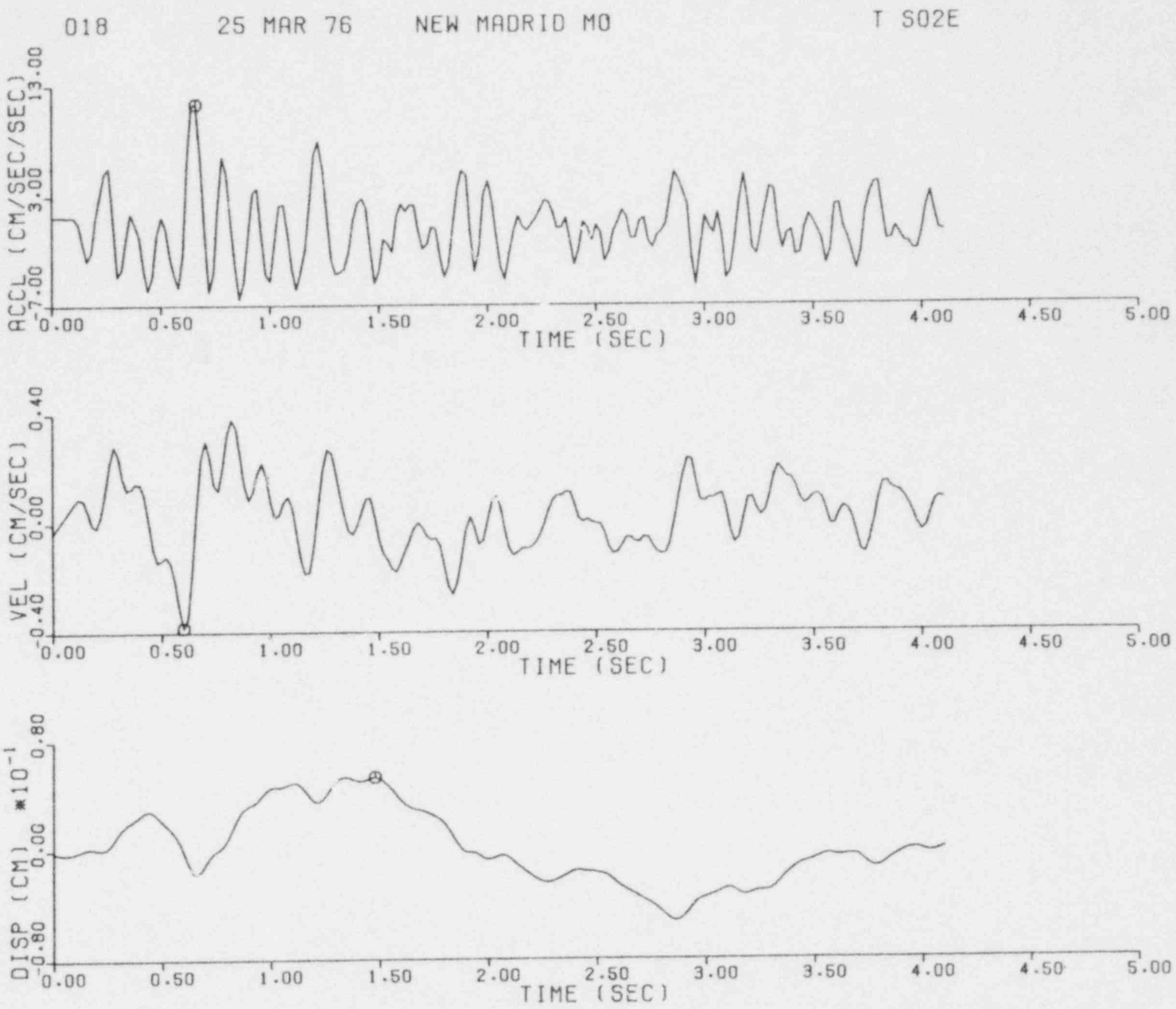
018
25 MAR 76
NEW MADRID MO
T S02E
ACCL (CM/SEC/SEC)
13.00
3.00
-7.00
VEL (CM/SEC)
0.40
0.00
-0.40
DISP (CM) *10⁻¹
0.80
0.00
-0.80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
TIME (SEC)

FIG. 22A-6

APPENDIX B

FIELD EXPLORATIONS

APPENDIX B

FIELD EXPLORATIONS

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APPENDIX B
FIELD EXPLORATIONS

INTRODUCTION

A field exploration program consisting of a deep boring and downhole geophysical testing was performed at each of the five sites. The purpose of the boring was to study subsurface stratigraphy and to obtain soil samples suitable for laboratory testing. The completed boring was then cased in preparation for later geophysical testing. Downhole geophysical tests were conducted in each of the borings to obtain shear wave velocities of the subsurface materials.

This section of the appendix contains a general description of the field exploration procedures. Details of the findings at each of the sites, including variations from the procedures discussed below, are presented in the five sections which follow (Sections 18B-22B).

FIELD EXPLORATION PROCEDURES

Drilling and Sampling

At each site, a deep boring was advanced to bedrock or to a depth of about 350 feet. The borings were generally advanced using rotary drilling techniques, in which a bentonite slurry is used to maintain stability of the walls of the hole and to return drill cuttings to the surface. Water table measurements were generally not made in the borings owing to the use of these drilling fluids.

Both disturbed and undisturbed soil samples were taken from the borings. Samples were generally taken at 5-foot intervals for the first 100 feet of boring depth, at 10-foot intervals between depths of 100 and 200 feet, and at 20-foot intervals thereafter. Drill cutting returns were observed between sampling intervals to detect changes in material types. All drilling and sampling was continuously observed by a geologist from Shannon & Wilson, Inc.

Disturbed or drive soil samples were obtained in conjunction with the Standard Penetration Test (American Society for Testing and Materials - ASTM - test designation D 1586). In this test, a 2-inch O.D. split spoon sampler, attached to the end of the drill rods, is driven into the soil by the impact of a 140-pound weight falling freely a distance of 30 inches. The sampler is either driven 18 inches into the soil or a lesser amount if the blow count would exceed 100 blows/foot. The blow count required to produce the final 12 inches of an 18-inch penetration of the sampler is defined as the standard penetration resistance value. Blow counts were recorded for all drive samples. All soil samples obtained in the SPT test were sealed in containers and returned to our laboratory for examination and testing.

Undisturbed or tube soil samples were taken in the more cohesive soil units using Shelby tube and Pitcher sampling techniques. Shelby tube samples were attempted in the softer soil units. This consisted of pushing a thin-walled, 3-inch O.D. steel tube into the soil by the hydraulic ram of the drill rig (ASTM procedure D 1587). Pitcher barrel samples were attempted in the harder soil units that could not be sampled using the Shelby tube technique. The Pitcher sampler consists of an outer barrel equipped with a carbide bit and an inner sampling barrel, generally a 3-inch O.D. thin-wall steel tube. This sampling tube is spring loaded and protrudes about 6 inches beyond the carbide cutting bit. In softer soils, the sampler is advanced by pushing with the hydraulic ram of the drill rig. Harder soil units, which resist penetration of the sampler, cause the spring loaded inner barrel to retract into the outer barrel. Sampling is then accomplished as the outer barrel overcuts the soil around the inner sampling tube.

The undisturbed tube samples were not extruded in the field. The soil appearing at the ends of each tube was visually classified in the field, then the tube ends were sealed. All tubes were shipped to our laboratory for examination and testing.

Two-inch I.D. schedule 40 PVC plastic pipe was installed in each completed boring to facilitate later geophysical testing. A coarse sand backfill or a grout mixture, consisting of three parts of hydrated lime to one part of cement by weight, was used to fill the annular space between the plastic pipe and the boring wall. A covering was then placed over the pipe for access in geophysical testing.

Geophysical Testing

Geophysical testing was conducted at each site to obtain low strain, shear wave velocities of the subsurface materials. All measurements were performed using the downhole testing procedure. This technique is described in detail by Schwarz and Musser (1972) and is briefly summarized below.

The downhole geophysical test measures the travel time of vertically propagating shear waves between two or more points. In this test, shear waves are created by an energy source at the ground surface. The waves are detected as they travel by geophone sensors lowered to different depths in the boring. Wave travel times are recorded between two points, such as the surface energy source and a geophone in the boring, or between two or more geophones in the boring. Knowing the distance between these points and the arrival times of the waves, the shear wave velocities may then be calculated.

Shear waves were created at the ground surface using a bidirectional energy source. At each site, a wooden plank or railroad tie was used to generate shear waves in the ground. The plank was placed on the ground surface about 10 feet from the boring and held in place by the front wheels of a pickup truck. Bidirectional shear waves (waves of reverse polarity) were created by striking the plank with a hammer, first at one end and next at the other. This procedure was repeated at each test depth. Tests were generally made at 5-foot depth intervals in the near surface materials and at 10-foot depth intervals thereafter.

Shear waves were detected in the boring by three packages of geophones spaced at 10-foot intervals. Wave arrivals were recorded on a light beam oscilloscope. Since two oppositely polarized shear waves were generated for each test depth, the first arrivals of the shear waves were defined by the reversed polarity of the wave form signatures.

Values of shear wave velocity were determined by plotting the accumulated interval arrival times with boring depth. Points falling in a straight line indicate a constant value of shear wave velocity for that depth interval. The value of shear wave velocity is determined from the slope of the line. Interval velocities were also calculated for each test depth. These values correspond to the wave velocity observed between the three geophone packages at a given test depth.

Section 18B

UA Duckering Hall
Fairbanks, Alaska

SECTION 18B

FIELD EXPLORATIONS

UA DUCKERING HALL

FAIRBANKS, ALASKA

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UA DUCKERING HALL
FAIRBANKS, ALASKA

DRILLING AND SAMPLING

Subsurface conditions at Duckering Hall were explored with a 157-foot deep boring. This boring, indicated as boring B-1 in Fig. 18B-1, is located 16 feet north and 54 feet east of the southeast corner of Duckering. The ground elevation in the vicinity of the boring is estimated at 500 ft. MSL as interpolated from the USGS topographic quadrangle "Fairbanks (D-2, SW), Alaska," which has 10-foot contour intervals. This elevation is also in agreement with structural drawings for Duckering which indicate that the floor elevation in the basement is 503 ft. MSL. A log of the materials encountered in the boring is presented in Fig. 18B-2.

The boring at Duckering Hall was drilled on June 26 and 27, 1979, by Arctic Alaska Testing Laboratories of Fairbanks, Alaska. Equipment for this work consisted of a truck-mounted, Mobile B-61 drill rig. The first 94.5 feet of the hole was drilled using a 3-3/8 inch I.D. hollow-stem auger. Below this depth, the hole was cored using an NX size, rotary drill bit and compressed air to return drill cuttings to the surface. Drilling was terminated at a depth of 157 feet and 2-inch I.D. plastic casing was installed in the boring and grouted in place.

Limited sampling was conducted in boring B-1. Samples were taken at 5-foot intervals to a depth of 20 feet and at 20-feet intervals to a depth of 80 feet. Only samples of cuttings were taken below this depth. Sampling in the boring was limited to drive samples, except for one Shelby tube sample taken near the ground surface. The drive samples were obtained using a combination of split spoon sizes (2 and 3 inch O.D.) and hammer weights (140 and 340 lbs). Thus, because of the relatively few samples taken at the site, the description of materials encountered in the boring is largely based on cutting returns and observed drill action.

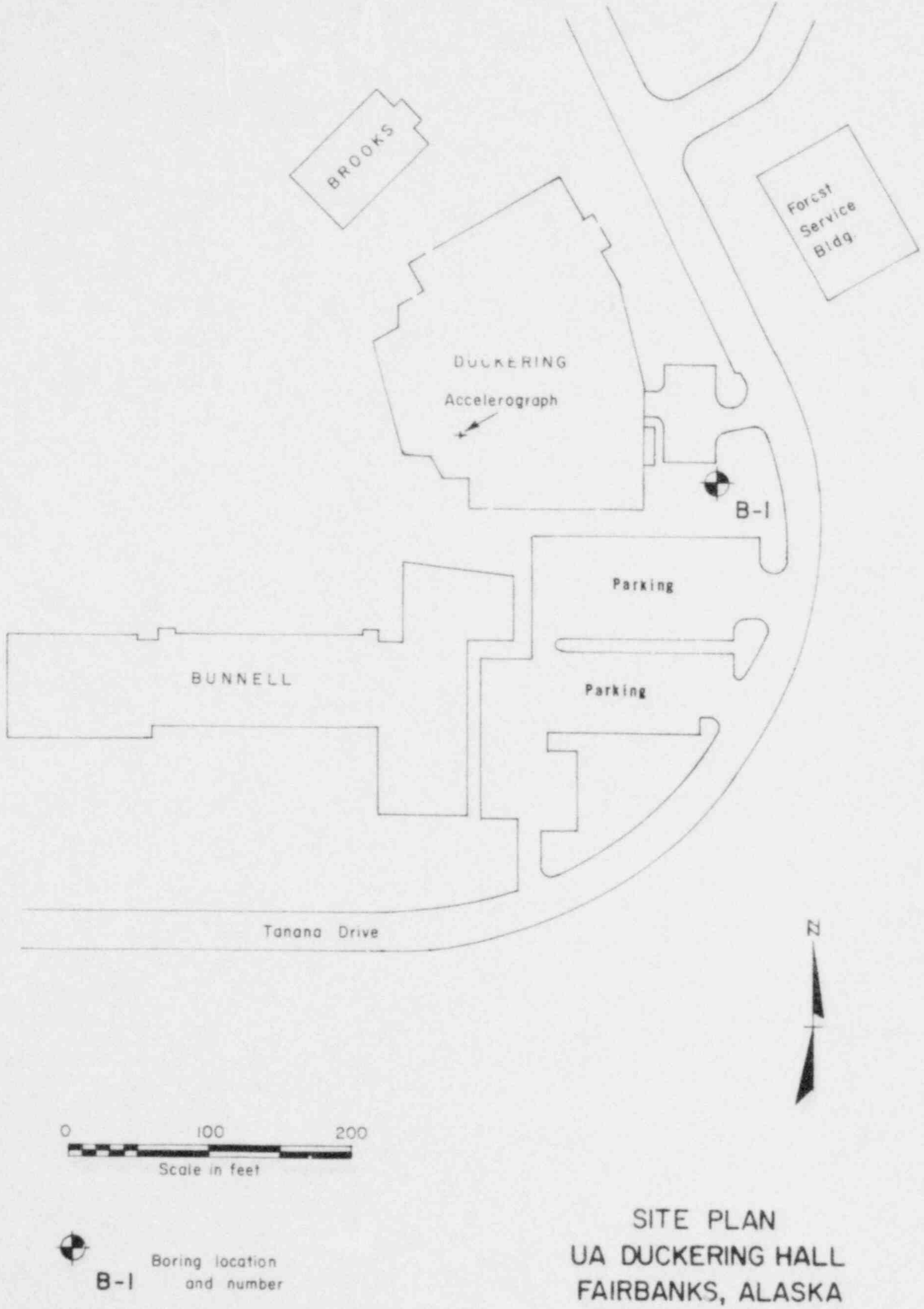
GEOPHYSICAL TESTING

A downhole geophysical survey was performed in boring B-1 by personnel from Shannon & Wilson, Inc., on July 10, 1979. Measurements were made to a total depth of 150 feet. The results are plotted in Fig. 18B-3 in terms of measured shear wave arrival times and computed shear wave velocities. Interval shear wave velocities calculated at each test depth are presented in Table 18B-1.

TABLE 18B-1
INTERVAL SHEAR WAVE VELOCITIES

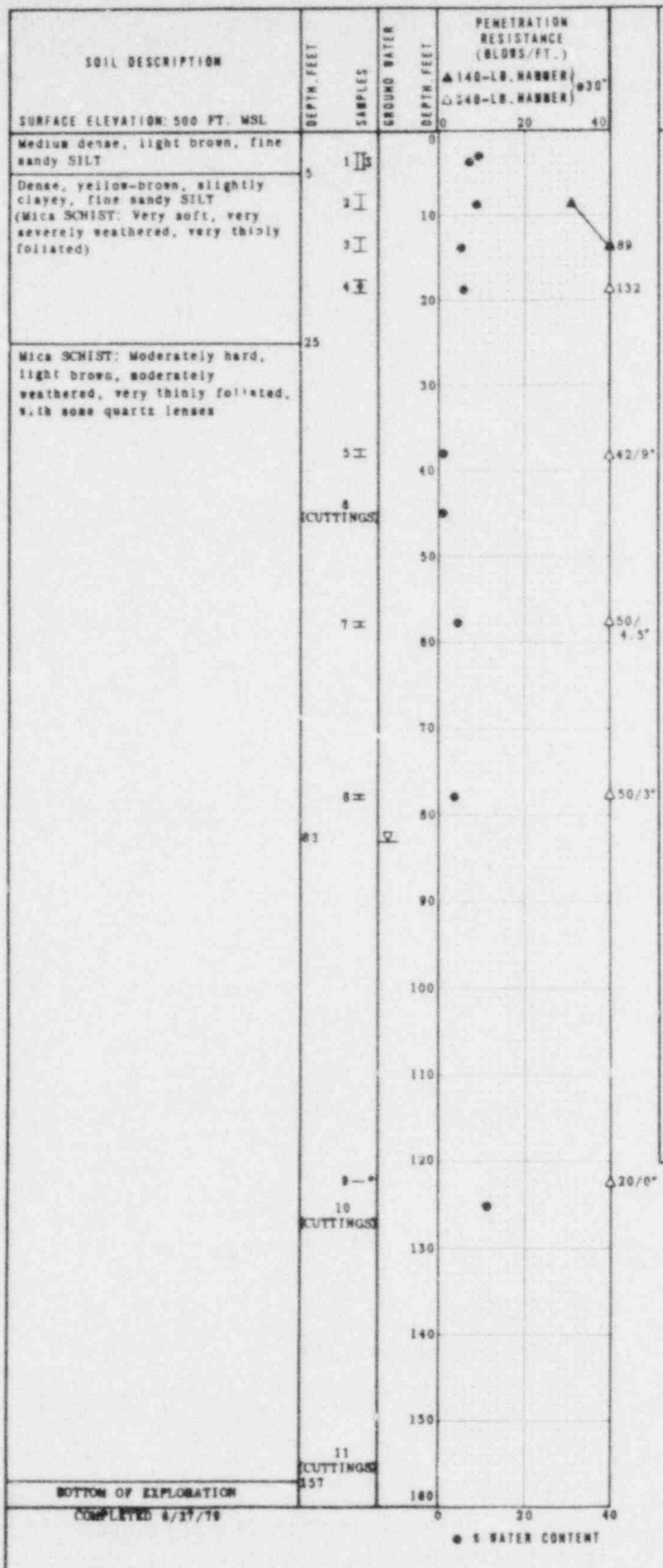
UA Duckering Hall
Fairbanks, Alaska

Mean Depth (ft)	Shear Wave Velocity (fps)	Mean Depth (ft)	Shear Wave Velocity (fps)
7.5	1600	82.5	4940
12.5	1750	87.5	4940
17.5	1410	92.5	4950
22.5	1510	97.5	4940
27.5	3920		
32.5	3010	102.5	4970
37.5	3100	107.5	4970
42.5	3160	112.5	4970
47.5	4690	117.5	4970
		122.5	4970
52.5	4760	127.5	4980
57.5	4810	132.5	4980
62.5	4850	137.5	4980
67.5	4880	142.5	4990
72.5	4900	147.5	4980
77.5	4900		



SITE PLAN
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18B-1



● % WATER CONTENT

LEGEND

- Ⅰ 2" O.D. SPLIT SPOON SAMPLE
- Ⅰ 3" O.D. SPLIT SPOON SAMPLE
- Ⅱ 3" O.D. THIN-WALL TUBE SAMPLE
- * SAMPLE NOT RECOVERED
- ATTERBERG LIMITS:
  - LIQUID LIMIT
  - NATURAL WATER CONTENT
  - PLASTIC LIMIT

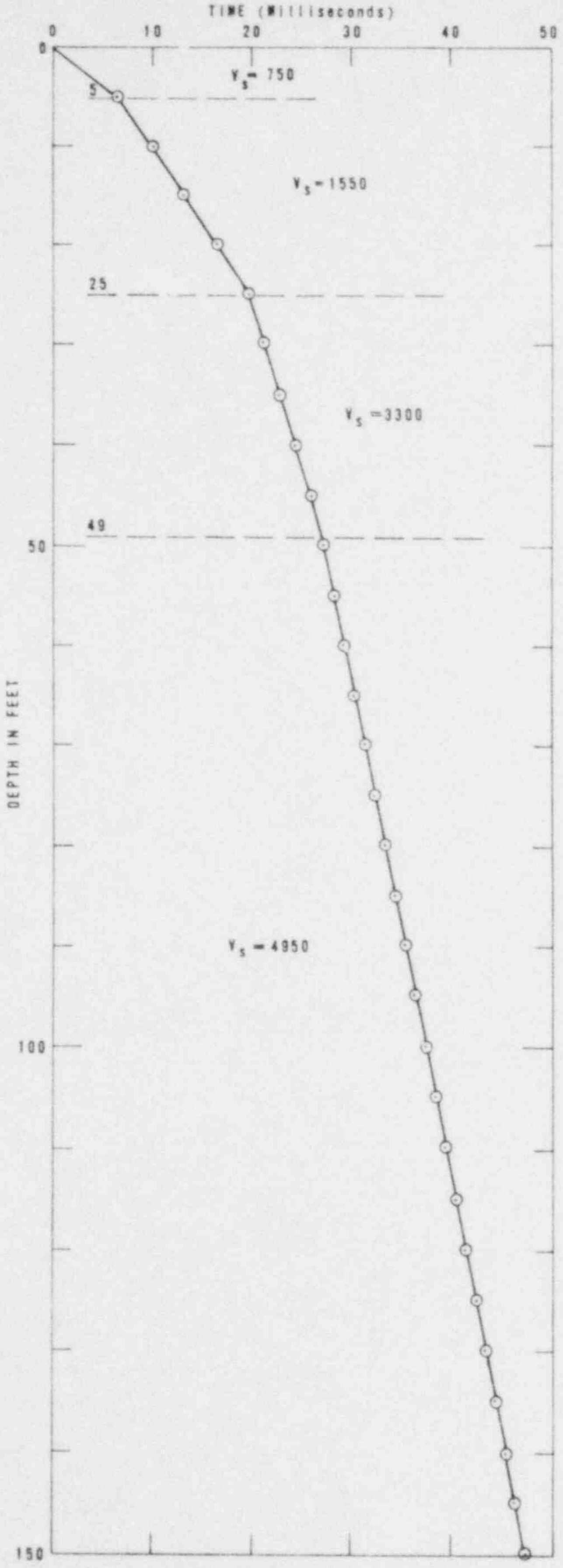
- IMPERVIOUS SEAL
- ▽ WATER LEVEL
- PIEZOMETER TIP
- S SHELBY (PUSH) SAMPLE

NOTE: THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

POOR ORIGINAL

LOG OF BORING B-I
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18B-2



BORING
Elevation: 500 ft. MSL
Depth: 157 ft.
Drilled: June 27, 1979
Misc.: Hollow stem augered to 94.5 ft., rotary drilled (air) to 157 ft. cased with 2" PVC for entire hole depth, grouted installation

GEOPHYSICAL MEASUREMENTS
Method: Downhole
Depth: 150 ft.
Date: July 10, 1979

LEGEND

⊙ Measured shear wave arrival times (cumulative)

V_s Computed shear wave velocity (fps)

WAVE ARRIVAL TIMES
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. 18B-3

POOR ORIGINAL

Section 19B

General Store
Petrolia, California

SECTION 19B
FIELD EXPLORATIONS
GENERAL STORE
PETROLIA, CALIFORNIA

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GENERAL STORE
PETROLIA, CALIFORNIA

DRILLING AND SAMPLING

Subsurface conditions at the General Store in Petrolia were explored with a 180.3-foot deep boring. This boring, indicated as boring B-1 in Fig. 19B-1, is located 60 feet north and 28 feet east of the instrument shelter adjacent to the General Store. The ground elevation in the vicinity of the boring is estimated at 105 ft. MSL as interpolated from the USGS topographic quadrangle "Petrolia, Calif.," which has 20-foot contour intervals. A log of the materials encountered in the boring is presented in Fig. 19B-2.

The boring at the General Store was drilled between April 2 and April 9, 1979, by Pitcher Drilling Company of Daly City, California. Equipment used for this work consisted of a truck-mounted, Failing 1500 rotary drill. Drilling was terminated at a depth of 180.3 feet and 2-inch I.D. plastic casing was installed in the boring and backfilled with coarse sand.

Samples taken in the boring include SPT drive samples, Shelby and Pitcher tube samples, and NX size rock core samples. Both drive samples and tube samples were used in the upper 56 feet of the boring. Below this depth, Pitcher samples and NX core samples were exclusively used. NX core samples were taken in the boring between depths of 92 and 103 feet and again from 117 to 118.2 feet.

GEOPHYSICAL TESTING

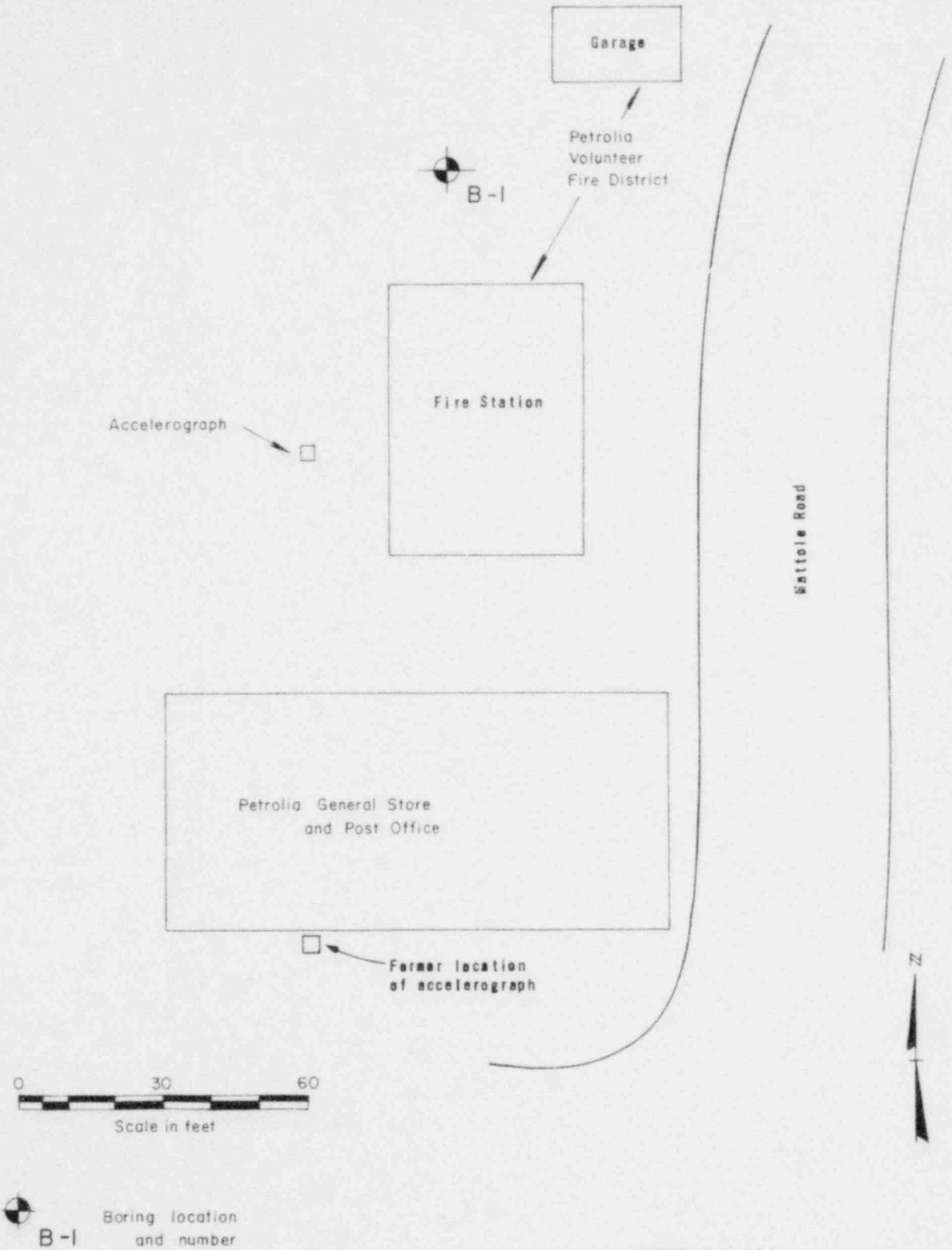
A downhole geophysical survey was performed in boring B-1 by personnel from Shannon & Wilson, Inc., on June 2, 1979. Measurements were made to a total depth of 180 feet. The results are plotted in Fig. 19B-3 in terms of measured shear wave arrival times and computed shear wave velocities. Interval shear wave velocities calculated at each test depth are presented in Table 19B-1.

TABLE 19B-1

INTERVAL SHEAR WAVE VELOCITIES

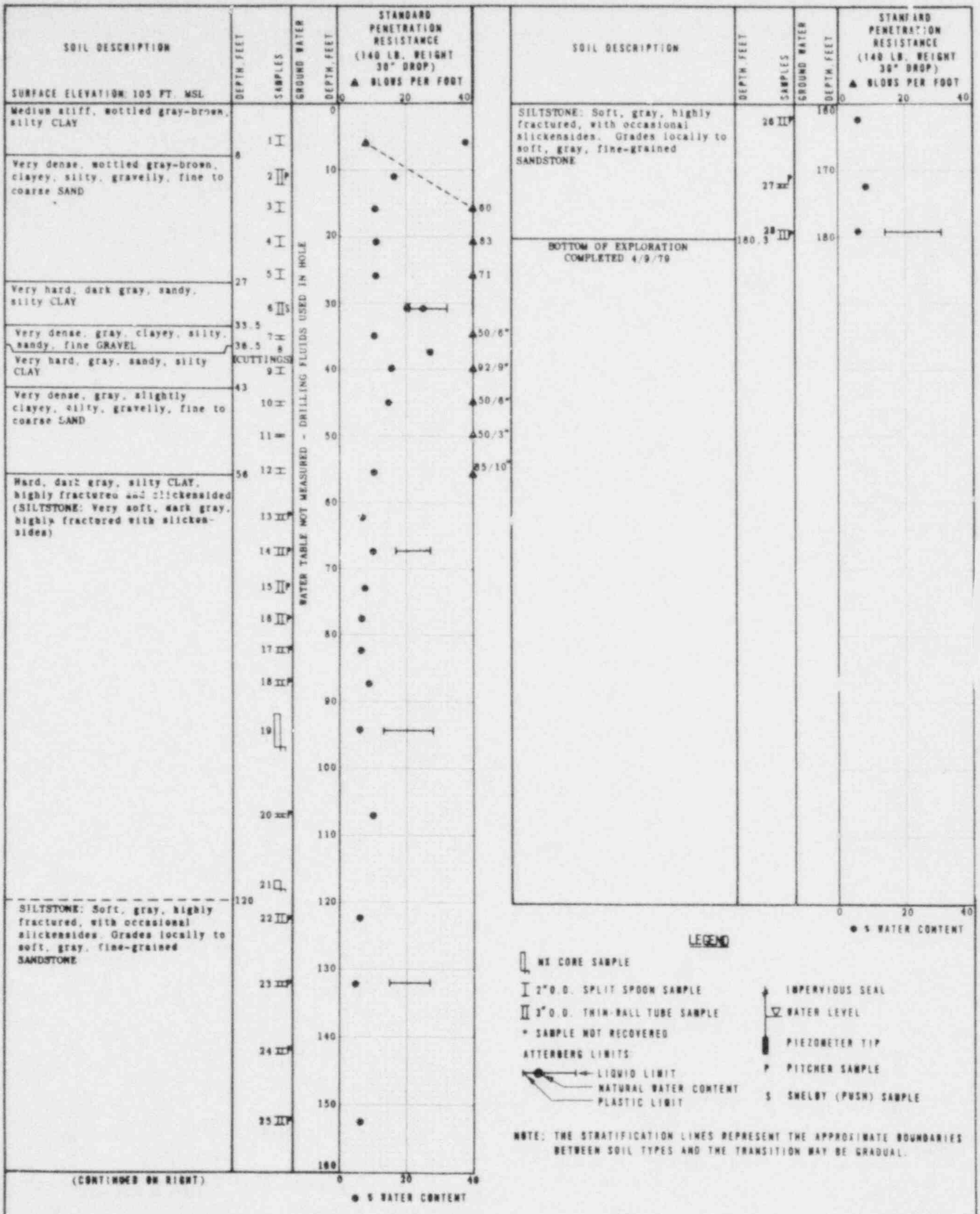
General Store
Petrolia California

Mean Depth (ft)	Shear Wave Velocity (fps)
2.5	610
7.5	610
12.5	840
17.5	990
22.5	660
27.5	640
32.5	940
37.5	1180
42.5	1200
47.5	1210
52.5	1380
57.5	1390
65.0	1610
75.0	1660
85.0	1970
95.0	1980
105.0	1980
115.0	1990
125.0	3300
135.0	3300
145.0	3310
155.0	3310
165.0	3320



SITE PLAN
GENERAL STORE
PETROLIA, CALIFORNIA

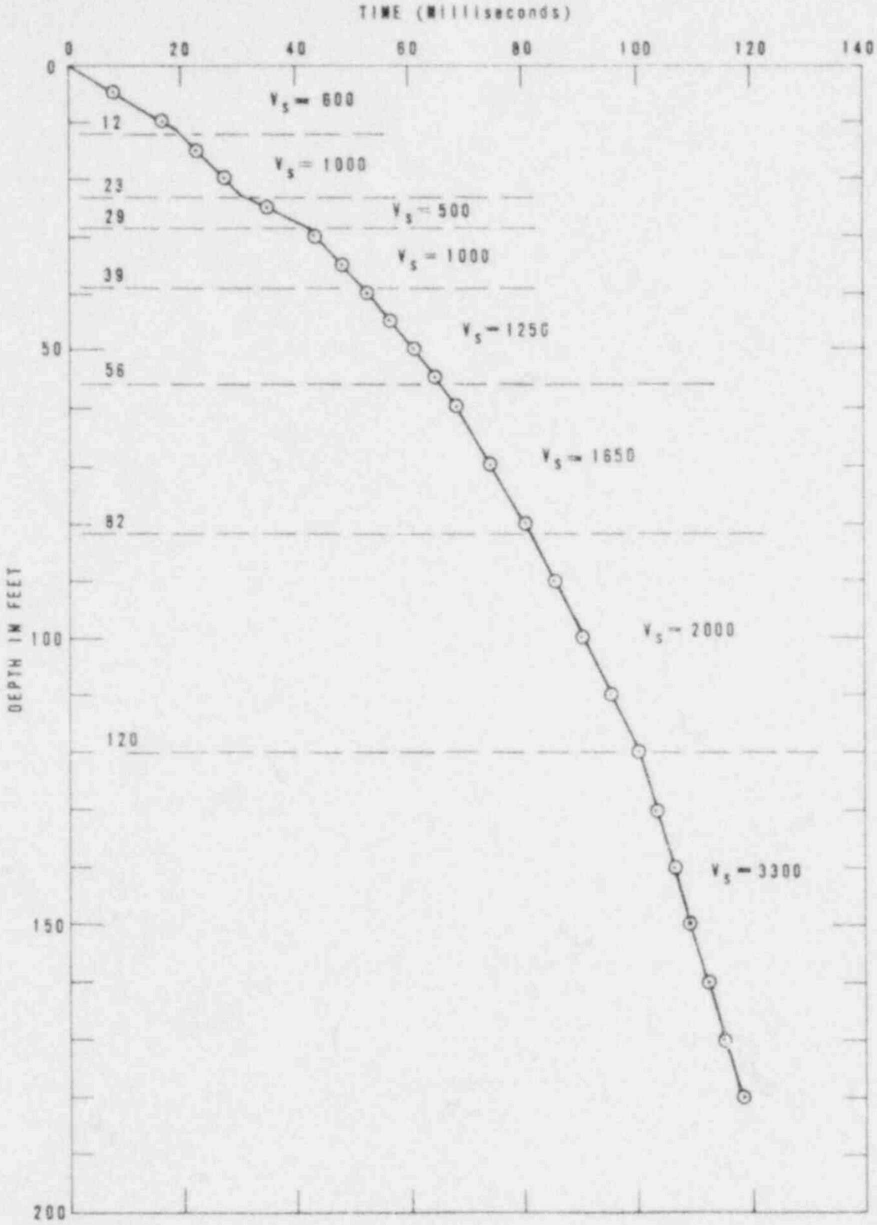
FIG. 19B-1



LOG OF BORING B-1
GENERAL STORE
PETROLIA, CALIFORNIA

POOR ORIGINAL

FIG. 19B-2



BORING

Elevation: 105 ft. MSL
Depth: 180.3 ft.
Drilled: April 9, 1979
Misc.: Rotary drilled (mud), cased with 2" PVC
for entire depth, backfilled with sand

GEOPHYSICAL MEASUREMENTS

Method: Downhole
Depth: 180 ft.
Date: June 2, 1979

LEGEND

⊙ Measured shear wave arrival times (cumulative)

V_s Computed shear wave velocity (fps)

WAVE ARRIVAL TIMES
GENERAL STORE
PETROLIA, CALIFORNIA

POOR ORIGINAL

FIG. 19B-3

Section 20B

City Hall
Hollister, California

SECTION 20B
FIELD EXPLORATIONS
CITY HALL
HOLLISTER, CALIFORNIA

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SECTION 20B
FIELD EXPLORATIONS
CITY HALL
HOLLISTER, CALIFORNIA

DRILLING AND SAMPLING

Subsurface conditions at the City Hall in Hollister were explored with a 349-foot deep boring. This boring, indicated as boring B-1 in Fig. 20B-1, is located approximately 700 feet west of the City Hall building. The ground elevation in the vicinity of the boring is estimated at 285 ft. MSL as interpolated from the USGS topographic quadrangle "Hollister, Calif.," which has 10-foot contour intervals. A log of the materials encountered in the boring is presented in Fig. 20B-2.

The boring at the City Hall was drilled between March 19 and March 23, 1979, by Pitcher Drilling Company of Daly City, California. Equipment used for this work consisted of a truck-mounted, Failing 1500 rotary drill. Drilling was terminated at a depth of 349 feet, and 2-inch I.D. plastic casing was installed in the boring and grouted in place.

Samples taken in the boring include drive samples, Shelby and Pitcher tube samples and Modified Pitcher samples. Drive samples in the upper 90 feet of the boring were obtained in conjunction with the Standard Penetration Test. Most of the drive samples below a depth of 90 feet were taken using a downhole hammer (slip jars which weigh 285 pounds and operate over a stroke of 18 inches) to drive the 2-inch O.D. split-spoon sampler. These different sample types are indicated on the boring log (Fig. 20B-2).

A Modified Pitcher sampler was used to take the last two samples in the boring (Fig. 20B-2). The Modified Pitcher differs from the Pitcher sampler in that a thick-walled split spoon drive barrel with liners is used for the inner sampling barrel rather than a thin-walled tube. The strength and rigidity of the split spoon inner barrel make the Modified Pitcher more suitable for sampling dense sands and gravels. These materials would ordinarily buckle or crimp the thin wall tube used with the regular Pitcher sampler.

GEOPHYSICAL TESTING

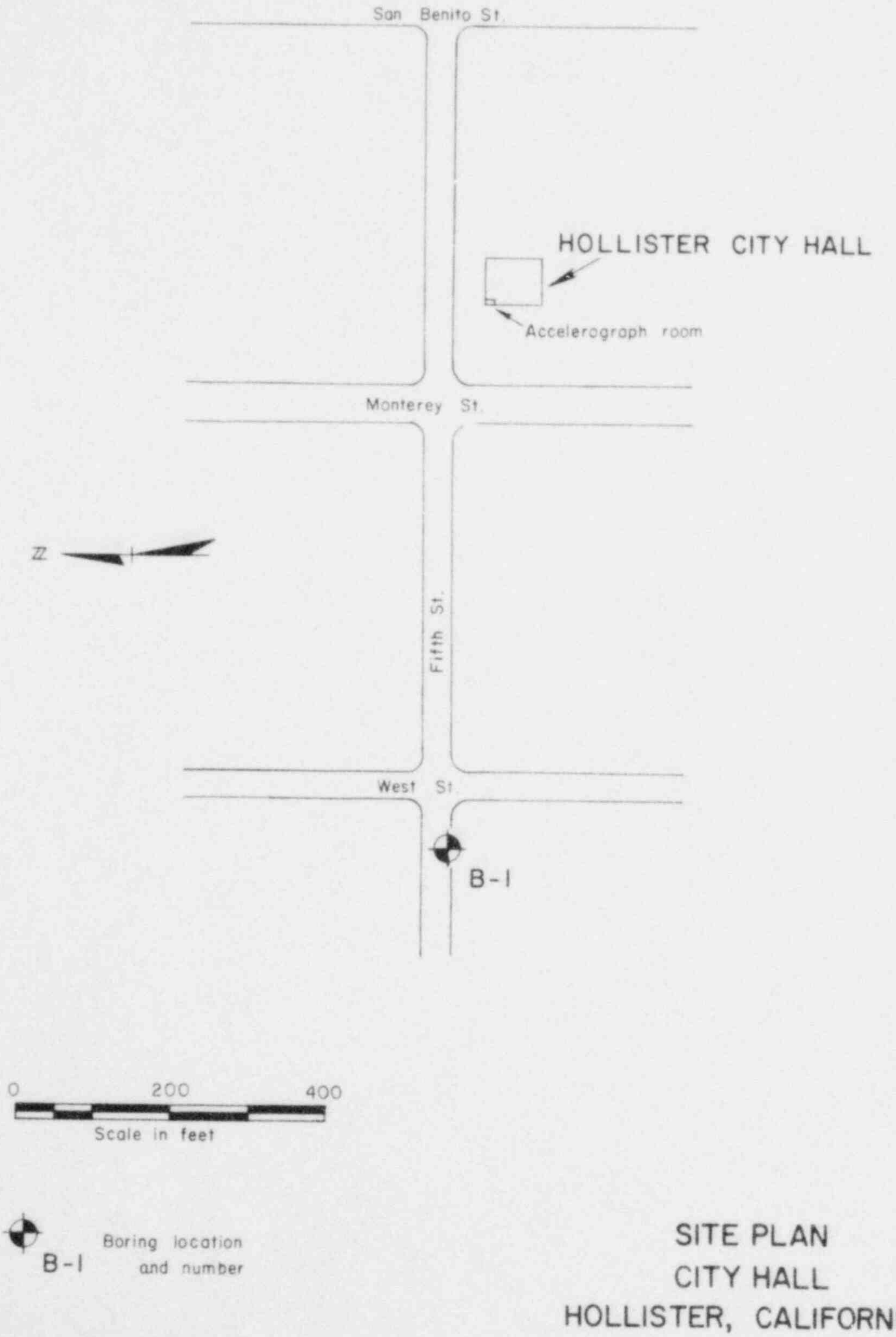
A downhole geophysical survey was performed in boring B-1 by personnel from Shannon & Wilson, Inc., on May 28, 1979. Measurements were made to a total depth of 345 feet. The results are plotted in Fig. 20B-3 in terms of measured shear wave arrival times and computed shear wave velocities. Interval shear wave velocities calculated at each test depth are presented in Table 20B-1.

TABLE 20B-1

INTERVAL SHEAR WAVE VELOCITIES

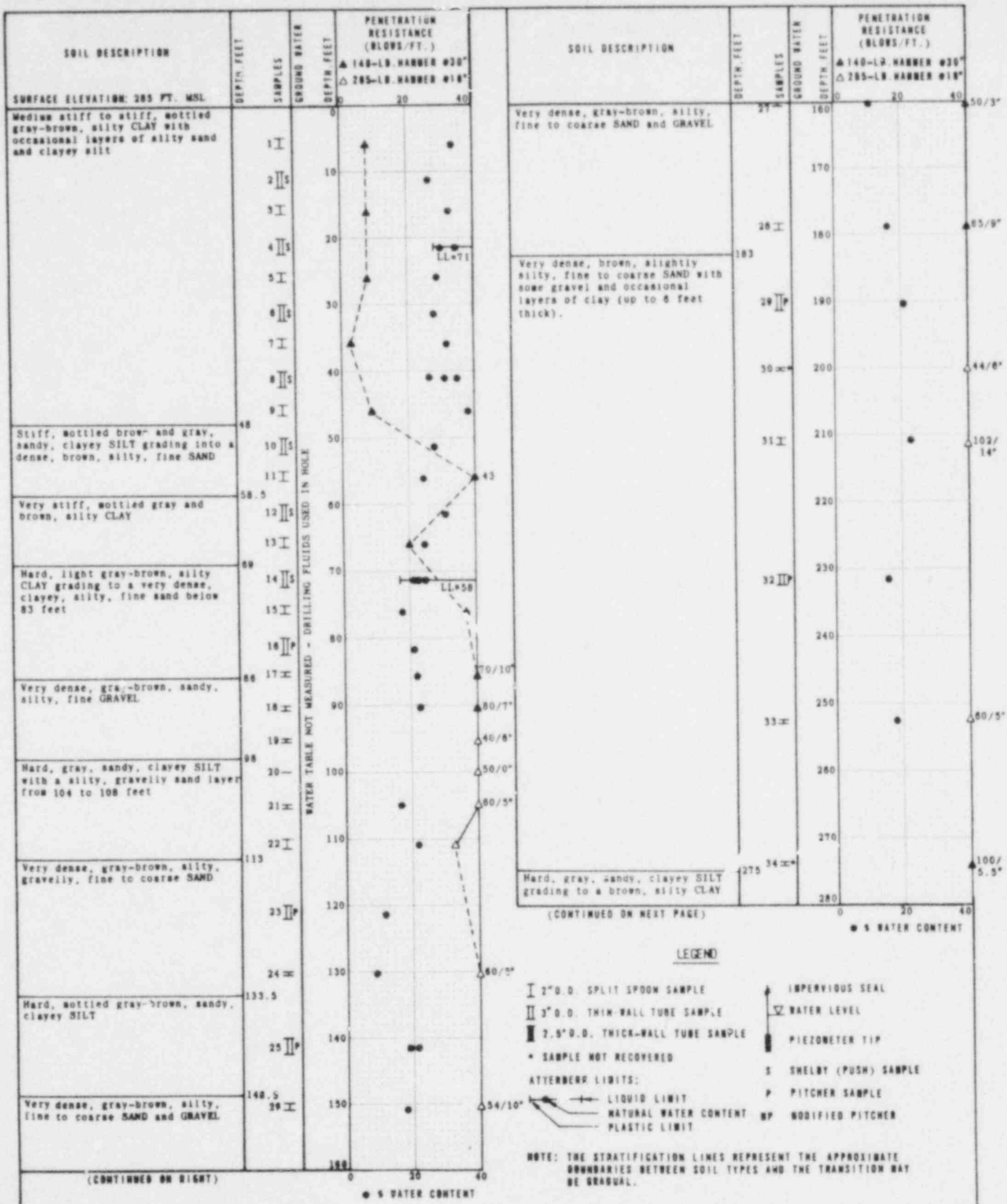
City Hall
Hollister, California

Mean Depth (ft)	Shear Wave Velocity (fps)	Mean Depth (ft)	Shear Wave Velocity (fps)
10	540	130	1180
15	540	135	1110
20	610	145	1110
25	580	155	1110
35	570	165	1250
40	600	175	1250
45	660	185	1670
50	620	195	1670
55	710	205	2000
60	770	215	2000
65	670	225	2000
70	770	235	2000
75	800	245	2000
80	910	255	2000
85	960	265	2000
90	1170	275	2000
95	1330	285	2000
100	1110	295	2000
105	1160	305	2000
110	1110	315	2000
115	910	325	2000
120	1000	335	2000
125	1110	345	2000



SITE PLAN
CITY HALL
HOLLISTER, CALIFORNIA

FIG.20B-1



Medium stiff to stiff, mottled gray-brown, silty CLAY with occasional layers of silty sand and clayey silt

Stiff, mottled brown and gray, sandy, clayey SILT grading into a dense, brown, silty, fine SAND

Very stiff, mottled gray and brown, silty CLAY

Hard, light gray-brown, silty CLAY grading to a very dense, clayey, silty, fine sand below 83 feet

Very dense, gray-brown, sandy, silty, fine GRAVEL

Hard, gray, sandy, clayey SILT with a silty, gravelly sand layer from 104 to 108 feet

Very dense, gray-brown, silty, gravelly, fine to coarse SAND

Hard, mottled gray-brown, sandy, clayey SILT

Very dense, gray-brown, silty, fine to coarse SAND and GRAVEL

(CONTINUED ON RIGHT)

Very dense, gray-brown, silty, fine to coarse SAND and GRAVEL

Very dense, brown, slightly silty, fine to coarse SAND with some gravel and occasional layers of clay (up to 8 feet thick).

Hard, gray, sandy, clayey SILT grading to a brown, silty CLAY

(CONTINUED ON NEXT PAGE)

LEGEND

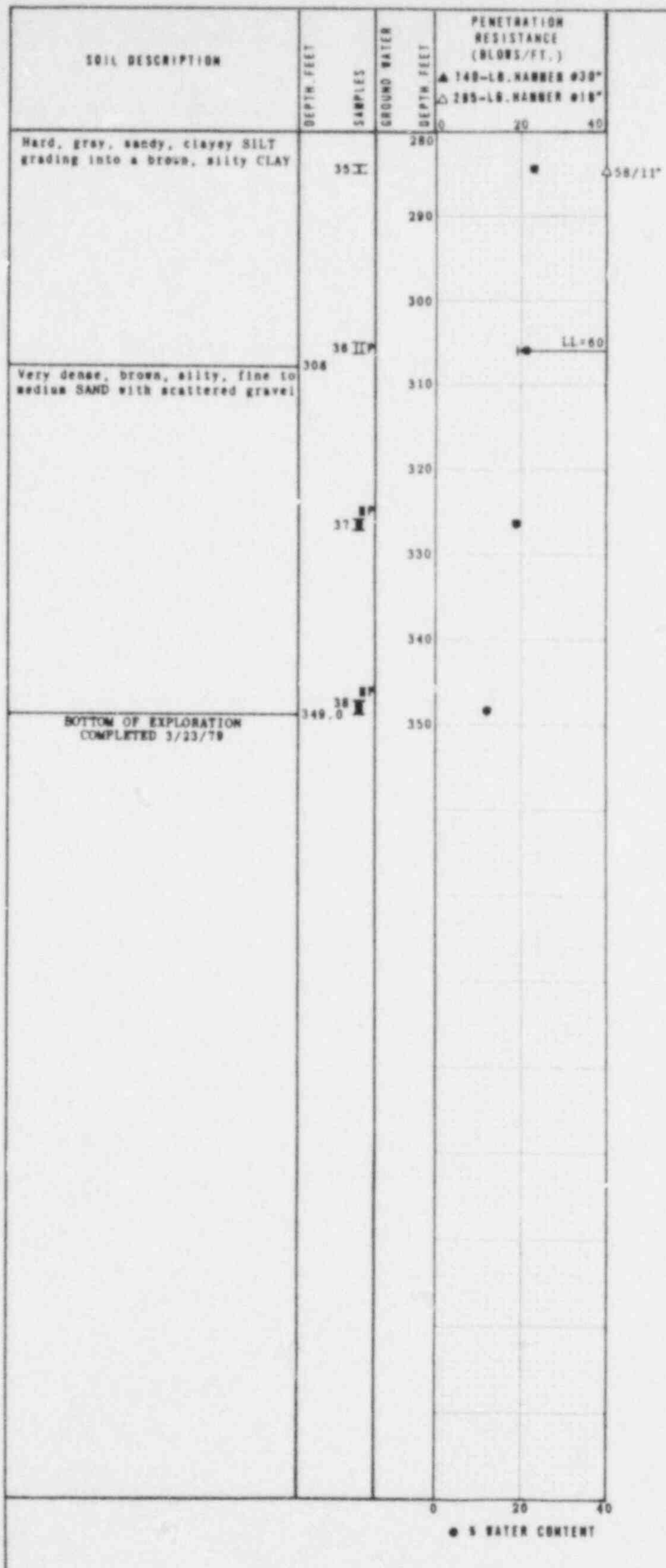
- 2" O.D. SPLIT SPOON SAMPLE
- 3" O.D. THIN-WALL TUBE SAMPLE
- 2.5" O.D. THICK-WALL TUBE SAMPLE
- * SAMPLE NOT RECOVERED
- ATTERBERG LIMITS: LIQUID LIMIT, NATURAL WATER CONTENT, PLASTIC LIMIT
- IMPERVIOUS SEAL
- ▽ WATER LEVEL
- PIEZOMETER TIP
- S SHELBY (PUSH) SAMPLE
- P PITCHER SAMPLE
- MP MODIFIED PITCHER

NOTE: THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

POOR ORIGINAL

LOG OF BORING B-1
CITY HALL
HOLLISTER, CALIFORNIA

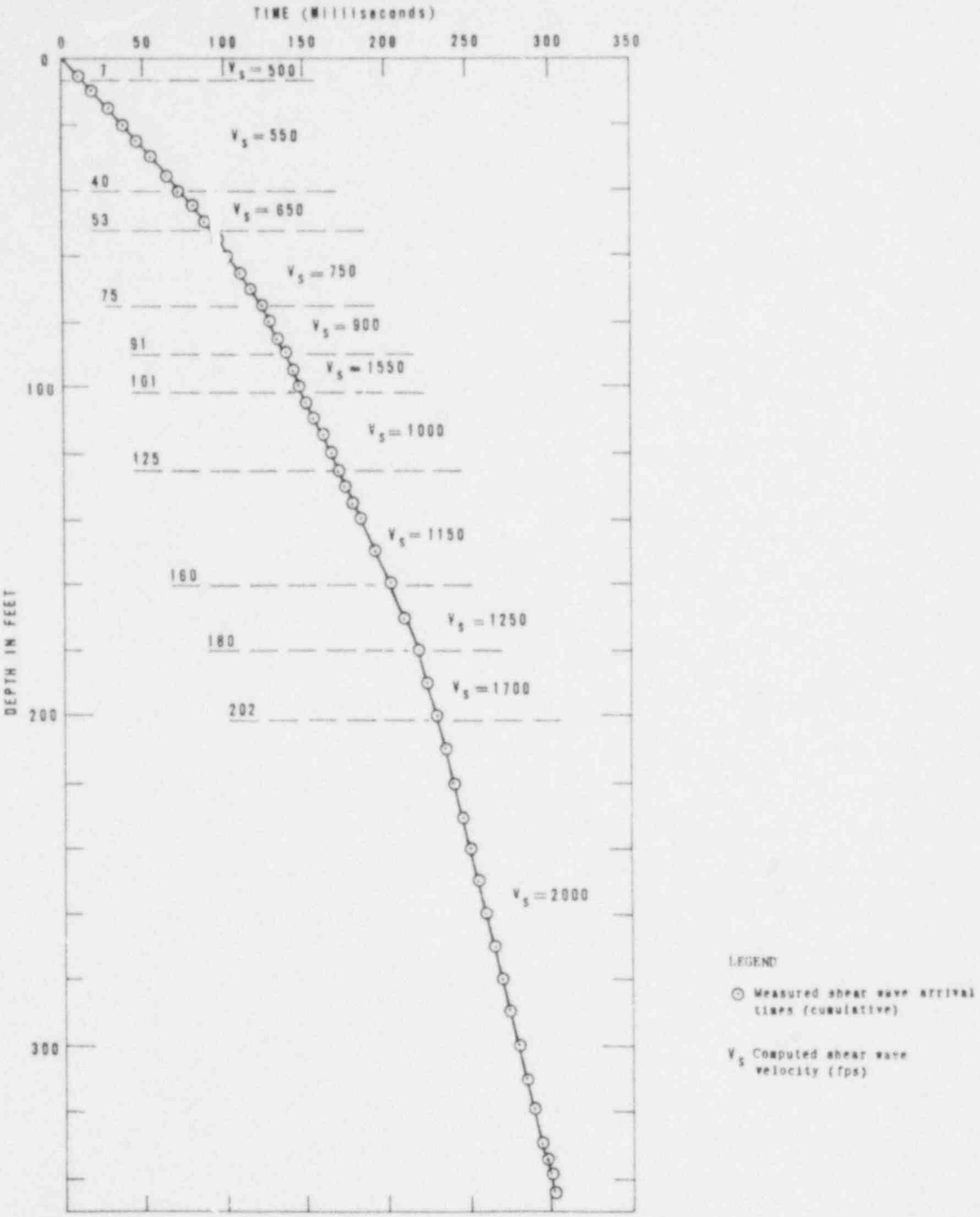
Sheet 1 of 2 FIG. 20B-2



POOR ORIGINAL

LOG OF BORING B-1
CITY HALL
HOLLISTER, CALIFORNIA

Sheet 2 of 2 FIG. 20B-2



BORING

Elevation: 285 ft. MSL
Depth: 349 ft.
Drilled: March 23, 1979
Misc.: Rotary drilled (mud), cased with 2" PVC for entire hole depth, grouted installation

GEOPHYSICAL MEASUREMENTS

Method: Downhole
Depth: 345 ft.
Date: May 28, 1979

WAVE ARRIVAL TIMES
CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20B-3

POOR ORIGINAL

Section 21B

Hollywood Storage Building
Los Angeles, California

SECTION 21B

FIELD EXPLORATIONS

HOLLYWOOD STORAGE BUILDING

LOS ANGELES, CALIFORNIA

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FIELD EXPLORATIONS
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

DRILLING AND SAMPLING

Subsurface conditions at the Hollywood Storage Building were explored with a 259.5-foot deep boring. This boring, indicated as boring B-1 in Fig. 21B-1, is located 25 feet south and 80 feet west of the southeast corner of the Hollywood Storage Building. The ground elevation in the vicinity of the boring is estimated at 290 ft. MSL as interpolated from the USGS topographic quadrangle "Hollywood, Calif.," which has 10-foot contour intervals. A log of the materials encountered in the boring is presented in Fig. 21B-2.

The boring at the Hollywood Storage Building was drilled between February 11 and February 13, 1979, by Pitcher Drilling Company of Daly City, California. Equipment used for this work consisted of a truck-mounted, Failing 1500 rotary drill. Drilling was terminated at a depth of 359.5 feet, and a 2-inch I.D. plastic casing was installed in the boring and backfilled with coarse sand.

Samples taken in the boring include drive samples and Pitcher tube samples. Drive samples in the upper 100 feet of the boring were obtained in conjunction with the Standard Penetration Test. Drive samples below a depth of 100 feet were taken using a downhole hammer (slip jars which weigh 325 pounds and operate over a stroke of 18 inches) to drive the 2-inch O.D. split-spoon sampler. The different sample types are indicated on the boring log (Fig. 21B-2).

The hole was advanced with drilling fluids to return cuttings to the surface. Consequently, the water table was not measured in the boring. However, information from Duke, et al. (1971) places the water table at a depth of 40 feet near the site.

GEOPHYSICAL TESTING

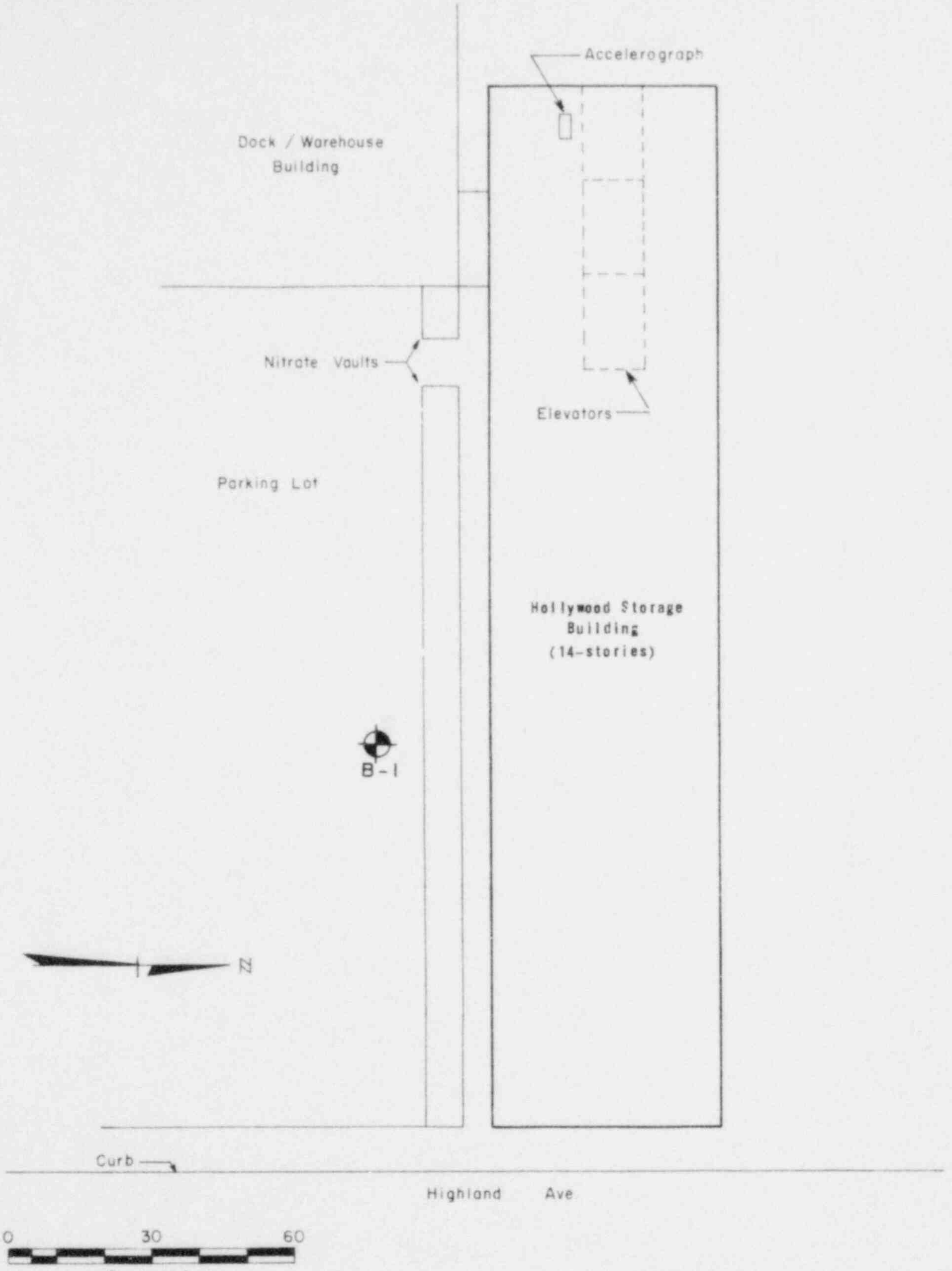
A downhole geophysical survey was performed in boring B-1 by personnel from Shannon & Wilson, Inc., on May 23, 1979. Measurements were made to a total depth of 350 feet. The results are plotted in Fig. 21B-3 in terms of measured shear wave arrival times and computed shear wave velocities. Interval shear wave velocities calculated at each test depth are presented in Table 21B-1.

TABLE 21B-1

INTERVAL SHEAR WAVE VELOCITIES

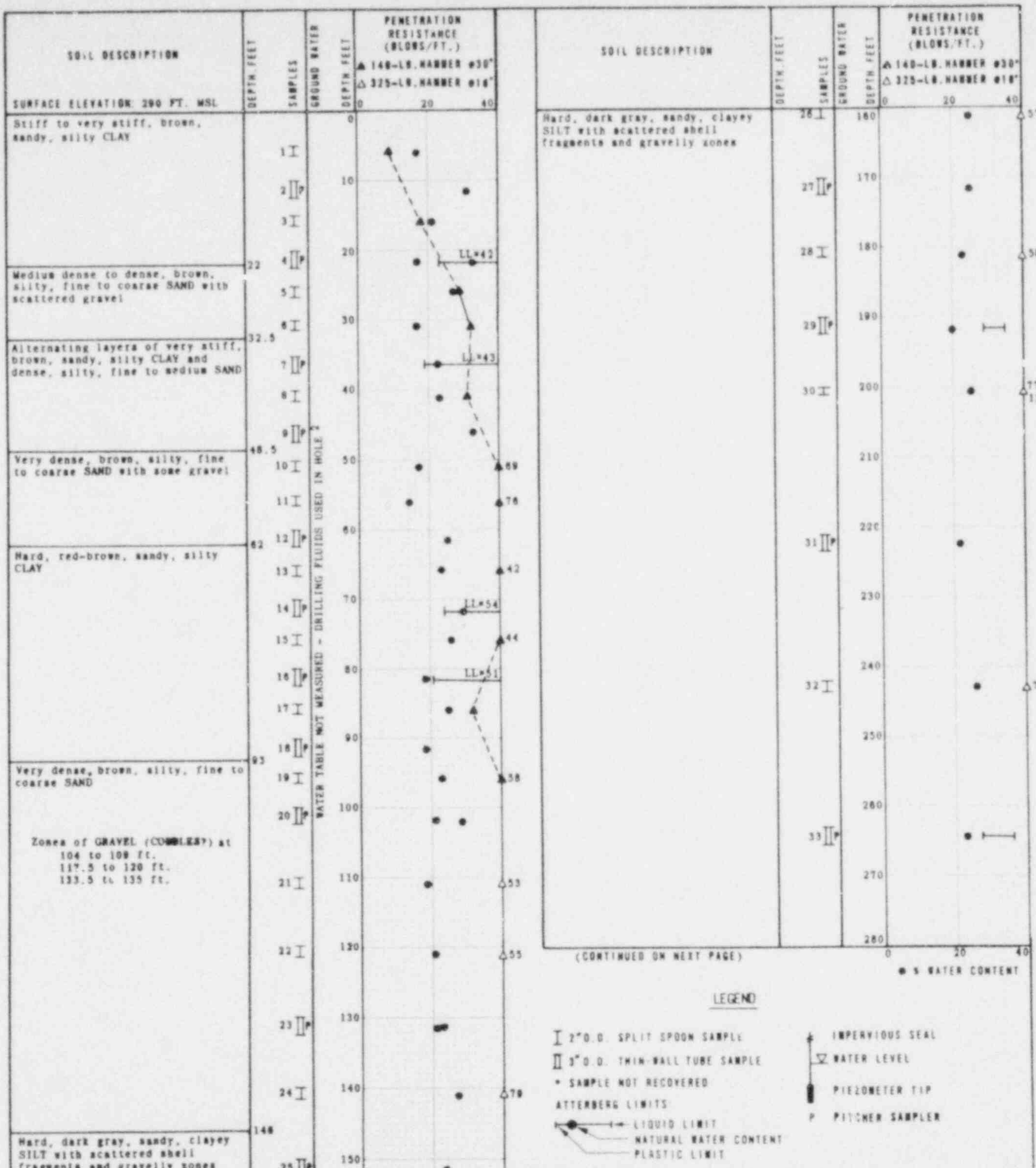
Hollywood Storage Building
Los Angeles, California

Mean Depth (ft)	Shear Wave Velocity (fps)
15	790
25	810
35	1170
45	1080
55	1220
65	1230
75	1230
85	1320
95	1420
105	1420
115	1420
125	1420
135	1420
145	1530
155	1990
165	1990
175	1990
185	1990
195	1990
205	2000
215	2000
225	2000
235	2000
245	2000
255	2000
265	2000
275	2000
285	2000
295	2000
305	2000
315	2000
325	2000
335	2000
345	2000



SITE PLAN
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21B-1



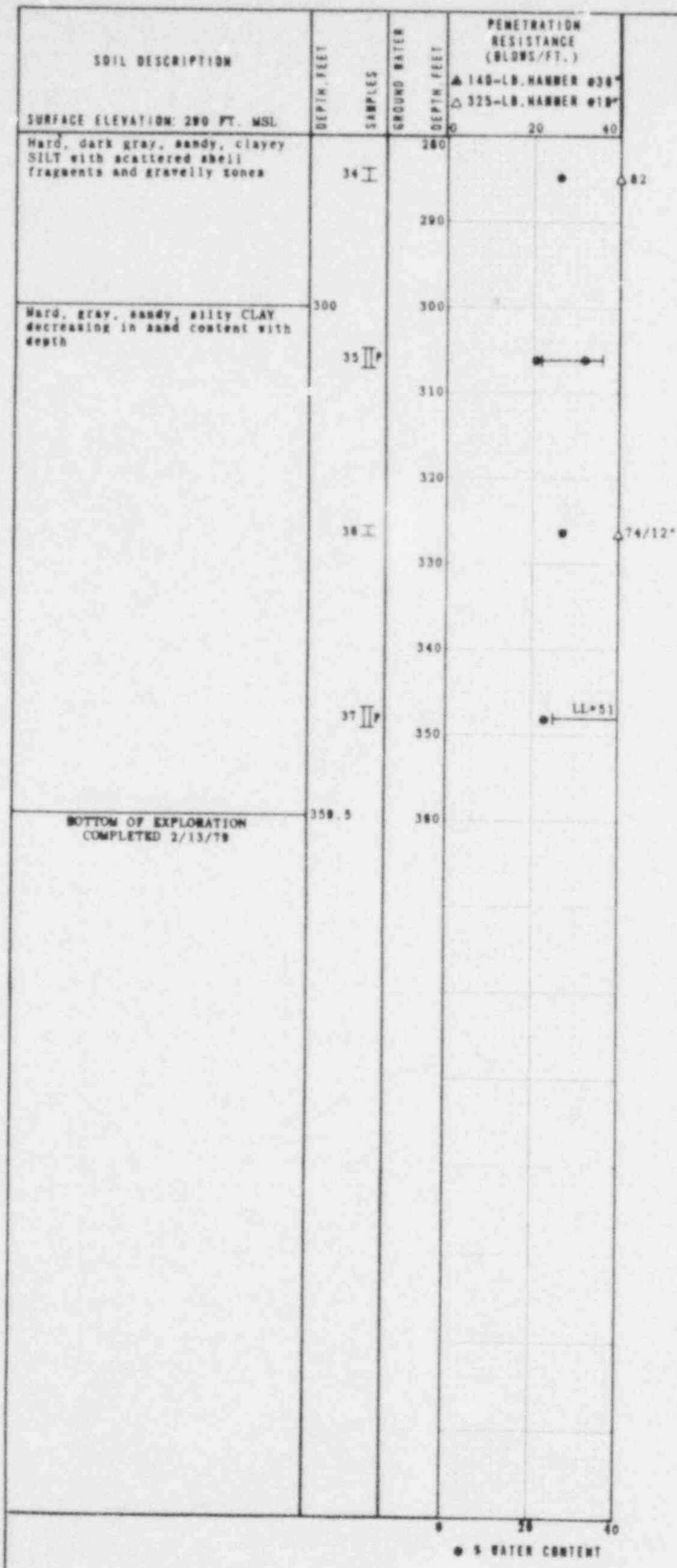
NOTES: 1. THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

2. INFORMATION OF OTHERS (DUKE, et al., 1971) INDICATES THAT THE WATER TABLE IS AT A DEPTH OF ABOUT 40 FEET NEAR THE SITE.

LOG OF BORING B-1
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

POOR ORIGINAL

Sheet 1 of 2 FIG. 21B-2



SURFACE ELEVATION: 290 FT. MSL

Hard, dark gray, sandy, clayey SILT with scattered shell fragments and gravelly zones

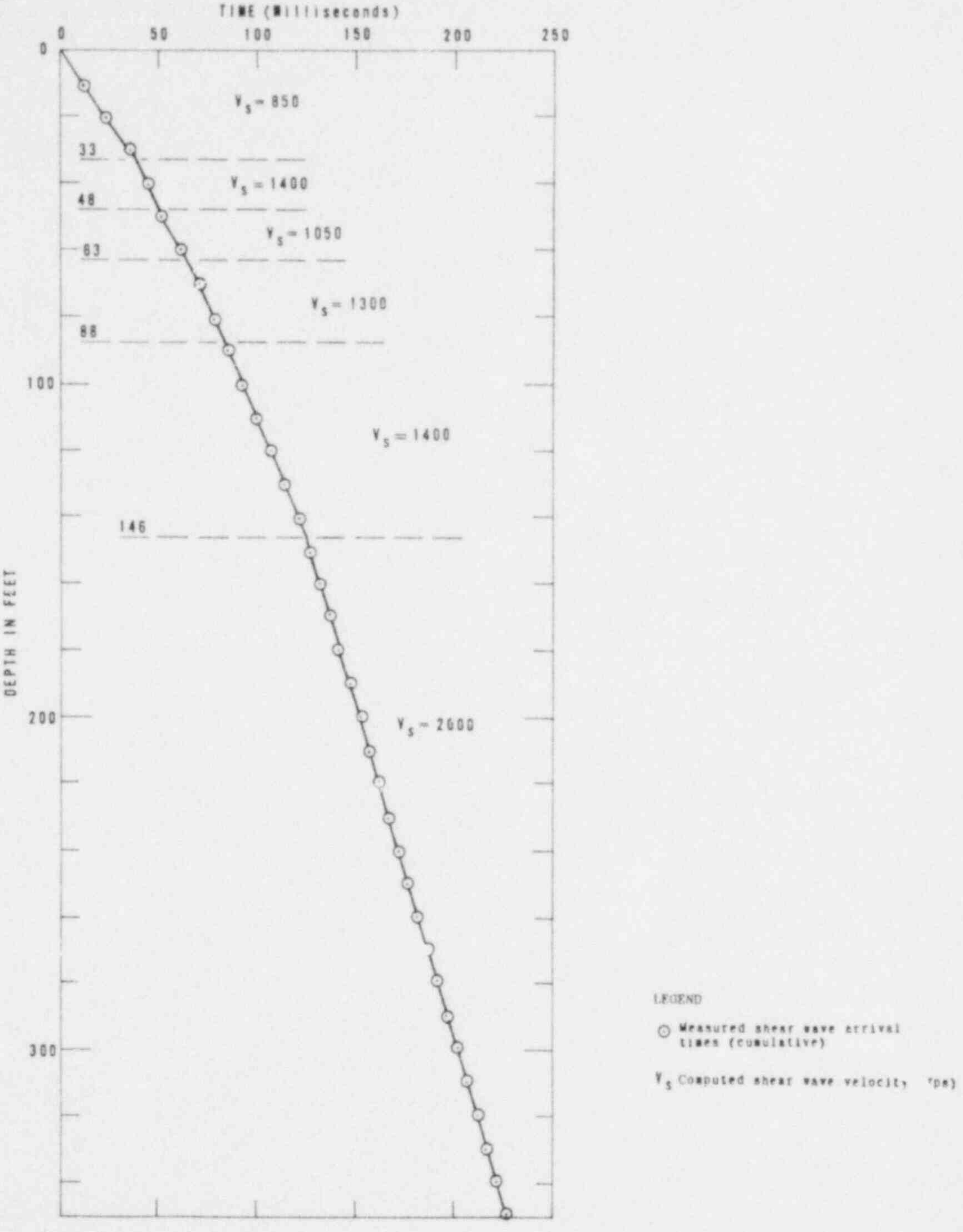
Hard, gray, sandy, silty CLAY decreasing in sand content with depth

BOTTOM OF EXPLORATION
COMPLETED 2/13/79

POOR ORIGINAL

LOG OF BORING B-1
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Sheet 2 of 2 FIG. 21B-2



BORING

Elevation: 290 ft. MSL
Depth: 359.5 ft.
Drilled: February 13, 1979
Misc.: Rotary drilled (mud), cased with 2" PVC for entire hole depth, backfilled with coarse sand

GEOPHYSICAL MEASUREMENTS

Method: Downhole
Depth: 350 ft.
Date: May 23, 1979

WAVE ARRIVAL TIMES
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

POOR ORIGINAL

FIG.21B-3

Section 22B

Noranda Aluminum Plant
New Madrid, Missouri

SECTION 22B

FIELD EXPLORATIONS
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

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SECTION 22B

FIELD EXPLORATIONS
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

DRILLING AND SAMPLING

Subsurface conditions at the Noranda Aluminum Plant were explored with a 329-foot deep boring. This boring, indicated as boring B-1 in Fig. 22B-1, is located approximately 600 feet southwest of the Rectifier/Control building which contains the accelerograph. The ground elevation in the vicinity of the boring is approximately 297 ft. MSL, as determined by hand leveling from a nearby benchmark (Fig. 22B-1). A log of the materials encountered in the boring is presented in Fig. 22B-2.

The boring at the Noranda Aluminum Plant was drilled between May 1 and May 4, 1979, by Test Drilling Service of Maryland Heights, Missouri. A truck-mounted, CME-55 drill rig was used to drill the hole to a depth of 176.5 feet. The upper 29 feet of the boring was drilled using 3¼ inch I.D. hollow-stem auger. Below this depth, the hole was cored using an NX size rotary drill bit and a bentonite slurry to return drill cuttings to the surface. At a depth of 176.5 feet, the CME-55 was removed, and the hole was completed using a Mobile B-80 drill using rotary techniques. Drilling was terminated at a depth of 329 feet, and 2-inch I.D. plastic casing was installed in the boring and grouted in place.

Sampling in boring B-1 was limited to drive samples taken in conjunction with the Standard Penetration Test. Samples were taken at 5 foot intervals to a depth of 100 feet and at 10-foot intervals to a depth of 180 feet. Because of difficulties in operating the drilling equipment, only one drive sample was attempted below a depth of 180 feet. Consequently, the primary bases for logging the material below 180 feet were cutting returns and observed drill action

GEOPHYSICAL TESTING

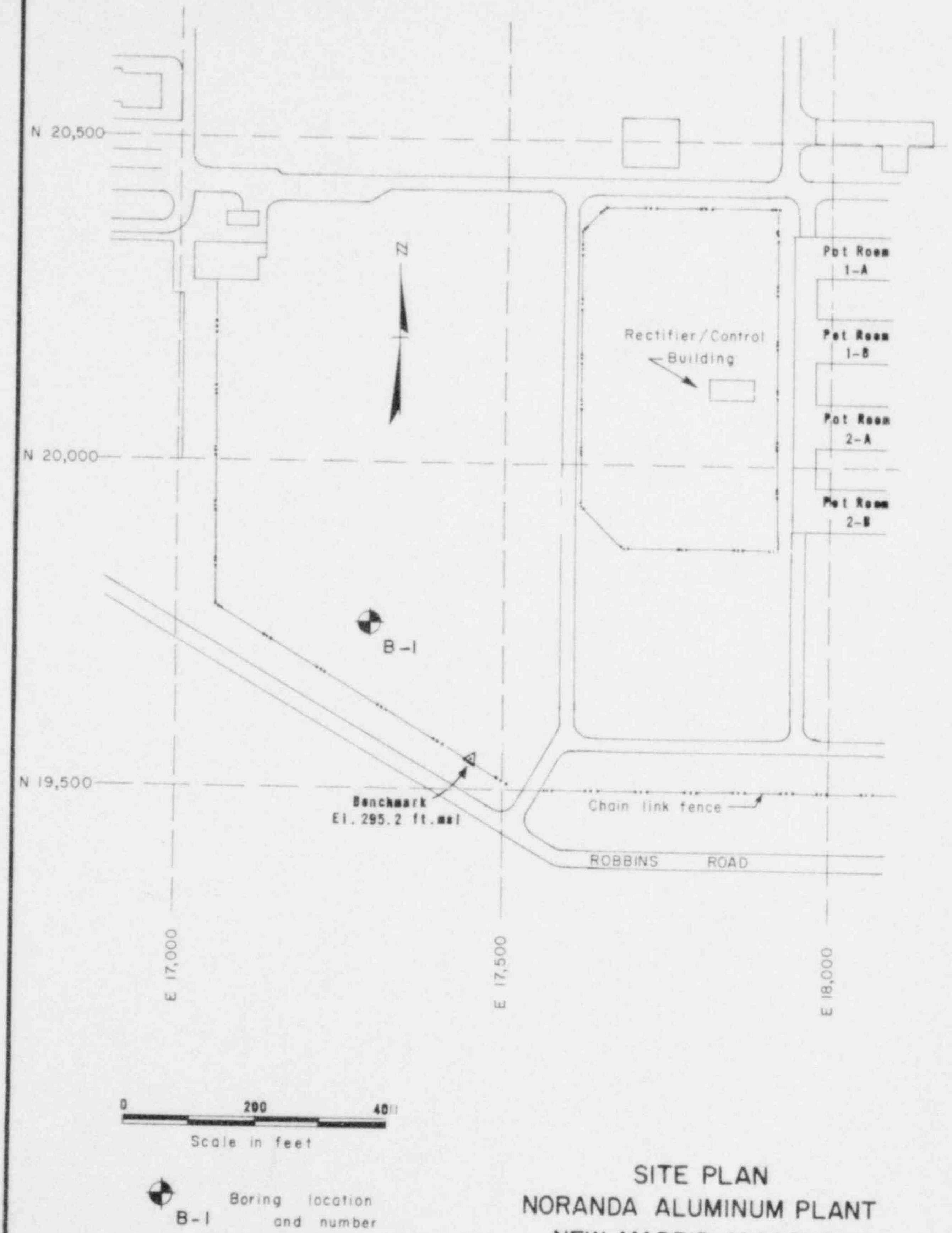
A downhole geophysical survey was performed in boring B-1 by personnel from Shannon & Wilson, Inc., on June 5, 1979. Measurements were made to a total depth of 328 feet. The results are plotted in Fig. 22B-3 in terms of measured shear wave arrival times and computed shear wave velocities. Interval shear wave velocities calculated at each test depth are presented in Table 22B-1.

TABLE 22B-1

INTERVAL SHEAR WAVE VELOCITIES

Noranda Aluminum Plant
New Madrid, Missouri

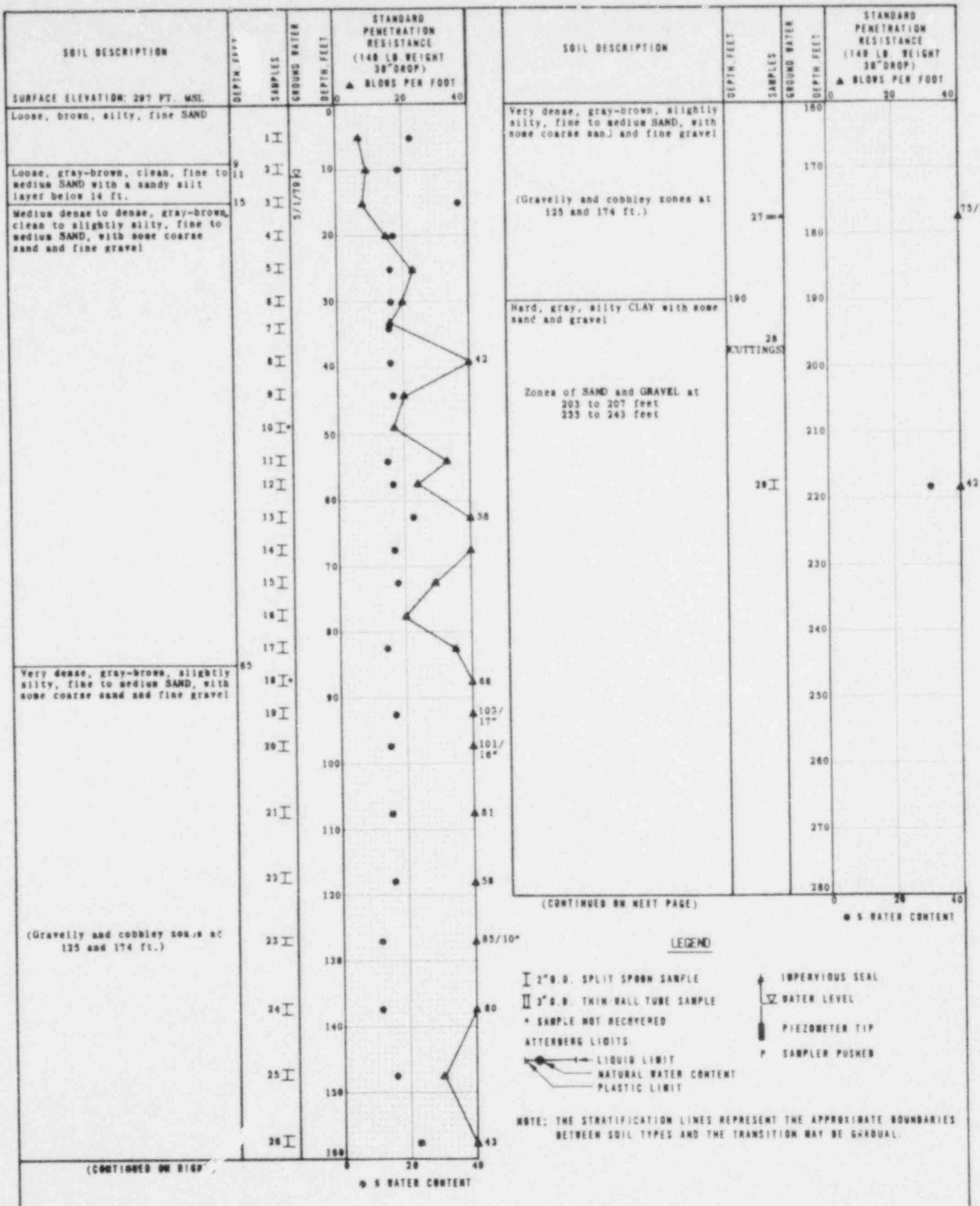
Mean Depth (ft)	Shear Wave Velocity (fps)
5.5	510
10.5	530
15.5	760
23.0	870
33.0	650
43.0	750
53.0	790
63.0	730
73.0	900
83.0	990
93.0	1000
103.0	1000
113.0	1000
123.0	1000
133.0	1000
143.0	1000
153.0	1050
163.0	1110
173.0	1110
183.0	1110
193.0	1110
203.0	1430
213.0	1430
223.0	1430
233.0	1430
243.0	1540
253.0	1670
263.0	1670
273.0	1670
283.0	1670
293.0	1670
303.0	1670
313.0	1670
323.0	1670



SITE PLAN
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

POOR ORIGINAL

FIG. 22B-1



Loose, brown, silty, fine SAND

Loose, gray-brown, clean, fine to medium SAND with a sandy silt layer below 14 ft.

Medium dense to dense, gray-brown, clean to slightly silty, fine to medium SAND, with some coarse sand and fine gravel

Very dense, gray-brown, slightly silty, fine to medium SAND, with some coarse sand and fine gravel

(Gravelly and cobbley zones at 125 and 174 ft.)

(CONTINUED ON RIGHT)

Very dense, gray-brown, slightly silty, fine to medium SAND, with some coarse sanJ and fine gravel

(Gravelly and cobbley zones at 125 and 174 ft.)

Hard, gray, silty CLAY with some sanc and gravel

Zones of SAND and GRAVEL at
203 to 207 feet
233 to 243 feet

(CONTINUED ON NEXT PAGE)

LEGEND

- I 2" O.D. SPLIT SPOON SAMPLE
- II 3" O.D. THIN-WALL TUBE SAMPLE
- * SAMPLE NOT RECOVERED
- ATTERBERG LIMITS
  - LIQUID LIMIT
  - NATURAL WATER CONTENT
  - PLASTIC LIMIT
- IMPERVIOUS SEAL
- ▽ WATER LEVEL
- PIEZOMETER TIP
- P SAMPLER PUSHED

NOTE: THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

POOR ORIGINAL

LOG OF BORING B-1
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

Sheet 1 of 2 FIG. 22B-2

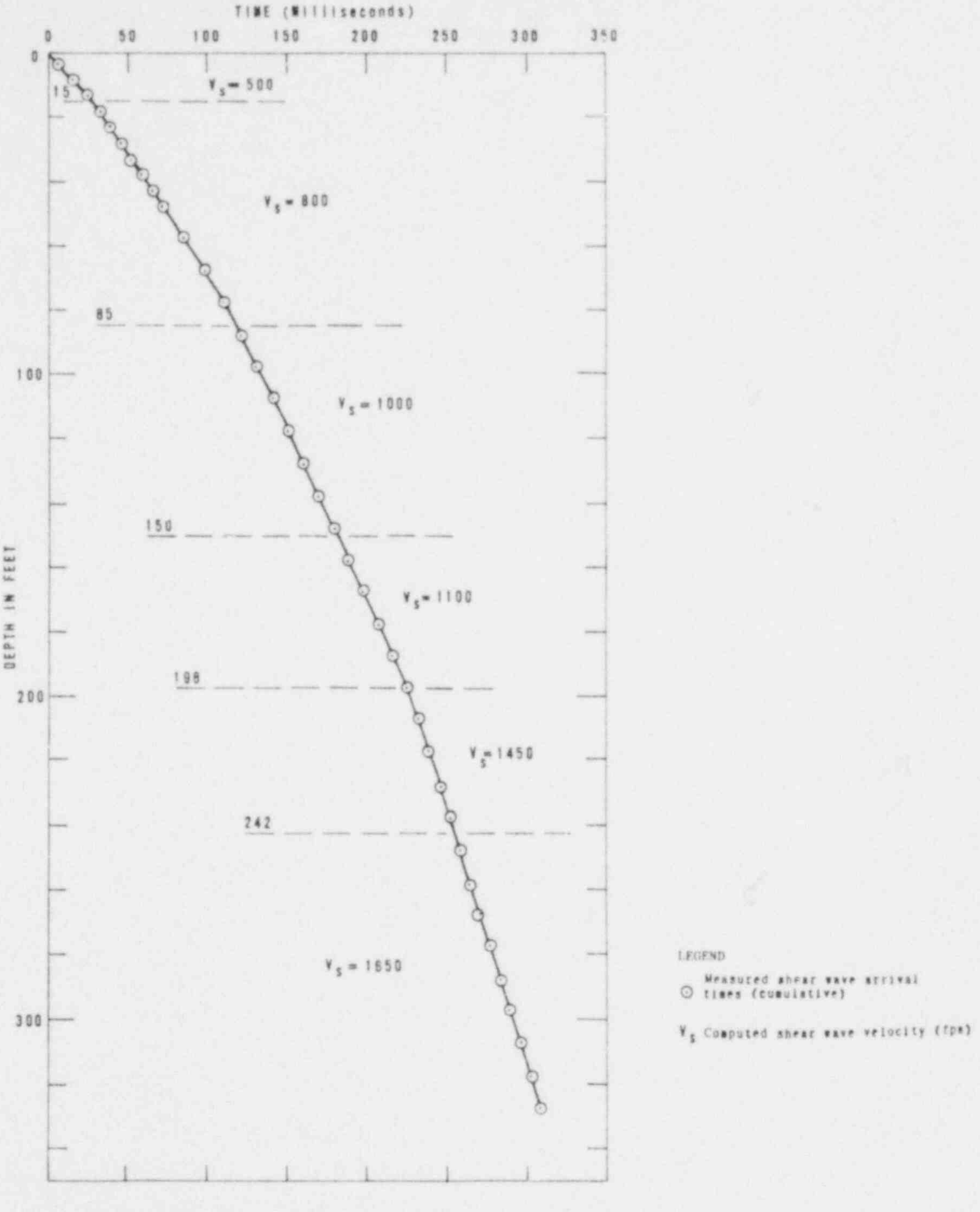
SOIL DESCRIPTION	DEPTH, FEET	SAMPLES	GROUND WATER	DEPTH, FEET	STANDARD PENETRATION RESISTANCE (140 LB WEIGHT 30" DROP) ▲ BLOWS PER FOOT 0 40
Hard, gray, silty CLAY with some sand and gravel		30 [CUTTINGS]		280	
				290	
				300	
				310	
				320	
BOTTOM OF EXPLORATION COMPLETED 5/4/79	329.0			330	

0 20 40
● % WATER CONTENT

POOR ORIGINAL

LOG OF BORING B-1
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

Sheet 2 of 2 FIG. 22B-2



BORING

Elevation: 297 ft. MSL
Depth: 329 ft.
Drilled: May 4, 1979
Misc.: Hollow stem augered to 29 ft., rotary drilled (mud) 29 t^ 329 ft., cased with 2" PVC for entire hole depth, grouted installation

GEOPHYSICAL MEASUREMENTS

Method: Downhole
Depth: 328 ft.
Date: June 5, 1979

WAVE ARRIVAL TIMES
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG. 22B-3

POOR ORIGINAL

APPENDIX C

LABORATORY TESTING

APPENDIX C

LABORATORY TESTING

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APPENDIX C

LABORATORY TESTING

INTRODUCTION

This appendix contains detailed information on laboratory testing procedures and results. The purpose of the laboratory testing was to determine index and engineering properties of selected soil samples obtained in the field.

General information on test procedures is presented below. Except for minor deviations, the laboratory testing procedures generally followed the methods presented in the American Society for Testing and Materials, Annual Book of Standards (ASTM, 1979). Following this discussion are five sections containing tables and figures which present the test results for the individual accelerograph stations (Sections 18C through 22C).

All of the tests described below were not necessarily performed for each accelerograph station. This primarily applies to the testing program for the Fairbanks and New Madrid sites, Sections 18C and 22C, respectively. At both locations, drive samples and drill cuttings were the primary means of obtaining soil samples. Consequently, laboratory testing of these disturbed samples was limited to index tests for material classification and water content.

INDEX TESTS

Index Tests were performed on selected specimens to aid in identifying similar properties and to distinguish between material types. Index tests that were performed in this investigation include visual classifications, water contents, density tests, Atterberg limits, and grain size analyses. Descriptions of these tests and the format of data presentation are discussed below.

Visual Classifications

All samples shipped to the laboratory were visually examined and classified to supplement and check the material descriptions given in the field. All soil samples were classified in general accordance with the ASTM procedure D 2488-69, while classifications for rock samples generally follow recommendations of the ASCE (1972). Dual classifications were given to samples in those instances where the material had properties similar to a soil and where rock "fabric" was discernible in the sample. The resulting material descriptions are contained in the Summary of Laboratory Test Data tables.

Following some of the soil descriptions in the Summary of Laboratory Test Data tables are the two letter group symbols of the Unified Soil Classification System (USC). Where these symbols stand alone, the material classification has been based upon the results of either Atterberg limit tests or grain-size analyses or both. When the group symbols are enclosed in parentheses, the material classification was estimated for the soil.

Water Contents

Natural water contents of selected soil specimens were determined in general accordance with ASTM Procedure D 2216-71. The water content values are presented in the Summary of Laboratory Test Data tables.

Density Tests

Dry unit weights were determined for undisturbed soil samples (tube samples) by the trimmed sample method. All unit weight determinations were performed in conjunction with static and dynamic tests, which will be discussed later. Dry unit weight values are presented in the Summary of Laboratory Test Data tables.

Dry unit weights are determined by the trimmed sample method as follows. First, the top and bottom of the cylindrical specimen are trimmed normal to the longitudinal axis of the sample. Next, the height and diameter of the specimen are measured and the volume calculated. The specimen is then weighed to determine the wet unit weight, and a portion of the sample is used for a water content determination. The dry unit weight is calculated as follows:

$$\text{Dry Unit Weight} = \frac{\text{Wet unit weight}}{1 + (\text{Water content }(\%)/100)}$$

Atterberg Limits

Atterberg limit tests, which consist of liquid and plastic limits, were performed on selected samples of cohesive soils. Liquid limit tests were performed in general accordance with the one-point test method, ASTM D 423-66 (Reapproved 1972). Plastic limit tests follow ASTM D 424-59 (Reapproved 1971). Tests results are presented in the Summary of Laboratory Test Data tables, and plotted on the Plasticity Chart figures.

Grain Size Analyses

Grain size analyses were primarily performed on selected samples of cohesionless soils to check visual classifications made in the field and in the laboratory. These tests were performed in general accordance with the procedures described in the Engineering Manual for Laboratory Soil Testing by the Department of the Army (pages V-1 through V-25). The results of these tests are presented in Grain Size Classification plots which indicate the relative proportioning of particle size of the soil specimen.

TESTS TO DETERMINE ENGINEERING PROPERTIES

Both static and dynamic tests were performed on selected, undisturbed soil samples of the more cohesive units to determine their engineering properties. Static tests consisted of unconfined compression tests and unconsolidated-undrained triaxial compression tests to determine soil shear strength and load-deformation characteristics. Dynamic tests, including resonant column and cyclic triaxial tests, were performed to determine soil modulus and damping characteristics. Both the static and dynamic tests were performed on specimens at their natural water content. Descriptions of these tests and the format of data presentation are discussed below.

Unconfined Compression Tests

Unconfined compression tests were performed in general accordance with ASTM procedure D 2166-66 (Reapproved 1972). Shear strength values determined from these tests (compressive strength/2) are presented in the Summary of Laboratory Test Data tables. Curves indicating the load-deformation characteristics of the samples during these tests are presented in the Unconfined Compression Test figures.

In some instances, specimens were subjected to non-destructive dynamic testing beforehand. This occurred when different specimens from the same tube sample were not available for the individual tests. Such occurrences are noted on the individual Unconfined Compression Test sheets.

Unconsolidated-Undrained Triaxial Compression Tests

Unconsolidated-undrained triaxial compression tests (Q tests) were performed in general accordance with ASTM procedure D 2850-70. In this test, a specimen approximately 2-7/8 inches in diameter and 6 inches in length, is encased in a rubber membrane and placed in a triaxial chamber. The specimen is then subjected to a confining pressure, approximately equal to the effective overburden pressure in the field. The specimen is then loaded to failure by increasing the axial stress (constant confining pressure) while allowing no drainage. Shear strength values determined from these tests (compressive strength/2) are presented in the Summary of Laboratory Test Data tables. Curves indicating the load-deformation characteristics of the samples during these tests are presented in the Unconsolidated-Undrained Triaxial Compression Test figures.

In some instances, specimens were subjected to non-destructive dynamic testing beforehand. This occurred when different specimens from the same tube sample were not available for the individual tests. Such occurrences are noted on the individual Unconsolidated-Undrained Triaxial Compression Test sheets.

Resonant Column Tests

Resonant column tests were performed to determine soil modulus and damping characteristics in the strain range from about 10^{-4} to 10^{-2} percent.

Modulus values were determined from the steady-state, forced vibration response of the specimen. Specifically, the modulus of elasticity (E) was determined from vibration in the axial direction, while shear modulus (G) was determined from vibration in a rotational mode. Damping was determined from the free vibration characteristics of the specimen in either the axial or rotational mode.

The objective of the resonant column test is to excite and observe the behavior of a cylindrical soil specimen. The specimen is tested in an air pressurized chamber. The specimen is vertically oriented between two end caps, with the cap at the base being fixed, and the top cap serving to drive or excite the specimen. Vibrations in either an axial or rotational mode are produced by systems of magnets and coils acting on the top cap. A frequency generator is used to control the amplitude and frequency of the forcing vibration. The response of the specimen is measured using accelerometers attached to the top cap. The output voltage from the accelerometers is displayed on the screen of an oscilloscope. Resonance is attained by varying the frequency of input motion until the specimen response (acceleration) reaches a maximum. The free vibrational characterisitcs of the specimen are observed by cutting off the power to the input motion after resonance has been attained.

The testing procedure is as follows. First, the specimen is placed in the test chamber and subjected to an all around confining pressure, generally taken as the effective overburden stress. The sample is then maintained under this condition until no change is observed in the measured resonant frequency. This consolidation process may be completed in about a day for hard soil samples or it may require several days for soft specimens. When consolidation is completed, the specimen is tested sequentially under forced and free vibration in both the axial and rotational modes. After completing this series of tests, the amplitude of the input motion vibration is increased and the measurements repeated. The sequence is arranged to start testing at low strain levels (low amplitude input motion) then progressively increasing to higher strain levels.

Values of soil moduli and damping determined at different strain levels in this test are tabulated in the Resonant Column Test figures and in the Summary of Dynamic Test Results tables.

Cyclic Triaxial Tests

Cyclic triaxial tests were performed to determine soil modulus and damping characteristics in the strain range from about 10^{-2} to 1 percent.

The objective of the cyclic triaxial test is to observe specimen behavior under repeated axial loading. Testing is performed in a triaxial chamber that has been modified to include a pair of pneumatically actuated belloframs which apply the cyclic axial load. The magnitude and duration of the applied load are controlled with a waveform generator. Generally, stress controlled tests are performed in which the applied load follows a sine wave pattern at a frequency of 1 Hz. Loading is usually applied for 8 to 10 cycles. System response, including applied loading and sample deformation, is recorded on a strip chart recorder. Generally the records from the fourth loading cycle in each test are used to compute the stress-strain behavior of the specimen.

The testing procedure consists of the following. First, the specimen is placed in the test chamber and subjected to an all around confining pressure, generally taken as the effective overburden stress. The sample is maintained in this state until primary consolidation is completed, which may require about a day for hard soil specimens and possibly several days for soft specimens. The sample is then tested after consolidation is completed. Testing is first accomplished at low strain levels (low amplitude input motion) then progressively increasing to higher strain levels. Generally a set of cyclic triaxial data consists of tests run at three different strain levels.

Hysteresis loops of axial stress and strain of the specimen are presented in the Cyclic Triaxial Test figures. Values of modulus of elasticity and soil damping, determined from the hysteresis loops (procedures in SW-AJA, 1972), are also indicated on these figures. In some instances the specimens were subjected to non-destructive, resonant column testing beforehand. This occurred when different specimens from the same tube sample were not available for the individual tests. Such occurrences are noted on the individual Cyclic Triaxial Test figures.

Shear moduli and strain values were computed from the results of the cyclic triaxial tests and are presented in the Summary of Dynamic Test Results tables.

Section 18C

UA Duckering Hall
Fairbanks, Alaska

SECTION 18C
LABORATORY TESTING
UA DUCKERING HALL
FAIRBANKS, ALASKA

LIST OF TABLES

TABLE 18C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler¹ or Blows/6"	Shear Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits LL	PL	PI	Other Tests	Sample Classification
B-1	S-1	2.5-4.5	Shelby			8.9					Top 1.5': Brown, fine sandy clayey SILT; numerous roots, organics and occasional quartz and schist fragment.
						7.1					Bottom 0.5': Yellow to orange-brown clayey silty fine SAND, micaceous; scattered quartz and schist fragments.
	S-2	7.5-9.0	11,15, 16[a]			8.6					Dense, yellow-brown, fine sandy SILT, micaceous; slightly clayey, laminated, dipping at about 30°. (Mica SCHIST: very soft, very severely weathered, very thinly foliated)
	S-3	12.5-14.0	47,42, 47[a]			5.4					Same as S-2, except very dense.
	S-4	17.5-19.0	65,81, 51[b]			5.4					Same as S-2, except very dense and containing occasional thin layers of quartz.
	S-5	37.5-38.2	17,25[c] 3"			1.2					Mica SCHIST: Moderately hard, gray-brown, moderately weathered, very thinly foliated with some quartz lenses and graphite.
	S-6	45.0 ±	Cuttings			1.2					Same as S-5.
	S-7	57.5-57.9	50[c] 4-1/2"			4.1					Mica SCHIST: Soft, light brown, severely weathered, very thinly foliated, bedding planes dipping at about 30-40°; occasional thin lenses of quartz. (Slough?)
	S-8	77.5-77.8	50[c] 3"			3.6					Same as S-7.
	S-9	122.5- 122.5	20/0"[c]			-					No Recovery.
	S-10	125.0 ±	Cuttings			11.3					Gray-brown, clayey, silty, fine SAND; occasional quartz and schist fragments.
	S-11	154.0 ±	Cuttings			-					Insufficient Sample

Notes:

1. Drive samples were taken with the following equipment:
   - a) 140-lb. hammer dropped 30 inches driving 2" O.D. split spoon.
   - b) 340-lb. hammer dropped 30 inches driving 3" O.D. split spoon.
   - c) 340-lb. hammer dropped 30 inches driving 2" O.D. split spoon.

POOR ORIGINAL

Section 19C

General Store
Petrolia, California

SECTION 19C
LABORATORY TESTING
GENERAL STORE
PETROLIA, CALIFORNIA

LIST OF TABLES

LIST OF FIGURES

TABLE 19C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler¹ or Blows/6"	Shear² Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits LL	PL	PI	Other³ Tests	Sample Classification
B-1	S-1	5.0-6.5	1,3,4			37.8					Medium stiff, mottled gray-brown, silty CLAY; iron oxide stains.
	S-2	10.0-12.5	Pitcher	1.1^u	112.8	16.5				RC,CT,MA	Very dense, mottled, gray-brown, silty, fine gravelly, fine to coarse SAND; iron oxide stains. SM.
	S-3	15.0-16.5	13,28, 32			10.6					Very dense, mottled gray-brown, clayey, silty, fine gravelly, fine to coarse SAND.
	S-4	20.0-21.5	19,45, 38			11.2				MA	Very dense, gray, silty, fine gravelly, fine to coarse SAND. SM.
	S-5	25.0-26.5	29,32, 39			11.7					Very dense, gray, clayey, silty, fine to medium SAND; trace of coarse sand and fine gravel; fragments of cemented silty sand.
	S-6	30.0-31.8	Shelby	2.1^u	102.0 102.6	24.9 20.8	32	21	11	 RC,CT	Very stiff, dark gray, fine sandy, silty CLAY; numerous wood fragments. CL.
	S-7	35.0-35.5	50/6"			10.7					Very dense, gray, clayey, silty, fine to coarse sandy, fine GRAVEL.
	S-8	36.5-39.5	Cuttings			27.2					Stiff to very stiff, gray, silty CLAY; trace of fine to coarse sand.
	S-9	40.0-40.8	42,50/3"			15.6					Very hard, gray, sandy, silty CLAY; trace of fine to coarse gravel.
	S-10	45.0-45.5	50/6"			14.3				Composite MA	Very dense, gray, slightly clayey, silty, fine gravelly, fine to coarse SAND; trace of coarse gravel. SM.
	S-11	50.0-50.2	50/3"			-					Insufficient Sample for classification. SM.
	S-12	55.0-55.8	35,50/4"			10.2					Very dense, gray, slightly clayey, silty, fine to coarse gravelly, fine to coarse SAND. SM.
	S-13	62.0-62.8	Pitcher			7.0					Hard, dark gray, silty CLAY, highly, fractured and slickensided; trace calcite lenses. (SILTSTONE: Very soft, dark gray, highly fractured with slickensides).
	S-14	67.0-68.1	Pitcher			10.0	27	17	10		Same as S-13, except large calcite lenses. CL.
	S-15	72.0-73.8	Pitcher			7.7					Same as S-13.
	S-16	77.0-78.6	Pitcher			6.6					Same as S-13
	S-17	82.0-82.8	Pitcher			6.4					Same as S-13.
	S-18	87.0-87.8	Pitcher			8.7					Same as S-13.
	S-19	92.0-97.0	Core			6.0	28	13	15		Same as S-1 CL.
	S-20	107.0-107.5	Pitcher			10.1					Same as S-1, except large lense of very dense, gray, fine to medium sand (SANDSTONE)

Sheet 1 of 2

POOR ORIGINAL

TABLE 19C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler[1] or Blows/6"	Shear[2] Strength TSF	Dry Density pcf	Water Content, %	Atterberg Limits LL	PL	PI	Other[3] Tests	Sample Classification
B-1 (Cont'd)	S-21	117.0-118.2	Core			-					No Recovery.
	S-22	122.0-123.3	Pitcher			5.9					Same as S-13.
	S-23	132.0-132.9	Pitcher			5.2	27	15	12		Same as S-13. CL.
	S-24	142.0-142.7	Pitcher			-					Same as S-13.
	S-25	152.0-153.3	Pitcher			6.2					Same as S-13.
	S-26	162.0-163.1	Pitcher			6.4					Same as S-13.
	S-27	172.0-172.5	Pitcher			8.8					Same as S-13, except large lense of very dense, gray, fine to medium sand (SANDSTONE).
	S-28	179.0-180.3	Pitcher			6.0	31	14	17		Same as S-13, except large lense of very dense, gray, fine to medium sand (SANDSTONE). CL.

Notes:

1. Drive sample blow count obtained in conjunction with the Standard Penetration Test (SPT).

2. Shear strengths denoted by "u" were determined from unconsolidated-undrained triaxial compression tests.

3. Legend for Tests:

Symbol	Explanation
MA	Mechanical Analysis
RC	Resonant Column Test
CT	Cyclic Triaxial Test

Sheet 2 of 2

POOR ORIGINAL

TABLE 19C-2

SUMMARY OF DYNAMIC TEST RESULTS

Boring B-1
General Store
Petrolia, California

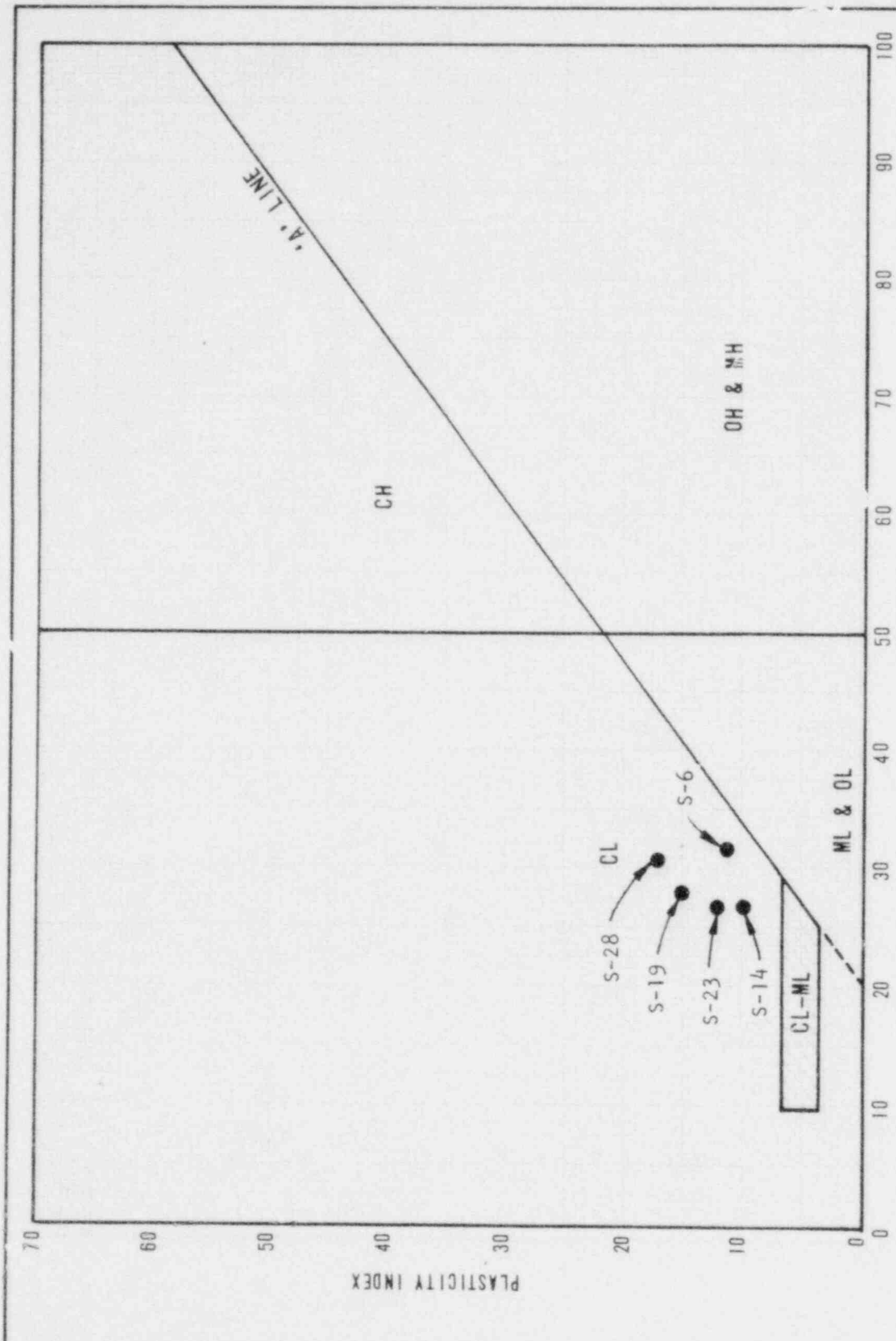
Sample	Depth ft.	Specimen Height in.	Specimen Diameter in.	Water Content %	Wet Unit Weight pcf	$\bar{\sigma}_3$ psi	Resonant Column G psi	Resonant Column γ %	Resonant Column λ %	Cyclic Triaxial G* psi	Cyclic Triaxial γ* %	Cyclic Triaxial λ %	Classification
S-2	10.0- 12.5	5.98	2.88	16.5	131.4	10	8040	5.3×10^{-4}	6.4	4290	3.2×10^{-2}	13.4	Mottled gray-brown, silty, gravelly SAND
							6360	3.3×10^{-3}	6.1	3100	7.1×10^{-2}	13.5	
							2510	3.6×10^{-2}	12.5	1232	0. 8	15.4	
S-6	30.0- 31.8	5.97	2.88	20.8	123.9	20	8990	4.3×10^{-4}	1.9	5780	2.1×10^{-2}	13.1	Dark gray, sandy, silty CLAY
							8140	2.4×10^{-3}	2.4	4210	5.5×10^{-2}	11.1	
							5270	1.6×10^{-2}	5.8	3480	0.13	12.8	
							3700	3.8×1^{-2}	4.9				

NOTES:

$\bar{\sigma}_3$	Effective Confining Pressure	$G^* = (E/2(1+\mu))$
G	Shear Modulus	$\gamma^* = (1+\mu)\epsilon$
γ, γ*	Single Amplitude Shear Strain	where:
λ	Damping	

E = Modulus of Elasticity
ε = Single Amplitude Axial Strain
μ = Poisson's Ratio (estimated at 0.4)

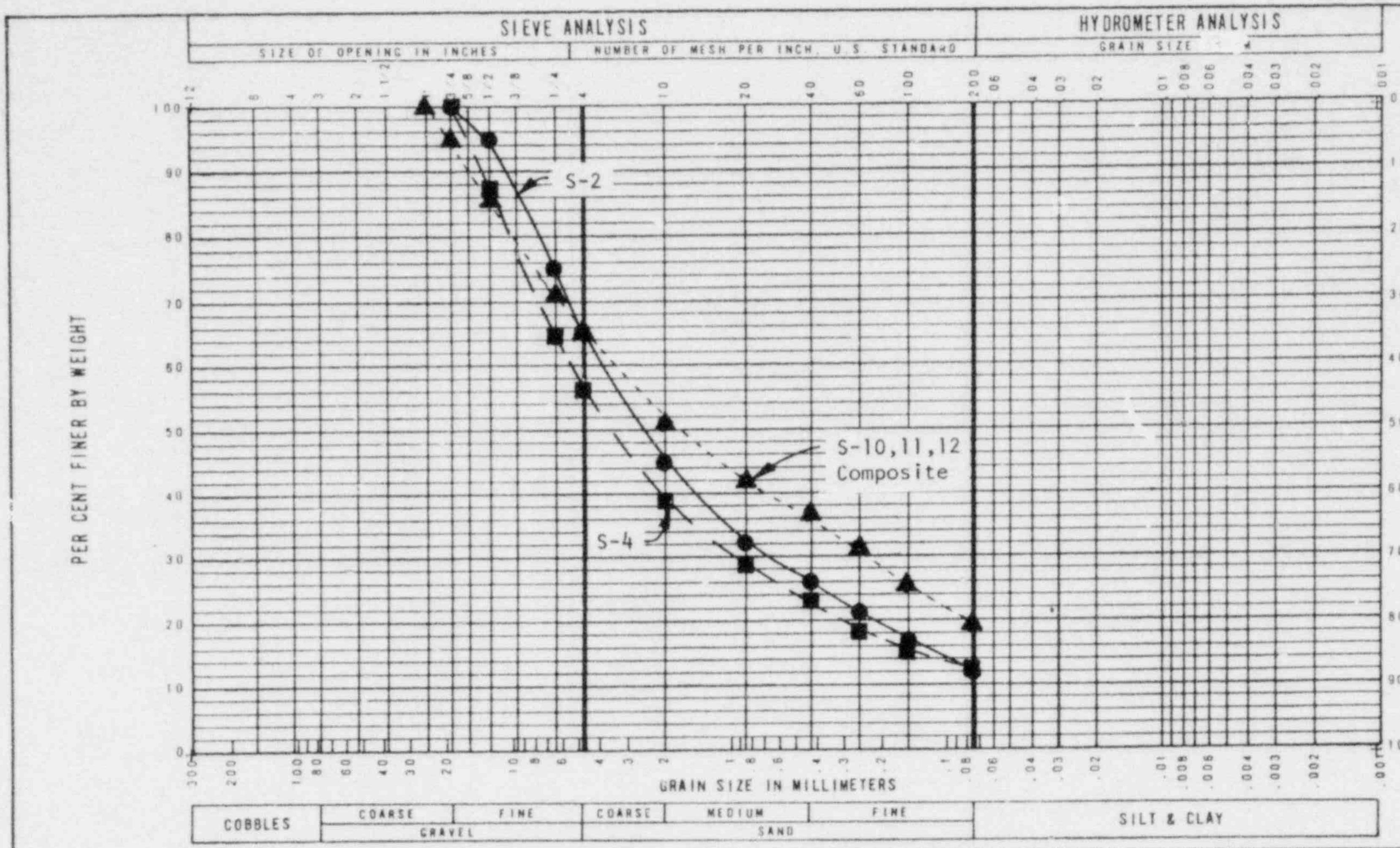
POOR ORIGINAL



PLASTICITY CHART
BORING B-1
GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19C-1

Drawn Jam Checked PMB Approved______ Revised______ Approved______
Date 4-23-79 Date 4/25/79 Date______ Date______ Date______



SAMPLE NO	DEPTH-FT	U.S.C.	CLASSIFICATION	G_S	NAT W.C. %	LL	PL	PI
S-2	10.0-12.5	SM	Gray-brown, silty, gravelly SAND		16.5			
S-4	20.0-21.5	SM	Gray, silty, gravelly SAND		11.2			
S-10, 11,12	45.0-55.8	SM	Gray, silty, gravelly SAND					

GRAIN SIZE CLASSIFICATION

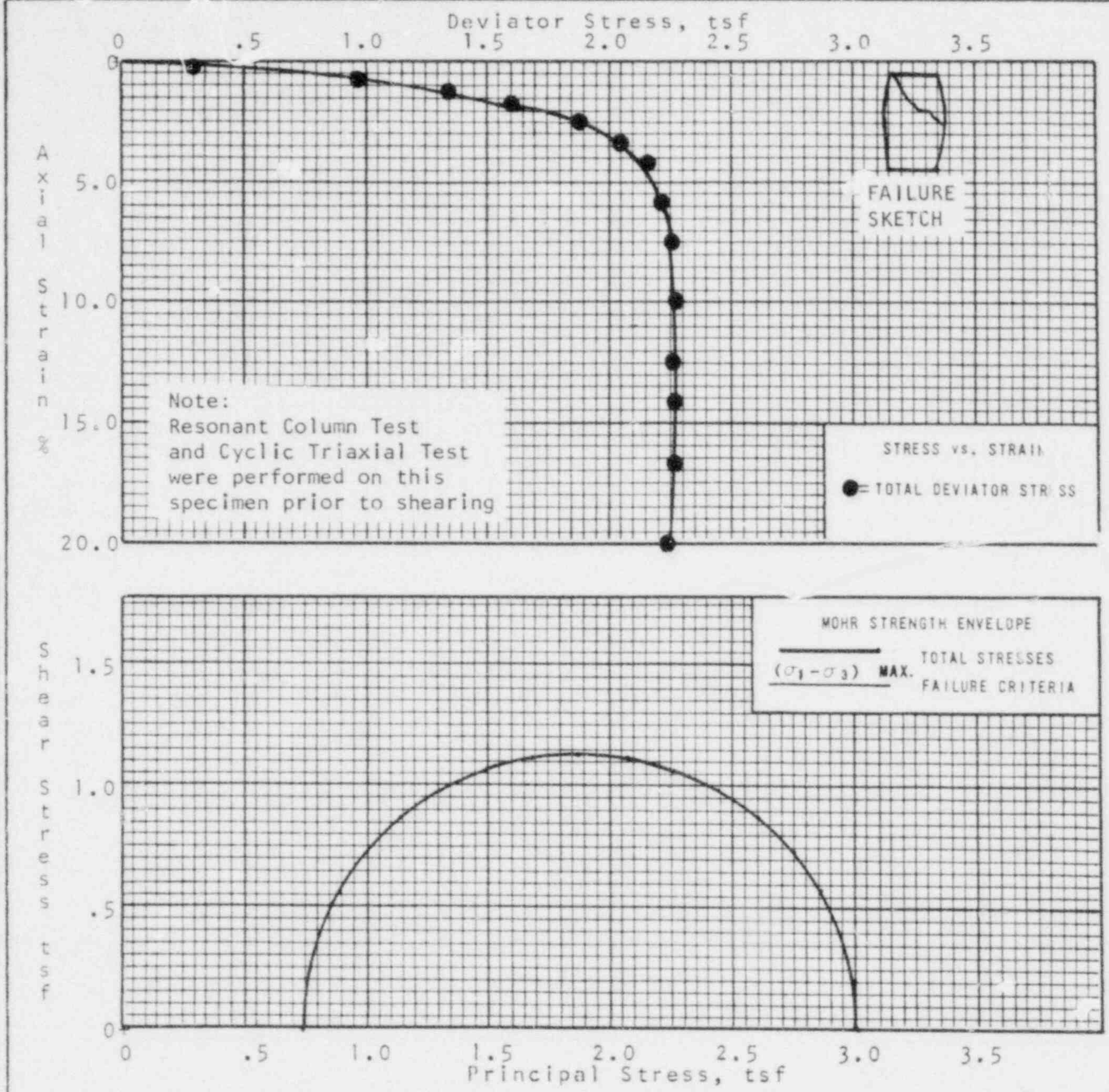
Boring B-1

GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19C-2

Drawn Lem Checked ______ Approved ______ Revised ______ Approved ______

Date 4-25-79 Date ______ Date ______ Date ______ Date ______



Test No.	UU-101
Boring No.	B-1
Sample No.	S-2
Confining Pressure, tsf	.72
Ht., in.	5.98
Dia., in.	2.88
Ht./Dia. Ratio	2.07
Wet Unit Wt., pcf	131.4
Water Content, %	
Before Test	16.5
After Test	16.5
Degree of Saturation, %	90.3
Avg. % Strain/Min.	.666

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION

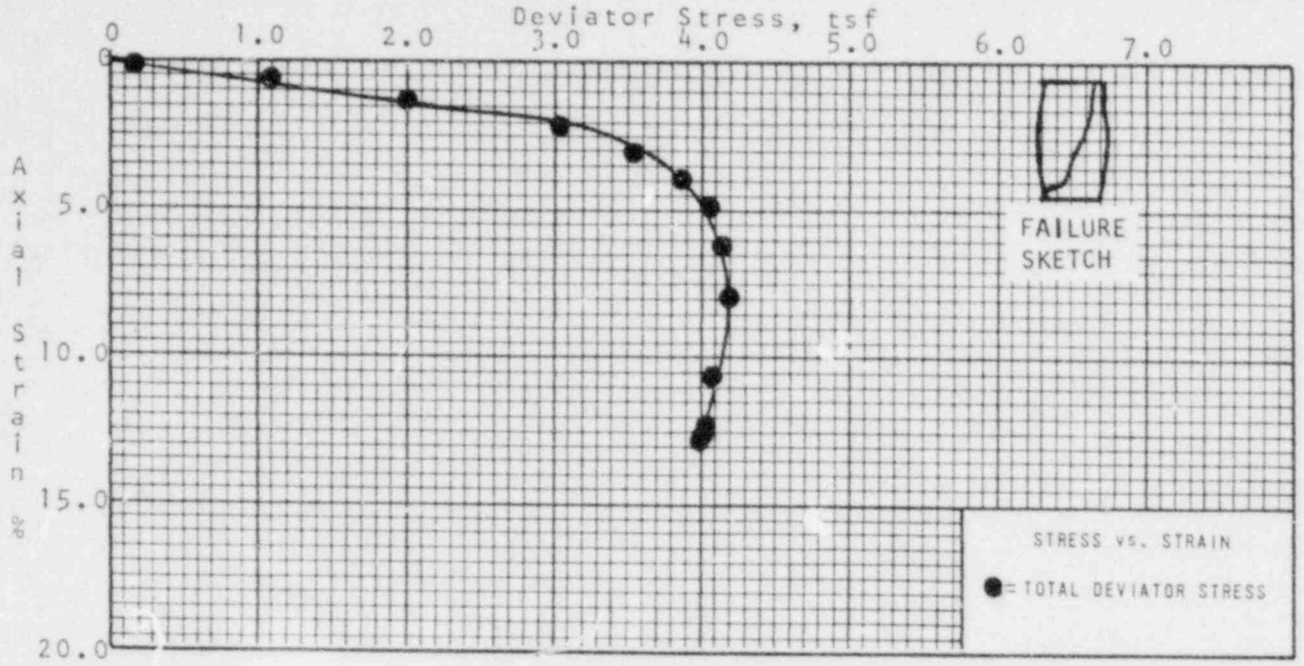
Mottled gray-brown, silty, gravelly SAND

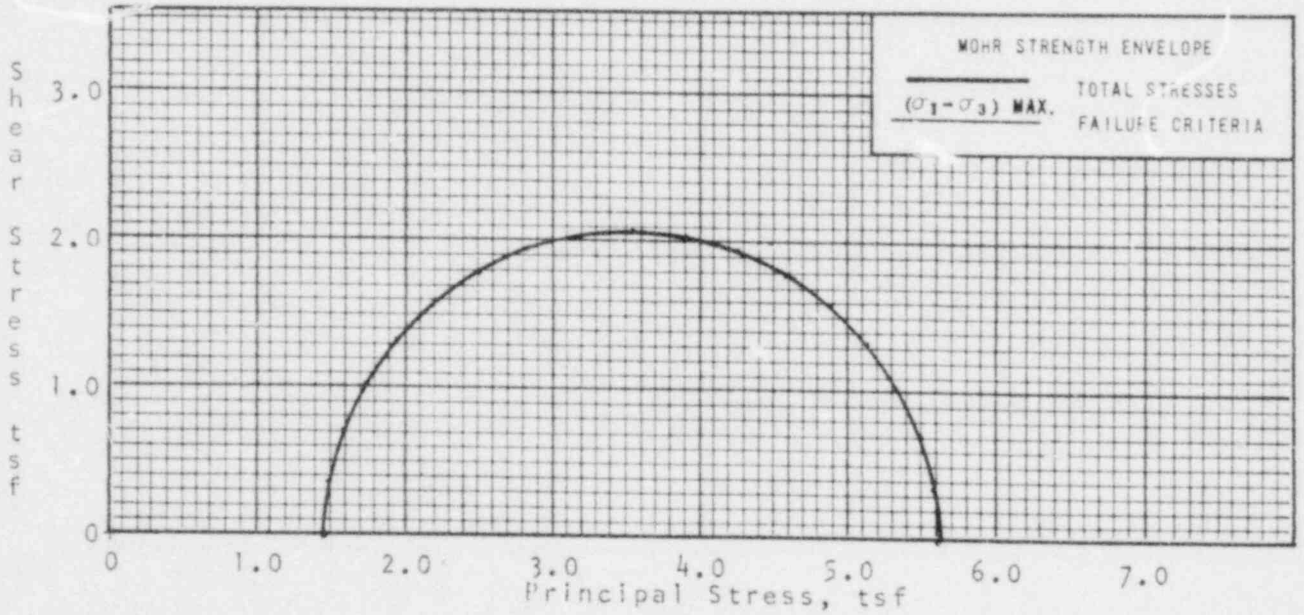
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 2
Depth 10.0 -12.5 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19C-3





Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 6
Confining Pressure, tsf	1.44
Ht., in.	5.72
Dia., in.	2.88
Ht./Dia. Ratio	1.98
Wet Unit Wt., pcf	127.4
Water Content, %	
Before Test	24.9
After Test	24.5
Degree of Saturation, %	100.0
Avg. % Strain/Min.	.574

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION

Dark gray, sandy silty CLAY

UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 6
Depth 30.0 -31.8 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn ____ Date 4-25-79
Checked ____ Date ____
Approved ____ Date ____
Revised ____ Date ____
Approved ____ Date ____

FIG. 19C-4

Modulus, psi		Single Amplitude Strain, %		Damping, %	
Shear, G	Elastic, E	Torsional	Longitudinal	Torsional	Longitudinal
8040		5.4×10^{-4}		6.4	
6360		3.3×10^{-3}		6.1	
2510		3.6×10^{-2}		12.5	
	25,300		1.5×10^{-5}		5.8
	24,050		7.8×10^{-4}		6.0
	17,000		3.3×10^{-3}		8.3

Specimen Data

Height	5.98 in
Diameter	2.88 in
Wet Unit Weight	131.4 pcf
Water Content	16.5 %
Degree of Saturation	90.3 %
Effective Confining Pressure	10 psi

Classification:

Mottled gray-brown, silty
gravelly SAND

RESONANT COLUMN TEST

Boring B- 1
Sample S- 2
Depth 10.0-12.5 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19C-5

Modulus, psi		Single Amplitude Strain, %		Damping, %	
Shear, G	Elastic, E	Torsional	Longitudinal	Torsional	Longitudinal
8990		4.3×10^{-4}		1.9	
8140		2.4×10^{-3}		2.4	
5270		1.6×10^{-2}		5.8	
3700		3.8×10^{-2}		4.9	
	25,400		1.2×10^{-4}		2.2
	24,900		6.6×10^{-4}		3.0
	22,500		2.7×10^{-3}		3.5
	18,100		5.4×10^{-3}		8.2

Specimen Data

Height	5.968	in
Diameter	2.876	in
Wet Unit Weight	123.9	pcf
Water Content	20.8	%
Degree of Saturation	83	%
Effective Confining Pressure	20	psi

Classification:

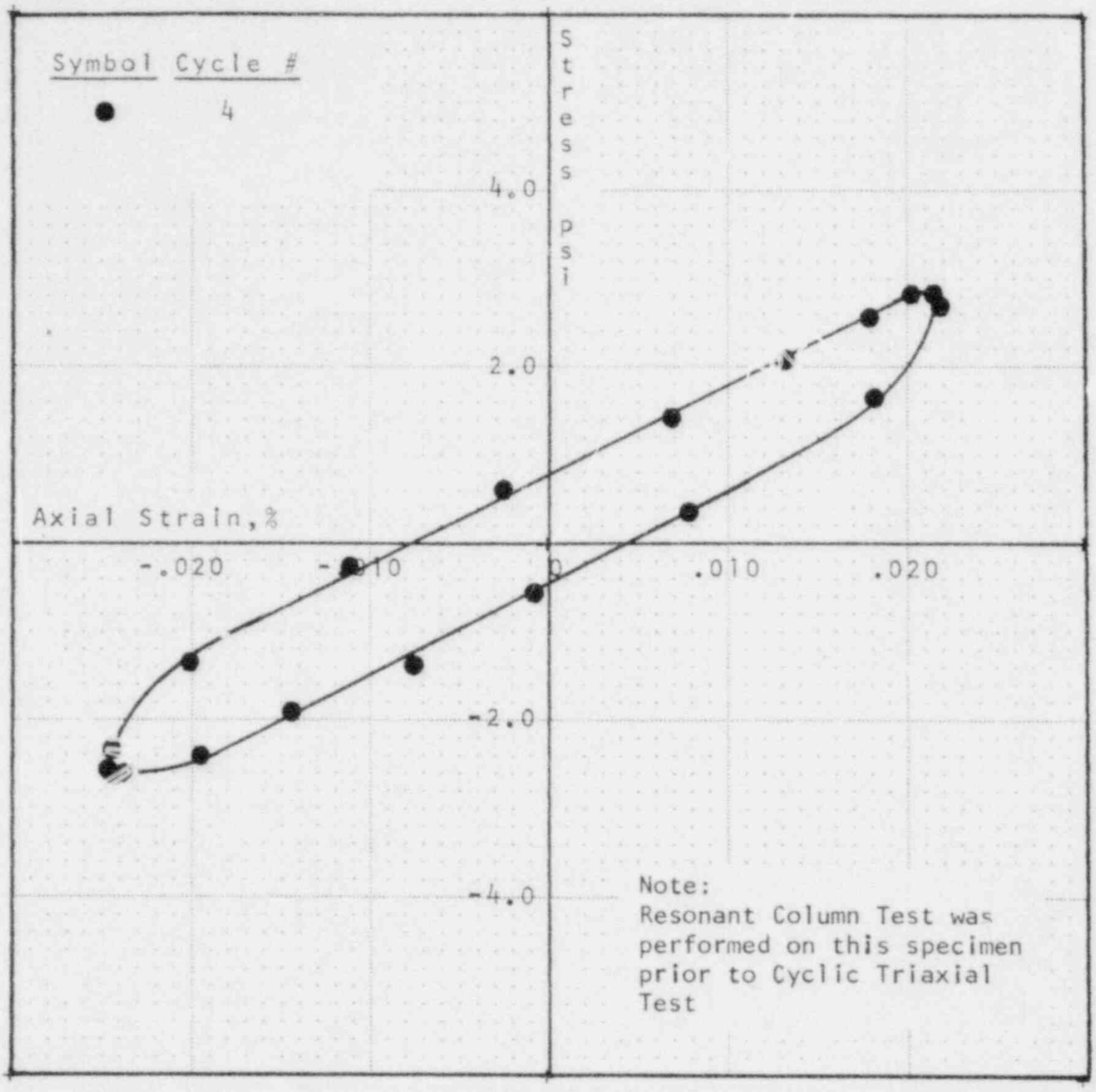
Dark gray, sandy silty CLAY

RESONANT COLUMN TEST

Boring B-1
Sample S-6
Depth 30.0-31.8 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

FIG. 19C-6



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	10.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.98 in.
Diameter	2.88 in.
Wet Unit Wt.	131.4 pcf
Water Content	
Before Test	16.5 %
After Test	16.5 %
Degree of Saturation	90.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	12020 psi
Damping	13.4 %
Double Amp. Strain	.0459 %

Classification:

Mottled, gray-brown silty gravelly SAND

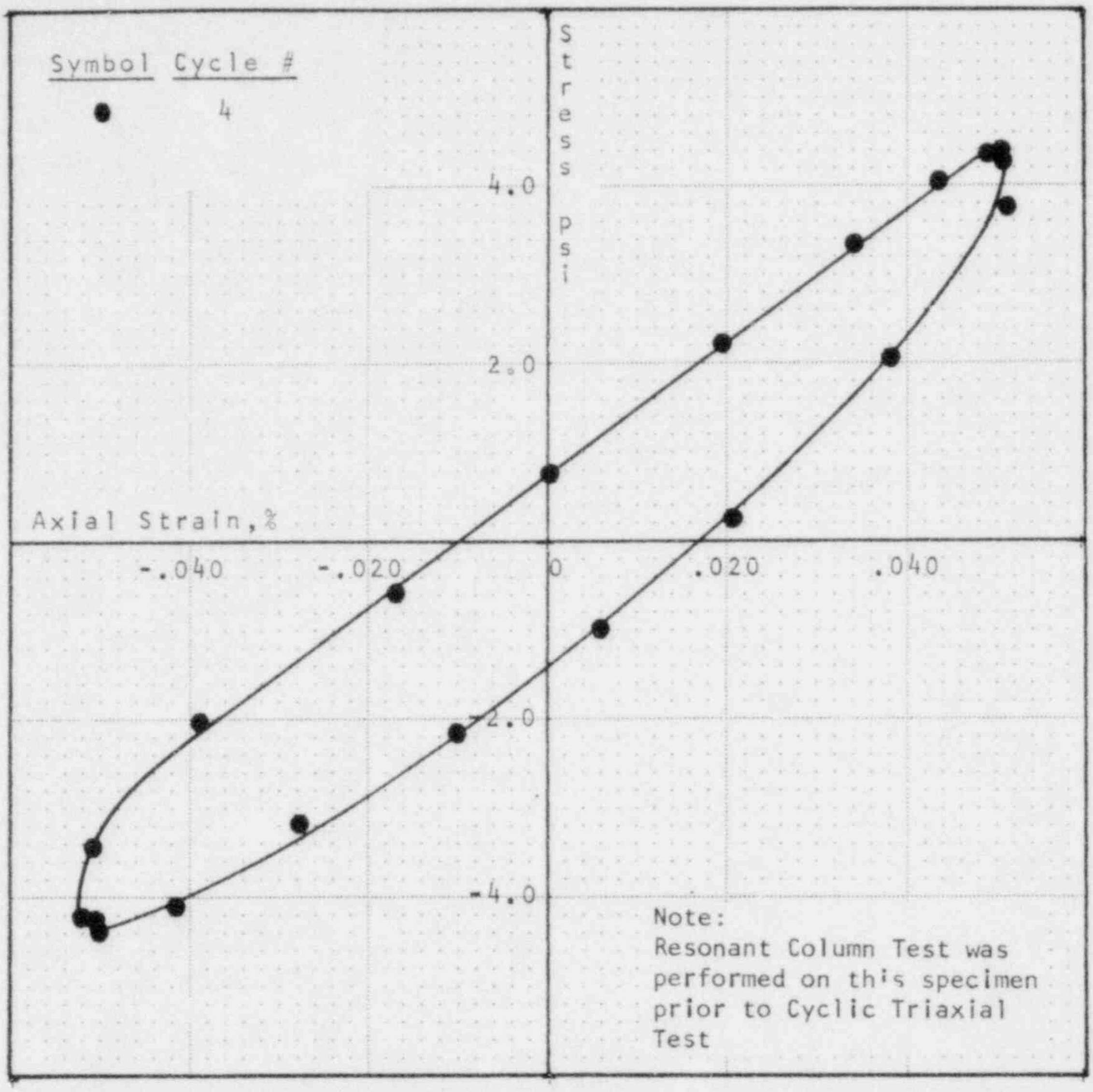
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 2
Depth 10.0 -12.5 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn JAM Checked ______ Approved ______ Revised ______ Approved ______
Date 4-25-79 Date ______ Date ______ Date ______ Date ______

FIG. 19C-7



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	10.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.98 in.
Diameter	2.88 in.
Wet Unit Wt.	131.4 pcf
Water Content	
Before Test	16.5 %
After Test	16.5 %
Degree of Saturation	90.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	8680 psi
Damping	13.5 %
Double Amp. Strain	.1012 %

Classification:

Mottled, gray-brown, silty gravelly SAND

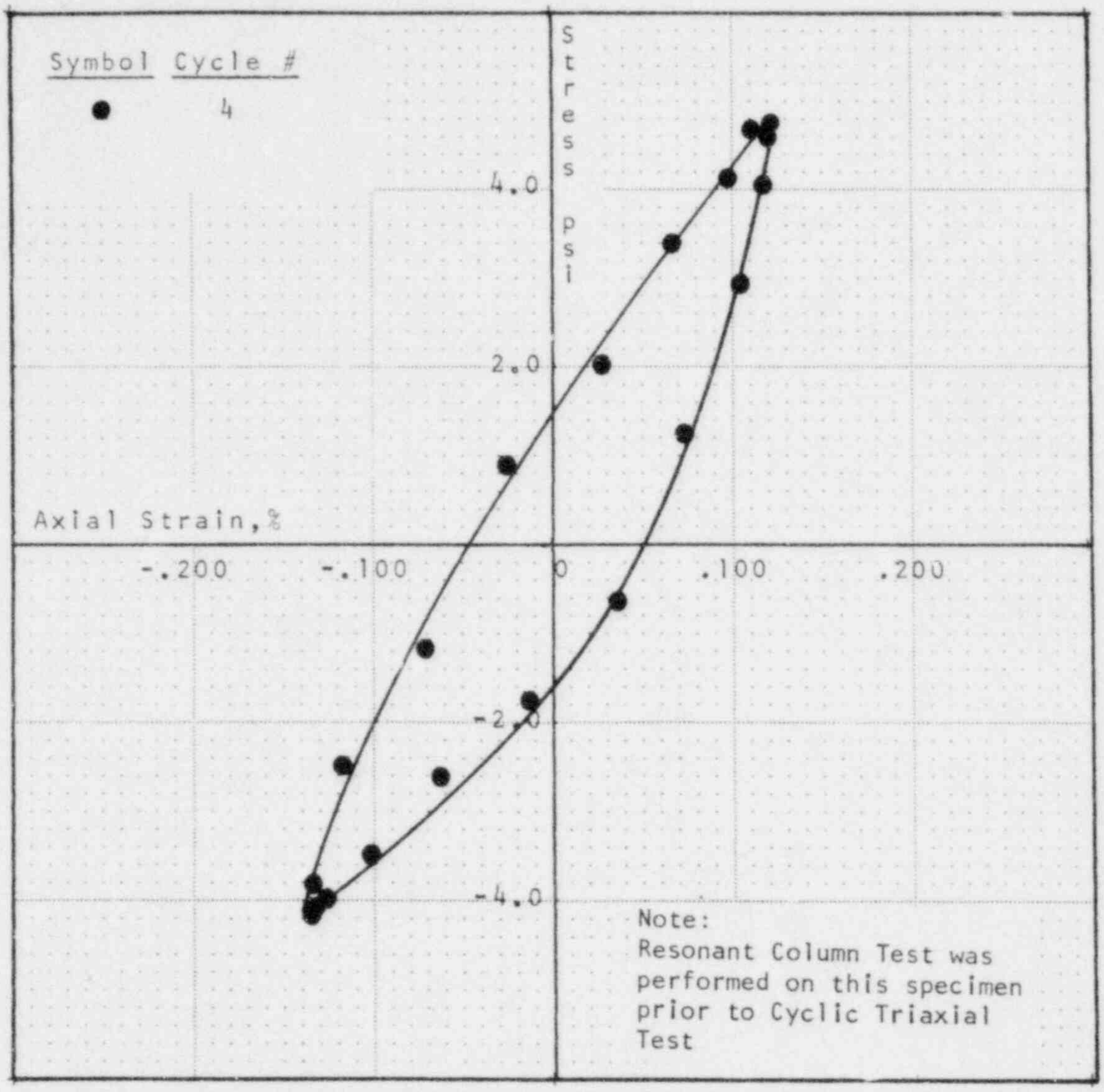
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 2
Depth 10.0 -12.5 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn Sam Checked____ Approved____ Revised____ Approved____
Date 4-25-79 Date____ Date____ Date____ Date____

FIG. 19C-8



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	10.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.98 in.
Diameter	2.88 in.
Wet Unit Wt.	131.4 pcf
Water Content	
Before Test	16.5 %
After Test	16.5 %
Degree of Saturation	90.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	3450 psi
Damping	15.4 %
Double Amp. Strain	.2570 %

Classification:

Mottled, gray-brown, silty gravelly SAND

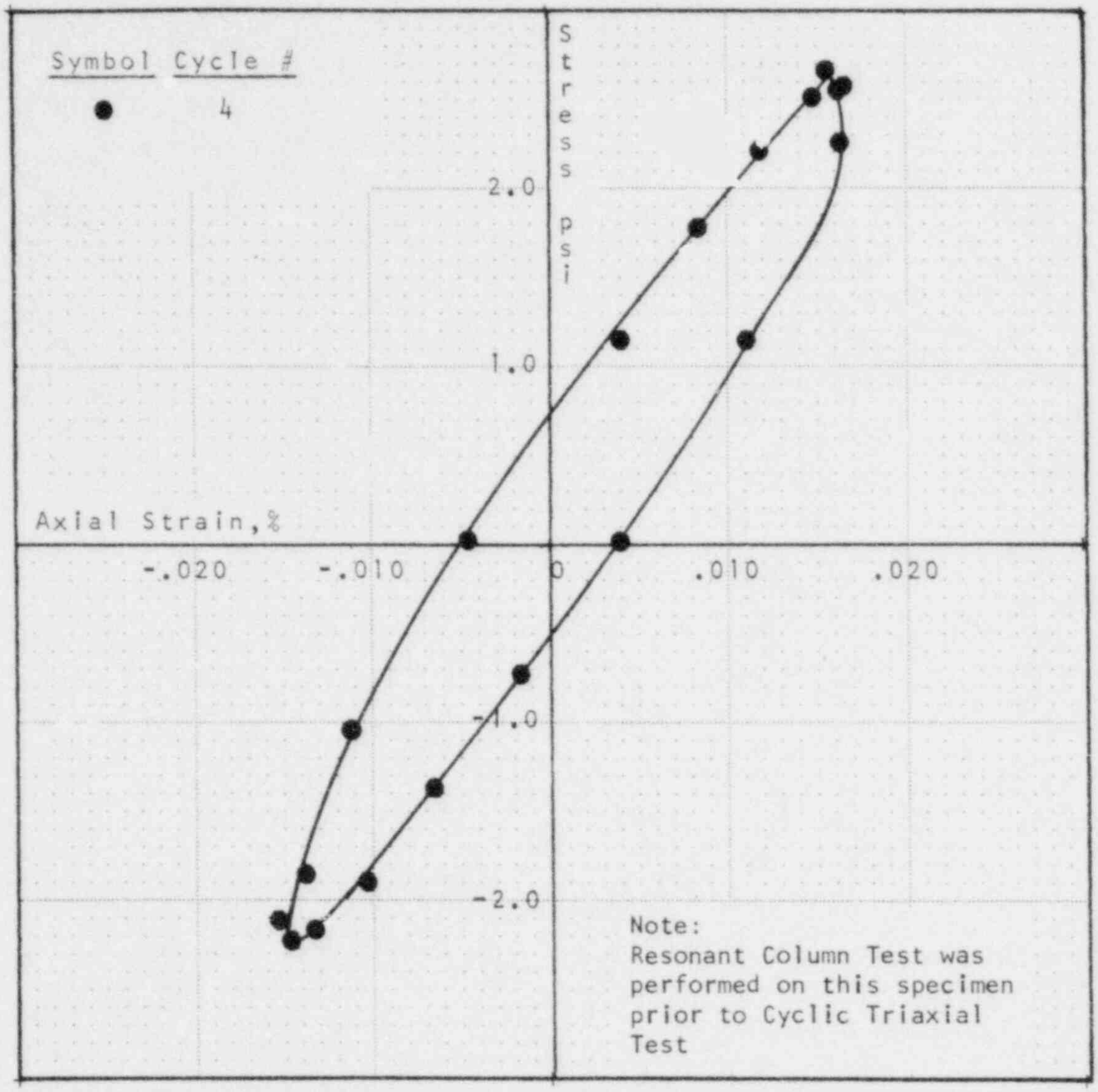
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 2
Depth 10.0 -12.5 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn JAm Checked ____ Approved ____ Revised ____ Approved ____
Date 4-25-79 Date ____ Date ____ Date ____ Date ____

FIG. 19C-9



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	20.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.97 in.
Diameter	2.88 in.
Wet Unit Wt.	123.9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	83 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	16190 psi
Damping	13.1 %
Double Amp. Strain	.0302 %

Classification:

Dark gray, sandy silty CLAY

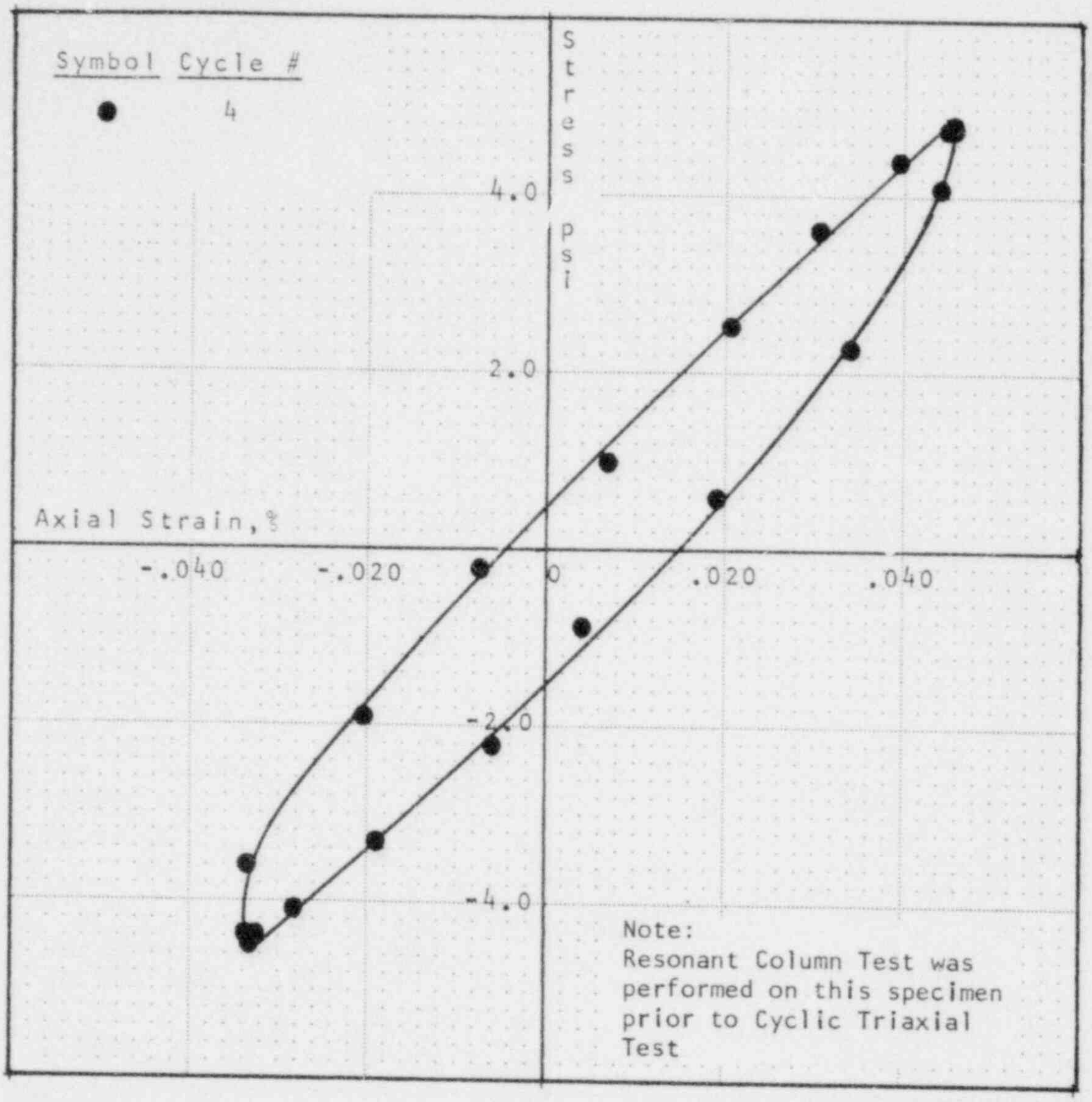
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 6
Depth 30.0 -31.8 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Date 4-25-79 Date Date Date

FIG. 19C-10



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	20.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.97 in.
Diameter	2.88 in.
Wet Unit Wt.	123.9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	83 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	11800 psi
Damping	11.1 %
Double Amp. Strain	.0788 %

Classification:

Dark gray, sandy silty CLAY

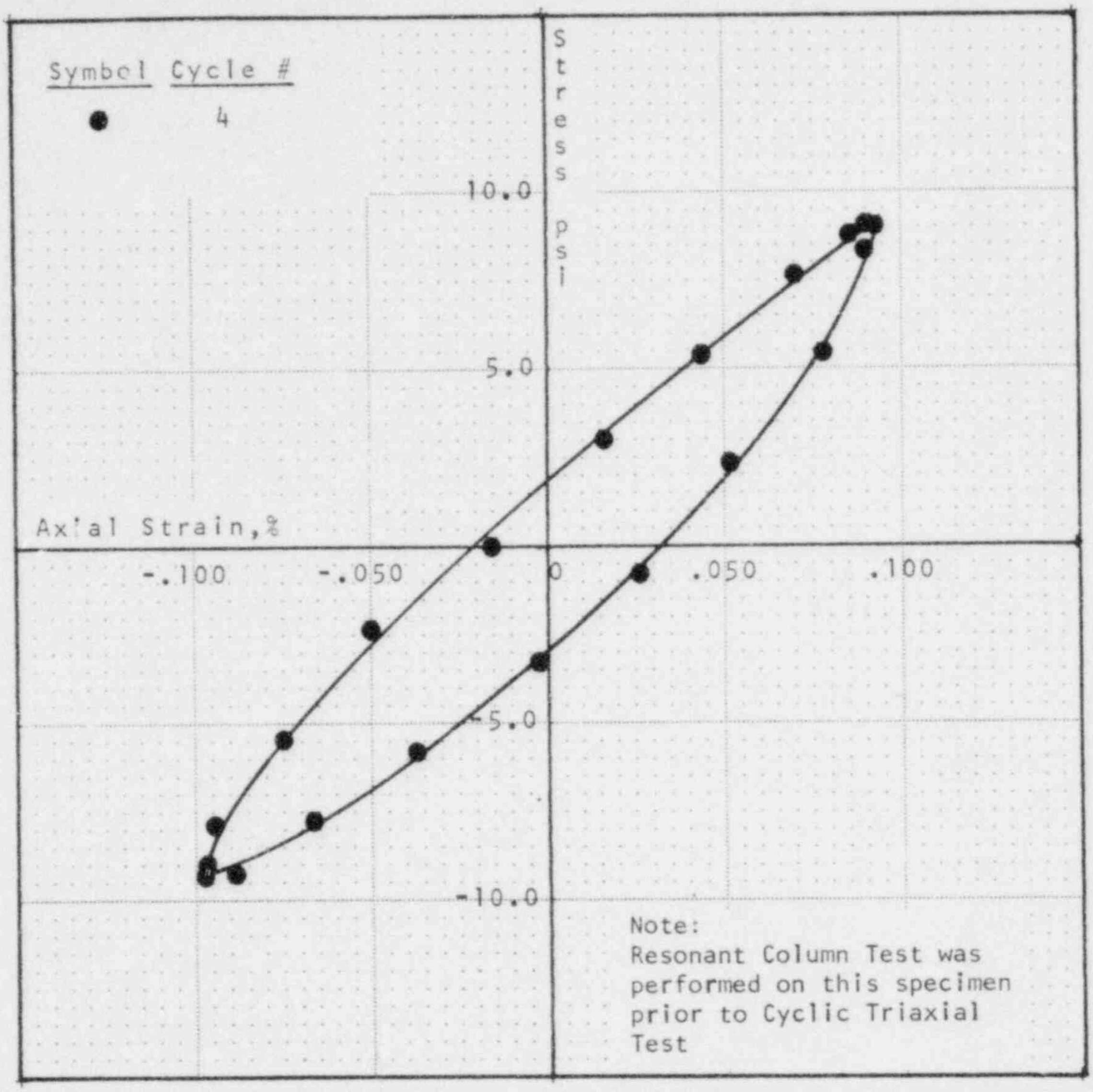
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 6
Depth 30.0 -31.8 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn Jam Checked___ Approved___ Revised___ Approved___
Date 4-25-79 Date___ Date___ Date___ Date___

FIG. 19C-11



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	20.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.97 in.
Diameter	2.88 in.
Wet Unit Wt.	123.9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	83 %

Specimen Undisturbed
Specimen Saturated

Modulus of Elasticity, E	9740 psi
Damping	12.8 %
Double Amp. Strain	.1889 %

Classification:

Dark gray, sandy silty CLAY

CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 6
Depth 30.0 -31.8 Ft.

GENERAL STORE
PETROLIA, CALIFORNIA

Drawn ____ Checked ____ Approved ____ Revised ____ Approved ____
Date 4-25-79 Date ____ Date ____ Date ____ Date ____

FIG. 19C-12

Section 20C

City Hall
Hollister, California

SECTION 20C

LABORATORY TESTING

CITY HALL

HOLLISTER, CALIFORNIA

LIST OF TABLES

LIST OF FIGURES

SECTION 20C

LIST OF FIGURES (Cont'd)

TABLE 20C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler[1] or Blows/6"	Shear[2] Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits			Other[3] Tests	Sample Classification
							LL	PL	PI		
B-1	S-1	5.0-6.5	4,4,3			34.1					Medium stiff, mottled brown, silty CLAY, trace of fine sand, roots and organic lenses.
	S-2	10.0-12.5	Shelby			26.6					Top 0.5': Medium stiff, mottled brown, fine sandy, silty CLAY; trace of organics.
						26.2					Bottom 1.9': Brown, clayey, silty fine SAND; trace of medium sand and organics.
	S-3	15.0-16.5	2,3,5			33.2					Medium stiff, mottled brown, silty CLAY; trace of fine sand and organics.
	S-4	20.0-22.5	Shelby		82.7	35.1	71	28	43	RC, CT	Top 1.1': Medium stiff, mottled brown, silty CLAY; trace of roots and organics. CH.
				0.66^{u}	87.0	30.4					Bottom 0.6': Medium stiff, mottled brown, fine sandy, clayey SILT.
	S-5	25.0-26.5	1,3,5			28.8					Medium stiff mottled brown and gray, silty CLAY; trace of fine sand, roots and organics.
	S-6	30.0-32.5	Shelby			28.1					Medium stiff, mottled brown and gray, silty CLAY; trace of fine sand, roots, organics, and calcareous nodules.
	S-7	35.0-36.5	2,1,2			32.0					Soft, mottled brown and gray, silty CLAY; trace of fine sand and organics.
	S-8	40.0-42.5	Shelby	2.3^{u}	96.5 84.4	26.6 31.4				MA RC, CT	Top 1.6': Stiff, mottled brown and gray, clayey, fine sandy SILT; trace of organics.
						34.8					Bottom 0.7': Stiff, mottled brown and gray, silty CLAY; organic lense near bottom.
	S-9	45.0-46.5	3,3,6			37.9					Stiff, mottled brown and gray, silty CLAY; trace of roots, organics, and iron-oxide stains.
	S-10	50.0-52.5	Shelby			27.9					Stiff, mottled brown and gray, fine sandy, clayey SILT; trace of organics.
	S-11	55.0-56.5	25,23,20			24.6					Dense, brown, silty, fine SAND.
	S-12	60.0-62.5	Shelby			31.5					Stiff to very stiff, mottled brown and gray, silty CLAY; trace of fine sand; lenses of clayey, silty, fine sand; trace of organics and iron-oxide stains.
	S-13	65.0-66.5	7,8,12			24.8					Very stiff, dark gray, silty CLAY; trace of fine to medium sand and organics.
	S-14	70.0-72.5	Shelby	1.0^{u}	100.7 98.8 103.9	22.6 24.6 21.5	58	17	41	RC CT	Very stiff to hard, light gray, silty CLAY; trace of fine to coarse sand, fine gravel, calcareous lenses, and organics. CH.
	S-15	75.0-76.5	14,15,22			18.2					Hard, light brown-gray, fine sandy silty CLAY; trace of medium sand.
	S-16	80.0-82.5	Pitcher			21.5					Hard, light brown-gray, silty CLAY; trace of fine to coarse sand, organics and iron-oxide stains; lense of fine sandy, silty clay near bottom.
	S-17	85.0-85.8	20,50/4"			22.1					Very dense, brown-gray, clayey, silty, fine SAND; iron-oxide stains.
	S-18	90.0-90.6	30,50/1"			23.2					Very dense, brown and gray, fine to coarse sandy, silty, fine GRAVEL; trace of clay binding.
	S-19	95.0-95.5	40/6"*			-					Insufficient Recovery (Weathered rock)
	S-20	100.0-100.0	50/0"*			-					No Recovery (On a rock)
	S-21	105.0-105.4	60/5"*			17.4					Very dense, mottled brown, silty, fine gravelly, fine to coarse SAND.
	S-22	110.0-111.5	15,16,17*			22.0					Dense, gray, clayey, fine sandy SILT; trace of organics.
	S-23	120.0-122.0	Pitcher			11.8				MA	Very dense, brown, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel. SW-SM.
	S-24	130.0-130.5	60/6"*			9.1					Very dense, brown-gray, fine gravelly, silty, fine to coarse SAND; trace of coarse gravel and iron-oxide stains.
	S-25	140.0-142.5	Pitcher	2.5^{u}	107.5 102.9	19.3 21.6				MA RC, CT	Hard, mottled brown-gray, clayey, fine sandy, SILT; lenses of silty, fine sand.
	S-26	150.0-150.8	24,30/4"*			18.0					Very dense, brown-gray, silty, fine to medium SAND; trace of coarse sand and fine gravel.
	S-27	160.0-160.3	50/3"			11.1					Very dense, brown and gray, slightly silty, fine to coarse sandy, fine to coarse GRAVEL.
	S-28	178.5-179.3	15,50/3"			15.9					Very dense, brown, silty, fine to coarse sandy, fine to coarse GRAVEL.
	S-29	189.0-191.5	Pitcher			21.0				MA	Very dense, brown, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel. SP-SM.

Sheet 1 of 2

POOR ORIGINAL

TABLE 20C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler[1] or Blows/6"	Shear[2] Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits LL	PL	PI	Other[3] Tests	Sample Classification
B-1 (Cont'd)	S-30	200.0-200.5	44/6"*			-					No Recovery.
	S-31	210.5-211.7	45,27, 30/2"*			23.1					Hard, mottled brown and gray, fine sandy, silty CLAY; trace of medium sand and iron-oxide stains.
	S-32	231.0-[illegible]2.5	Pitcher			15.9				MA	Medium dense, brown, slightly silty, fine to coarse SAND; trace of fine gravel. SW-SM.
	S-33	25[illegible]	60/5"*			18.1					Very dense, brown, silty, fine to medium SAND; trace of coarse sand.
	S-34	273.5-274.0	100/5.5"*			-					No Recovery.
	S-35	284.0-284.9	28,30/5"*			22.9					Hard, gray, fine sandy, clayey SILT.
	S-36	305.0-306.2	Pitcher	3.9u	104.5	21.3	60	19	41	RC, CT	Hard brown, silty CLAY; trace of fine sand; lense of fine sandy silt near bottom. CH.
	S-37	326.0-327.5	Mod. Pitcher			19.2				MA	Very dense, brown, slightly silty, fine to medium SAND. SW-SM.
	S-38	347.5-349.0	Mod. Pitcher			12.0					Top 3": Very dense, brown, silty, fine to medium SAND. Bottom 5": Very dense, brown, fine to coarse gravelly, silty, fine to coarse SAND.

Notes:

1. Downhole jars (285 lb. weight, 18" stroke) used in lieu of SPT equipment (140 lb. hammer, 30" stroke) for drive samples indicated with an "*"
2. Shear strengths denoted by "u" were determined from unconsolidated undrained compression tests.
3. Legend for Tests

Symbol	Explanation
MA	Mechanical Analysis
RC	Resonant Column Test
CT	Cyclic Triaxial Test

Sheet 2 of 2

POOR ORIGINAL

TABLE 20C-2

SUMMARY OF DYNAMIC TEST RESULTS

Boring B-1
City Hall
Hollister, California

Sample	Depth ft.	Specimen Height in.	Specimen Diameter in.	Water Content %	Wet Unit Weight pcf	$\bar{\sigma}_3$ psi	Resonant Column G psi	Resonant Column γ %	Resonant Column λ %	Cyclic Triaxial G* psi	Cyclic Triaxial γ* %	Cyclic Triaxial λ* %	Classification
S-4	20.0-22.5	5.82	2.85	35.1	111.7	18	4100	8.9×10^{-4}	-	3610	2.9×10^{-2}	9.1	Mottled brown silty CLAY
							3700	5.9×10^{-3}	-	2520	9.8×10^{-2}	11.3	
							2700	3.3×10^{-2}	-	1360	0.28	11.8	
							1700	9.9×10^{-2}	-				
S-8	40.0-42.5	6.01	2.86	31.4	110.9	30	8700	4.7×10^{-4}	-	6620	2.6×10^{-2}	10.5	Mottled gray-brown, clayey, fine sandy SILT
							8200	2.3×10^{-3}	-	5150	6.8×10^{-2}	11.8	
							6700	1.2×10^{-2}	-	3820	0.156	12.5	
							4700	4.1×10^{-2}					
S-14	70.0-72.5	5.71	2.88	24.6	123.1	40	17400	2.6×10^{-4}	-				Light gray, silty CLAY
							17400	1.1×10^{-3}	-				
							17400	2.9×10^{-3}	-				
		6.13	2.88	21.5	126.2	18				3780	2.75×10^{-2}	7.0	
										2440	7.5×10^{-2}	7.3	
										1504	0.19	9.3	
S-25	140.0-142.5	6.00	2.88	21.6	125.1	70	11600	3.5×10^{-4}	-	9940	3.2×10^{-2}	7.3	Mottled gray-brown, clayey, sandy SILT
							11500	1.7×10^{-3}	-	7900	6.4×10^{-2}	8.3	
							10000	8.6×10^{-3}	-	5350	0.19	11.1	
							7700	2.5×10^{-2}	-				
S-36	305.0-306.2	5.73	2.90	21.3	126.7	100	16500	3.1×10^{-4}	-	10,750	3.35×10^{-2}	6.3	Brown silty CLAY
							16300	1.0×10^{-3}	-	8930	7.8×10^{-2}	7.4	
							15700	3.2×10^{-3}	-	6100	0.23	9.0	
							13500	8.2×10^{-3}	-				

NOTES:

$\bar{\sigma}_3$ Effective Confining Pressure $G^* = (E/2(1+\mu))$

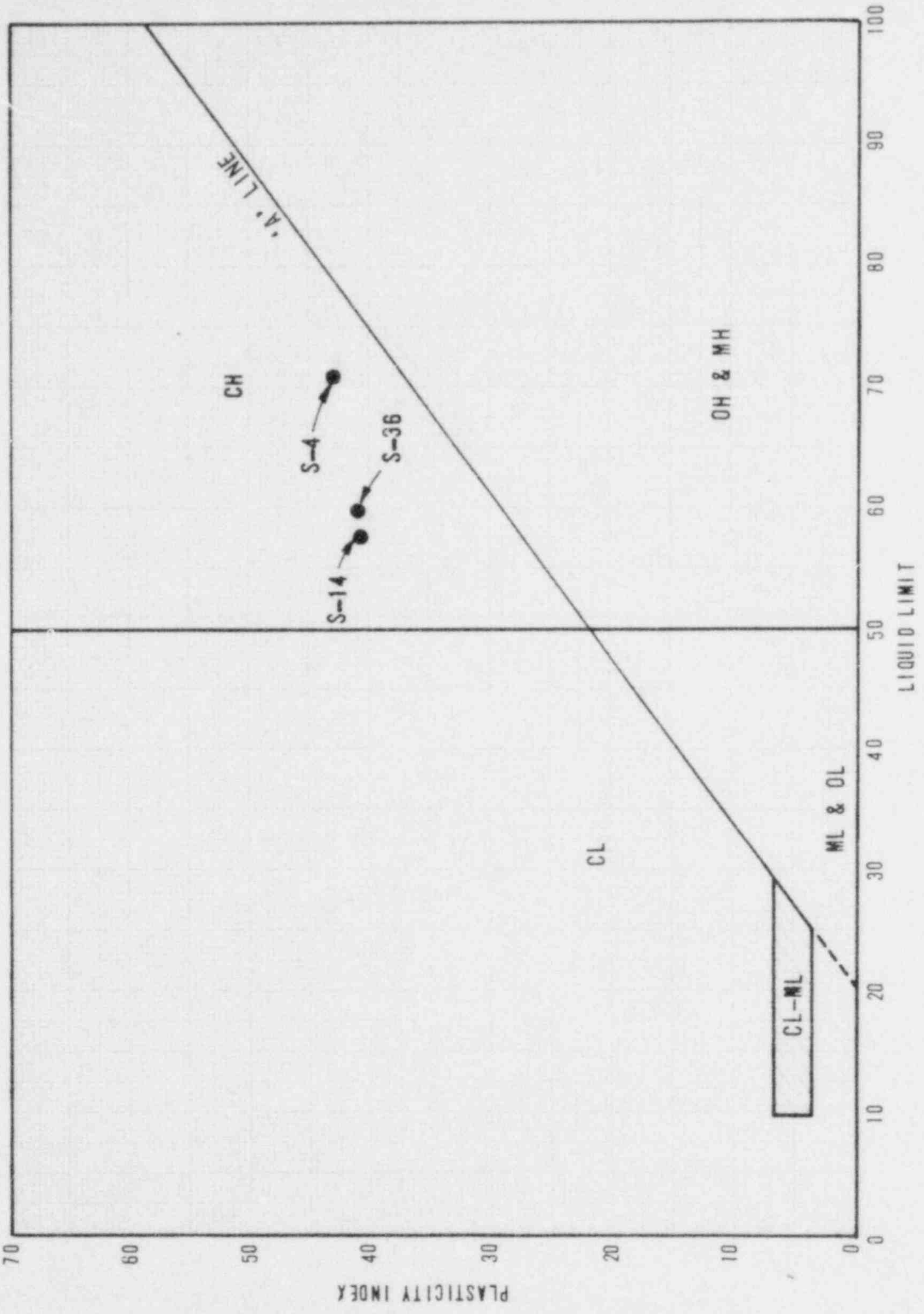
G Shear Modulus $\gamma^* = (1+\mu)\varepsilon$

γ, γ^* Single Amplitude Shear Strain where:

λ Damping

E = Modulus of Elasticity
ε = Single Amplitude Axial Strain
μ = Poisson's Ratio (estimated at 0.4)

POOR ORIGINAL

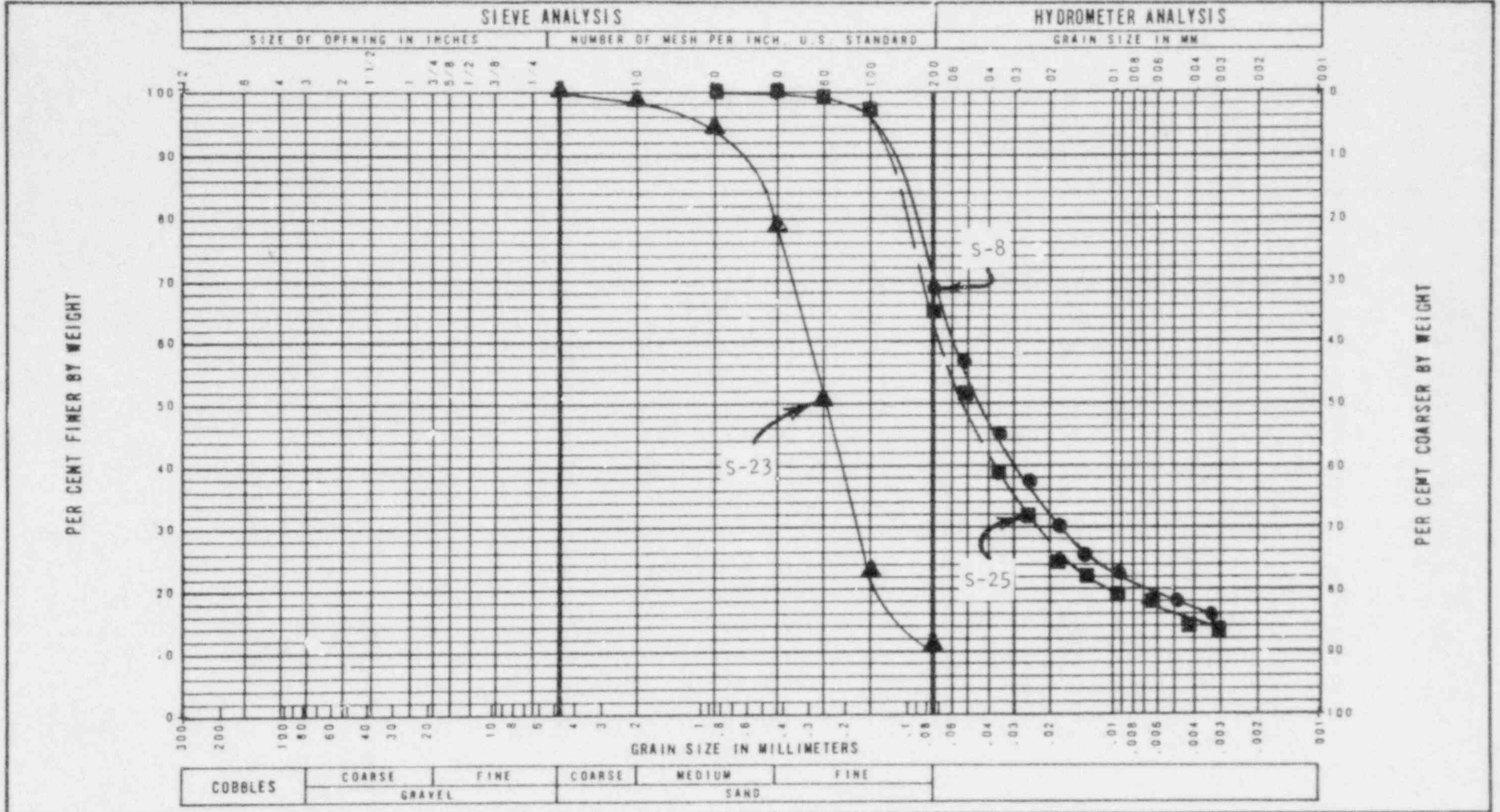


PLASTICITY CHART
BORING B-1
CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-1

Drawn________ Checked________ Approved________ Revised________ Approved________

Date________ Date________ Date________ Date________ Date________



SAMPLE NO	DEPTH-FT	U.S.C.	CLASSIFICATION	G_s	NAT. W.C. %	LL	PL	PI
S-8	40.0-42.5		Mottled brown-gray, clayey, fine sandy SILT		26.6			
S-23	120.0-122.0	SW-SM	Brown, slightly silty SAND		11.8			
S-25	140.0-142.5		Mottled brown-gray, clayey, fine sandy SILT		19.3			

GRAIN SIZE CLASSIFICATION

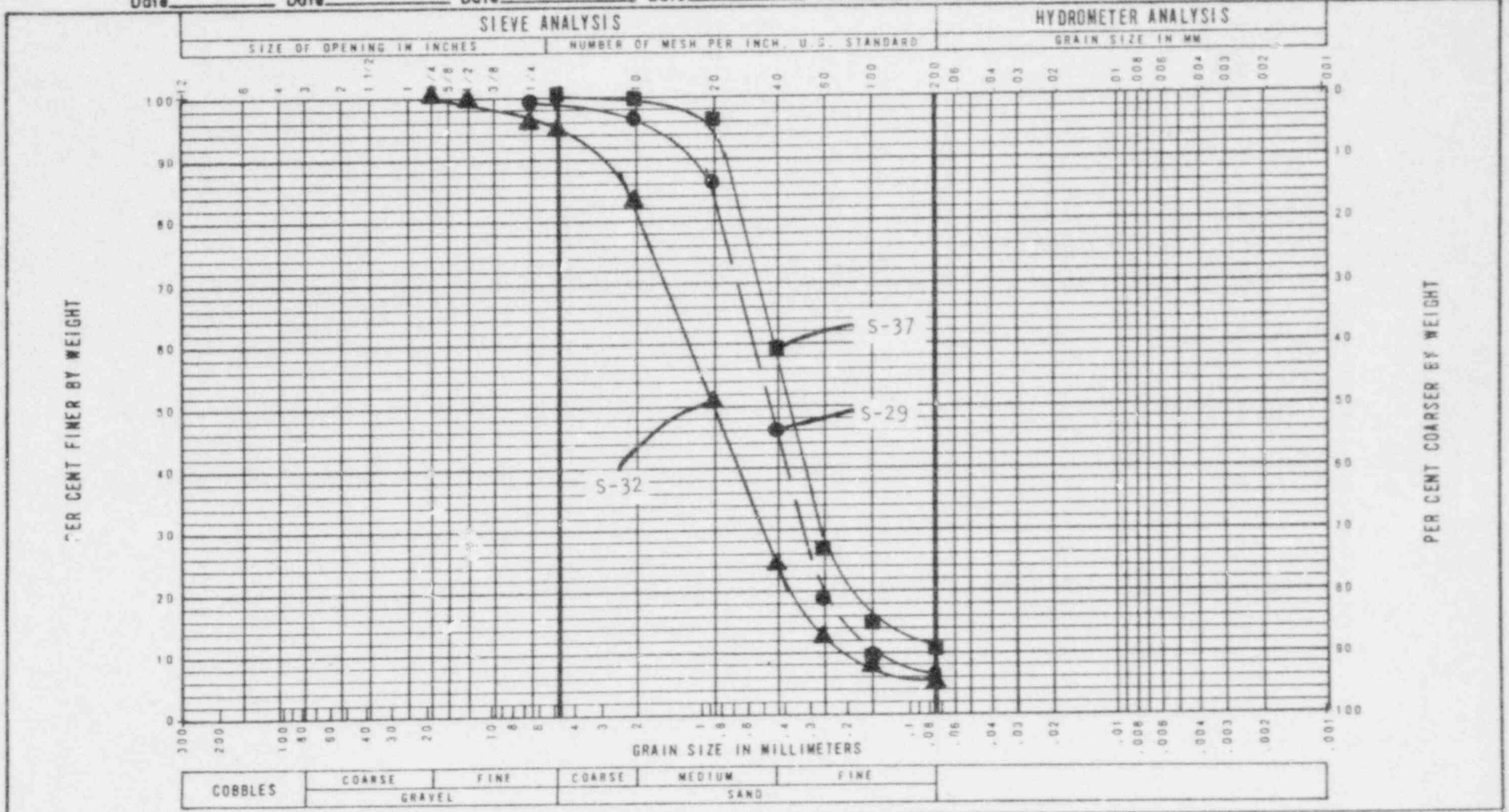
Boring B-1

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-2

Drawn________ Checked________ Approved________ Revised________ Approved________

Date________ Date________ Date________ Date________ Date________

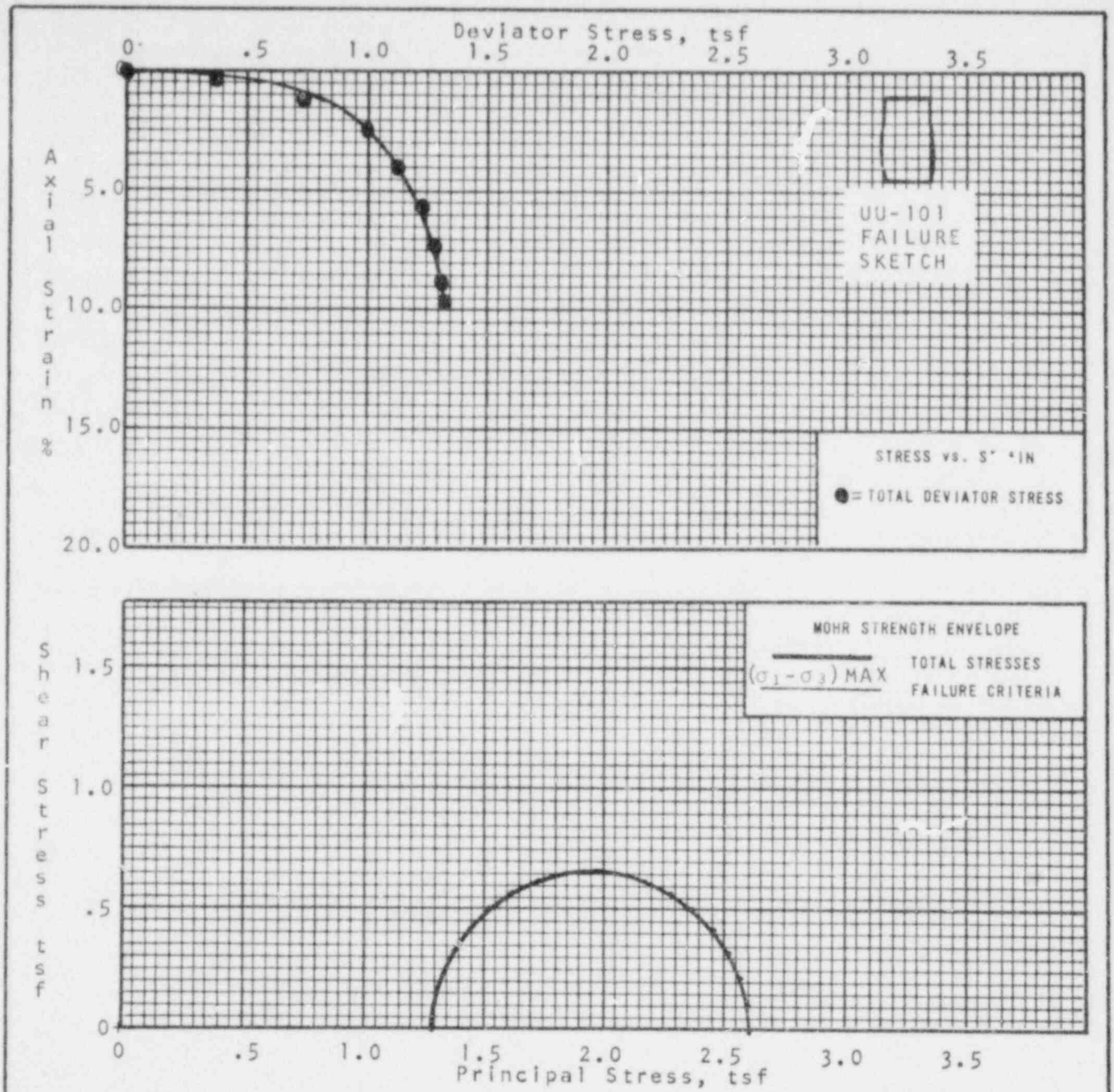


SAMPLE NO	DEPTH-FT	U.S.C.	CLASSIFICATION	G_s	NAT W.C. %	LL	PL	PI
S-29	189.0-191.5	SP-SM	Brown, slightly silty, SAND		21.0			
S-32	231.0-232.5	SW-SM	Brown, slightly silty, SAND		15.9			
S-37	326.0-327.5	SW-SM	Brown, slightly silty, SAND		19.2			

GRAIN SIZE CLASSIFICATION
Boring B-1

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-3



Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 4
Confining Pressure, tsf	1.29
Ht., in.	6.18
Dia., in.	2.87
Ht./Dia. Ratio	2.15
Wet Unit Wt., pcf	113.5
Water Content, % Before Test	30.4
After Test	30.8
Degree of Saturation, %	88.4
Avg. % Strain/Min.	1.470

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Mottled brown, silty CLAY

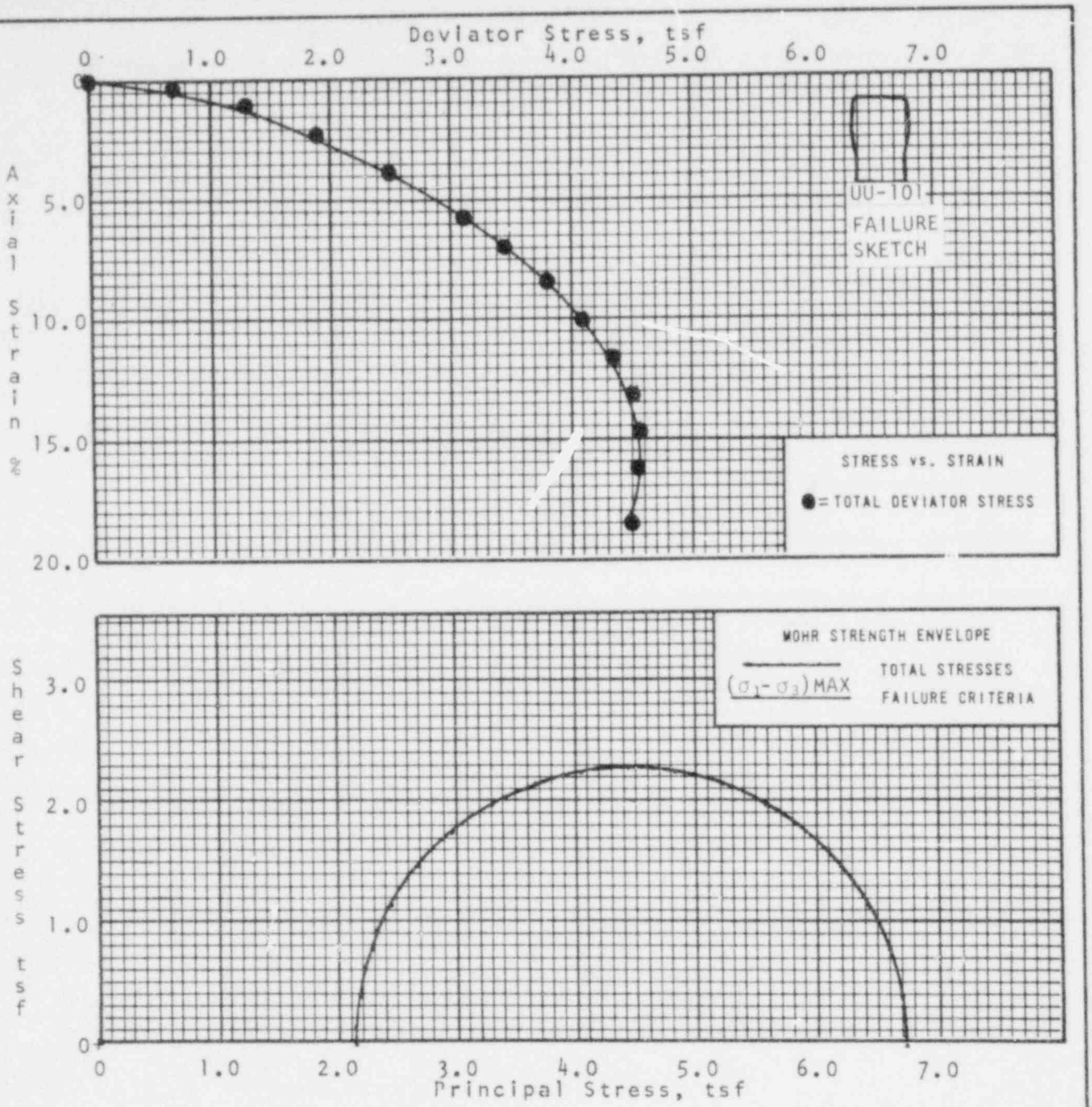
UNCONSOLIDATED, UNDRAINED,
TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 4
Depth 20.0 -22.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn_____ Date_____
Checked f/70 Date 4/16/79
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 20C-4



Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 8
Confining Pressure, tsf	2.16
Ht., in.	6.50
Dia., in.	2.87
Ht./Dia. Ratio	2.26
Wet Unit Wt., pcf	122.2
Water Content, %	
Before Test	26.6
After Test	27.2
Degree of Saturation, %	98.5
Avg. % Strain/Min.	1.147

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Mottled gray-brown, clayey, fine sandy SILT

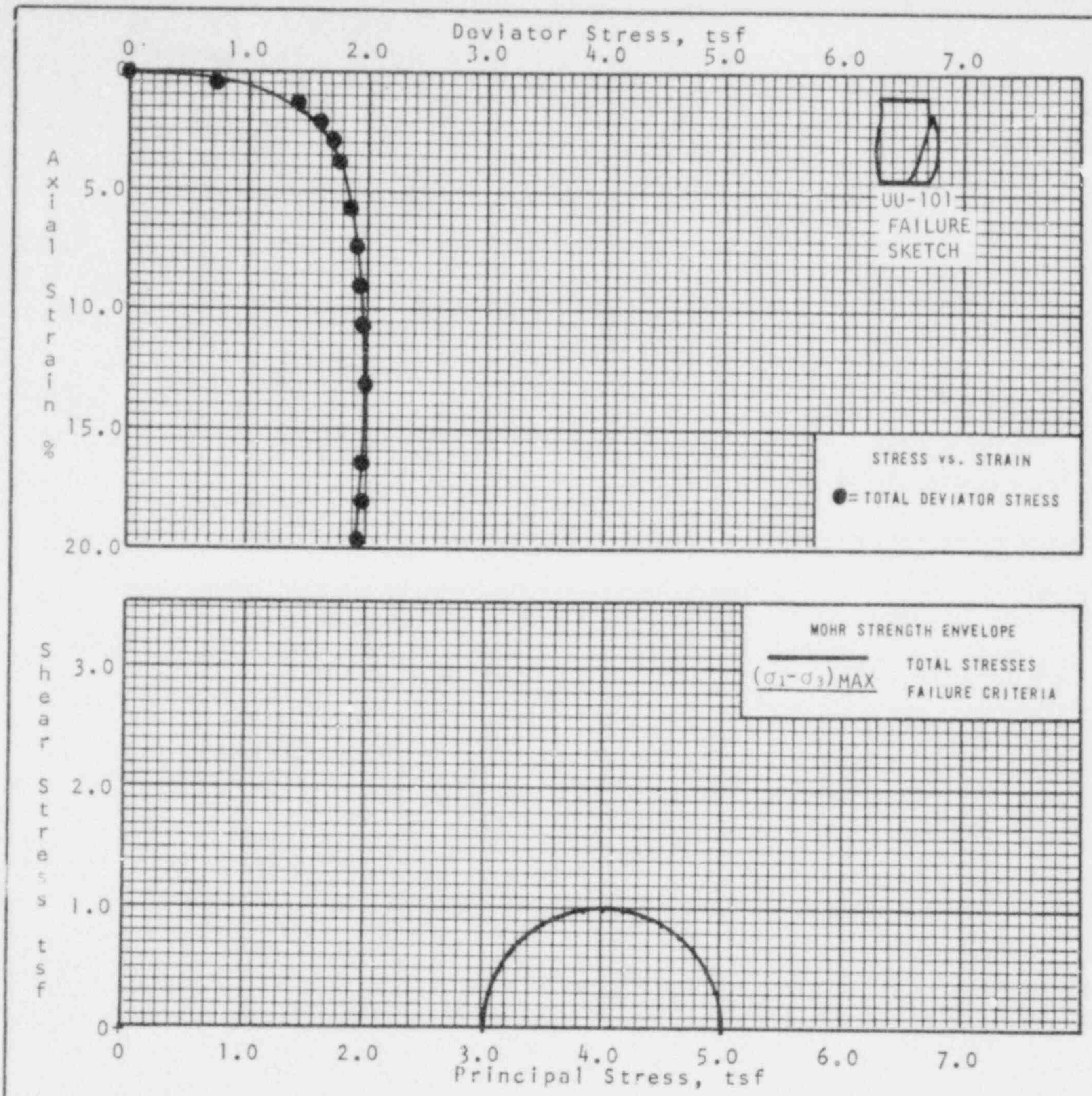
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 8
Depth 40.0 -42.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Date____
Checked____ Date____
Approved____ Date____
Revi____ Date____
Approved____ Date____

FIG. 20C-5



Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 14
Confining Pressure, tsf	3.02
Ht., in.	6.14
Dia., in.	2.87
Ht./Dia. Ratio	2.13
Wet Unit Wt., pcf	123.5
Water Content, %	
Before Test	22.6
After Test	22.6
Degree of Saturation, %	89.8
Avg. % Strain/Min.	1.234

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Light gray, silty CLAY, trace of sand and gravel

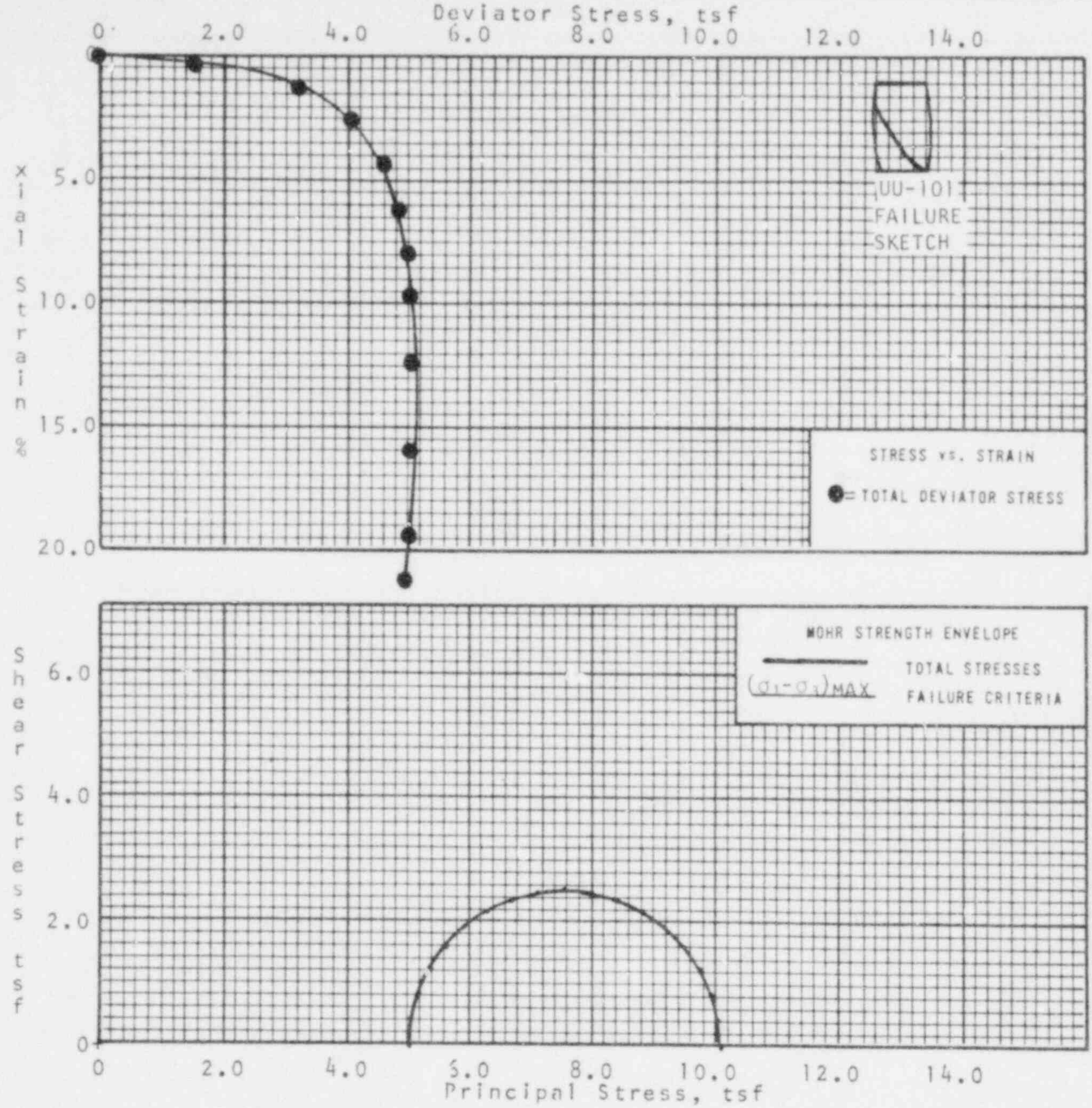
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 14
Depth 70.0 -72.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn______ Checked______ Approved______ Revised______ Approved______
Date______ Date______ Date______ Date______ Date______

FIG. 20C-6



Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 25
Confining Pressure, tsf	5.04
Ht., in.	5.67
Dia., in.	2.87
Ht./Dia. Ratio	1.97
Wet Unit Wt., pcf	128.3
Water Content, %	
Before Test	19.3
After Test	19.3
Degree of Saturation, %	91.9
Avg. % Strain/Min.	1.313

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Mottled gray-brown, clayey, sandy SILT

UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 25
Depth 140.0-142.5 Ft.

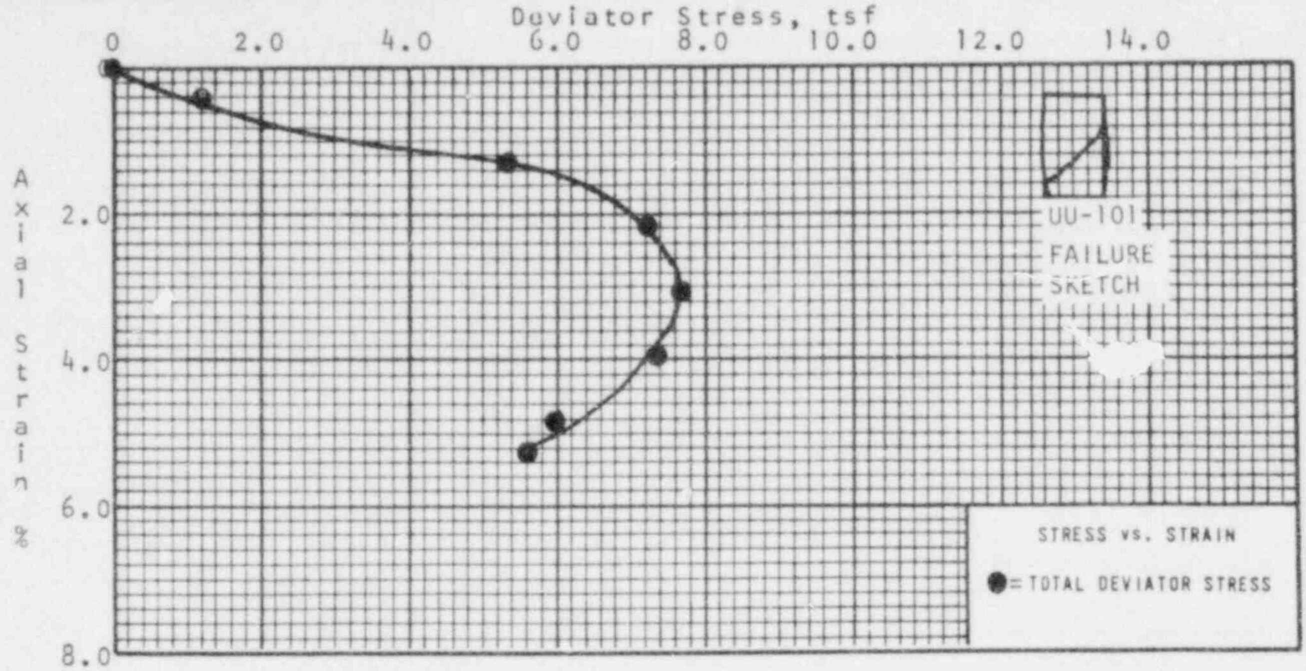
CITY HALL
HOLLISTER, CALIFORNIA

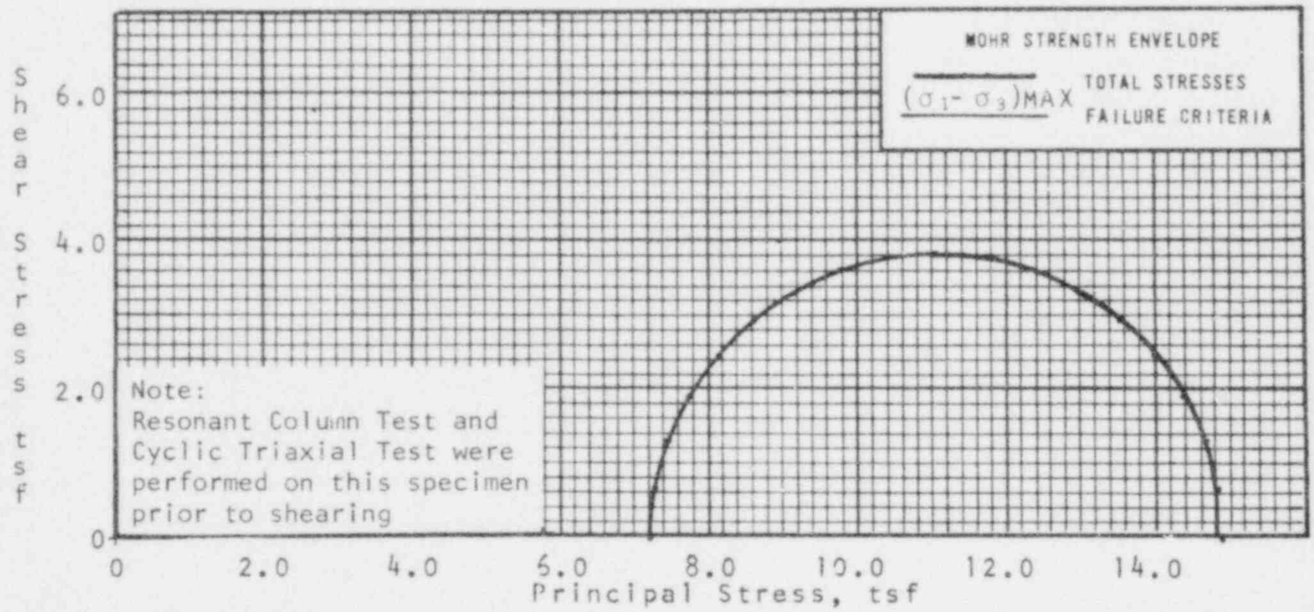
Date_____ Drawn_____
Date_____ Checked_____
Date_____ Approved_____
Date_____ Revised_____
Date_____ Approved_____

FIG. 20C-7

Drawn Jam Checked Approved Revised Approved

Date 4-11-79 Date Date Date Date





Note:
Resonant Column Test and Cyclic Triaxial Test were performed on this specimen prior to shearing

Test No.	UU-101
Boring No.	B- 1
Sample No.	S- 36
Confining Pressure, tsf	7.19
Ht., in.	5.73
Dia., in.	2.89
Ht./Dia. Ratio	1.97
Wet Unit Wt., pcf	126.7
Water Content, %	
Before Test	21.3
After Test	21.0
Degree of Saturation, %	92.5
Avg. % Strain/Min.	.210

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Brown silty CLAY, trace of sand

UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 36
Depth 305.0-306.2 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-8

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
4,100		8.9×10^{-4}	
3,700		5.9×10^{-3}	
2,700		3.3×10^{-2}	
1,700		9.9×10^{-2}	
	12,000		2.7×10^{-4}
	11,700		1.4×10^{-3}
	9,900		7.8×10^{-3}
	8,500		1.2×10^{-2}

Specimen Data

Height	5.817 in
Diameter	2.852 in
Wet Unit Weight	111.7 pcf
Water Content	35.1%
Degree of Saturation	100 %
Effective Confining Pressure	18 psi

Classification:

Mottled brown, silty CLAY

RESONANT COLUMN TEST

Boring	B-1
Sample	S-4
Depth	20.0 - 22.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-9

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
8,700		4.7×10^{-4}	
8,200		2.3×10^{-3}	
6,700		1.2×10^{-2}	
4,700		4.1×10^{-2}	
	22,200		1.7×10^{-4}
	22,000		7.4×10^{-4}
	20,400		3.4×10^{-3}
	17,800		6.2×10^{-3}

Specimen Data

Height	6.007 in
Diameter	2.857 in
Wet Unit Weight	110.9 pcf
Water Content	31.4 %
Degree of Saturation	94.0 %
Effective Confining Pressure	30 psi

Classification:

Mottled gray-brown, clayey, fine sandy SILT

RESONANT COLUMN TEST

Boring	B-1
Sample	S-8
Depth	40.0 - 42.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-10

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
17,400		2.6×10^{-4}	
17,400		1.1×10^{-3}	
17,100		2.9×10^{-3}	
	49,500		6.8×10^{-5}
	49,200		3.5×10^{-4}
	48,400		1.2×10^{-3}
	47,800		1.5×10^{-3}

Specimen Data

Height	5.712 in
Diameter	2.875 in
Wet Unit Weight	123.1 pcf
Water Content	24.6 %
Degree of Saturation	96.8 %
Effective Confining Pressure	40 psi

Classification:

Light gray, silty CLAY,
trace of sand and gravel

RESONANT COLUMN TEST

Boring B-1
Sample S-14
Depth 70.0 - 72.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-11

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
11,600		5.5×10^{-4}	
11,500		1.7×10^{-3}	
10,000		8.6×10^{-3}	
7,700		2.5×10^{-2}	
	38,500		9.4×10^{-5}
	38,300		4.3×10^{-4}
	37,500		1.8×10^{-3}
	34,100		3.3×10^{-3}

Specimen Data

Height	5.998 in
Diameter	2.876 in
Wet Unit Weight	125.1 pcf
Water Content	21.6%
Degree of Saturation	88.4 %
Effective Confining Pressure	70 psi

Classification:

Mottled gray-brown, clayey, sandy SILT

RESONANT COLUMN TEST

Boring B-1
Sample S-25
Depth 140.0 - 142.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-12

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
16,500		3.1×10^{-4}	
16,300		1.0×10^{-3}	
15,700		3.2×10^{-3}	
13,500		8.2×10^{-3}	
	51,400		8.9×10^{-5}
	51,000		2.3×10^{-4}
	50,300		7.7×10^{-4}
	48,600		2.0×10^{-3}

Specimen Data

Height	5.733 in
Diameter	2.898 in
Wet Unit Weight	126.7 pcf
Water Content	21.3 %
Degree of Saturation	92.5 %
Effective Confining Pressure	100 psi

Classification:

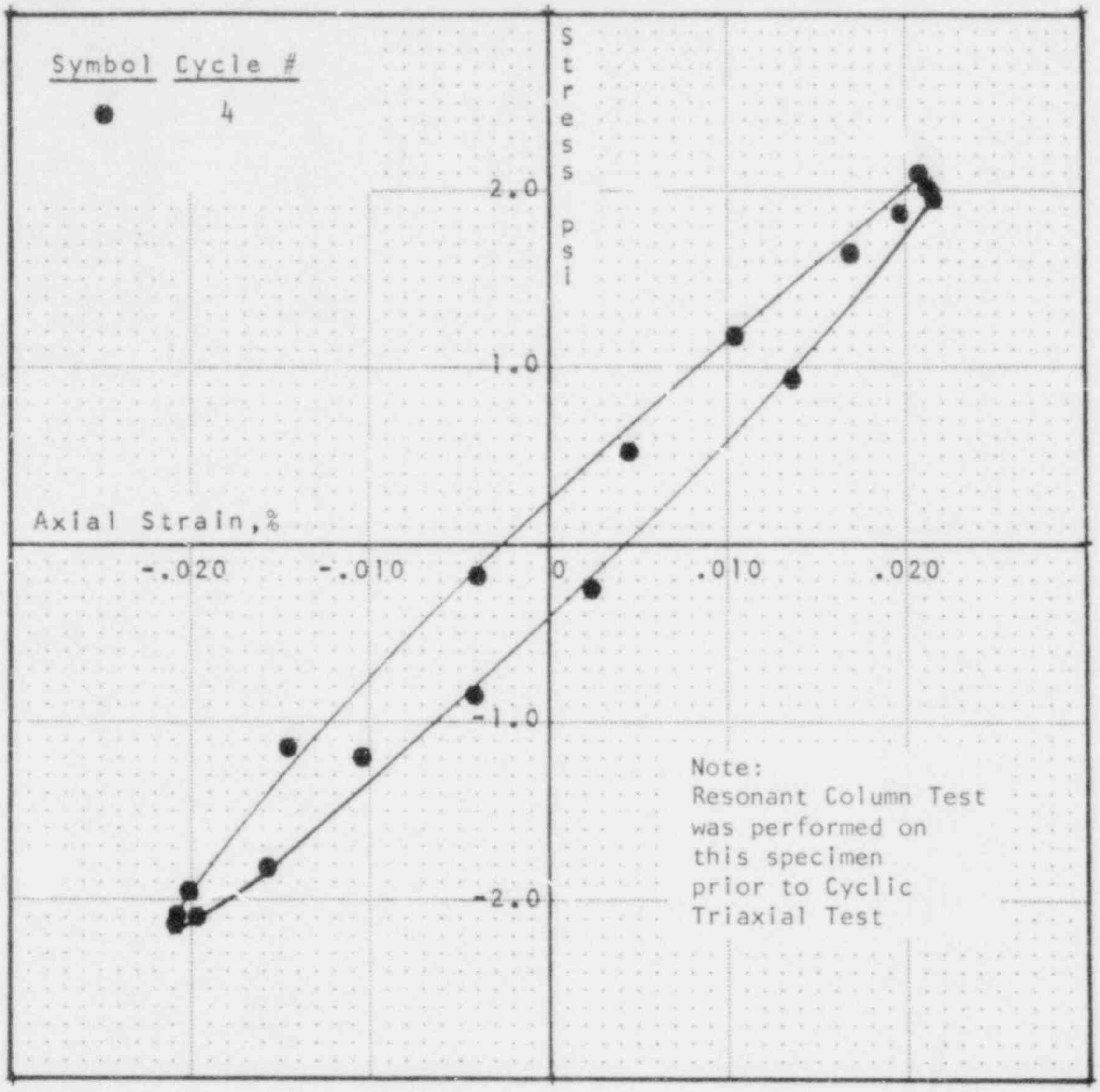
Brown silty CLAY, trace of sand

RESONANT COLUMN TEST

Boring	B-1
Sample	S-36
Depth	305.0 - 306.2 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-13



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	18.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.82 in.
Diameter	2.85 in.
Wet Unit Wt.	111.7 pcf
Water Content	
Before Test	35.1 %
After Test	38.6 %
Degree of Saturation	100.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	10110 psi
Damping	9.1 %
Double Amp. Strain	.0419 %

Classification:
Mottled brown, silty CLAY

CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 4
Depth 20.0 -22.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Date____
Checked____ Date____
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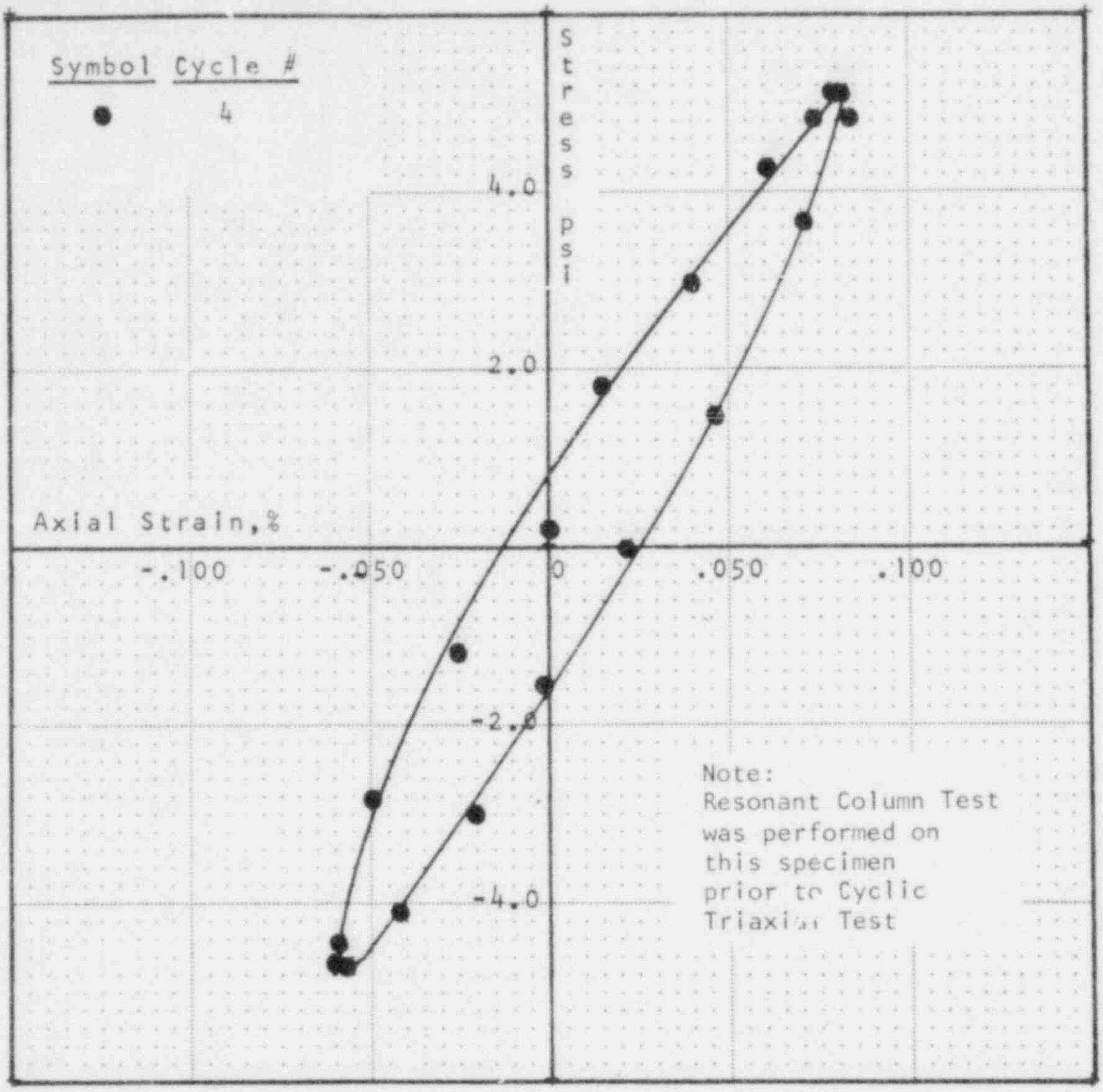
Approved____ Date____

FIG. 20C-14



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 2

Effective Confining Pressure	18.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.82 in.
Diameter	2.85 in.
Wet Unit Wt.	111.7 pcf
Water Content	
Before Test	35.1 %
After Test	38.6 %
Degree of Saturation	100.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	7060 psi
Damping	11.3 %
Double Amp. Strain	.1395 %

Classification:

Mottled brown, silty CLAY

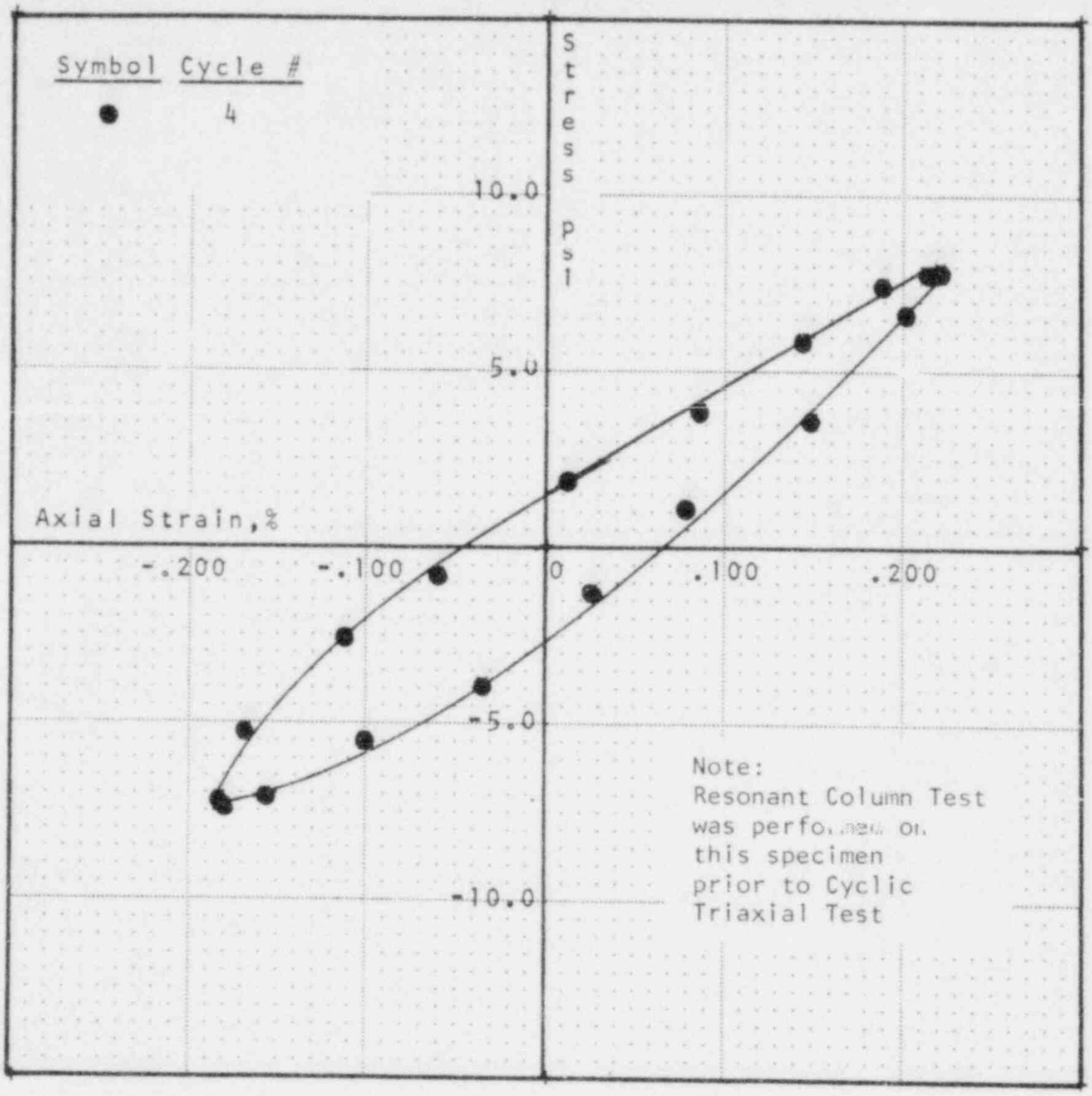
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 4
Depth 20.0 -22.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 20C-15



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	18.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	5.82 in.
Diameter	2.85 in.
Wet Unit Wt.	111.7 pcf
Water Content	
Before Test	35.1 %
After Test	38.6 %
Degree of Saturation	%

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	3800 psi
Damping	11.8 %
Double Amp. Strain	.4020 %

Classification:

Mottled brown, silty CLAY

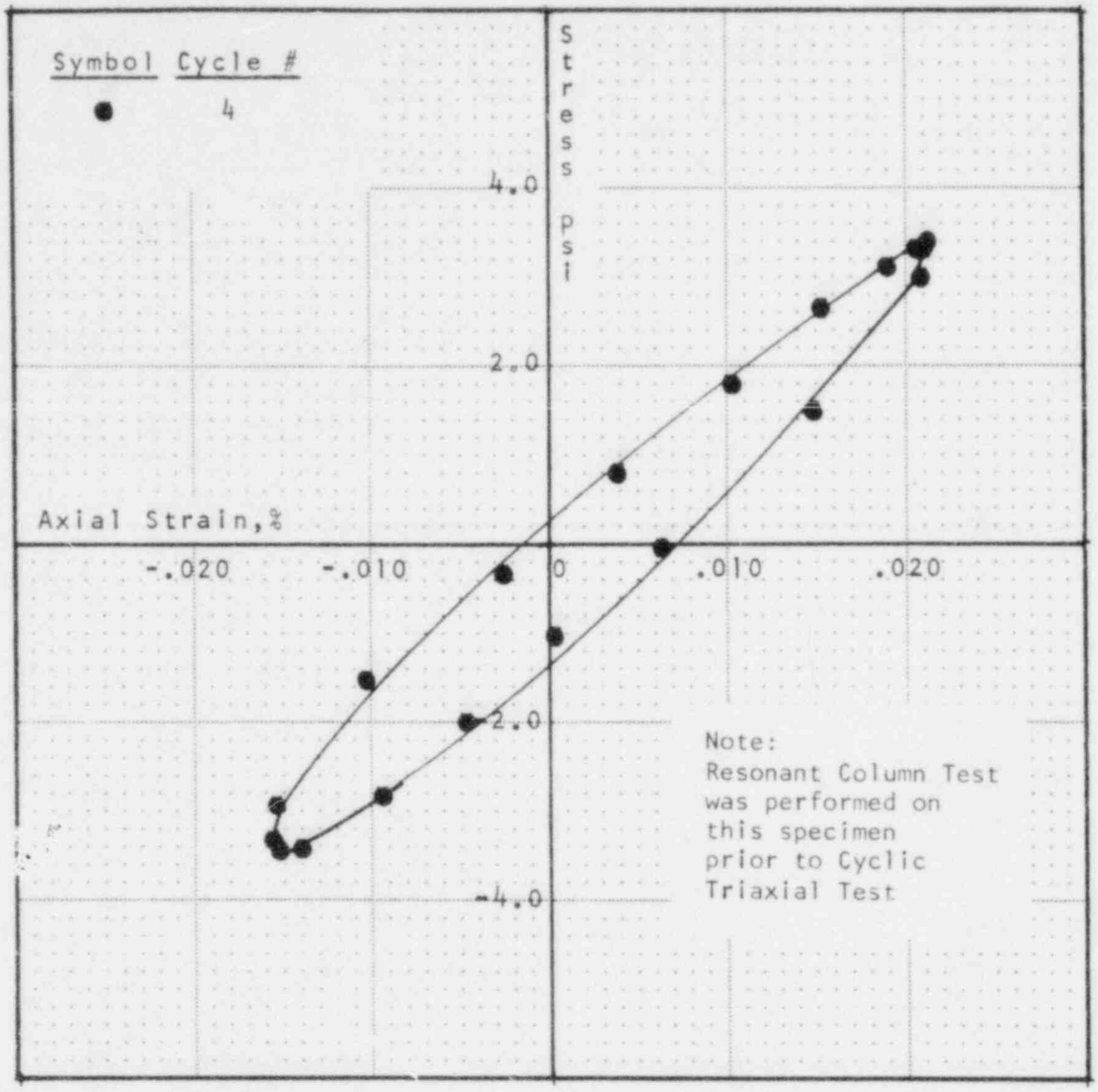
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 4
Depth 20.0 -22.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 20C-16



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	30.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	6.01 in.
Diameter	2.86 in.
Wet Unit Wt.	110.9 pcf
Water Content	
Before Test	31.4 %
After Test	31.4 %
Degree of Saturation	94.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	18550 psi
Damping	10.5 %
Double Amp. Strain	.0367 %

Classification:

Mottled gray-brown, clayey, fine sandy SILT

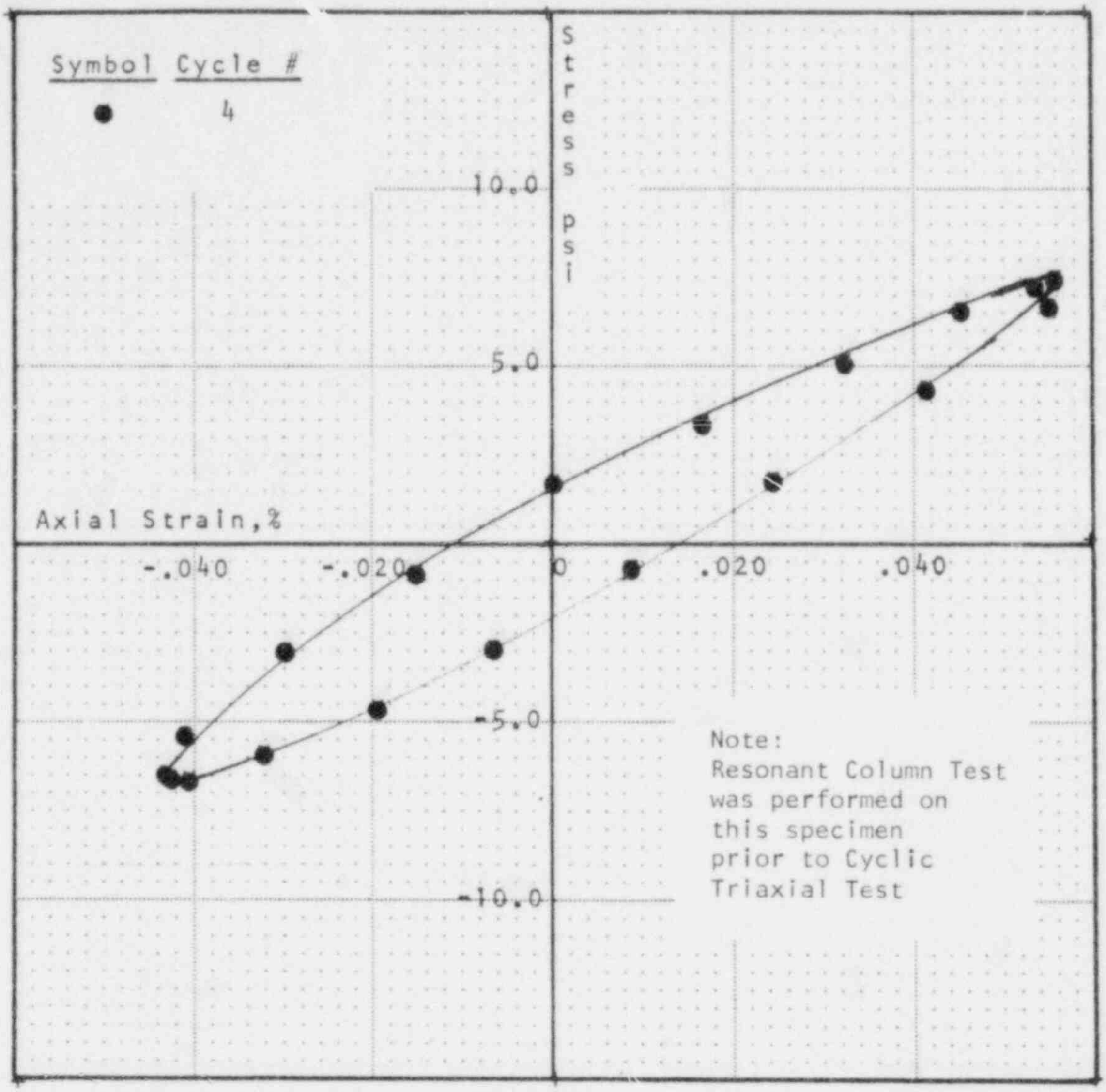
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 8
Depth 40.0 -42.5 Ft.

C TY HALL
HOLLISTER, CALIFORNIA

Drawn____ Date____
Checked____ Date____
Approved____ Date____
Revised____ Date____
Approved____ Date____

FIG. 20C-17



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 2

Effective Confining Pressure	30.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	6.01 in.
Diameter	2.86 in.
Wet Unit Wt.	110.9 pcf
Water Content	
Before Test	31.4 %
After Test	31.4 %
Degree of Saturation	94.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	14430 psi
Damping	11.8 %
Double Amp. Strain	.0970 %

Classification:

Mottled gray-brown, clayey, fine sandy SILT

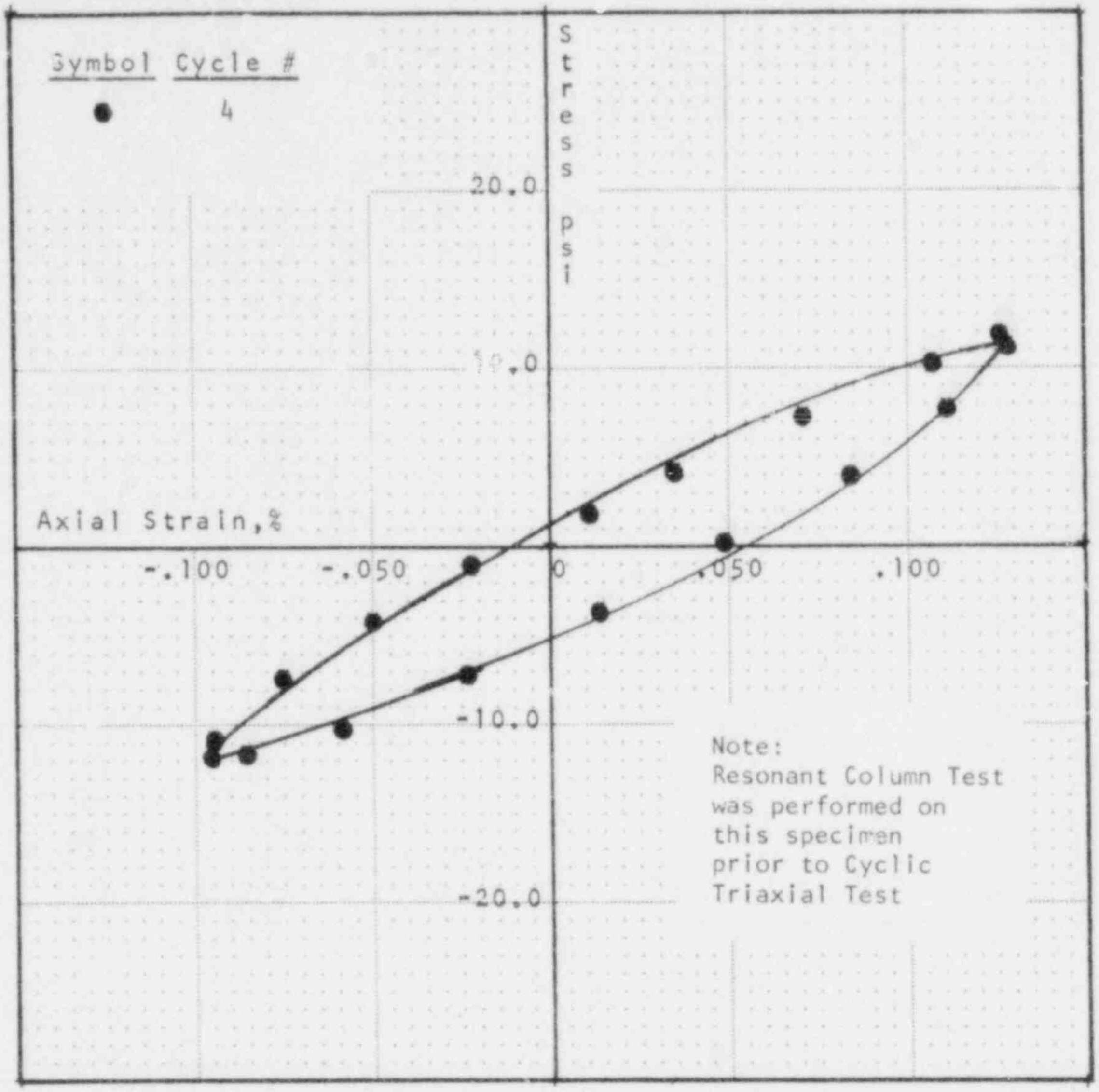
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 8
Depth 40.0 -42.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 20C-18



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 3

Effective Confining Pressure	30.0 psi
Back Pressure	50.0 psi

Specimen Data

Height	6.01 in.
Diameter	2.86 in.
Wet Unit Wt.	110.9 pcf
Water Content	
Before Test	31.4 %
After Test	31.4 %
Degree of Saturation	94.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	10690 psi
Damping	12.5 %
Double Amp. Strain	.2227 %

Classification:

Mottled gray-brown, clayey, fine sandy SILT

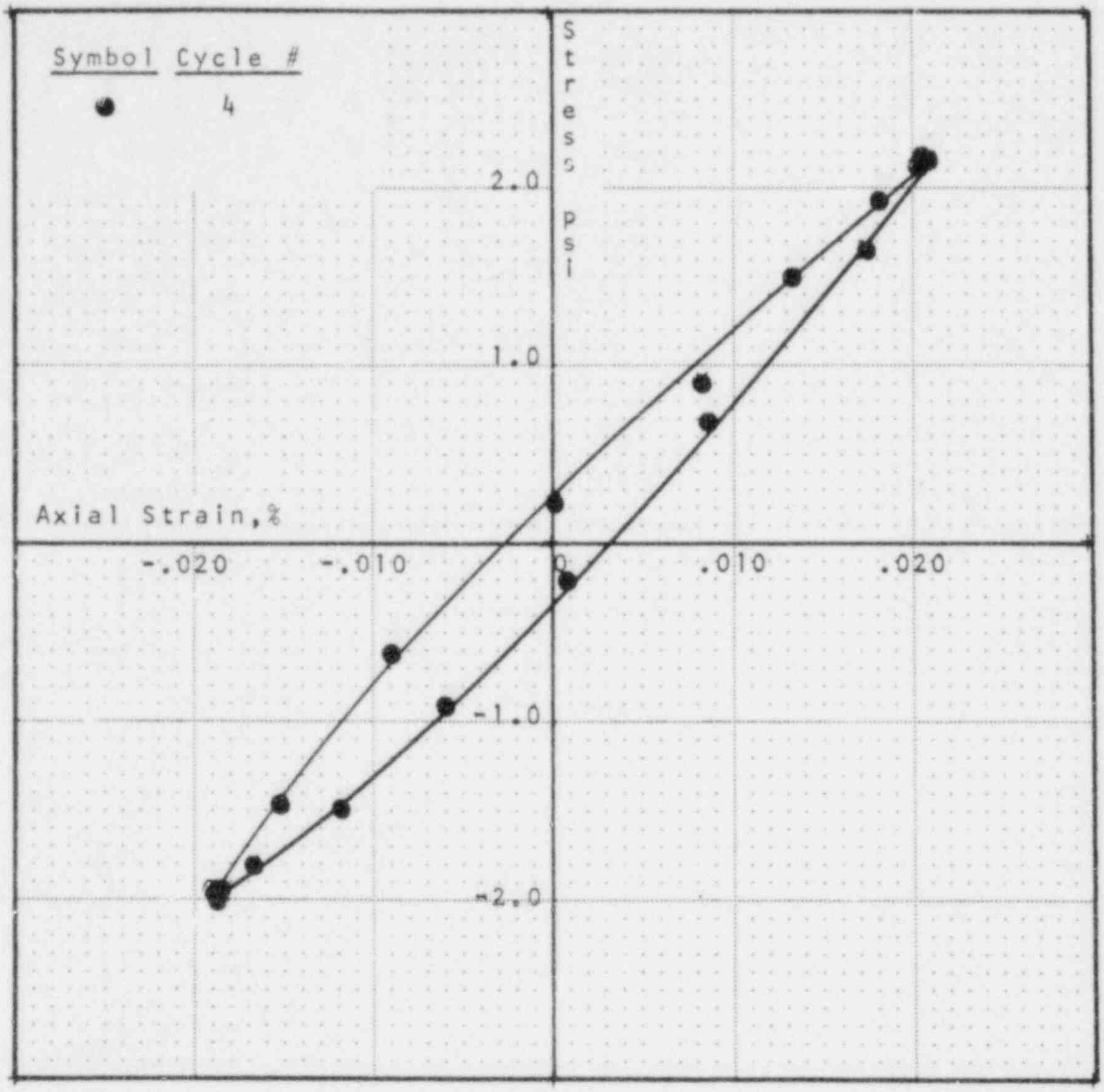
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 8
Depth 40.0 -42.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn_____ Date_____ Checked_____ Date_____ Approved_____ Date_____ Revised_____ Date_____ Approved_____ Date_____

FIG. 20C-19



Test No. 1

Effective Confining Pressure	18.0 psi
Back Pressure	30.0 psi

Specimen Data

Height	6.13 in.
Diameter	2.88 in.
Wet Unit Wt.	126.2 pcf
Water Content	
Before Test	21.5 %
After Test	22.1 %
Degree of Saturation	96.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	10580 psi
Damping	7.0 %
Double Amp. Strain	.0393 %

Classification:
Light gray, silty CLAY, trace of sand and gravel

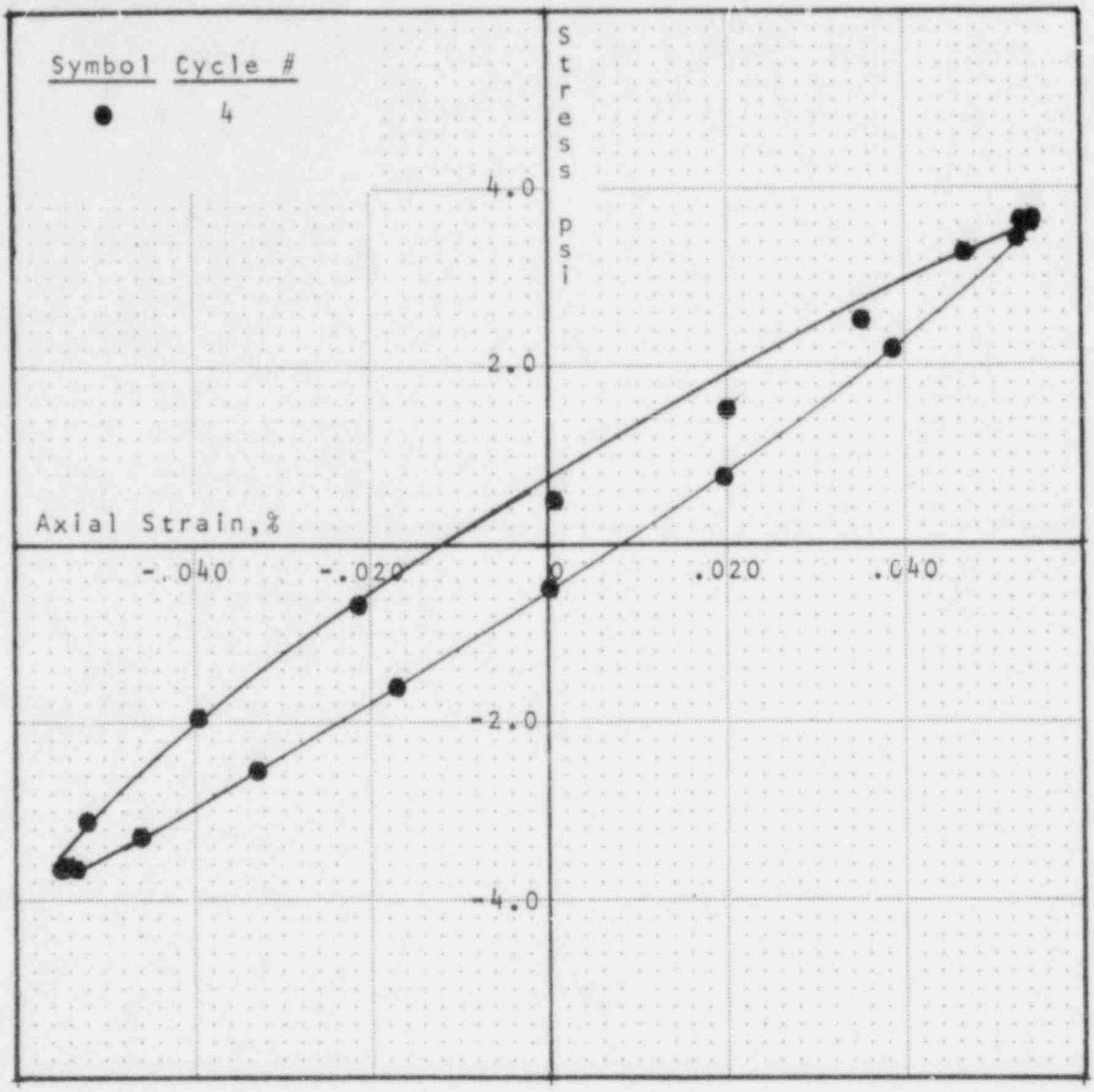
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 14
Depth 70.0 -72.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn______ Date______
Checked______ Date______
Approved______ Date______
Revised______ Date______
Approved______ Date______

FIG. 20C-20



Test No. 2

Effective Confining Pressure 18.0 psi
Back Pressure 30.0 psi

Specimen Data

Height	6.13 in.
Diameter	2.88 in.
Wet Unit Wt.	126.2 pcf
Water Content	
Before Test	21.5 %
After Test	22.1 %
Degree of Saturation	96.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	6840 psi
Damping	7.3 %
Double Amp. Strain	.1067 %

Classification:

Light gray, silty CLAY, trace of sand and gravel

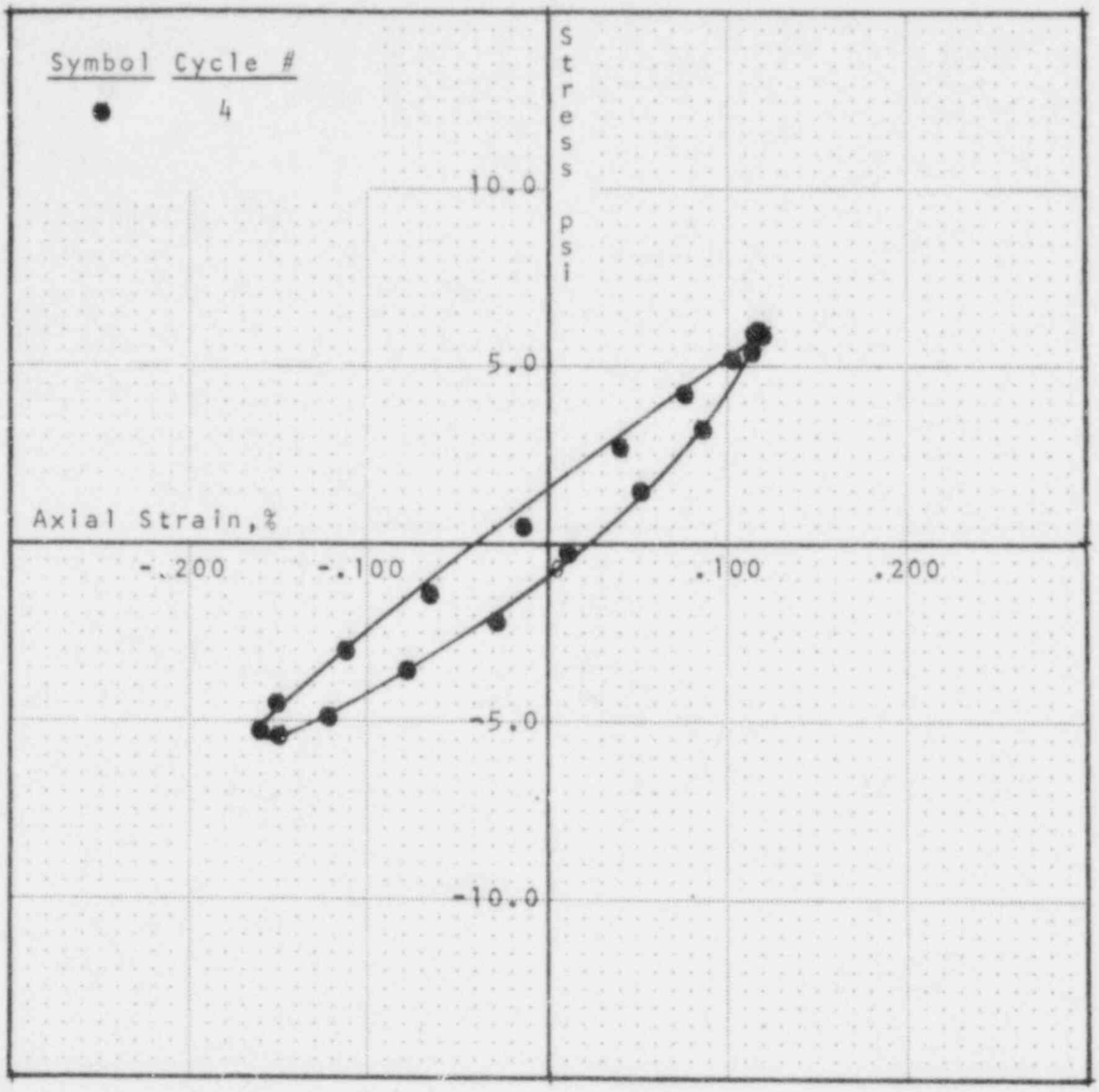
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 14
Depth 70.0 -72.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 20C-21



Test No. 3

Effective Confining Pressure	18.0 psi
Back Pressure	30.0 psi

Specimen Data

Height	6.13 in.
Diameter	2.88 in.
Wet Unit Wt.	126.2 pcf
Water Content	
Before Test	21.5 %
After Test	22.1 %
Degree of Saturation	96.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	4210 psi
Damping	9.3 %
Double Amp. Strain	.2697 %

Classification:

Light gr y, silty CLAY, trace of sand and gravel

CYCLIC TRIAXIAL TEST

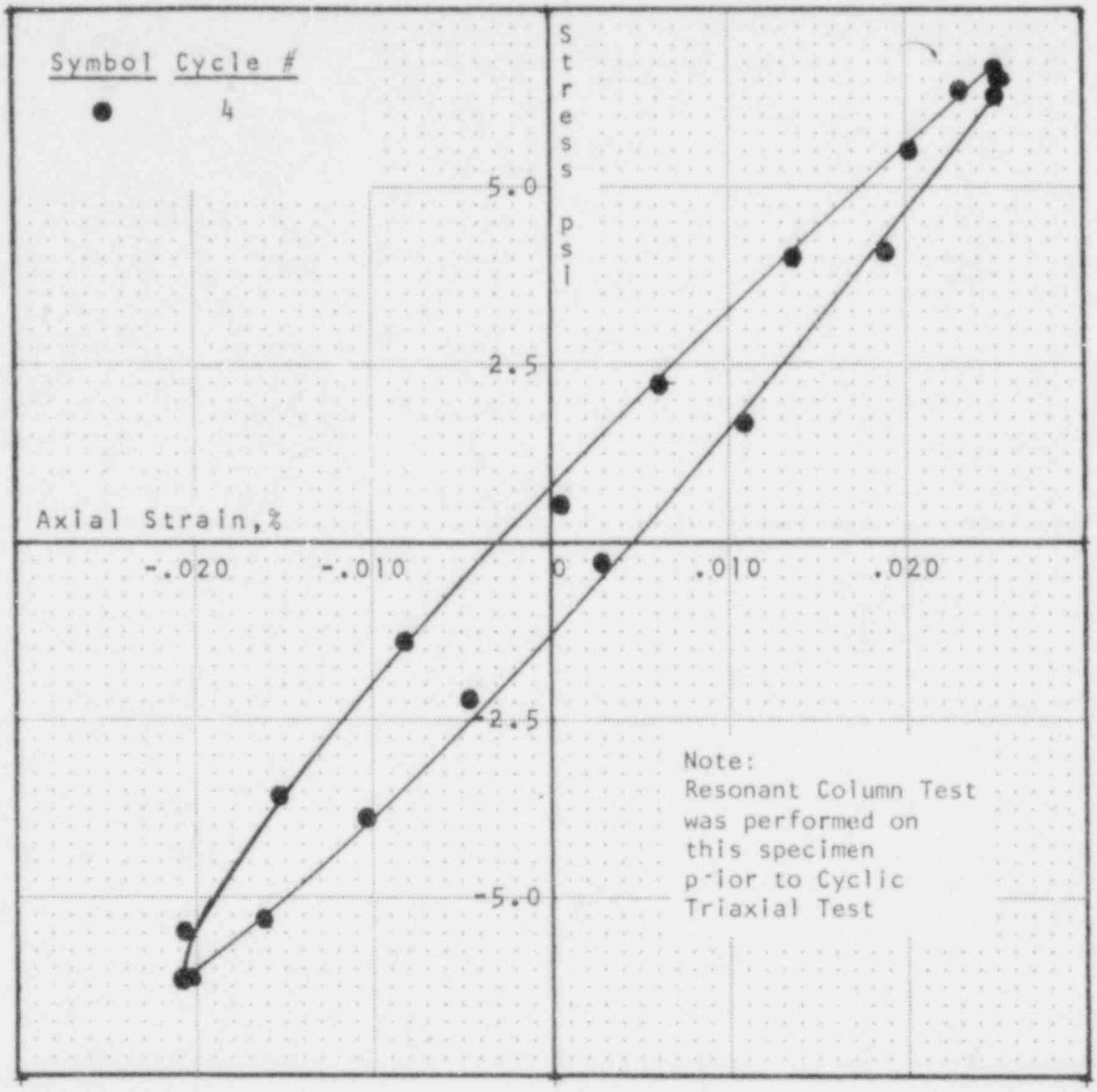
Boring B- 1
Sample S- 14
Depth 70.0 -72.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 20C-22

Drawn______ Checked______ Approved______ Revised______ Approved______
Date______ Date______ Date______ Date______ Date______



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 1

Effective Confining Pressure	70.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.99 in.
Diameter	2.88 in.
Wet Unit Wt.	125.1 pcf
Water Content	
Before Test	21.6 %
After Test	22.5 %
Degree of Saturation	88.4 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	27820 psi
Damping	7.3 %
Double Amp. Strain	.0461 %

Classification:

Mottled gray-brown, clayey, sandy SILT

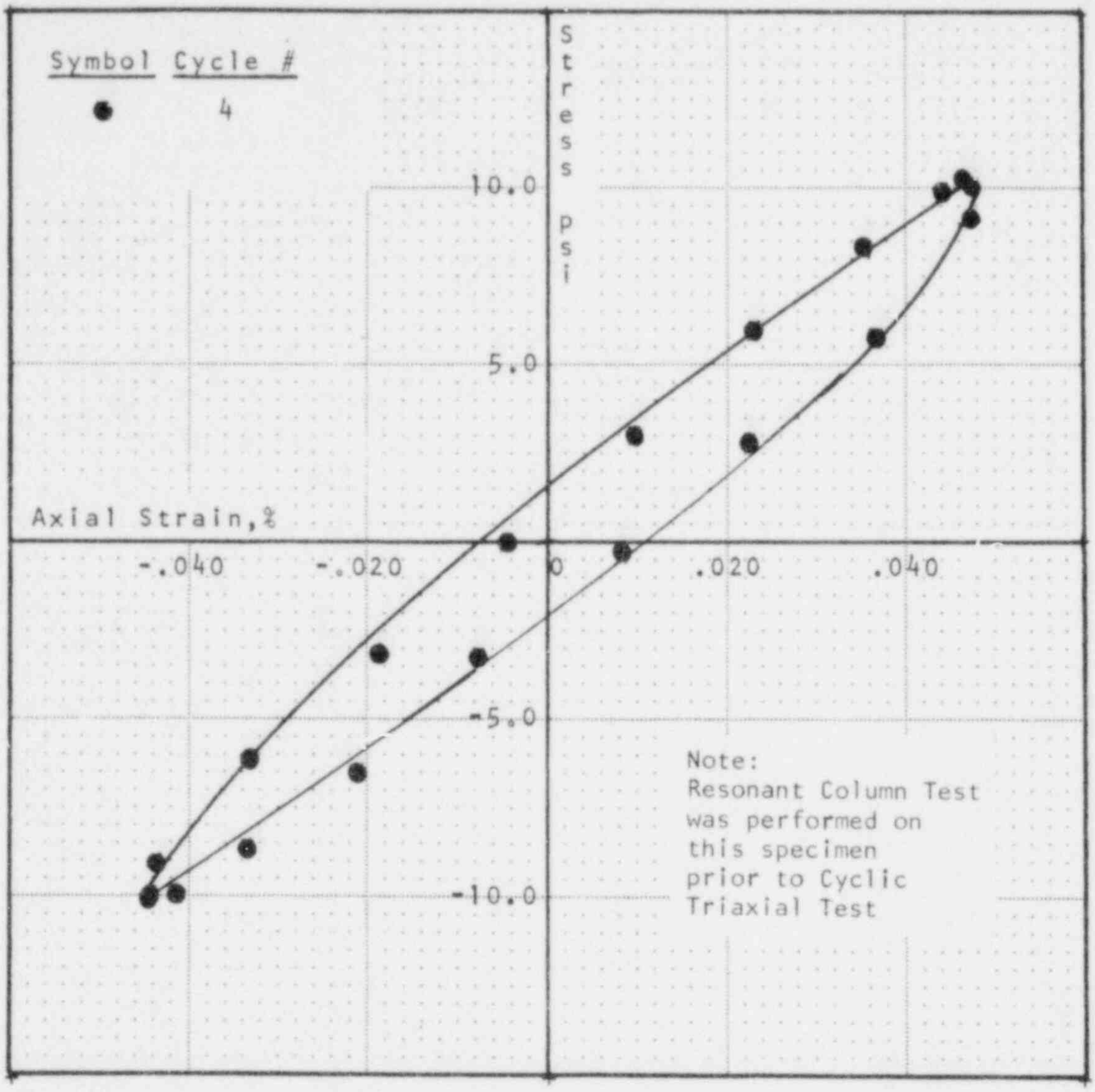
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 25
Depth 140.0-142.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-23

Drawn______ Checked______ Approved______ Revised______ Approved______
Date______ Date______ Date______ Date______ Date______



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 2

Effective Confining Pressure	70.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.99 in.
Diameter	2.88 in.
Wet Unit Wt.	125.1 pcf
Water Content	
Before Test	21.6%
After Test	22.5%
Degree of Saturation	88.4%

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	22120 psi
Damping	8.3 %
Double Amp. Strain	.0914 %

Classification:

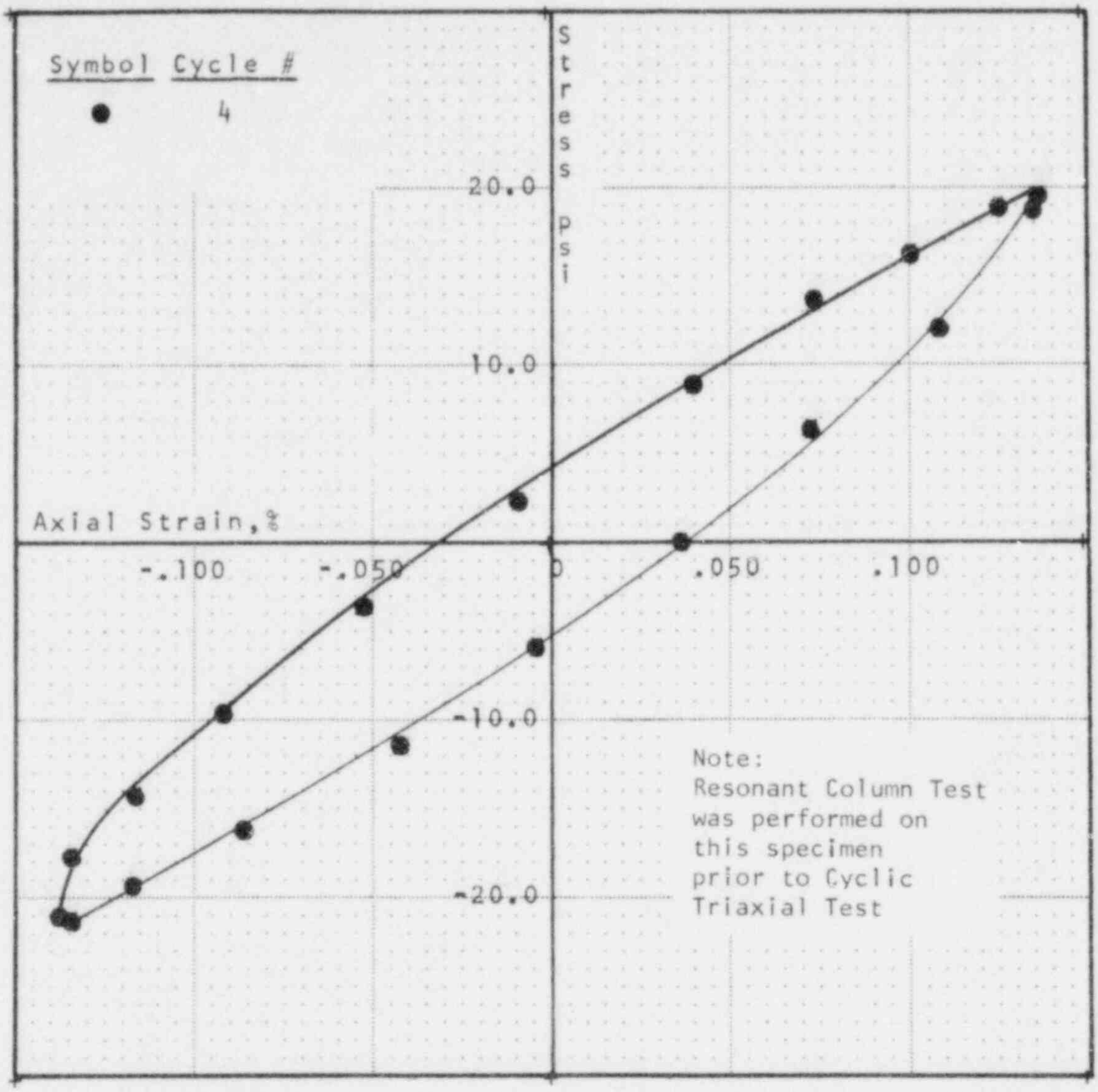
Mottled gray-brown, clayey, sandy SILT

CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 25
Depth 140.0-142.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

FIG. 20C-24



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 3

Effective Confining Pressure	70.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.99 in.
Diameter	2.88 in.
Wet Unit Wt.	125.1 pcf
Water Content	
Before Test	21.6
After Test	22.5%
Degree of Saturation	88.4%

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	14970 psi
Damping	11.1 %
Double Amp. Strain	.2717 %

Classification:

Mottled gray-brown, clayey, sandy SILT

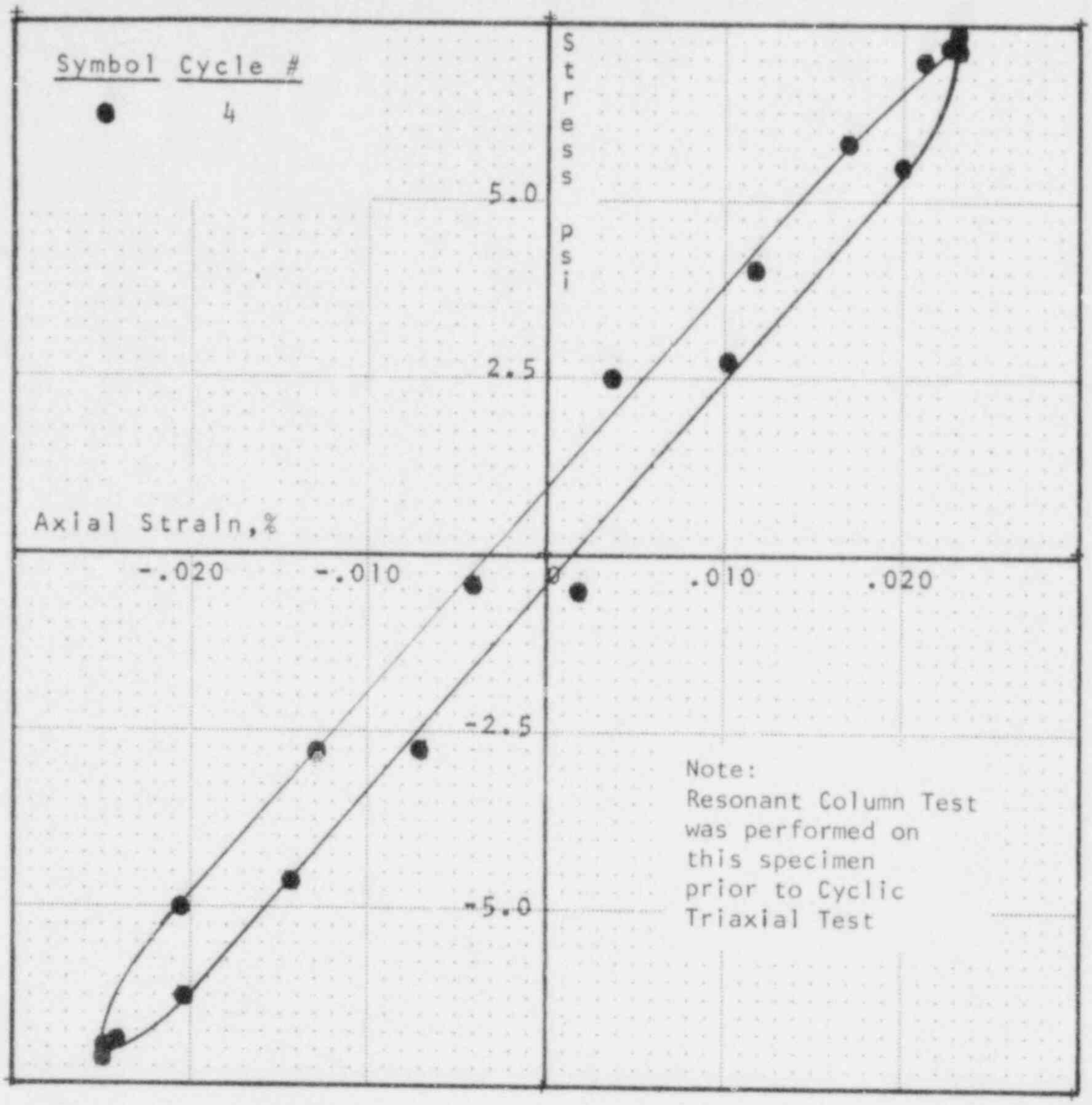
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 25
Depth 140.0-142.5 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn___ Date___
Checked___ Date___
Approved___ Date___
Revised___ Date___
Approved___ Date___

FIG. 20C-25



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 1

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.73 in.
Diameter	2.90 in.
Wet Unit Wt.	126.7 pcf
Water Content	
Before Test	21.3 %
After Test	21.3 %
Degree of Saturation	92.5 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	30110 psi
Damping	6.3 %
Double Amp. Strain	0480 %

Classification:

Brown silty CLAY,
trace of sand

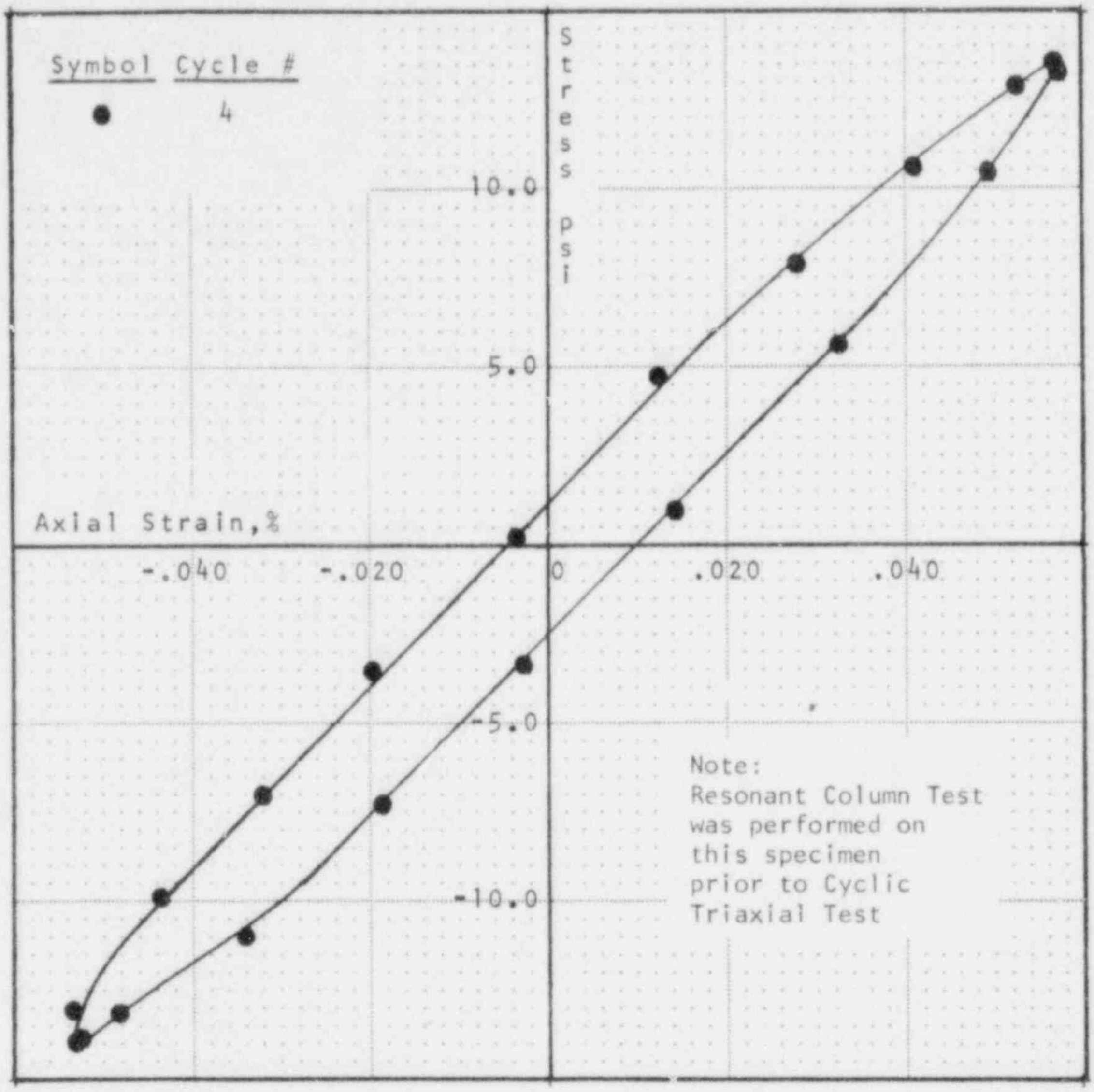
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 36
Depth 305.0-306.2 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 20C-26



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 2

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.73 in.
Diameter	2.90 in.
Wet Unit Wt.	126.7 pcf
Water Content	
Before Test	21.3 %
After Test	21.3 %
Degree of Saturation	92.5 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	25010 psi
Damping	7.4 %
Double Amp. Strain	.1110 %

Classification:

Brown silty CLAY,
trace of sand

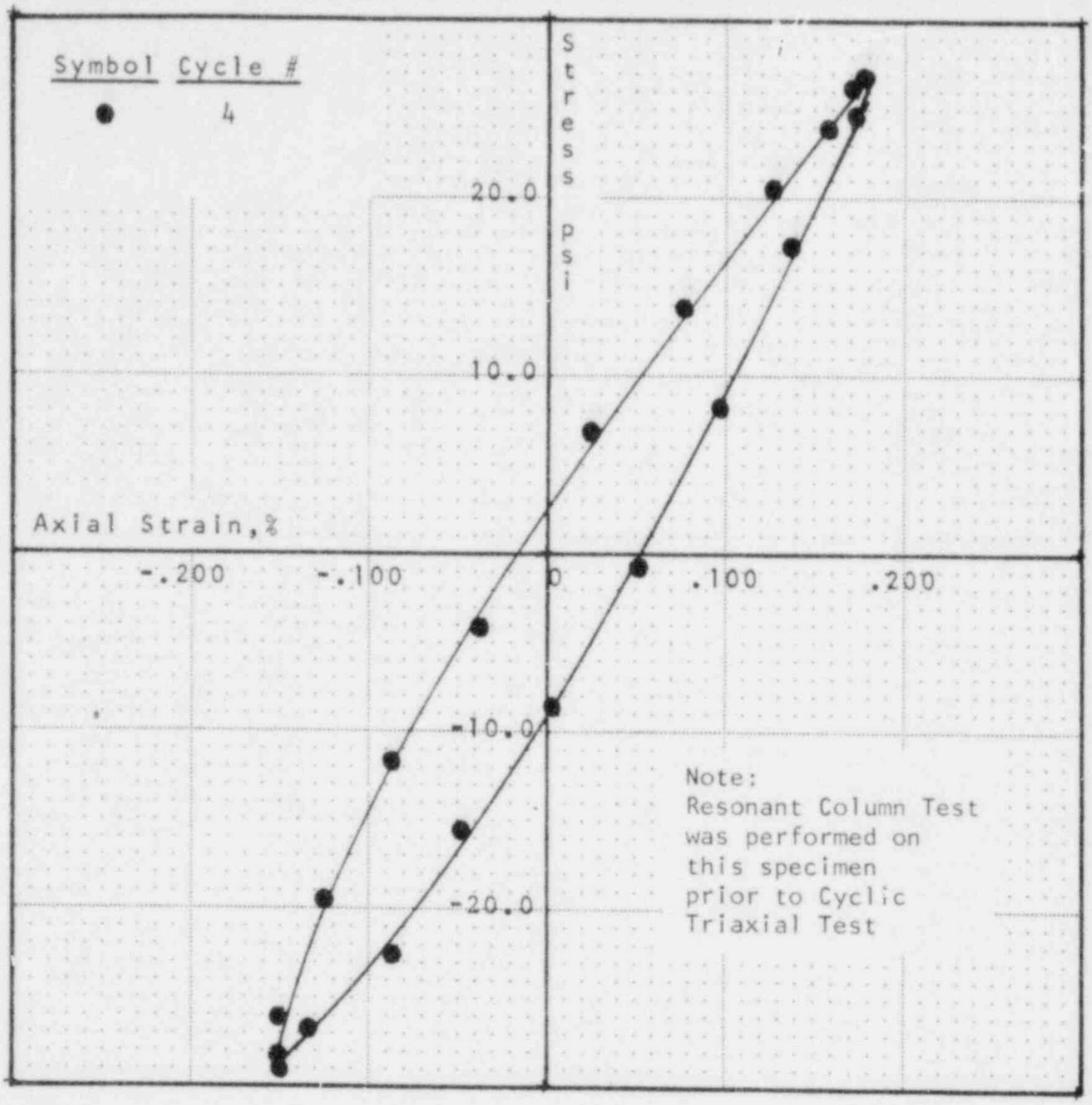
CYCLIC TRIAXIAL TEST

Boring B-1
Sample S-36
Depth 305.0-306.2 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 20C-27



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 3

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.73 in.
Diameter	2.90 in.
Wet Unit Wt.	126.7 pcf
Water Content	
Before Test	21.3 %
After Test	21.3 %
Degree of Saturation	92.5 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	17090 psi
Damping	9.8 %
Double Amp. Strain	.3266 %

Classification:

Brown silty CLAY,
trace of sand

CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 36
Depth 305.0-306.2 Ft.

CITY HALL
HOLLISTER, CALIFORNIA

Drawn______ Date______
Checked______ Date______
Approved______ Date______
Revised______ Date______
Approved______ Date______

FIG. 20C-28

Section 21C

Hollywood Storage Building
Los Angeles, California

SECTION 21C

LABORATORY TESTING

HOLLYWOOD STORAGE BUILDING

LOS ANGELES, CALIFORNIA

LIST OF TABLES

LIST OF FIGURES

SECTION 21C

LIST OF FIGURES (Cont'd)

TABLE 21C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler[1] or Blows/6"	Shear[2] Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits			Other[3] Tests	Sample Classification
							LL	PL	PI		
B-1	S-1	5.0-6.5	6,5,4			16.9					Stiff, dark brown, fine to medium sandy, silty CLAY; trace of coarse sand and organics.
	S-2	10.0-12.5	Pitcher			31.5					Very stiff, brown, fine to coarse sandy, silty CLAY; decreasing sand content with depth; blocky and slickensided.
	S-3	15.0-16.5	4,6,12			21.8					Very stiff, brown, fine sandy, clayey SILT; lenses of clayey, silty, fine to coarse SAND.
	S-4	20.0-22.5	Pitcher			32.6	42	23	19		Top 0.7': Stiff, brown, fine sandy, silty CLAY; scattered fine gravel. CL.
						17.3					Bottom 0.9': Medium dense, brown, silty, fine to coarse SAND; trace of fine gravel.
	S-5	25.0-26.5	16,14,15			27.3					Medium dense, brown, silty, fine to medium SAND.
	S-6	30.0-31.5	12,17,15			16.7					Dense, brown, silty, fine to coarse SAND, and fine to coarse GRAVEL.
	S-7	35.0-37.5	Pitcher	1.46	101.6	22.7	43	19	24		Very stiff, brown, fine to medium sandy, silty CLAY; trace of coarse sand and fine to coarse gravel. CL.
	S-8	40.0-41.5	10,13,18			23.5					Alternating layers of very stiff, brown, fine sandy, silty CLAY, and dense, silty, fine to medium SAND, with trace of coarse sand.
	S-9	45.0-47.5	Pitcher			33.5					Same as S-8.
	S-10	50.0-51.5	14,25,44			17.5					Very dense, brown, silty, fine to coarse SAND; trace of fine gravel and clayey lenses.
	S-11	55.0-56.5	24,36,40			14.3					Very dense, brown, silty, fine to coarse gravelly, fine to coarse SAND; trace of clayey lenses.
	S-12	60.0-62.5	Pitcher			25.6					Alternating layers of very dense, red-brown, silty, fine SAND and hard, red-brown, fine sandy, silty CLAY.
	S-13	65.0-66.5	12,17,25			23.7					Hard, brown, fine sandy, silty CLAY; trace of medium to coarse sand.
	S-14	70.0-72.5	Pitcher	0.72	89.6	29.2	54	24	30		Stiff, red-brown, fine sandy, silty CLAY. CH.
	S-15	75.0-76.5	12,18,26			25.9					Hard, red-brown, fine sandy, silty CLAY; trace of medium sand and carbonaceous stains.
	S-16	80.0-82.5	Pitcher	 3.75^u	105.3 108.0	19.9 18.2	51	18	33	RC,CT,MA	Hard, red-brown, fine sandy, silty CLAY; scattered carbonaceous specks. CH.
	S-17	85.0-86.5	12,13,19			25.2					Same as S-16.
	S-18	90.0-92.5	Pitcher			19.0					Hard, red-brown, fine sandy, silty CLAY; increasing sand content with depth.
	S-19	95.0-96.5	12,23,35			22.9					Very dense, red-brown, silty, fine to medium SAND; trace of carbonaceous stains.
	S-20	100.0-102.5	Pitcher			28.4					Top 0.9': Very dense, red-brown, silty, fine to medium SAND.
						21.4					Bottom 0.2': Very dense, red-brown, silty, fine to coarse SAND; trace of fine gravel.
	S-21	110.0-111.5	24,28,25*			18.4					Same as Bottom of S-20.
	S-22	120.0-121.5	24,24,31*			20.4					Same as Bottom of S-20.
	S-23	130.0-132.5	Pitcher	 10.8^u	100.0 99.6	20.8 23.2				RC,CT,MA	Very dense, brown, fine SAND; trace of medium sand. SP.
	S-24	140.0-141.5	31,31,48*			27.4					Very dense, gray-brown, silty, fine SAND.
	S-25	150.0-152.5	Pitcher	3.96	102.1	23.5					Hard, dark gray, fine sandy, clayey SILT; trace of small shell fragments.
	S-26	160.0-161.5	14,17,40*			25.0					Same as S-25.
	S-27	170.0-172.5	Pitcher			24.8					Same as S-25.
	S-28	180.0-181.5	14,19,39*			23.3					Same as S-25.
	S-29	190.0-192.5	Pitcher	10.9^u	103.5	20.0	35	29	6	RC,CT,MA	Hard, dark gray, fine sandy, clayey SILT. ML
	S-30	200.0-201.0	27, 50*/5"			24.7					Same as S-29.
	S-31	221.0-223.5	Pitcher			22.0					Same as S-29.
	S-32	242.0-243.5	27,39,40*			26.3					Same as S-29.
	S-33	263.0-265.5	Pitcher	3.43	102.1	23.5	36	27	9		Same as S-29. ML.
	S-34	284.0-285.5	18,32,50*			26.2					Same as S-29.
	S-35	305.0-307.5	Pitcher	 12.5^u	96.1 104.4	32.1 21.1	36	22	14	RC,CT,MA	Hard, dark gray, fine sandy, silty CLAY. CL.

Sheet 1 of 2

POOR ORIGINAL

TABLE 21C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler[1] or Blows/6"	Shear[2] Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits			Other Tests[3]	Sample Classification
							LL	PL	PI		
B-1 (Cont'd)	S-36	326.0-327.0	24, $\frac{50^{*}}{6''}$			27.0					Hard, dark gray, fine sandy, silty CLAY.
	S-37	347.0-349.5	Pitcher	12.7^{u}	105.1	20.6	51	25	26	RC,CT,MA	Hard, gray, silty CLAY; trace of fine sand. CH.

Notes:

1. Downhole jars (325 lb. weight, 18" stroke) used in lieu of SPT equipment (140 lb. hammer, 30" stroke) for drive sample indicated with an "*".

2. Shear strengths were determined from unconfined compression tests ($q_u/2$) except values denoted by "u" which correspond to unconsolidated-undrained compression tests.

3. Legend for Tests

Symbol	Explanation
MA	Mechanical Analysis
RC	Resonant Column Test
CT	Cyclic Triaxial Test

POOR ORIGINAL

TABLE 21C-2

SUMMARY OF DYNAMIC TEST RESULTS

Boring B-1
Hollywood Storage Building
Los Angeles, California

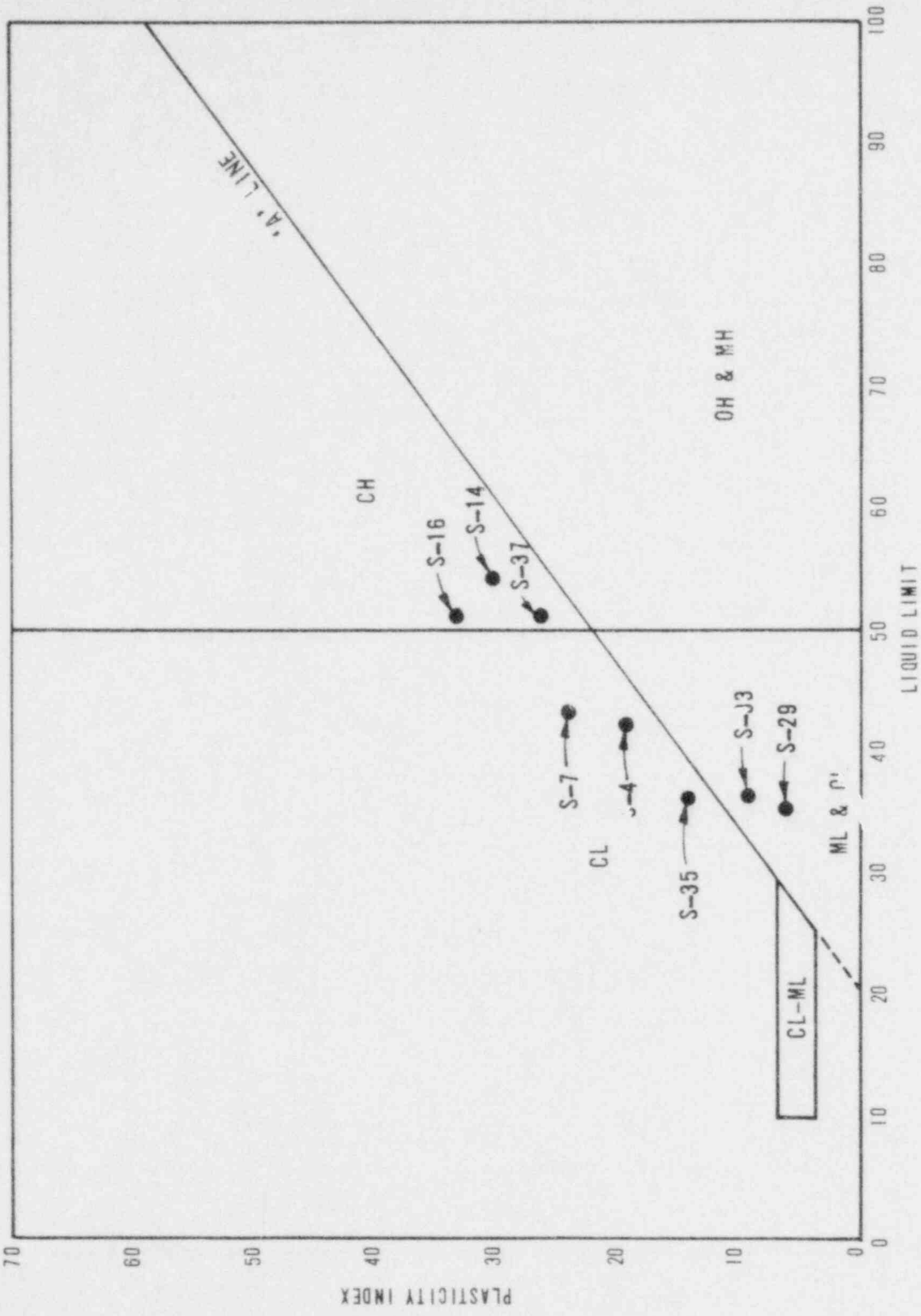
Sample	Depth ft.	Specimen Height in.	Specimen Diameter in.	Water Content %	Wet Unit Weight pcf	$\bar{\sigma}_3$ psi	Resonant Column G psi	Resonant Column γ %	Resonant Column λ %	Cyclic Triaxial G* psi	Cyclic Triaxial γ* %	Cyclic Triaxial λ %	Classification
S-16	80.0-82.5	5.40	2.86	19.9	126.3	80	31100	6.7×10^{-5}	-	14400	3.41×10^{-2}	6.7	Red-brown, sandy silty CLAY
							30600	2.7×10^{-4}	-	11300	7.29×10^{-2}	7.5	
							30800	1.4×10^{-3}	-	8530	0.169	9.5	
							30200	5.4×10^{-3}	-				
S-23	130.0-132.5	5.91	2.74	20.8	120.9	100	33400	1.2×10^{-4}	-				Brown SAND
							31600	7.0×10^{-4}	-				
							30400	3.0×10^{-3}	-				
							27100	9.4×10^{-3}	-				
		5.50	2.73	20.8	120.9	100				15900	3.27×10^{-2}	7.0	
										15300	6.29×10^{-2}	7.4	
										12000	0.154	6.8	
S-29	190.0-192.5	5.94	2.84	20.0	124.2	100	24100	1.8×10^{-4}	-	12200	3.92×10^{-2}	6.6	Dark gray, sandy clayey SILT
							23800	$9.0-10^{-4}$	-	11500	6.29×10^{-2}	5.6	
							22400	3.9×10^{-3}	-	9790	0.15	8.8	
							18700	1.8×10^{-2}	-				
S-35	305.0-307.5	5.91	2.84	32.1	127.0	100	32800	6.8×10^{-5}	-	22900	1.61×10^{-2}	8.0	Dark gray, sandy, silty CLAY
							32700	2.5×10^{-4}	-	17600	7.03×10^{-2}	9.3	
							32200	1.3×10^{-3}	-	13600	0.146	11.9	
							28700	7.1×10^{-3}	-				
S-37	347.0-349.5	5.96	2.84	20.6	126.8	100	28000	$8.0-10^{-5}$	-	14900	3.20×10^{-2}	8.4	Gray, silty CLAY
							27600	2.4×10^{-4}	-	12000	6.10×10^{-2}	6.8	
							28000	1.6×10^{-3}	-	9250	0.158	9.2	
							27500	7.2×10^{-3}	-				

NOTES:

$\bar{\sigma}_3$ Effective Confining Pressure
G Shear Modulus
γ,γ* Single Amplutude Shear Strain
λ Damping

$G^* = (E/2(1+\mu))$
$\gamma^* = (1+\mu)\varepsilon$
where:
E = Modulus of Elasticity
ε = Single Amplitude Axial Strain
μ = Poisson's Ratio (estimated as 0.4)

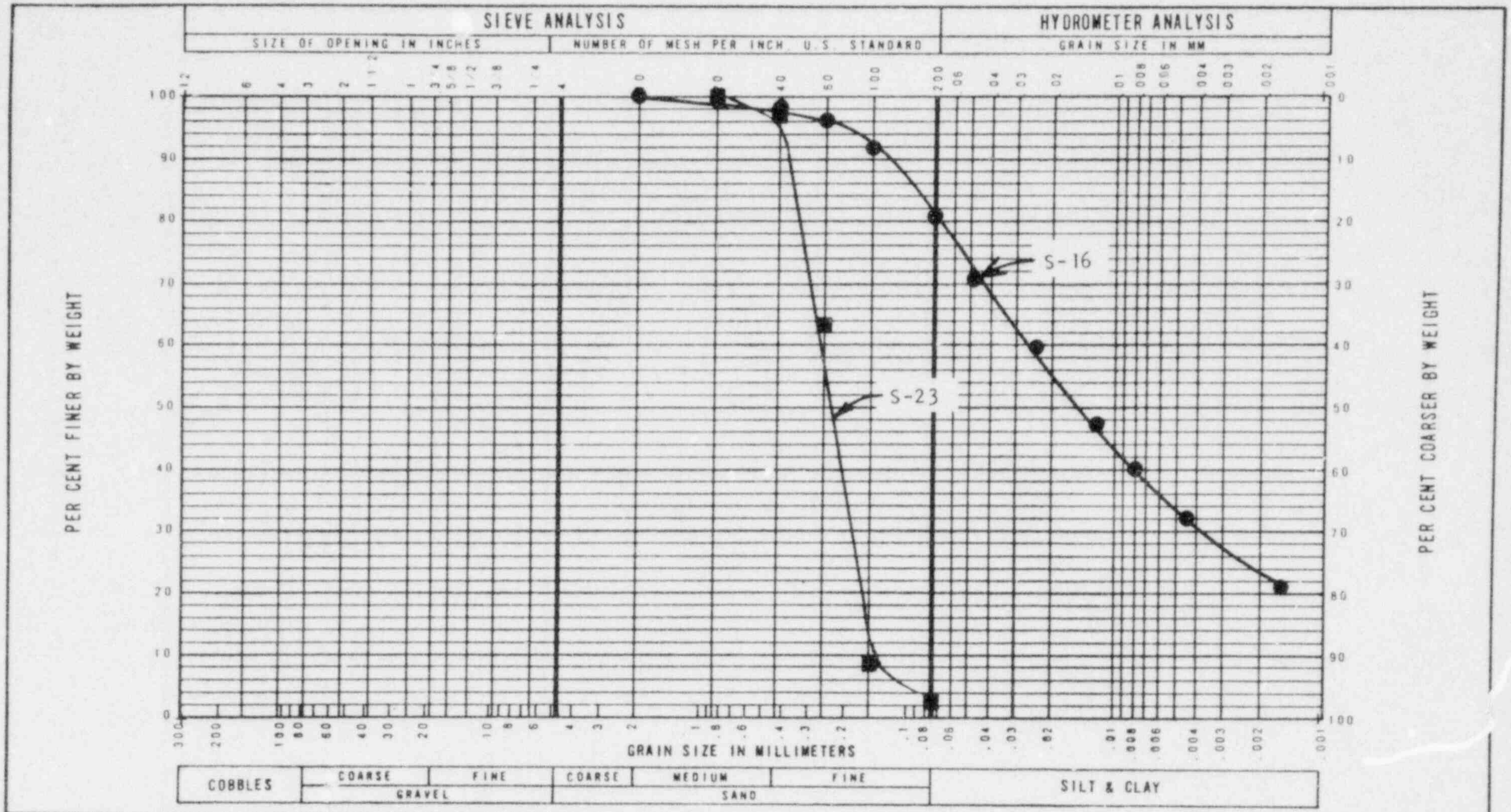
POOR ORIGINAL



PLASTICITY CHART
BORING B-1
HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-1

Drawn JAm Checked________ Approved________ Revised________ Approved________
Date 2.26.79 Date________ Date________ Date________ Date________



SAMPLE NO.	DEPTH-FT	U.S.C.	CLASSIFICATION	G_s	NAT W.C. %	LL	PL	PI
S-16	80.0-82.5	CH	Red-brown, sandy, silty CLAY		20.7	51	18	33
S-23	130.0-132.5	SP	Brown, SAND		20.8			

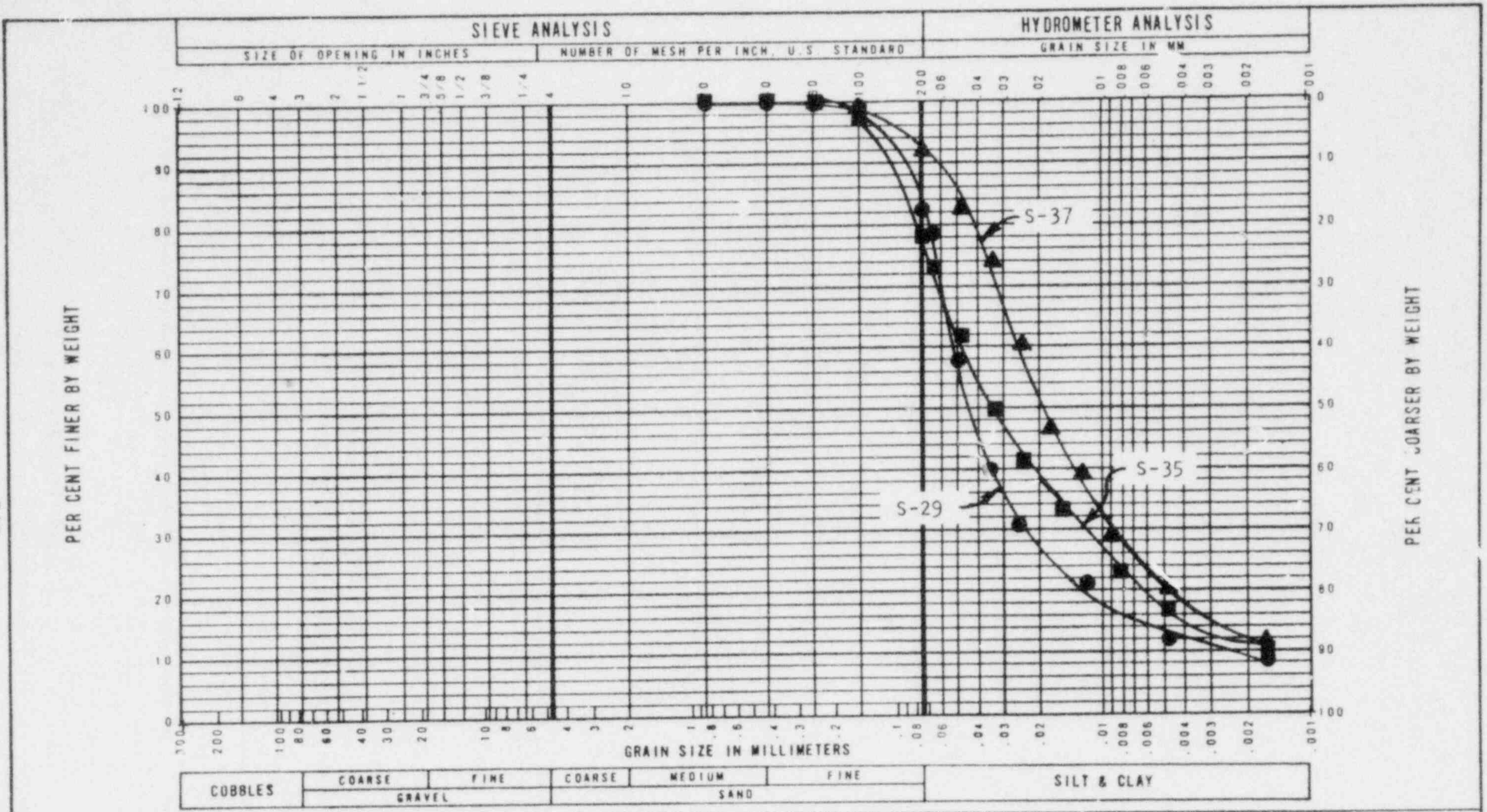
GRAIN SIZE CLASSIFICATION

Boring B-1

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-2

Drawn SDm Checked Approved Revised Approved
Date 2-26-79 Date Date Date Date



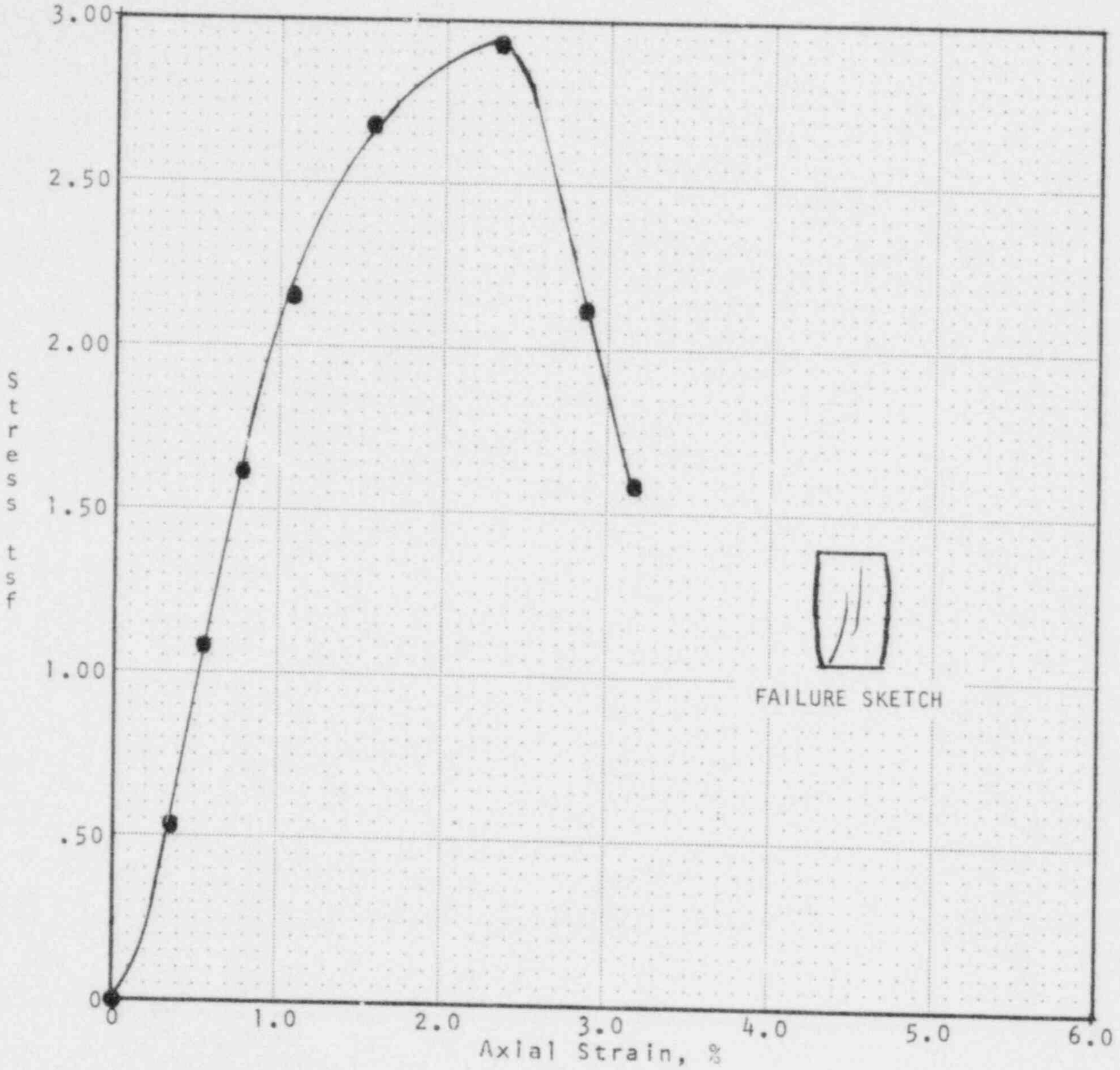
SAMPLE NO	DEPTH-FT.	U.S.C.	CLASSIFICATION	G_S	NAT. W.C. %	LL	PL	PI
S-29	190.0-192.5	ML	Dark gray, sandy, clayey SILT		24.6	35	29	6
S-35	305.0-307.5	CL	Dark gray, sandy, silty CLAY		22.9	36	22	14
S-37	347.0-349.5	CH	Gray, silty CLAY; trace of sand		23.5	51	25	26

GRAIN SIZE CLASSIFICATION

Boring B-1

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-3



Specimen Data:

Height	6.65	in.
Diameter	2.88	in.
Ht./Dia. Ratio	2.31	
Wet Unit Wt.	124.7	pcf
Water Content	22.7	%
Degree of Saturation	93.1	%
Rate of Strain	.714	%/min.
Unconf. Comp. Strength	2.92	tsf
Shear Strength	1.46	tsf

Specimen Undisturbed

Classification:
Brown, sandy, silty CLAY,
trace of gravel

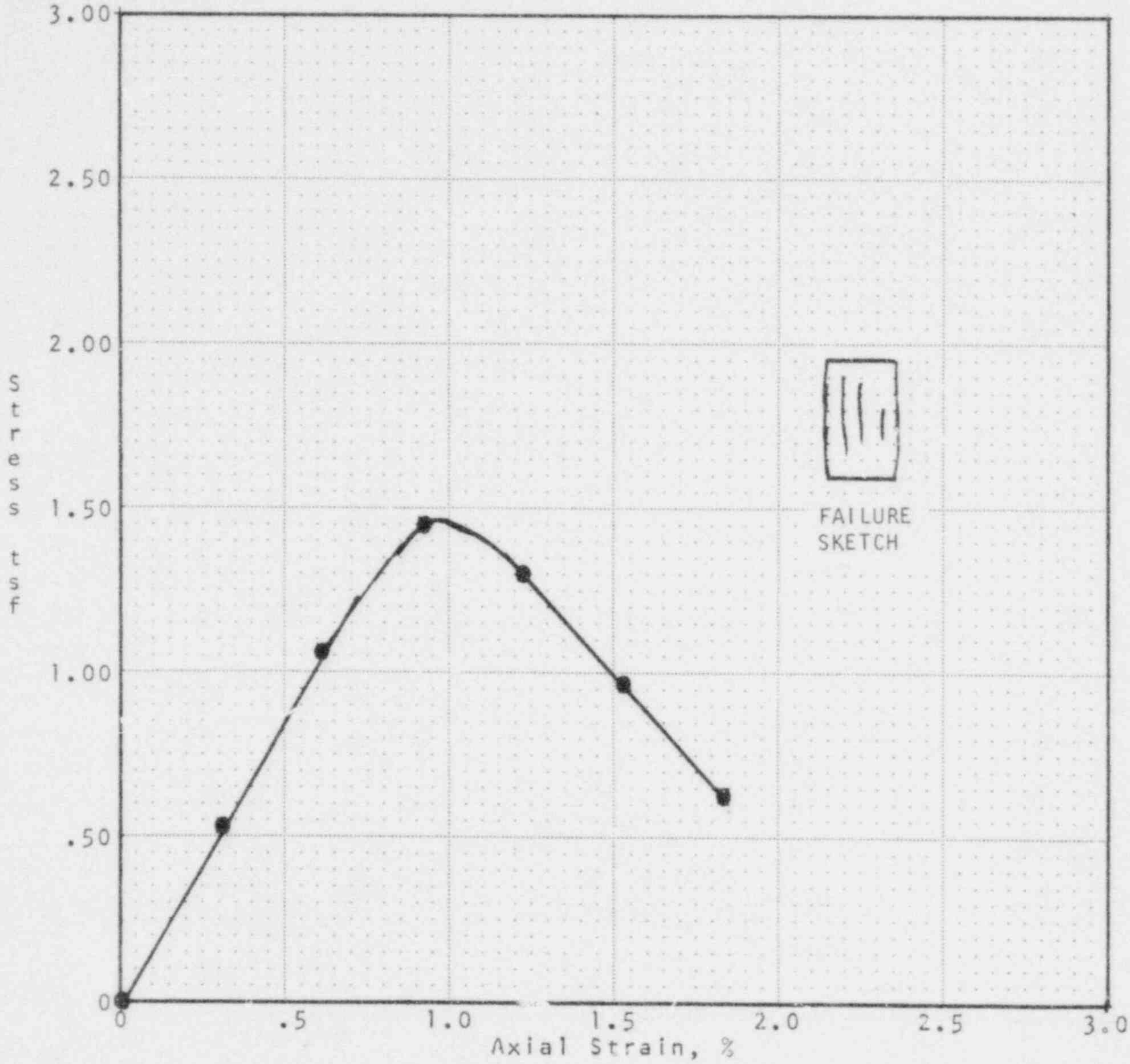
UNCONFINED
COMPRESSION TEST

Boring B- 1
Sample S- 7
Depth 35.0 -37.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Checked_____ Approved_____ Revised_____ Approved_____
Date_____ Date_____ Date_____ Date_____ Date_____

FIG. 21C-4



Specimen Data:

Height	6.53 in.
Diameter	2.89 in.
Ht./Dia. Ratio	2.26
Wet Unit Wt.	115.8 pcf
Water Content	29.2 %
Degree of Saturation	89.6 %
Rate of Strain	.918 %/min.
Unconf. Comp. Strength	1.45 tsf
Shear Strength	.72 tsf

Specimen Undisturbed

Classification:
Red-brown, sandy, silty CLAY

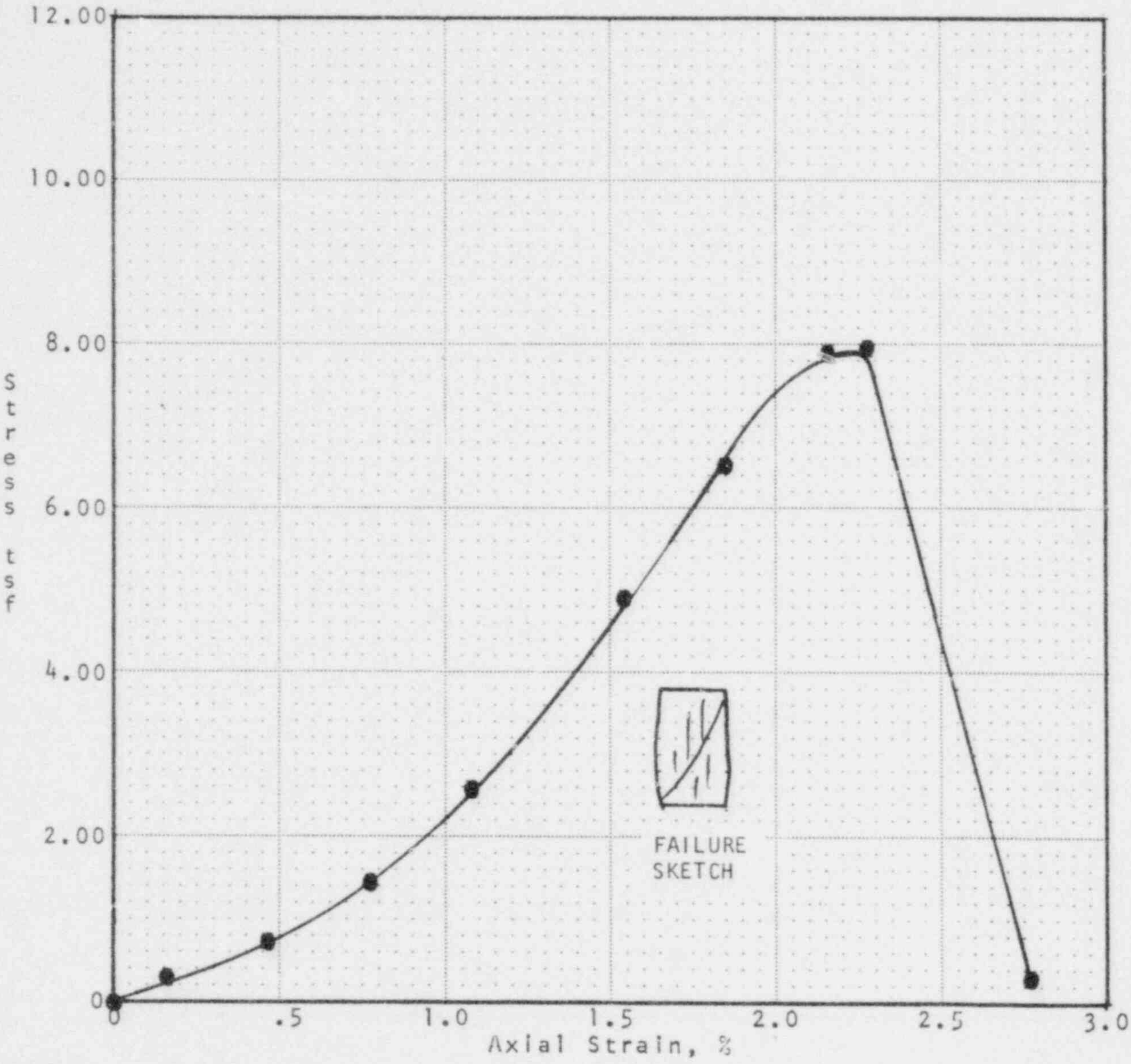
UNCONFINED
COMPRESSION TEST

Boring B- 1
Sample S- 14
Depth 70.0 -72.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-5



Specimen Data:

Height	6.50 in.
Diameter	2.85 in.
Ht./Dia. Ratio	2.28
Wet Unit Wt.	126.1 pcf
Water Content	23.5 %
Degree of Saturation	97.6 %
Rate of Strain	.791 %/min.
Unconf. Comp. Strength	7.93 tsf
Shear Strength	3.96 tsf

Specimen Undisturbed

Classification:
Dark-gray, sandy clayey SILT

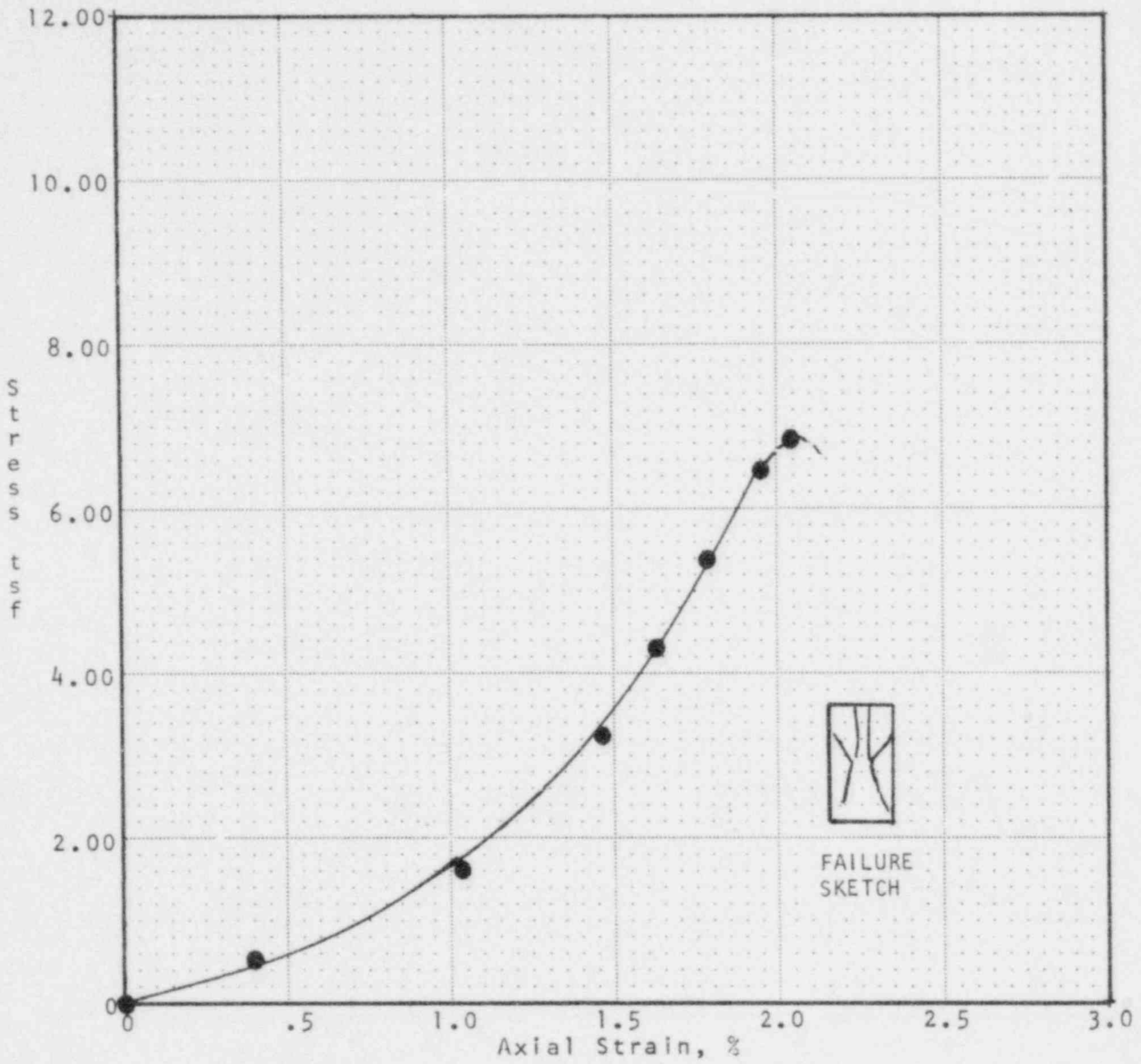
UNCONFINED
COMPRESSION TEST

Boring B- 1
Sample S- 25
Depth 150.0-152.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn______ Date______
Checked______ Date______
Approved______ Date______
Revised______ Date______
Approved______ Date______

FIG. 21C-6



Specimen Data:

Height	6.16 in.
Diameter	2.86 in.
Ht./Dia. Ratio	2.15
Wet Unit Wt.	126.1 pcf
Water Content	23.5 %
Degree of Saturation	97.6 %
Rate of Strain	.409 %/min.
Unconf. Comp. Strength	6.87 tsf
Shear Strength	3.43 tsf

Specimen Undisturbed

Classification:
Dark gray, sandy clayey SILT

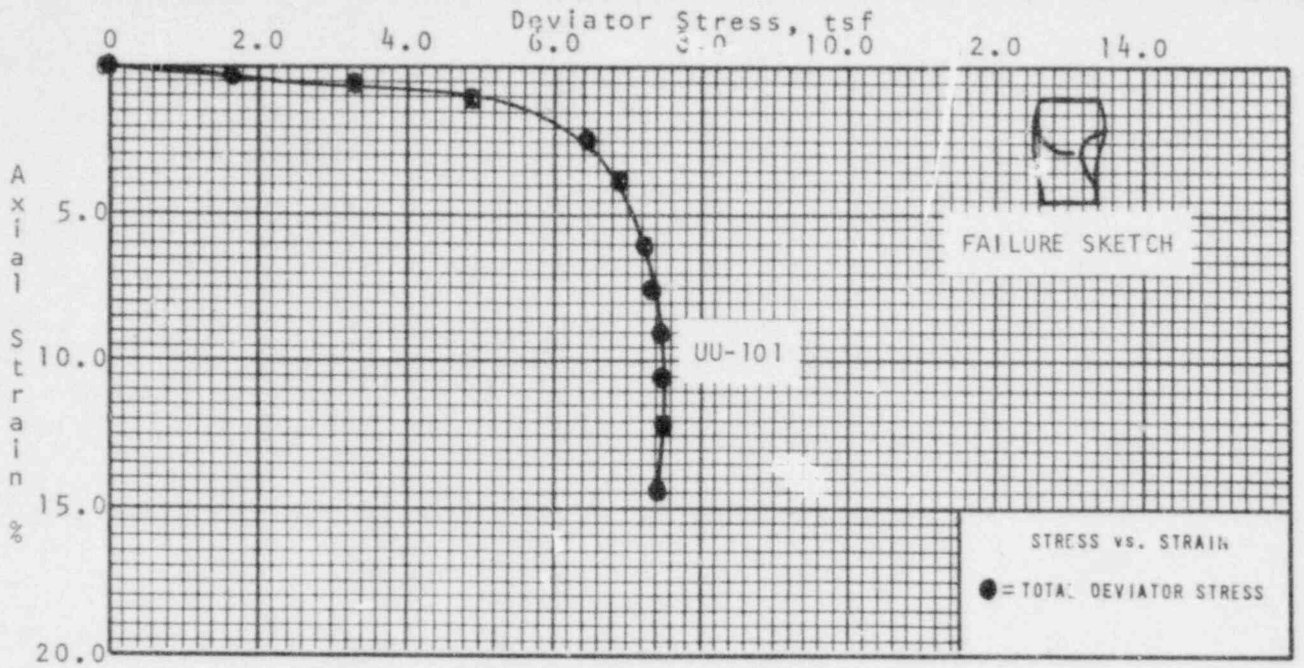
UNCONFINED
COMPRESSION TEST

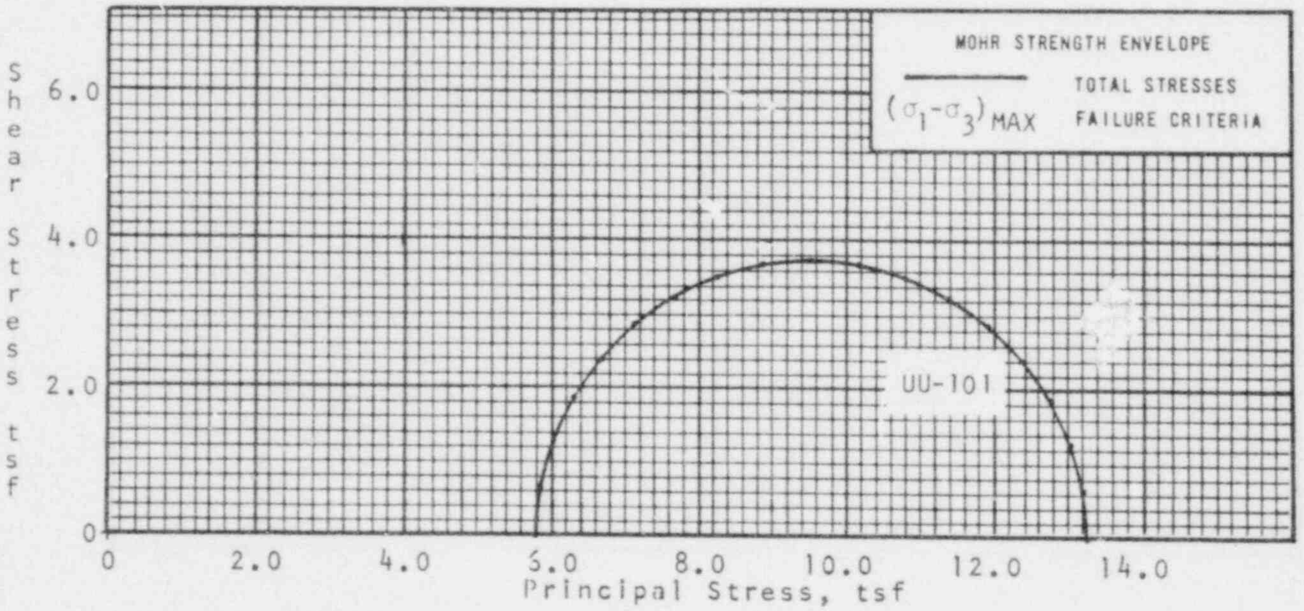
Boring B- 1
Sample S- 33
Depth 263.0-265.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn Dml Checked___ Approved___ Revised___ Approved___
Date 8-08-79 Date___ Date___ Date___ Date___

FIG. 21C-7





Test No.	UU-101
Boring No.	B - 1
Sample No.	S -16
Confining Pressure, tsf	5.76
Ht., in.	6.61
Dia., in.	2.86
Ht./Dia. Ratio	2.31
Wet Unit Wt., pcf	127.6
Water Content, %	
Before Test	18.2
After Test	19.9
Degree of Saturation, %	87.0
Avg. % Strain/Min.	1.310

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Red-brown, sandy, silty CLAY

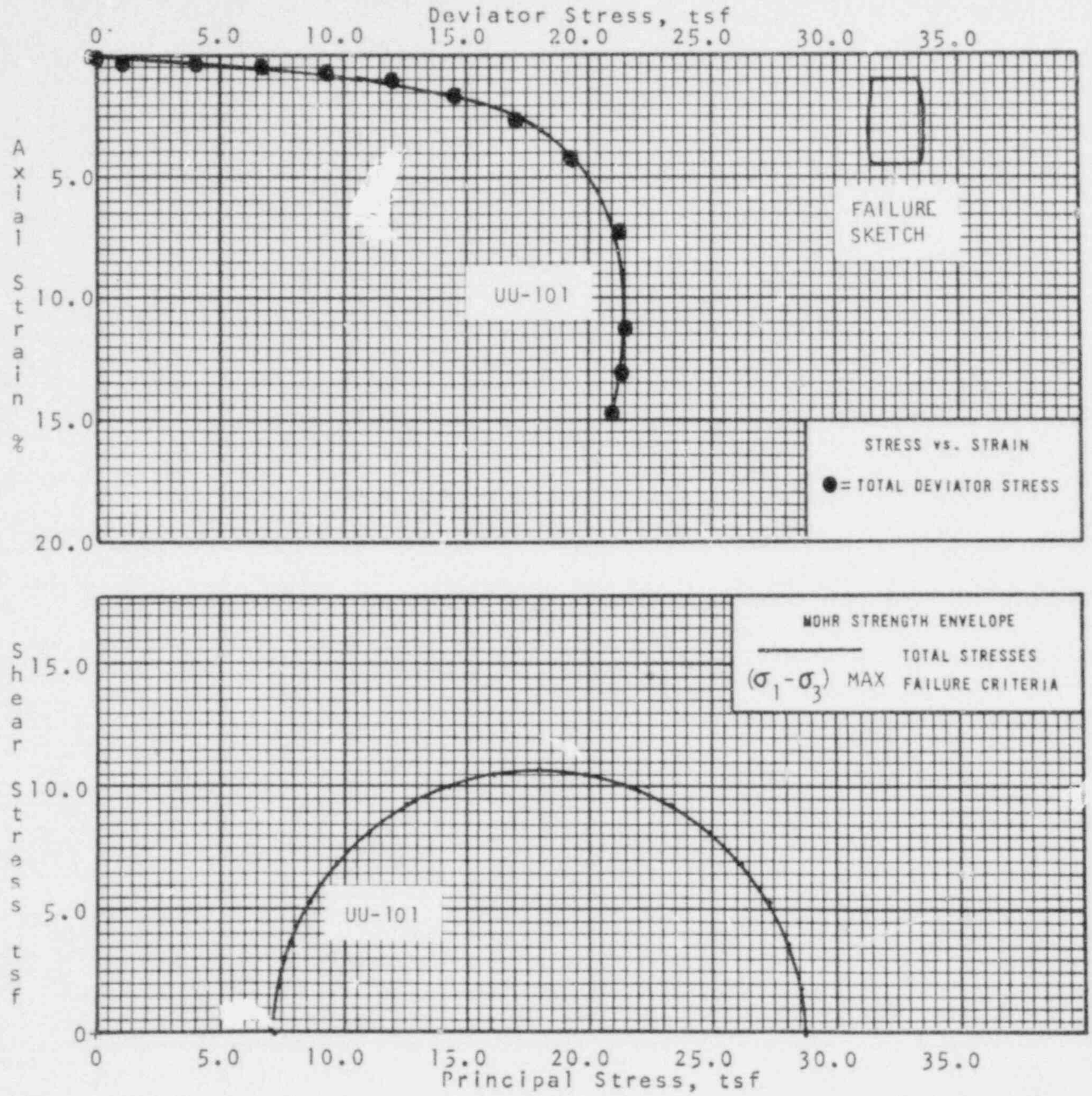
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 16
Depth 80.0 -82.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____ Checked_____ Date_____ Approved_____ Date_____ Revised_____ Date_____ Approved_____ Date_____

FIG. 21C-8



Test No.	UU-101
Boring No.	B - 1
Sample No.	S- 23
Confining Pressure, tsf	7.19
Ht., in.	6.14
Dia., in.	2.75
Ht./Dia. Ratio	2.23
Wet Unit Wt., pcf	122.7
Water Content, %	
Before Test	23.2
After Test	23.2
Degree of Saturation, %	86.3
Avg. % Strain/Min.	.650

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Brown SAND

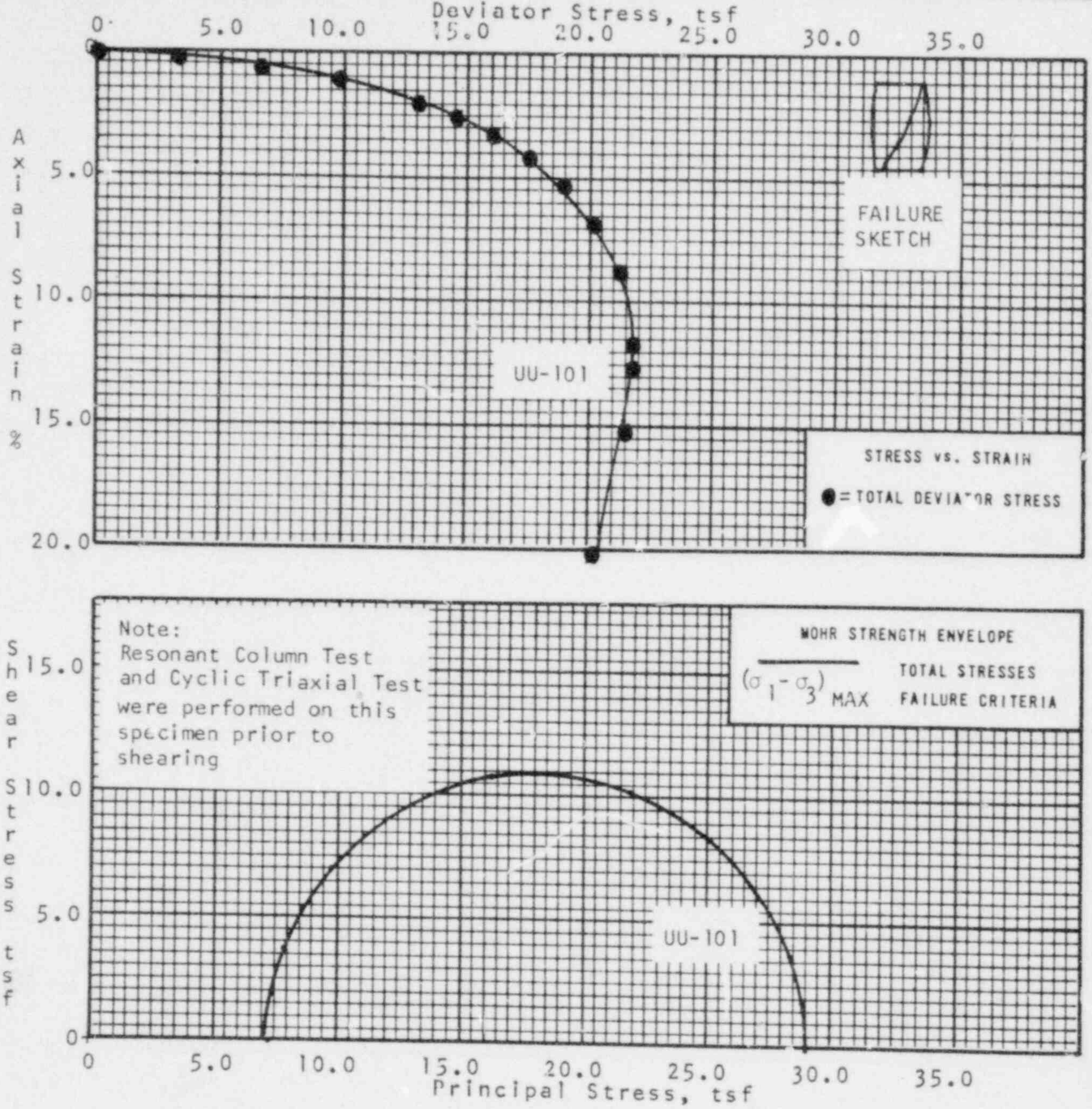
UNCONSOLIDATED, UNDRAINED,
TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 23
Depth 130.0-132.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____ Checked____ Date____ Approved____ Date____ Revised____ Date____ Approved____ Date____

FIG. 21C-9



Test No.	UU-101
Boring No.	B - 1
Sample No.	S - 29
Confining Pressure, tsf	7.19
Ht., in.	5.94
Dia., in.	2.84
Ht./Dia. Ratio	2.08
Wet Unit Wt., pcf	124.2
Water Content, %	
Before Test	20.0
After Test	21.6
Degree of Saturation, %	92.9
Avg. % Strain/Min.	1.188

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Dark gray, sandy clayey SILT

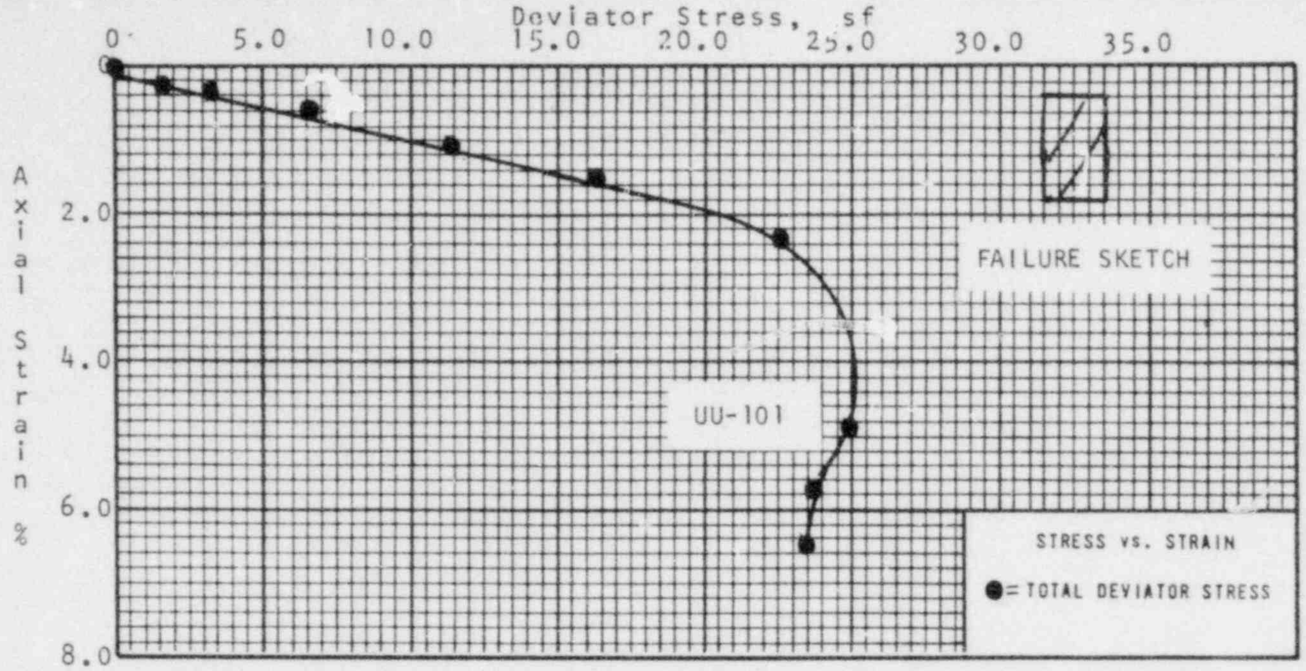
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

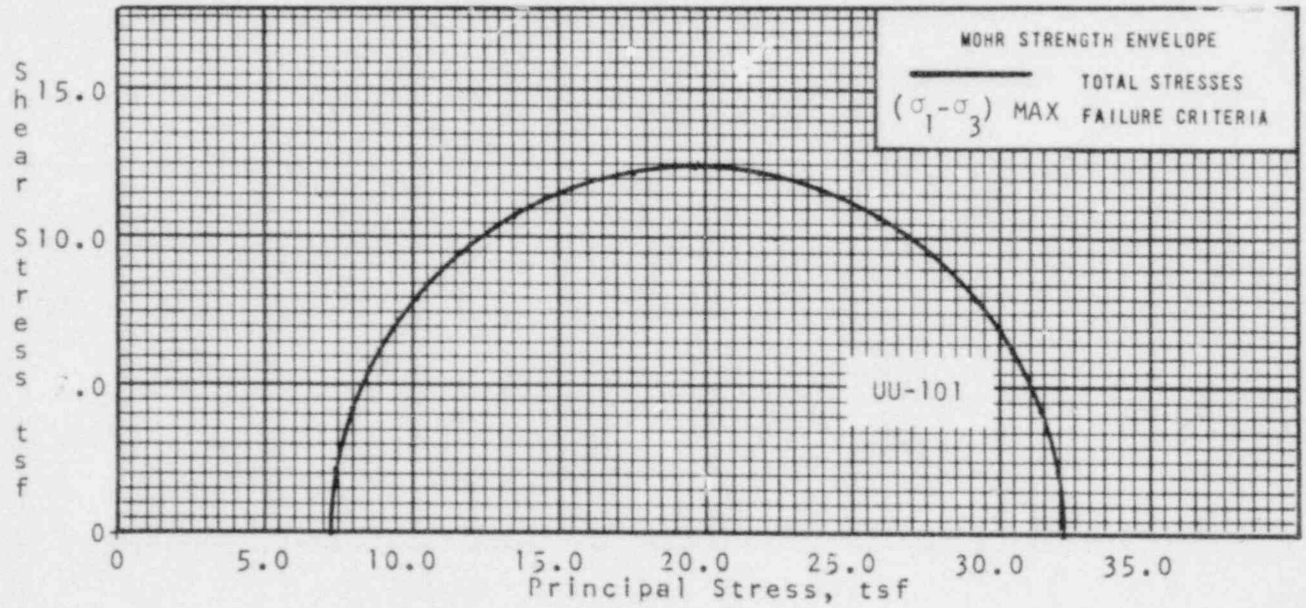
Boring B- 1
Sample S- 29
Depth 190.0-192.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____
Checked____ Date____
Approved____ Date____
Revised____ Date____
Approved____ Date____

FIG. 21C-10





Test No.	UU-101
Boring No.	B -1
Sample No.	S-35
Confining Pressure, tsf	7.19
Ht., in.	6.99
Dia., in.	2.86
Ht./Dia. Ratio	2.44
Wet Unit Wt., pcf	126.4
Water Content, %	
Before Test	21.1
After Test	21.9
Degree of Saturation, %	96.6
Avg. % Strain/Min.	.715

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Dark gray, sandy, silty CLAY

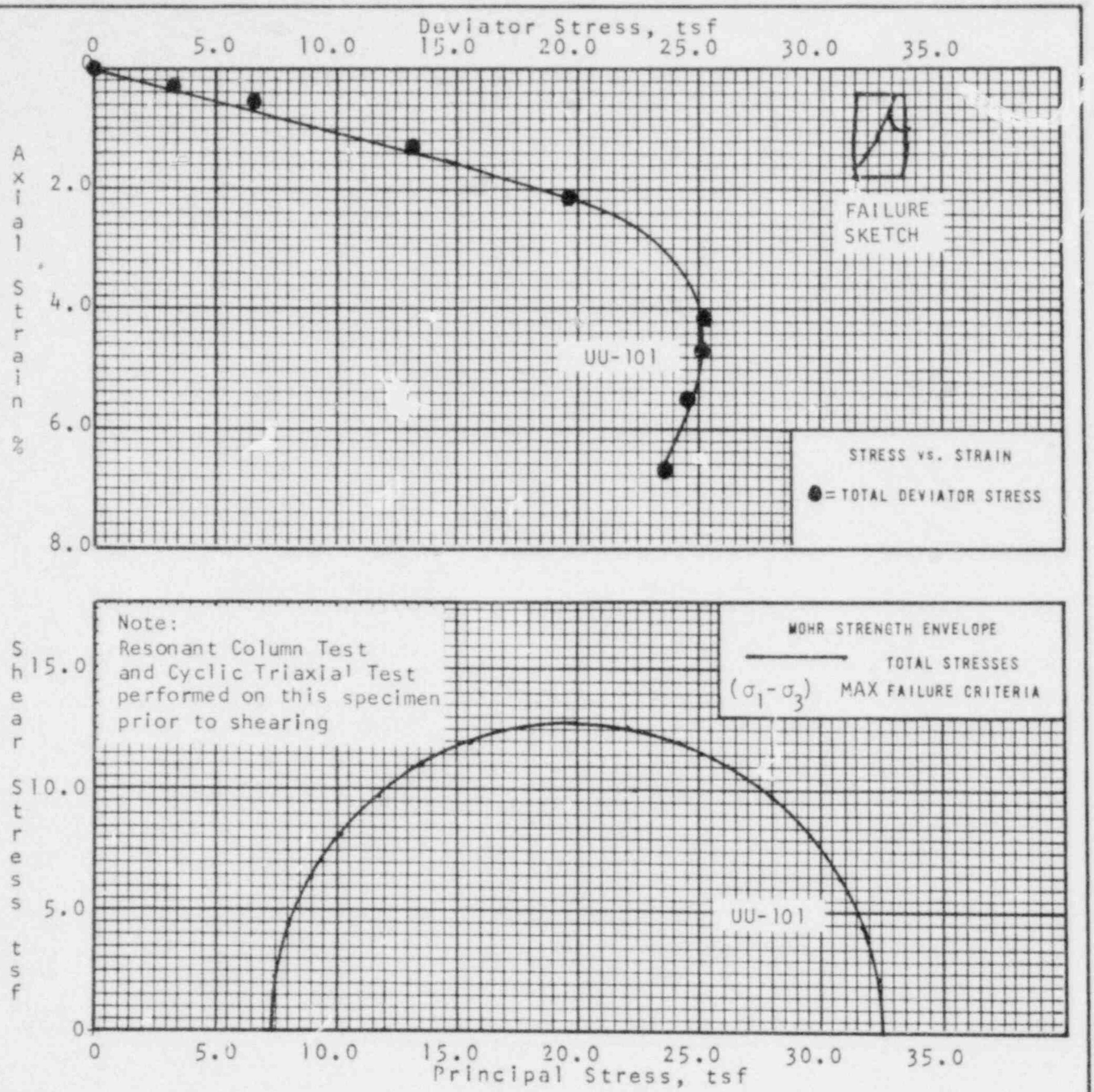
UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 35
Depth 305.0-307.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Date______
Date______
Date______
Date______
Date______

FIG. 21C-11



Test No.	UU-101
Boring No.	B- 1
Sample No.	S-37
Confining Pressure, tsf	7.19
Ht., in.	5.96
Dia., in.	2.84
Ht./Dia. Ratio	2.09
Wet Unit Wt., pcf	126.8
Water Content, % Before Test	20.6
Water Content, % After Test	21.2
Degree of Saturation, %	95.2
Avg. % Strain/Min.	1.320

Specimens Undisturbed
Strain Controlled Test

CLASSIFICATION:

Gray, silty CLAY; trace of sand

UNCONSOLIDATED, UNDRAINED, TRIAXIAL COMPRESSION TEST

Boring B- 1
Sample S- 37
Depth 347.0-349.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____ Checked_____ Date_____ Approved_____ Date_____ Revised_____ Date_____ Approved_____ Date_____

FIG. 21C-12

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
31,100		7×10^{-5}	
30,600		2.7×10^{-4}	
30,800		1.4×10^{-3}	
30,200		5.4×10^{-3}	
	89,800		1.7×10^{-5}
	88,900		7.9×10^{-5}
	98,200		4.1×10^{-4}
	92,300		4.3×10^{-4}

Specimen Data

Height	5.40 in
Diameter	2.86 in
Wet Unit Weight	126.3 pcf
Water Content	19.9 %
Degree of Saturation	87.0 %
Effective Confining Pressure	80 psi

Classification:

Red-brown, sandy silty CLAY

RESONANT COLUMN TEST

Boring B-1
Sample S-16
Depth 80.0-82.5 Ft

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-13

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
33,400		1.2×10^{-4}	
31,600		7.0×10^{-4}	
30,400		3.0×10^{-3}	
27,100		9.4×10^{-3}	
	106,000		3.2×10^{-5}
	105,400		1.5×10^{-5}
	102,500		7.3×10^{-4}
	98,400		1.[illegible]$\times10^{-3}$

Specimen Data

Height	5.91 in
Diameter	2.74 in
Wet Unit Weight	120.5 pcf
Water Content	20.8 %
Degree of Saturation	86.3 %
Effective Confining Pressure	100 psi

Classification:

Brown SAND

RESONANT COLUMN TEST

Boring B-1
Sample S-23
Depth 130.0-132.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-14

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
24,100		1.8×10^{-4}	
23,800		9.0×10^{-4}	
22,400		3.9×10^{-3}	
18,700		1.8×10^{-2}	
	81,700		4.3×10^{-5}
	81,600		2.4×10^{-4}
	80,700		8.9×10^{-4}
	78,100		1.7×10^{-3}

Specimen Data

Height	5.94 in
Diameter	2.84 in
Wet Unit Weight	124.2 pcf
Water Content	20. 0 %
Degree of Saturation	92.9 %
Effective Confining Pressure	100 psi

Classification:
Dark gray, sandy clayey SILT

RESONANT COLUMN TEST

Boring B-1
Sample S-29
Depth 190.0-192.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-15

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
32,800		6.8×10^{-5}	
32,700		2.5×10^{-4}	
32,200		1.3×10^{-3}	
28,700		7.1×10^{-3}	
	106,400		1.8×10^{-5}
	106,300		7.7×10^{-5}
	105,300		3.5×10^{-4}
	101,000		1.6×10^{-3}

Specimen Data

Height	5.91 in
Diameter	2.84 in
Wet Unit Weight	127.0 pcf
Water Content	32.1 %
Degree of Saturation	97 %
Effective Confining Pressure	100 psi

Classification:

Dark gray, sandy, silty CLAY

RESONANT COLUMN TEST

Boring	B - 1
Sample	S - 35
Depth	305.0 - 307.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-16

Modulus, psi		Single Amplitude Strain %	
Shear, G	Elastic, E	Torsional	Longitudinal
28,000		8.0×10^{-5}	
27,600		2.4×10^{-4}	
28,000		1.6×10^{-3}	
27,500		7.2×10^{-3}	
	102,600		1.7×10^{-5}
	101,300		7.5×10^{-5}
	100,700		3.9×10^{-4}
	96,300		1.7×10^{-3}

Specimen Data

Height	5.96 in
Diameter	2.84 in
Wet Unit Weight	126.8 pcf
Water Content	20.6 %
Degree of Saturation	95.2 %
Effective Confining Pressure	100 psi

Classification:

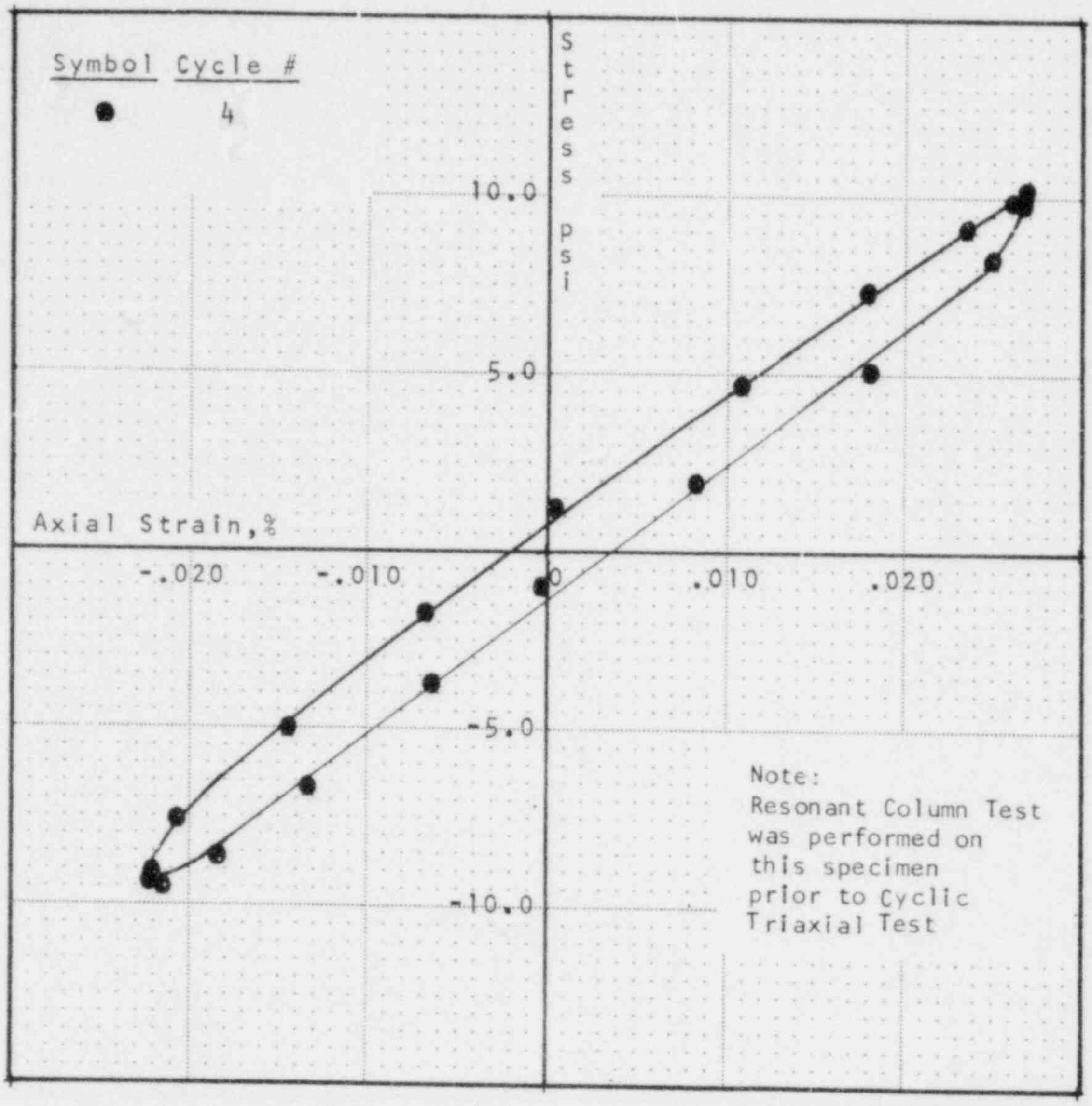
Gray, silty CLAY; trace of sand.

RESONANT COLUMN TEST

Boring B-1
Sample S-37
Depth 347.0-349.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-17



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	80.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.40 in.
Diameter	2.85 in.
Wet Unit Wt.	126.3 pcf
Water Content	
Before Test	19.9 %
After Test	19.9 %
Degree of Saturation	87.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	40440 psi
Damping	6.7 %
Double Amp. Strain	.0487 %

Classification:
Red-brown, sandy silty CLAY

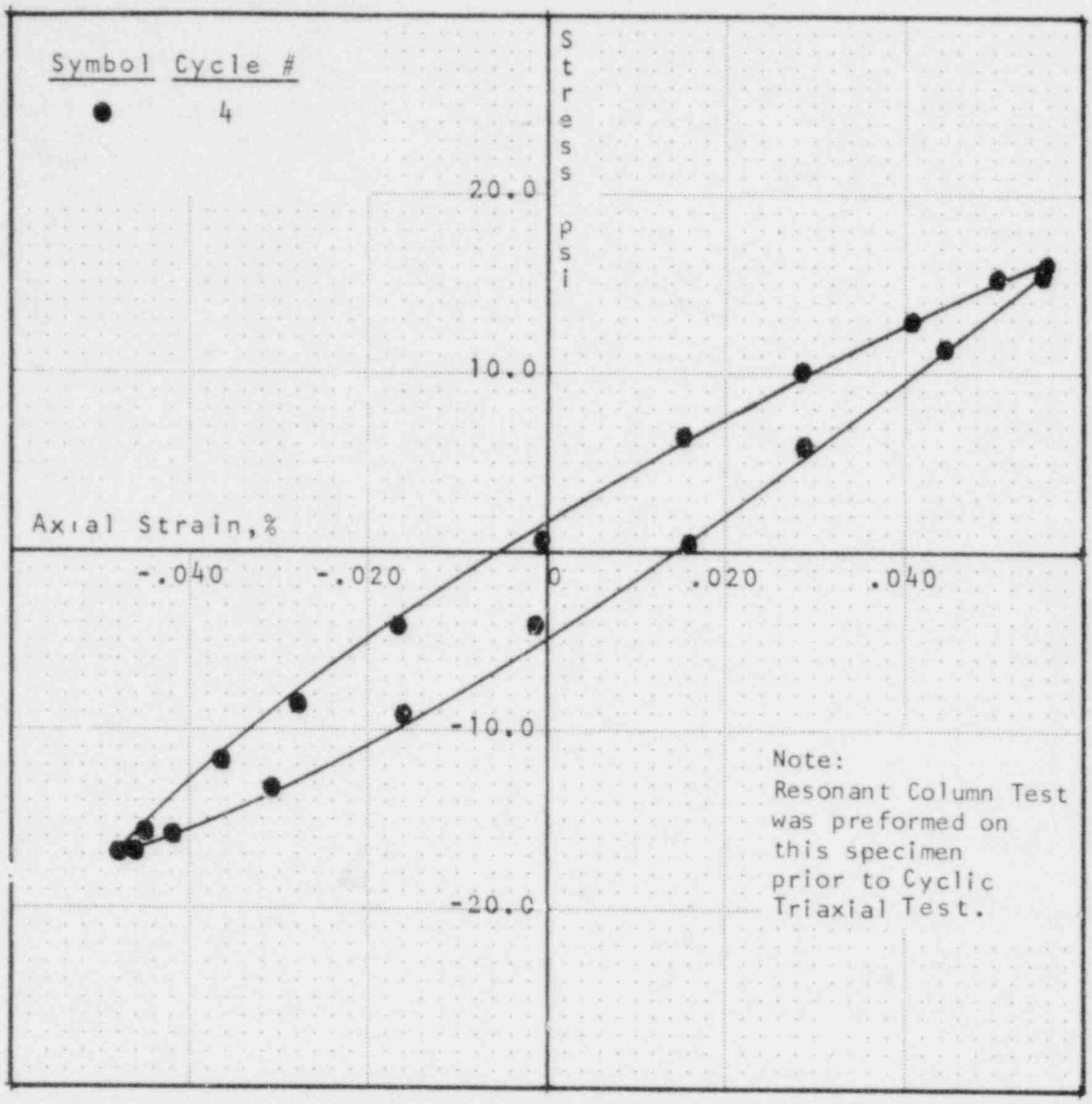
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 16
Depth 80.0 -82.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn______ Checked______ Approved______ Revised______ Approved______
Date______ Date______ Date______ Date______ Date______

FIG. 21C-18



Note:
Resonant Column Test
was preformed on
this specimen
prior to Cyclic
Triaxial Test.

Test No. 2

Effective Confining Pressure	80.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.40 in.
Diameter	2.85 in.
Wet Unit Wt.	126.3 pcf
Water Content	
Before Test	19.9 %
After Test	19.9 %
Degree of Saturation	87.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	31660 psi
Damping	7.5 %
Double Amp. Strain	.1041 %

Classification:

Red-brown, sandy silty CLAY

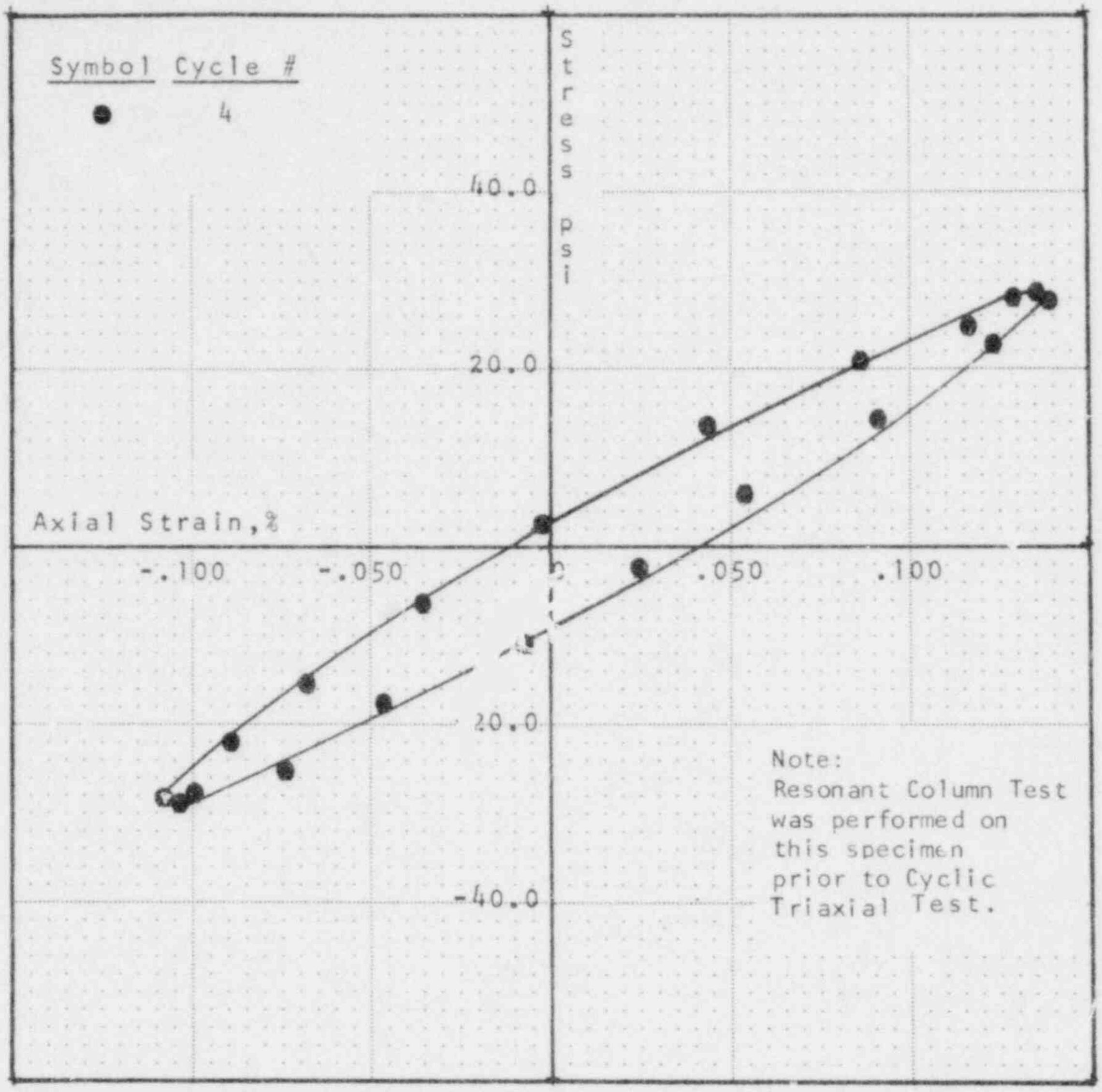
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 16
Depth 80.0 -82.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-19



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test.

Test No. 3

Effective Confining Pressure	80.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.40 in.
Diameter	2.85 in.
Wet Unit Wt.	126.3 pcf
Water Content	
Before Test	19.9 %
After Test	19.9 %
Degree of Saturation	87.0 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	23890 psi
Damping	9.5 %
Double Amp. Strain	.2411 %

Classification:

Red-brown, sandy silty CLAY

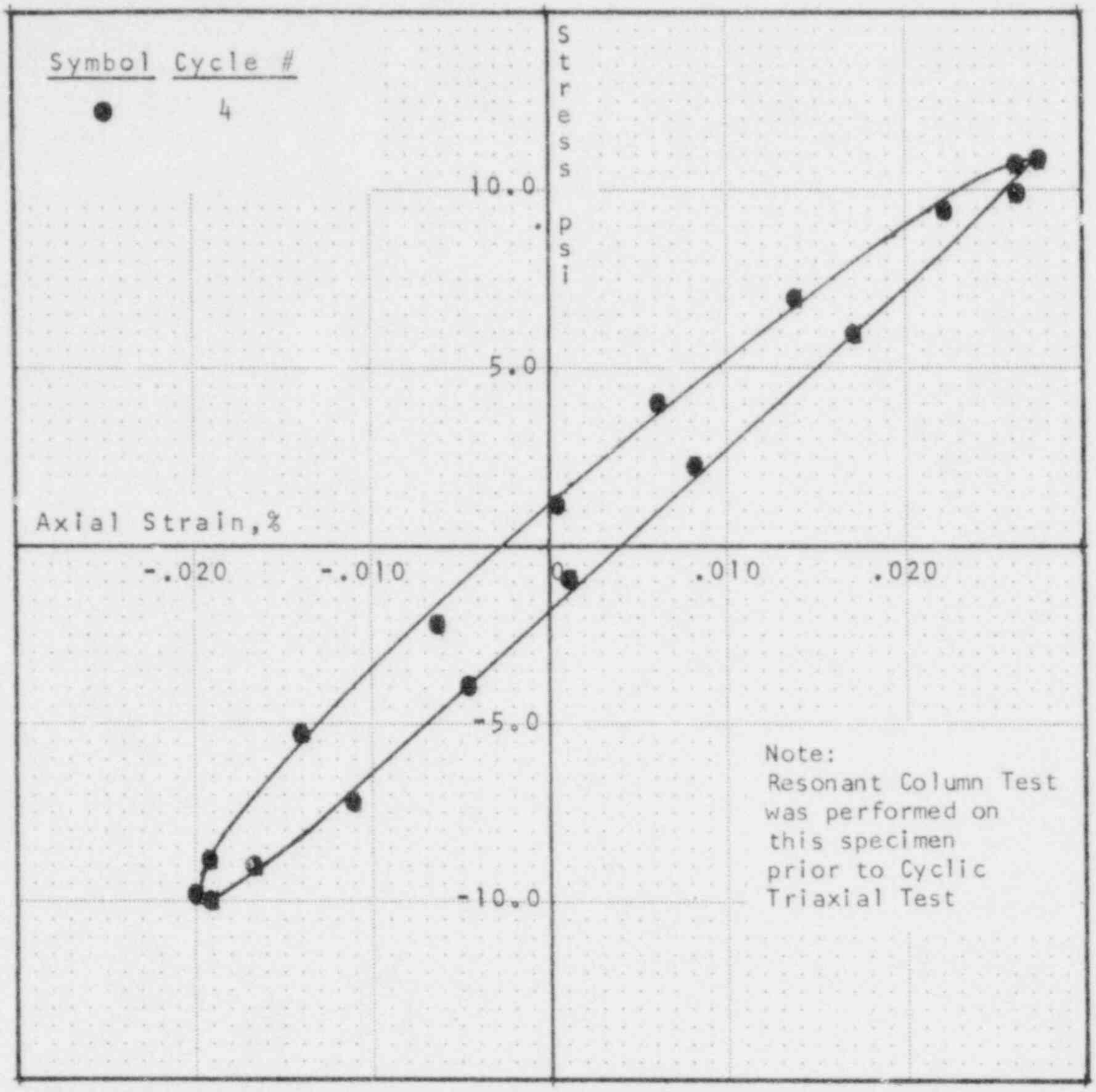
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 16
Depth 80.0 -82.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 21C-20



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic
Triaxial Test

Test No. 1

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.50 in.
Diameter	2.73 in.
Wet Unit Wt.	120.9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	86.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus or Elasticity, E	44550 psi
Damping	7.0 %
Double Amp. Strain	.0467 %

Classification:

Brown SAND

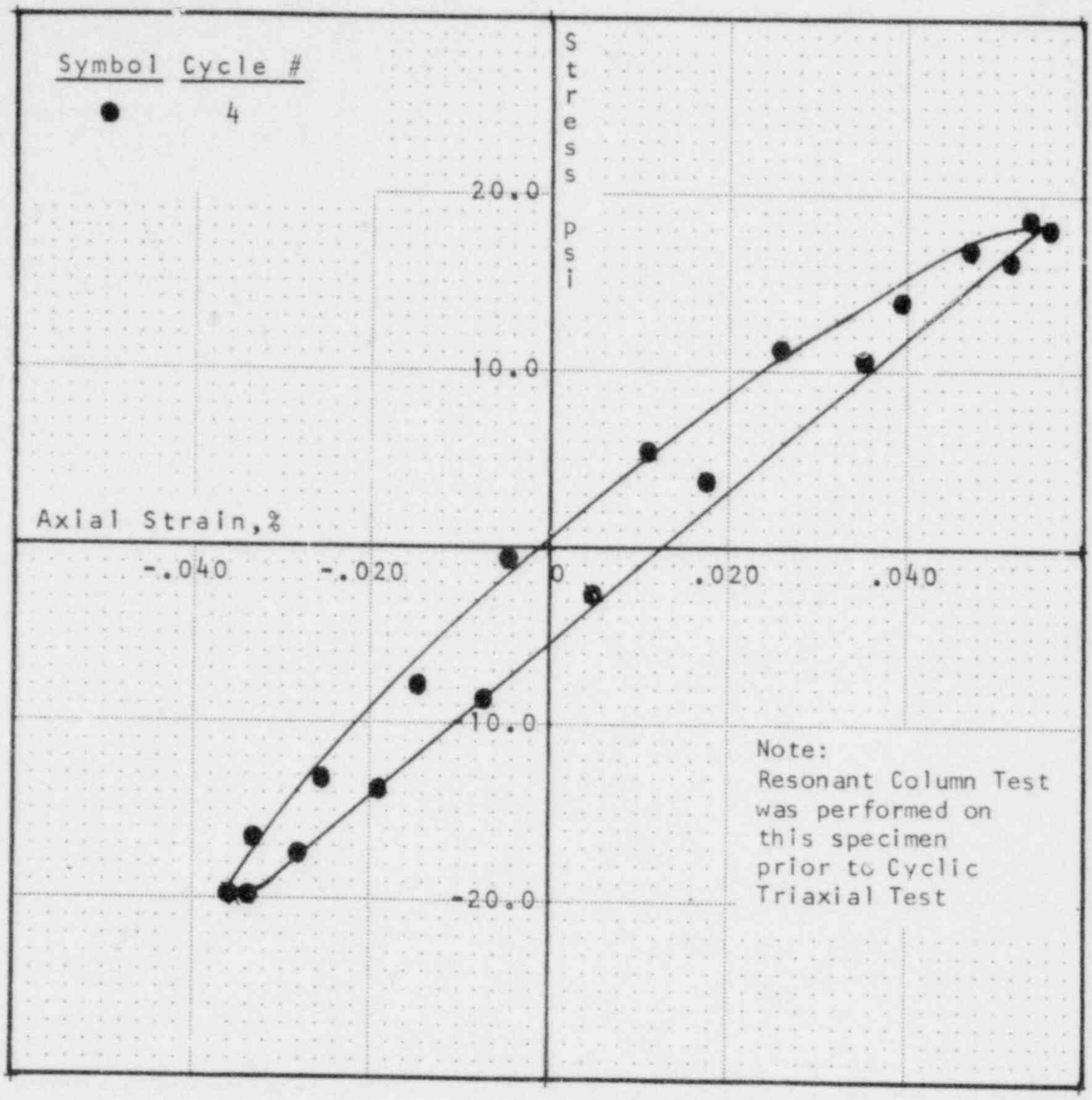
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 23
Depth 130.0-132.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Checked____ Approved____ Revised____ Approved____
Date____ Date____ Date____ Date____ Date____

FIG. 21C-21



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.50 in.
Diameter	2.73 in.
Wet Unit Wt.	120 .9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	86.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	42940 psi
Damping	7.4 %
Double Amp. Strain	.0898 %

Classification:

Brown SAND

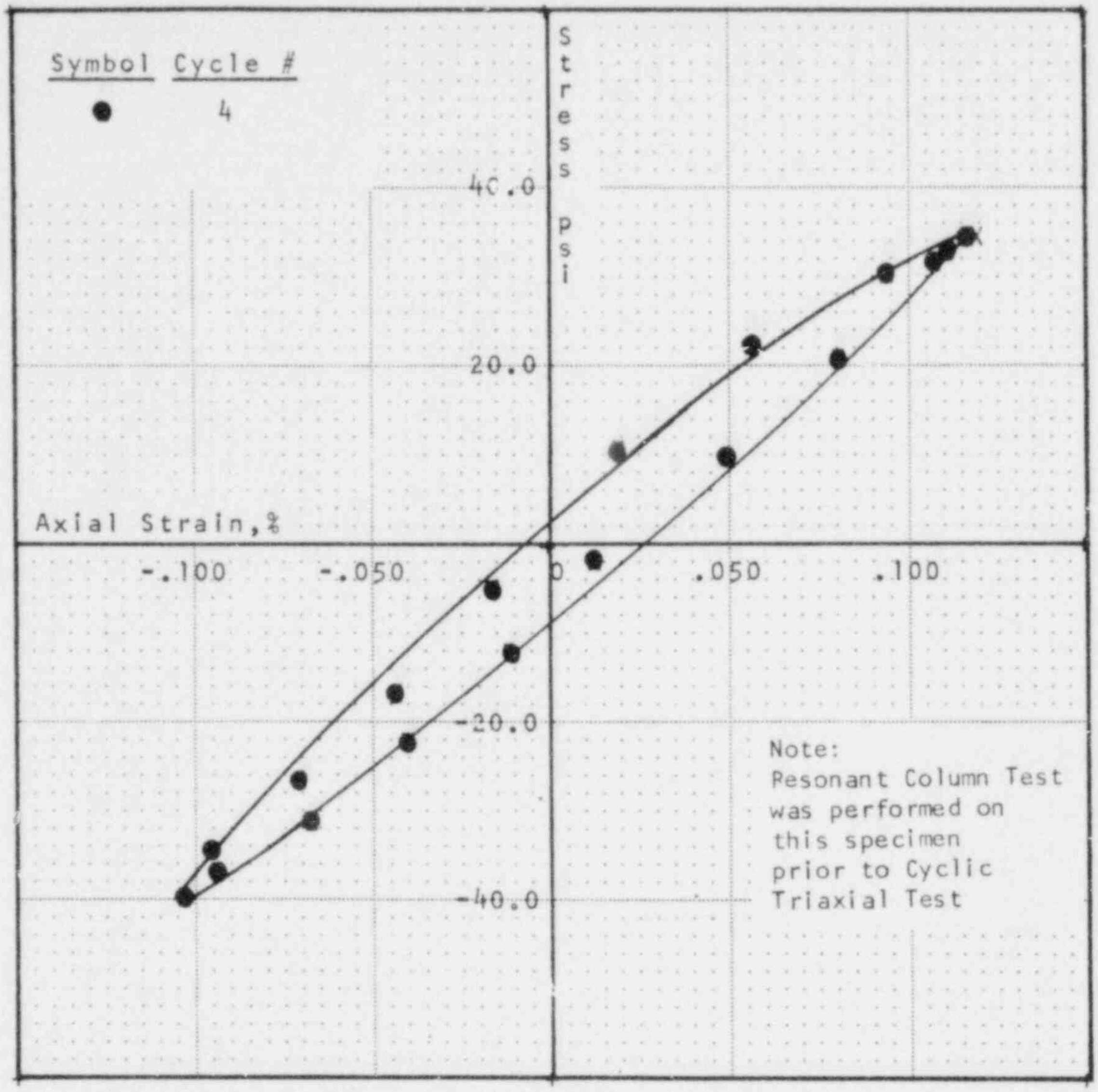
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 23
Depth 130.0-132.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____ Checked____ Date____ Approved____ Date____ Revised____ Date____ Approved____ Date____

FIG. 21C-22



Test No. 3

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.50 in.
Diameter	2.73 in.
Wet Unit Wt.	120.9 pcf
Water Content	
Before Test	20.8 %
After Test	20.8 %
Degree of Saturation	86.3 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	33690 psi
Damping	6.8 %
Double Amp. Strain	.2206 %

Classification:

Brown SAND

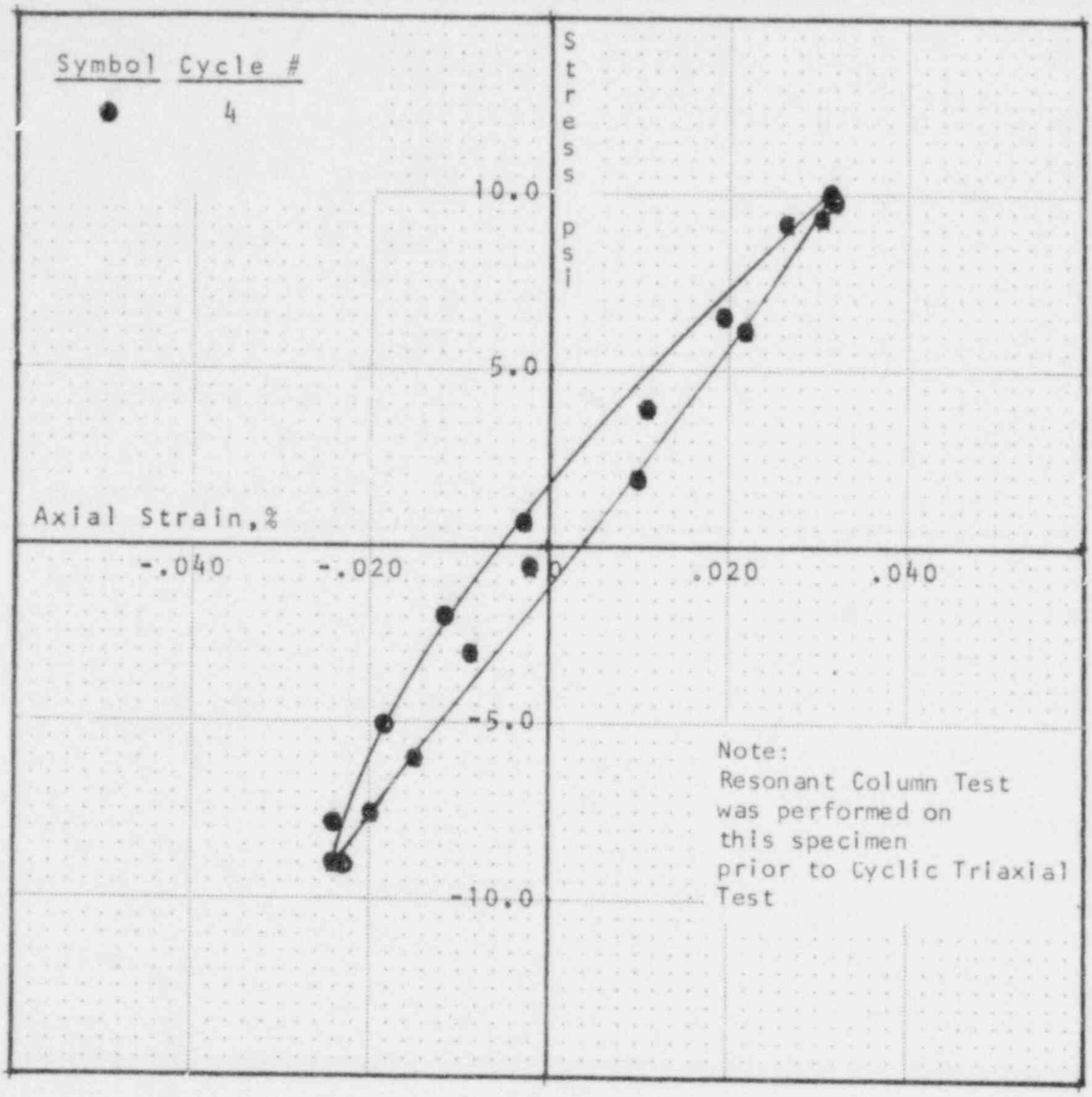
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 23
Depth 130.0-132.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____ Checked____ Date____ Approved____ Date____ Revised____ Date____ Approved____ Date____

FIG. 21C-23



Note:
Resonant Column Test
was performed on
this specimen
prior to Cyclic Triaxial
Test

Test No. 1

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.94 in.
Diameter	2.84 in.
Wet Unit Wt.	124.2 pcf
Water Content	
Before Test	20.0 %
After Test	20.0 %
Degree of Saturation	92.9 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	34030 psi
Damping	6.6 %
Double Amp. Strain	.0560 %

Classification:
Dark gray, sandy clayey SILT

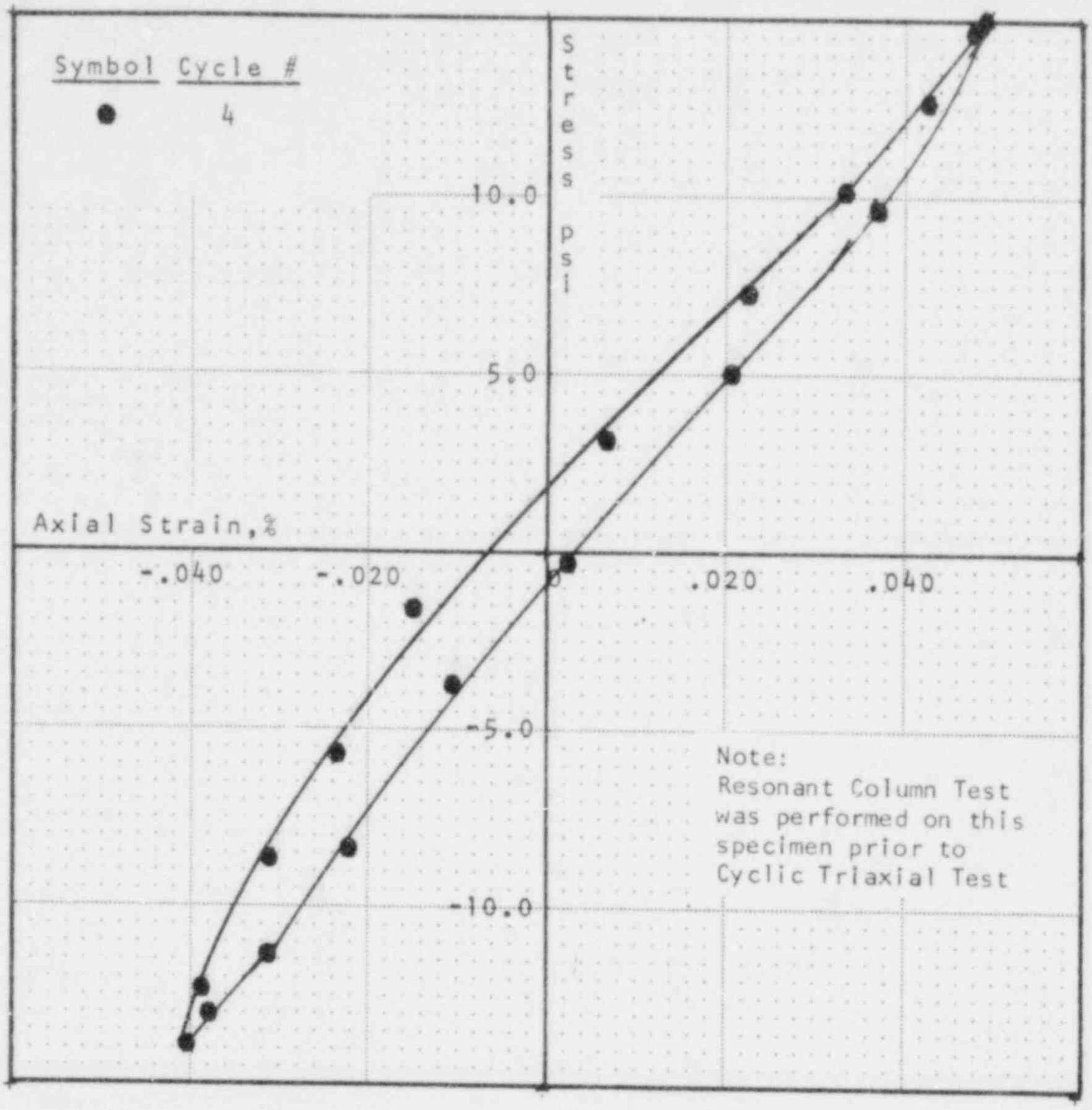
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 29
Depth 190.0-192.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____
Checked____ Date____
Approved____ Date____
Revised____ Date____
Approved____ Date____

FIG. 21C-24



Note:
Resonant Column Test
was performed on this
specimen prior to
Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.94 in.
Diameter	2.84 in.
Wet Unit Wt.	124.2 pcf
Water Content	
Before Test	20.0 %
After Test	20.0 %
Degree of Saturation	92.6 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	32260 psi
Damping	5.6 %
Double Amp. Strain	.0899 %

Classification:

Dark gray, sandy clayey SILT

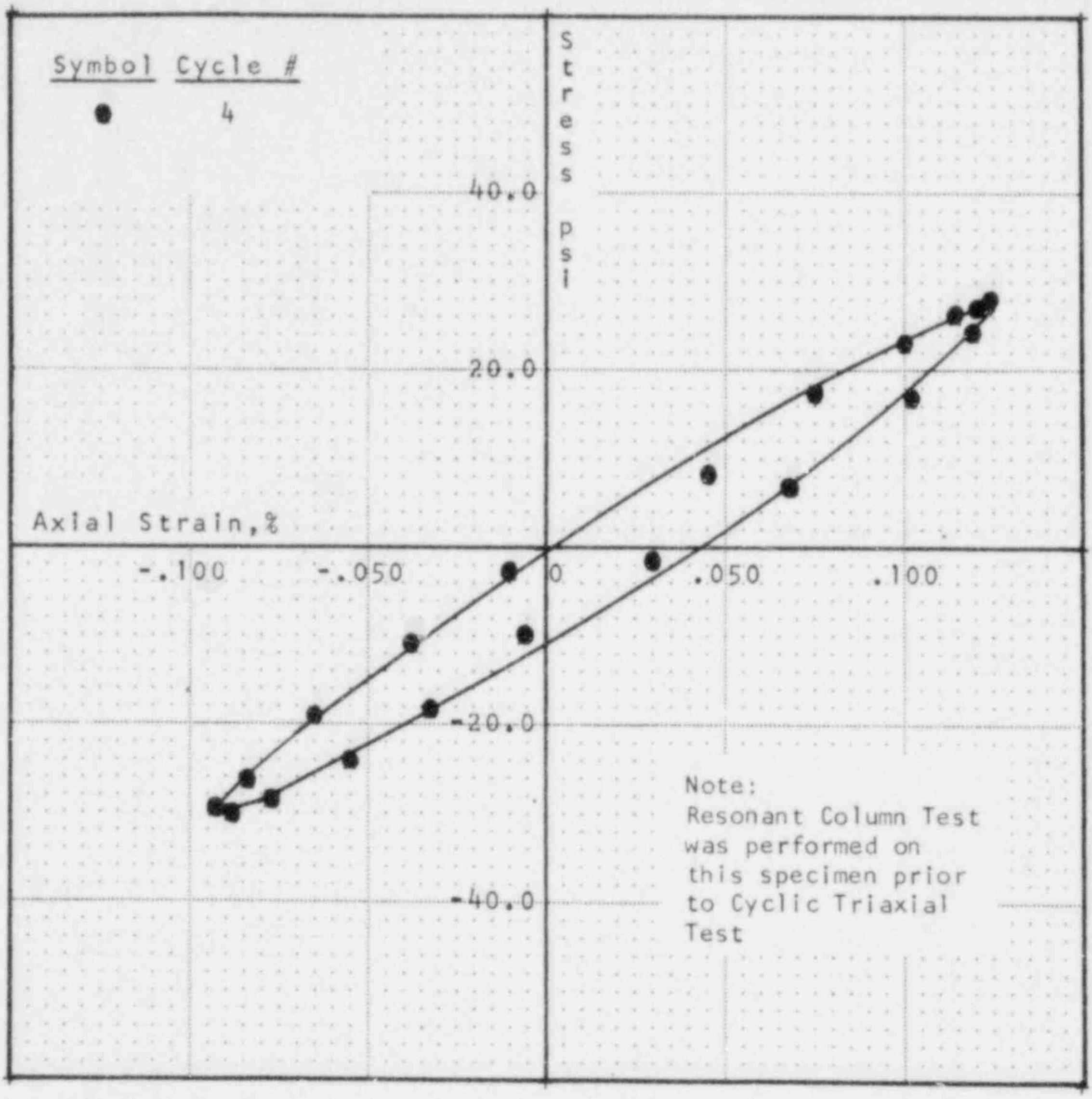
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 29
Depth 190.0-192.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn____ Date____ Checked____ Date____ Approved____ Date____ Revised____ Date____ Approved____ Date____

FIG. 21C-25



Note:
Resonant Column Test was performed on this specimen prior to Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.94 in.
Diameter	2.84 in.
Wet Unit Wt.	124.2 pcf
Water Content	
Before Test	20.0 %
After Test	20.0 %
Degree of Saturation	92.9 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	27400 psi
Damping	8.8 %
Double Amp. Strain	.2128 %

Classification:
Dark gray, sandy clayey SILT

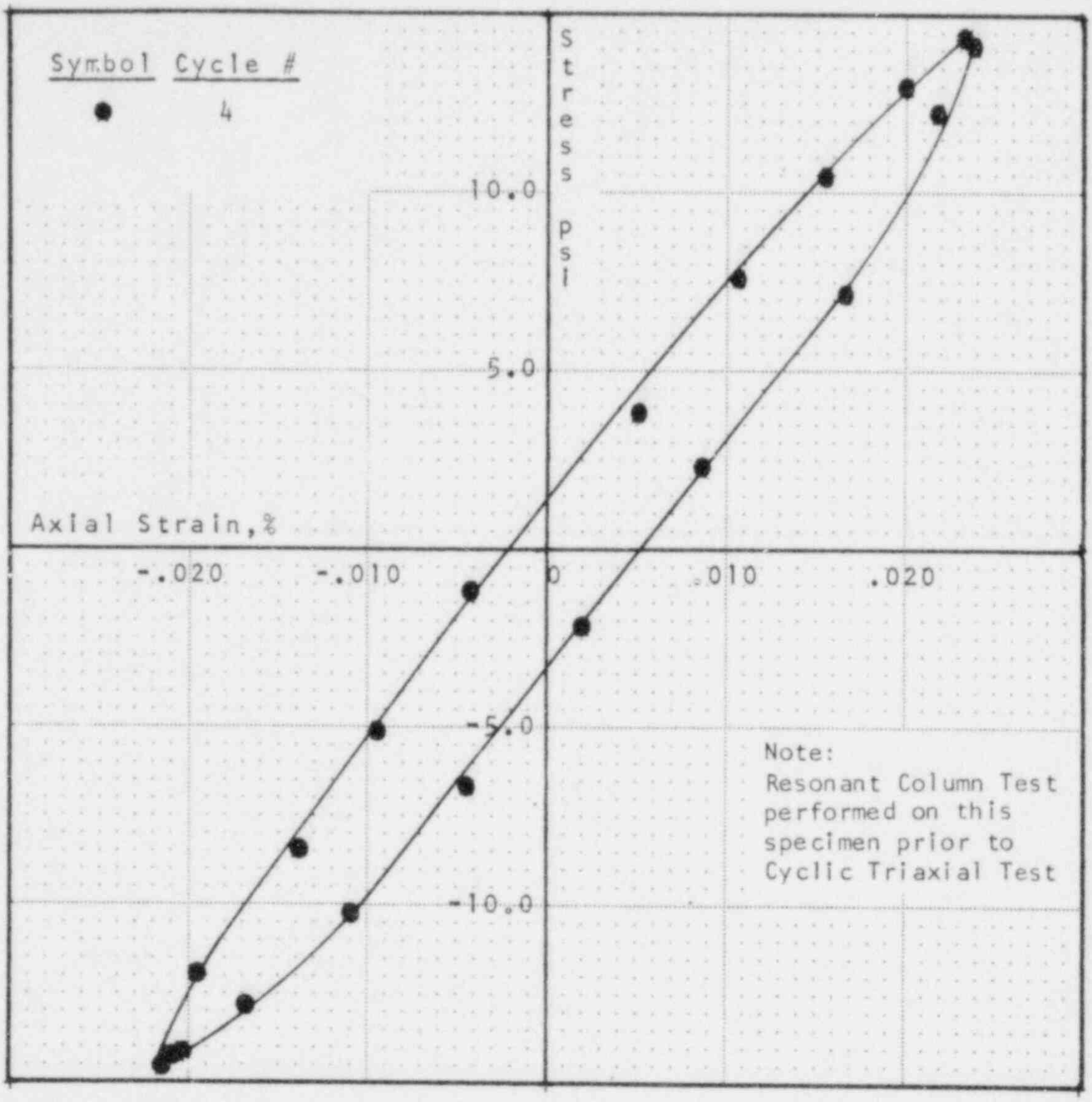
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 29
Depth 190.0-192.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-26



Note:
Resonant Column Test performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.92 in.
Diameter	2.83 in.
Wet Unit Wt.	127.0 pcf
Water Content	
Before Test	32.1 %
After Test	32.2 %
Degree of Saturation	96.6 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	64180 psi
Damping	8.0 %
Double Amp. Strain	.0451 %

Classification:

Dark gray, sandy, silty CLAY

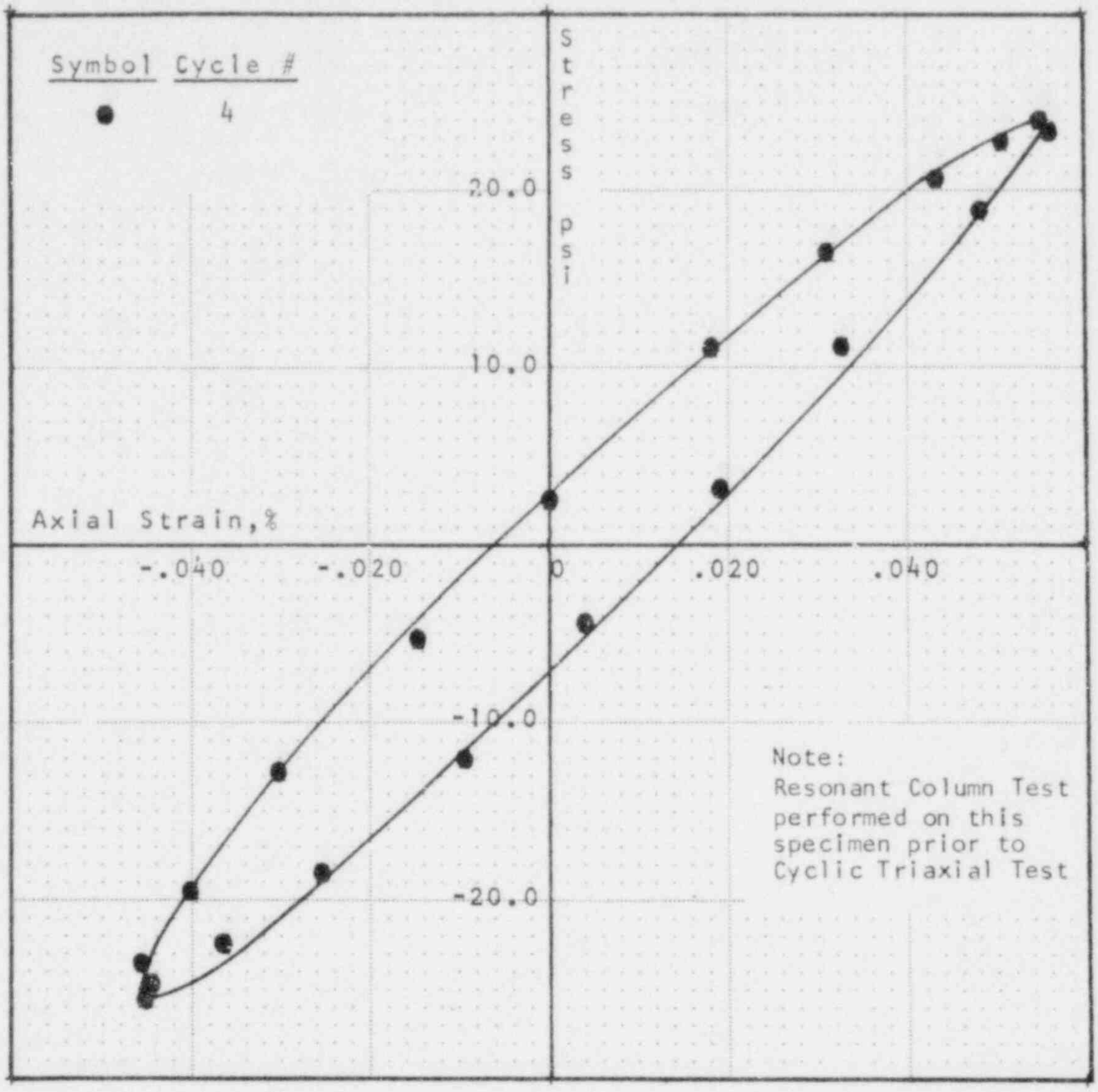
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 35
Depth 305.0-307.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-27



Note:
Resonant Column Test performed on this specimen prior to Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.92 in.
Diameter	2.83 in.
Wet Unit Wt.	127.0 pcf
Water Content	
Before Test	32.1 %
After Test	32.2 %
Degree of Saturation	96.6 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	49350 psi
Damping	9.3 %
Double Amp. Strain	.1004 %

Classification:
Dark gray, sandy, silty CLAY

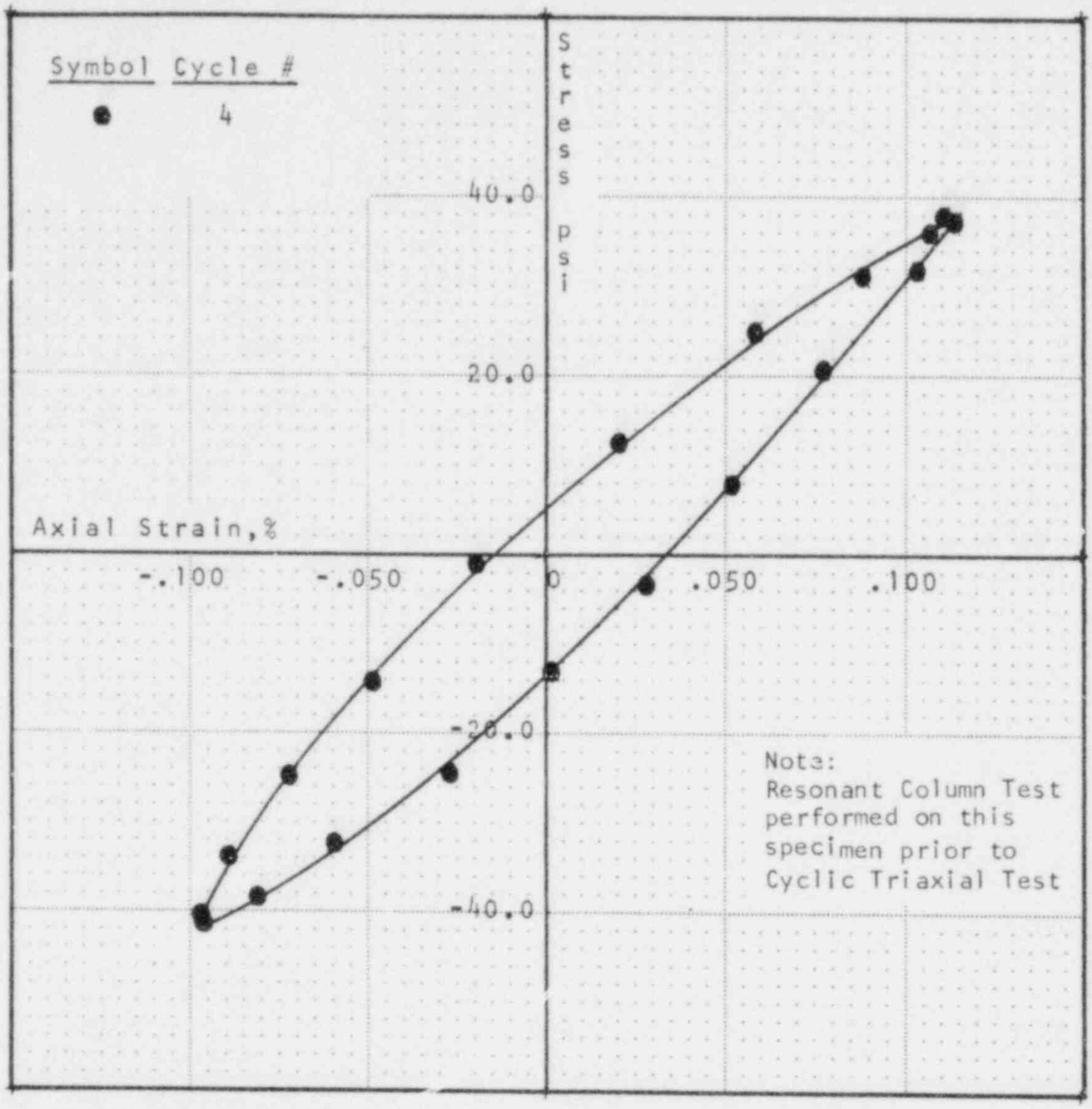
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 35
Depth 305.0-307.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-28



Note:
Resonant Column Test
performed on this
specimen prior to
Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.92 in.
Diameter	2.83 in.
Wet Unit Wt.	127.0 pcf
Water Content	
Before Test	32.1 %
After Test	32.2 %
Degree of Saturation	96.6 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	38070 psi
Damping	11.9 %
Double Amp. Strain	.2079 %

Classification:

Dark gray, sandy, silty CLAY

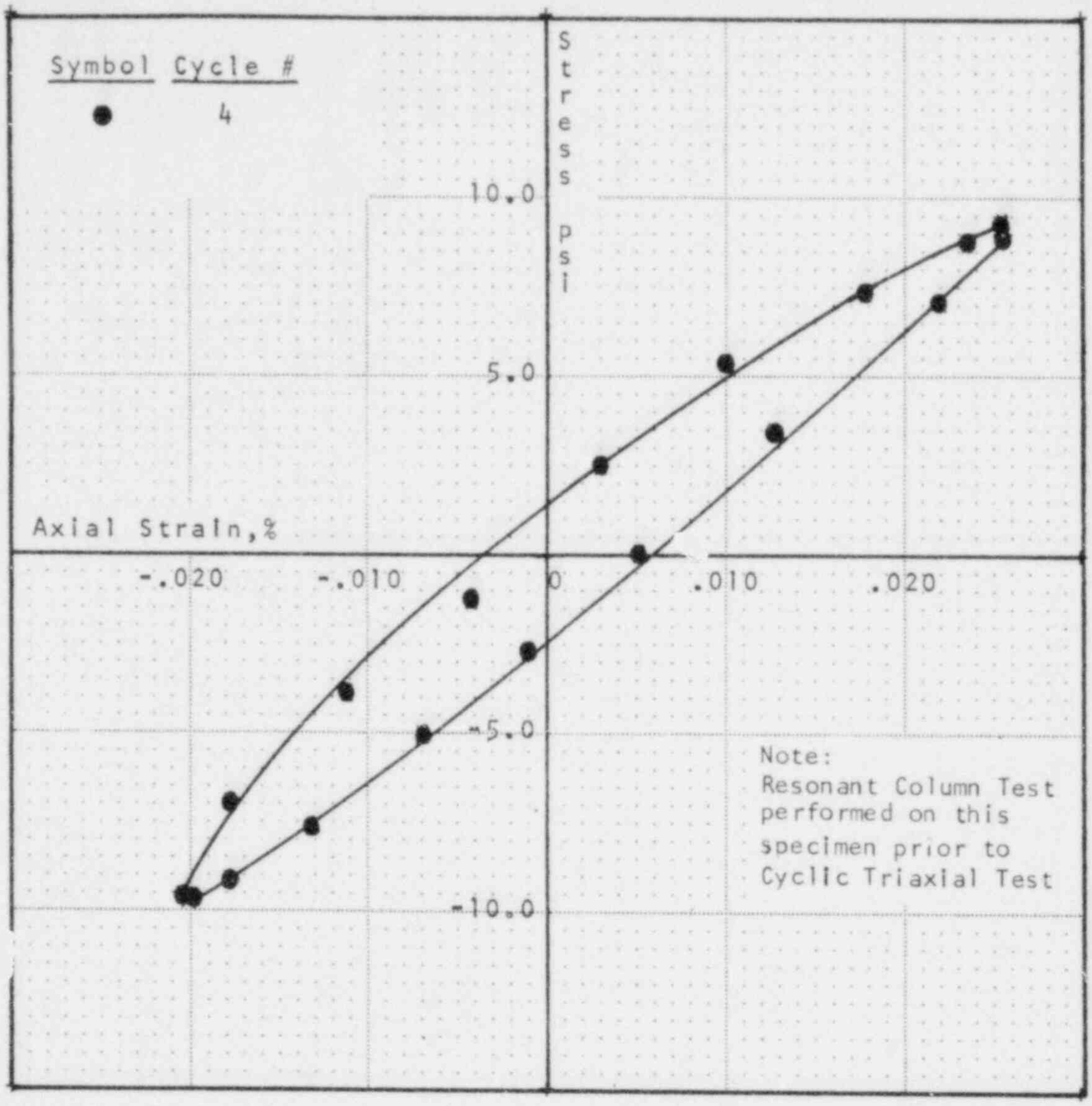
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 35
Depth 305.0-307.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Checked_____ Approved_____ Revised_____ Approved_____
Date_____ Date_____ Date_____ Date_____ Date_____

FIG. 21C-29



Note:
Resonant Column Test performed on this specimen prior to Cyclic Triaxial Test

Test No. 1

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.96 in.
Diameter	2.84 in.
Wet Unit Wt.	126.8 pcf
Water Content	
Before Test	20.6 %
After Test	20.6 %
Degree of Saturation	95.2 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	41840 psi
Damping	8.4 %
Double Amp. Strain	.0457 %

Classification:

Gray, silty CLAY; trace of sand

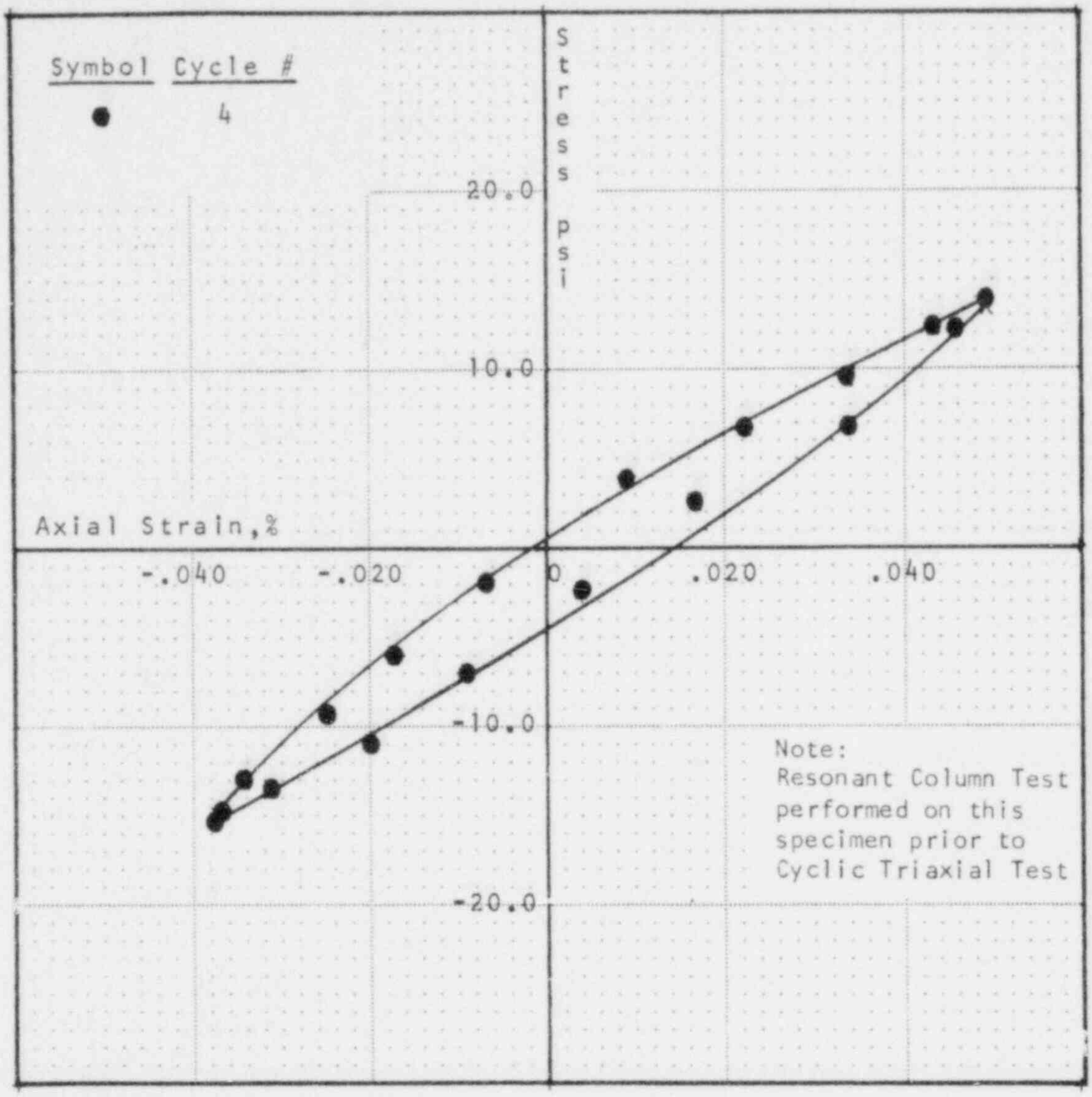
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 37
Depth 347.0-349.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

FIG. 21C-30

Drawn____ Date____
Checked____ Date____
Approved____ Date____
Revised____ Date____
Approved____ Date____



Note:
Resonant Column Test performed on this specimen prior to Cyclic Triaxial Test

Test No. 2

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.96 in.
Diameter	2.84 in.
Wet Unit Wt.	126.8 pcf
Water Content	
Before Test	20.6 %
After Test	20.6 %
Degree of Saturation	95.2 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	33740 psi
Damping	6.8 %
Double Amp. Strain	.0871 %

Classification:

Gray, silty CLAY; trace of sand

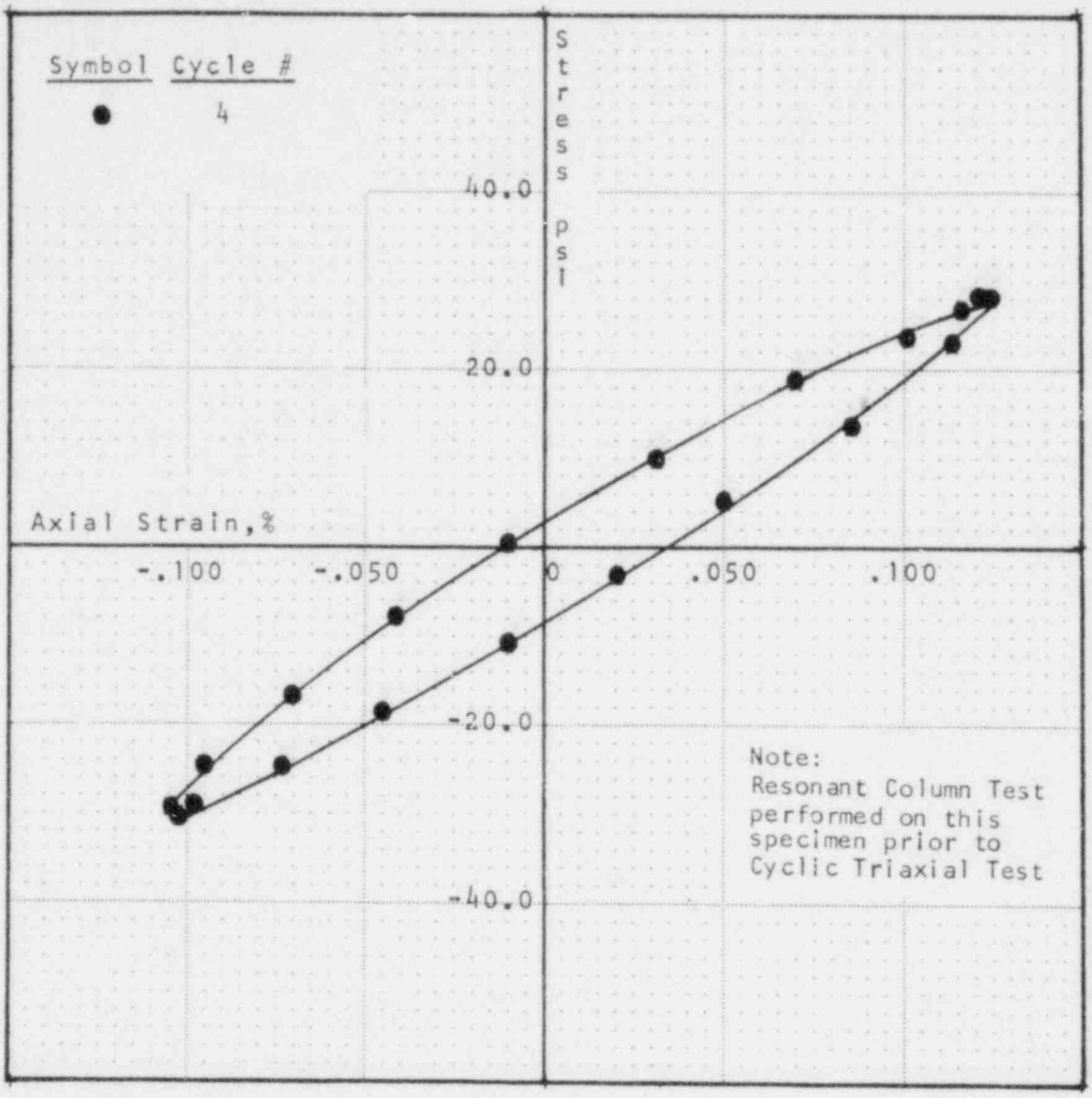
CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 37
Depth 347.0-349.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____ Checked_____ Date_____ Approved_____ Date_____ Revised_____ Date_____ Approved_____ Date_____

FIG. 21C-31



Note:
Resonant Column Test performed on this specimen prior to Cyclic Triaxial Test

Test No. 3

Effective Confining Pressure	100.0 psi
Back Pressure	0.0 psi

Specimen Data

Height	5.96 in.
Diameter	2.84 in.
Wet Unit Wt.	126.8 pcf
Water Content	
Before Test	20.6 %
After Test	20.6 %
Degree of Saturation	95.2 %

Specimen Undisturbed
Specimen Not Saturated

Modulus of Elasticity, E	25900 psi
Damping	9.2 %
Double Amp. Strain	.2257 %

Classification:

Gray, silty CLAY; trace of sand

CYCLIC TRIAXIAL TEST

Boring B- 1
Sample S- 37
Depth 347.0-349.5 Ft.

HOLLYWOOD STORAGE BUILDING
LOS ANGELES, CALIFORNIA

Drawn_____ Date_____
Checked_____ Date_____
Approved_____ Date_____
Revised_____ Date_____
Approved_____ Date_____

FIG. 21C-32

Section 22C

Noranda Aluminum Plant
New Madrid, Missouri

SECTION 22C
LABORATORY TESTING
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

LIST OF TABLES

TABL[illegible]2C-1 SUMMARY OF LABORATORY TEST DATA

Boring Number	Run or Sample Number	Depth, feet	Sampler or Blows/6"	Shear Strength TSF	Dry Density PCF	Water Content, %	Atterberg Limits			Other Tests	Sample Classification
							LL	PL	PI		
B-1	S-1	4.0-5.5	5,4,[illegible]			22.5					Loose, brown, silty, fine SAND; trace of organics. (SM)
	S-2	9.0-10.5	5,5,4			18.6					Loose, gray-brown, clean, fine to medium SAND.
	S-3	14.0-15.5	1,3,5			36.9					Loose, gray-brown, fine sandy SILT; layers of clayey silt; trace of fine organics.
	S-4	19.0-20.5	4,6,9			17.7					Medium dense, gray-brown, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel.
	S-5	24.0-25.5	17,11,12			16.3					Medium dense, gray-brown, clean, fine to medium SAND; trace of coarse sand and fine gravel. (SP)
	S-6	29.0-30.5	15,8,11			16.6					Same as S-5.
	S-7	33.0-34.5	7,7,9			16.0					Medium dense, gray-brown, clean, fine gravelly, fine to medium SAND; trace of coarse sand.
	S-8	38.0-39.5	10,18,24			16.3					Dense, gray, slightly silty, fine to medium SAND; trace of coarse sand, fine gravel and organics.
	S-9	43.0-44.5	9,8,12			16.9					Medium dense, gray-brown, clean, fine to medium SAND; trace of coarse sand and fine gravel.
	S-10	48.0-49.5	3,7,10			-					No Recovery.
	S-11	53.0-54.5	5,12,21			15.0					Dense, gray-brown to gray, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel. (SP-SM)
	S-12	56.5-58.0	10,10,14			17.1					Medium dense, gray-brown to gray, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel.
	S-13	61.5-63.0	20,26,32			22.3					Very dense, gray-brown, clean, fine to medium SAND; trace of coarse sand.
	S-14	66.5-68.0	10,16,24			16.8					Dense, gray-brown, clean, fine to coarse SAND; trace of fine to coarse gravel.
	S-15	71.5-73.0	13,14,15			18.2					Medium dense, gray-brown, clean, fine gravelly, fine to coarse SAND.
	S-16	76.5-78.0	7,10,10			-					Insufficient sample for classification.
	S-17	81.5-83.0	9,14,21			14.2					Dense, brown, clean, fine to coarse gravelly, fine to coarse SAND.
	S-18	86.5-88.0	24,24,42			-					No Recovery.
	S-19	91.5-92.9	13,40,50/5"			16.7					Very dense, brown, slightly silty, fine to medium SAND; trace of coarse sand and fine gravel. (SP-SM)
	S-20	96.5-97.8	21,30,50/4"			15.1					Same as S-19.
	S-21	106.5-108.0	24,31,50			15.6					Same as S-19.
	S-22	116.5-118.0	23,27,31			16.2					Same as S-19.
	S-23	126.5-127.3	35,50/4"			12.0					Very dense, gray-brown, slightly silty, fine to coarse gravelly, fine to coarse SAND.
	S-24	136.5-138.0	32,40,40			12.1					Very dense, gray-brown, slightly silty, fine to coarse SAND; trace of fine gravel. (SP-SM)
	S-25	146.5-148.0	10,10,20			16.1					Dense, gray-brown, silty, fine to medium SAND; trace of coarse sand and fine gravel.
	S-26	156.5-158.0	14,17,26			23.4					Dense, gray-brown, silty, fine SAND.
	S-27	177.2-177.5	75/3"			-					No Recovery.
	S-28	190.0-200.0	Cuttings			-					(Dense?), gray, medium to coarse SAND; trace of fine sand, fine gravel and organics. (Contaminated with drilling fluid)
	S-29	217.0-218.5	14,21,21			31.1					Hard, gray, silty CLAY; trace of carbonaceous spots; occasional partings of fine sandy silt. CL.
	S-30	285.0 ±	Cuttings			-					(Dense?), gray-brown, fine to coarse SAND, (Contaminated with drilling fluid)

POOR ORIGINAL

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This is the fifth in a series of reports presenting geotechnical and seismic data for selected accelerograph stations. This volume discusses the findings at five stations, one each in the following locations: Fairbanks, Alaska; Petrolia, California; Hollister, California; Los Angeles, California; and New Madrid, Missouri. The report contains information for each site describing the station building and instrumentation, geology and seismicity of the area, and site conditions. Deep borings, downhole geophysical measurements, and laboratory tests were conducted at each station to evaluate the subsurface conditions.

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