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Dynamic Behavior of Non-Structural Building Partitions and Ceiling Systems During Earthquakes

Final Technical Report

DYNAMIC TESTING OF WOOD-FRAMED BUILDING PARTITIONS

By

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The results of a testing program to investigate the seismic behavior and thresholds of damage of full-height building partitions are presented. Cyclic in-plane racking tests of four full-height wood-stud framed building partitions were carried out at different frequencies of imposed block cyclic displacements. Test results provide quantitative data on the earthquake resistance of typical full-height building assemblies, as well as the relationship between input motion parameters and resulting damage. Test results consisting of cyclic load-displacement curves; time-history plots of loads, displacements, acceleration etc., during each test run; analysis of peak response quantities, e.g. displacements and load-levels reached; variation of estimated rigidities at increasing levels of peak displacements of block cycles; as well as relationship between damage level and peak levels of displacements, are presented in graphical form.

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SUMMARY

The results of a testing program to investigate the seismic behavior and thresholds of damage of full-height building partitions are presented. Cyclic in-plane racking tests of four full-height wood-stud framed building partitions were carried out at different frequencies of imposed block cyclic displacements. All specimens were 8 feet wide and approximately 10 feet high, with representative facing panels (e.g., gypsum wallboard and plywood), fastenings and other details. Test results provide quantitative data on the earthquake resistance of typical full-height partition assemblies, as well as the relationship between input motion parameters (e.g., amplitude and frequencies of imposed cyclic displacements) and resulting damage. Test results consisting of cyclic load-displacement curves; time-history plots of loads, displacements, acceleration etc., during each test run; analysis of peak response quantities, e.g., displacements and load-levels reached; variation of estimated rigidities at increasing levels of peak displacements of block cycles; as well as relationship between damage level and peak levels of displacements, are presented in graphical form. Current practices for design, detailing and installation of building partitions as well as applicable provisions of the Uniform Building Code have been evaluated. In conclusion, results show that the earthquake resistance of wood-stud framed partitions in certain classes of buildings, can be relied upon, provided sound detailing practices (e.g., use of holdowns and fastener layout) are implemented. Test results indicate that there is a need to further evaluate the provided factors of safety under severe dynamic actions as compared to those implied in provisions of building codes. Test results presented also provide a basis for developing improved and more realistic models for predicting overall behavior of building systems during earthquakes.

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1. INTRODUCTION AND BACKGROUND

This report documents an ongoing research program being carried out to investigate the dynamic behavior of building partitions and suspended ceilings during earthquakes. Under the major phase of this research program, dynamic tests of building partitions and suspended ceiling systems were carried out to assess the correlation between input motion and resulting damage; and also to determine the fundamental dynamic properties, e.g., resonant frequencies and damping at increasing levels of excitation (23)[1].

Studies of observed building damage caused by recent earthquakes, e.g., Coalinga, California - 1983 (5), Morgan-Hill, California - 1984 (17), San Fernando, California - 1971 (27), and Anchorage, Alaska - 1964, etc., have clearly shown again and again that the majority of the damage in broad class of buildings is non-structural damage with resulting significant economic loss as well as potential hazard to building occupants, owners and public at large.

Now that it has been realized that the cost of non-structural components in a building is a significant percentage of the overall building cost, efforts are being made to mitigate non-structural component damage in buildings during earthquakes. The EERI/NSF Workshop on Non-Structural Issues was one step in this direction (7), so as to define practical research needs and directions for further research work.

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[1] Numbers in parentheses refer to list of references on page 46.

It is imperative that studies be undertaken to improve our understanding of the dynamic behavior of building components under earthquake motions as well as their fundamental characteristics, e.g., strength, stiffness, stability, damping as well as resonant frequencies.

Study of damage data from the Coalinga earthquake of May 2, 1983 (5), (23), (24) showed that in many buildings interior building partitions seemed to be intact while the rest of the low-rise masonry building structure suffered extensive damage. Furthermore it appears there is evidence that a well designed and constructed wood-framed low-rise building with gypboard as facing panels can survive a destructive earthquake, e.g., Coalinga - 1983 with only minor damage (5), (6).

The lack of an adequate data base of test data on the dynamic behavior of building partitions necessitates that testing using modern state-of-the-art test equipment be carried out to provide quantitative results on the strength and cyclic behavior of typical building partitions, including thresholds of damage, as well as their fundamental characteristics, e.g., damping, resonant frequencies, etc.

It is necessary to evaluate the effectiveness of the design provisions of the regulatory standards, e.g., Uniform Building Code (34), ATC 3-06 (32), SEAOC (31), State of California (29), and Tri-Services Manual (33), through correlation with test results, and improvements suggested wherever appropriate. Many of the seismic design provisions are based on static test results carried out in the late 1950's and such provisions need to be correlated with recent dynamic test results.

2. SCOPE AND OBJECTIVES

The main emphasis of this part of the research program is to experimentally investigate the dynamic behavior of full-height building partitions and threshold of damage.

The general objective of this phase of the dynamic testing program is to assess the effectiveness of current provisions of the Uniform Building Code (34) and other regulatory standards, e.g., State of California Title 21 and Title 24 (29), ATC 3-06 (32), SEAOC (31) and current practices governing the design, detailing and installation of building partitions.

The specific objectives of this dynamic testing program are to investigate:

1. The behavior of full-height wood-framed building partitions with and without holdowns.
2. The behavior and contribution of gypsum wallboard facing panels to the earthquake resistance of full-height wood-framed building partitions.
3. The behavior and earthquake resistance of full-height wood-framed building partitions with plywood on one side and gypsum wallboard on the opposite side.

3. REVIEW OF CURRENT DESIGN AND CONSTRUCTION PRACTICES

Building partition assemblies currently in use are dictated by the following:

Building type based on occupancy, e.g.

- Commercial (office, shopping, etc.)
- Residential (single family or multi-family, e.g., apartments, condominiums, etc.)
- Institutional (schools, hospitals, public, i.e., government, etc.) and

Governing regulations for fire resistance and separation as well as applicable acoustic criteria and economics.

The vast majority of partition systems in use in buildings fall into the following two categories:

3.1 Metal-Stud Framed Partitions with Gypsum-Wallboard as Facing Panels

These partition systems framed with 2-1/2 inch or 3-5/8 inch wide 25 gage metal studs spaced every 16 or 24 inches between top and bottom metal channel runners fastened to the structure and faced typically with gypboard panels (placed vertically or horizontally) are typically in use in a large majority of commercial and institutional buildings. The seismic design and detailing considerations as provided for in governing codes and regulations, can be satisfied by appropriate seismic detailing so that these partition components are isolated or separated from the primary structural system by an adequate amount. Such partition systems being reasonably light in weight, have been found to survive earthquakes with little or no damage. In-plane partition damage is likely to occur if the actual seismic drift in the building exceeds that the partition details can safely accommodate. Out-of-plane partition damage can occur in partitions with large height to thickness ratios with details that may not accommodate the alternating rotations, at top and bottom attachments or due to pounding of suspended-ceiling components at their interface (23).

3.2 Wood-Stud Framed Partitions with Gypsum-Wallboard, Plywood or Stucco as Facing Panels

These construction assemblies are typically found in residential construction and possibly in some buildings of other occupancies. Such partition components typically consist of 2 x 4 wood studs spaced every 16 inches or 24 inches, positioned between top and bottom wood-plates fastened to the main structure and faced with different types of facing panels as follows:

Interior Partitions: Gypboard facing panels applied vertically or horizontally on both sides.

Exterior Walls/Partitions:

- Gypsum facing panels applied vertically or horizontally on inside face and
- Plywood and/or stucco finish on the exterior face.

In the seismic design and detailing of wood-framed building systems, the designer assumes that the entire design lateral force caused by earthquake or wind will be resisted by a few strategically placed walls designated as shear walls. These wood-stud framed walls may have the following combination of finishing materials:

- Interior walls - gypsum wallboard panels on both sides or gypsum wallboard on one side and plywood panels on the opposite side.
- Exterior walls - gypsum wallboard panels on the inside face with plywood panels with or without stucco finish on the exterior face.

Furthermore, these walls are provided with holdown devices (if necessary) to resist the overturning actions of earthquake motions (1), (4), (6), (8), (16), (28), (30).

In these types of buildings, there are a large number of other non-structural walls or partitions that the designer assumes, do not participate in the overall system of earthquake resistance.

Because of the nature of existing construction practices for wood-framed buildings, it is likely that under certain conditions, many of the non-structural walls or partitions will participate in the overall earthquake resistance of such buildings.

4. DYNAMIC TESTING PROGRAM

4.1 Selection of Full-Height Partition Test Specimens

4.1.1 General

In accordance with the original objectives of this research program, it was decided to focus attention on those types of full-height building partitions that are more likely to participate in the overall seismic resistance of a building. Light metal-stud framed partitions with gypsum wallboard as facing panels (typically found in medium/high-rise buildings with steel or reinforced concrete framing systems), and with appropriate seismic detailing, can be effectively separated/isolated from the primary structural system. Appropriate seismic detailing will consist of adequate provisions for slip/separation joints at ends and at top of the partitions where these components interface with the main structural system. Such light components will suffer earthquake damage if the seismic building inter-story drift exceeds the provided separation at ends of the full-height partition. Therefore it was decided to explore the possible contribution of wood-framed building partition walls, to the overall earthquake resistance of buildings.

4.1.2 Description of Test Specimens

A detailed description of the full-height partition specimens tested is presented in Table I.

The details of the test specimens, as built, are presented in Appendix A (Figures 1-7).

All partitions are wood-stud framed and are 8 feet wide and approximately 10 feet high. Installation of building partitions is done according to accepted current practices.

The partition dynamic test specimens may be categorized as follows:

Specimen No. PD3-V Run No. 1

Wood-stud framed partition with gypboard panels applied vertically on both sides without any holdowns.

Specimen No. PD3-V Run No. 2

Wood-stud framed partition with gypboard panels applied vertically on both sides with holdowns.

Specimen No. PD3-H

Wood-stud framed partitions with gypsum panels applied horizontally on both sides with holdowns.

Specimen No. PD-4 Run No. 1/Run No. 2

Wood-stud framed partitions with gypboard panels applied on the inside face and plywood panels on the outside face with holdowns.

4.2 Dynamic Testing Method

4.2.1 Test Set-Up

The dynamic testing scheme developed in the early phase of this research program was also used in the dynamic testing of full-height building partitions. Complete details of the test set-up, equipment and instrumentation are presented elsewhere in an earlier report (23).

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TABLE I: LIST OF PARTITION TEST SPECIMENS

SPECIMEN NO.	PARTITION TYPE	FACING PANELS	SIZE IN-PLANE	REMARKS
PD3-V Run No. 1	2 X 4 Wood Studs at 16" O.C.	Single Layer 1/2" Gypsum Wall-Board Applied Vertically Each Side, Nail Spacing as per UBC Table 47-I	8 Ft. Wide X 10 Ft. High	No Holdowns.
PD3-V Run No. 2	2 X 4 Wood Studs at 16" O.C.	Same	8 Ft. Wide X 10 Ft. High	Simpson HD-2 Holdowns at Base at Each End.
PD3-H	2 X 4 Wood Studs at 16" O.C.	Single Layer 1/2" Gypsum Wall-Board Applied Horizontally Each Side, Nail Spacing as per UBC Table 47-I	8 Ft. Wide X 10 Ft. High	Simpson HD-5 Holdowns at Base at Each End. Two Inch Air Gap Provided Between Top of Partition and Steel Loading Grid Above. Load Transferred to Partition at Each End Through Steel Tubing Connected to Underside of Loading Grid.
PD-4 Run No. 1 Run No. 2	2 X 4 Wood Studs at 16" O.C.	Single Layer 1/2" Gypsum Wall-Board Applied Horizontally One Side (Nail Spacing as per UBC Table 47-I); 3/8" Plywood Opposite Side (Nail Spacing as per UBC Table 25-K)	8 Ft. Wide X 10 Ft. High	Simpson HD-5 Holdowns at Base at Each End. Two Inch Air Gap Provided Between Top of Partition and Steel Loading Grid Above. Load Transferred to Partition at Each End Through Steel Tubing Connected to Underside of Loading Grid.

The dynamic testing scheme basically consists of a steel-framed grid simulating a horizontal floor diaphragm that is free to roll on a wheel/bearing assembly. The full-height partitions are attached to the steel grid at the top and also fastened at the bottom to a precast concrete base bolted to the laboratory floor. The partition test specimens are subjected to cyclic racking motions at the center line of the loading grid using an MTS electro-hydraulic closed-loop system. The input excitation is sinusoidal and full-height partition specimens are subjected to cyclic displacements at controlled magnitudes and frequencies.

4.2.2 Test Equipment and Instrumentation

Data acquisition of dynamic test control and specimen responses are provided by the following transducers:

- Load-Cell
- LVDT's
- Strain Gages
- Accelerometer

The location and orientation of measurement transducers and the overall test set-up is presented in Appendix A (Figure 1). A detailed description of the six measurement transducers for all partition test specimens is presented in Table II. Each transducer output was conditioned by a pre-amplifier module in the Honeywell Visicorder Model 1858, which provided an almost immediate hard copy of each sensor's output.

From the Visicorder's buffered output drives, the signals on all seven channels are sent through a parallel-to-series multiplexer (MUX) to give three channels of test data and one timing signal for recording. The analog dynamic test data is recorded on an HP 3960A four channel, three-speed, instrumentation tape recorder using FM recording of signals from DC up to 5000 Hz at 15 ips. This provides a permanent record of all dynamic test data on one-quarter inch magnetic tape, for further processing.

The retrieval of any transducer's response signal is provided by playing back the magnetic tape through a series-to-parallel demultiplexer (DEMUX). Additional hard-copy recordings of a sensor's response were obtained by means of a strip chart recorder (e.g., B & K Graphic Recorder Model 2309).

A Block Diagram of Dynamic Testing Equipment and Instrumentation is shown in Figure 4-1.

Furthermore, a x-y recorder provided instantaneous hard copy plots of load-cell vs. LVDT mounted at the centerline of the loading grid for each test run.

4.2.3 Dynamic Testing Procedure

In accordance with the testing procedures developed and used in the earlier phase of this research project (23), (24) and after consideration of testing procedures used by other investigators (10), (25), (26) it was decided to subject the partition specimens to Block Cyclic Tests.

During each test run, frequency is fixed and specimens are subjected to several complete cycles of loading for each increasing level of peak command horizontal displacement starting with 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1-1/4, 1-1/2 ---- inches.

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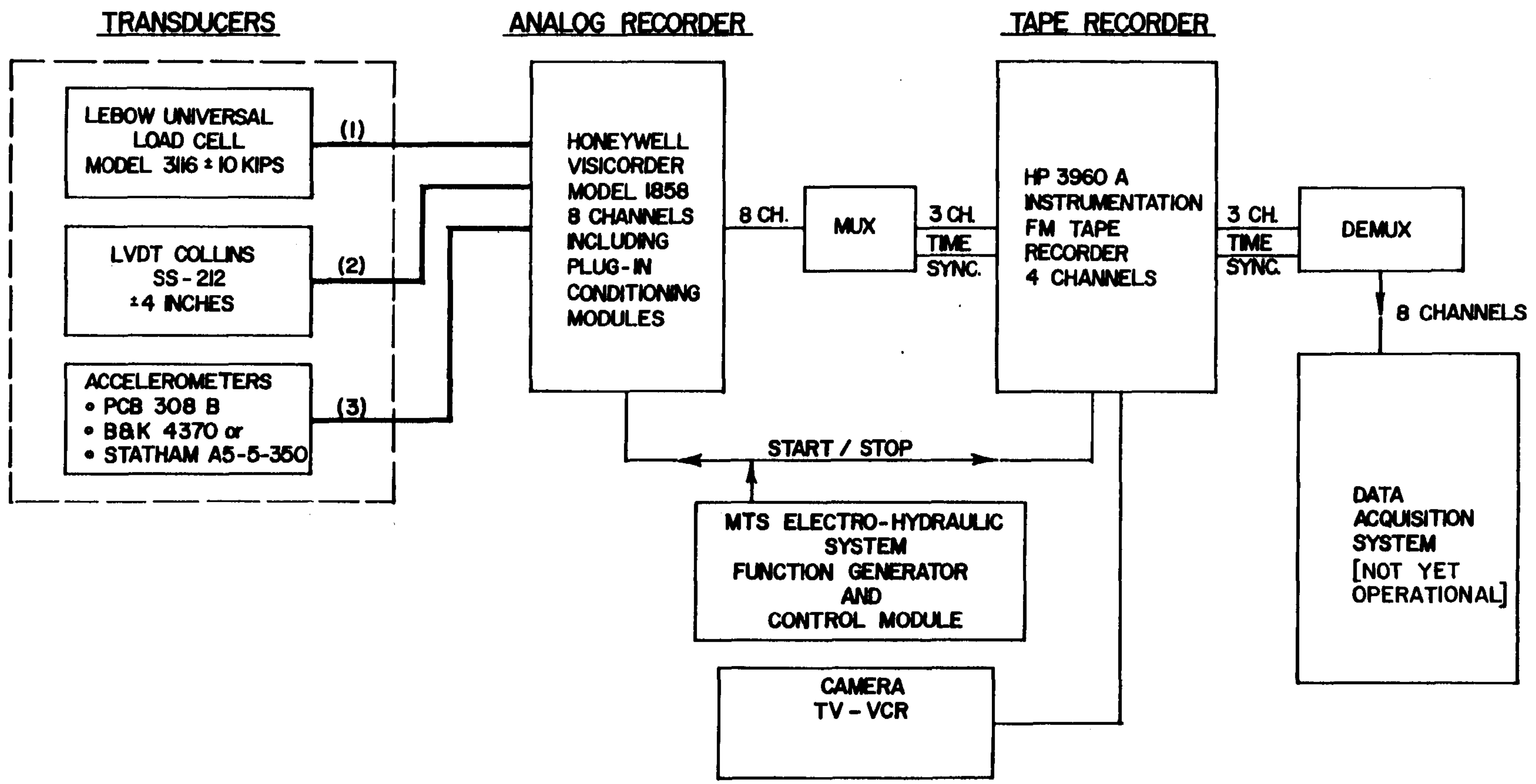
TABLE II: MEASUREMENT TRANSDUCERS

SPECIMEN NO.	CHANNEL No. 1	CHANNEL No. 2	CHANNEL No. 3	CHANNEL No. 4	CHANNEL No. 5	CHANNEL No. 6
PD3-V Run No. 1	Accelerometer Grid-Axial	Wire Potentiometer Displacement Transducer Left Bottom	Wire Potentiometer Displacement Transducer Right Bottom	Load-Cell	LVDT Grid-Axial	LVDT Partition-Grid Axial
PD3-V Run No. 2	Accelerometer Grid-Axial	Strain-Gage Left Holdown Bolt	Strain-Gage Right Holdown Bolt	Load-Cell	LVDT Grid-Axial	LVDT Partition-Grid Axial
PD3-H	Accelerometer Grid-Axial	Strain-Gage Left Holdown Bolt	Strain-Gage Right Holdown Bolt	Load-Cell	LVDT Grid-Axial	LVDT Partition-Grid Axial
PD-4 Run No. 1 Run No. 2	Accelerometer Grid-Axial	Strain-Gage Left Holdown	Strain-Gage Right Holdown Bolt	Load-Cell Bolt	LVDT Grid-Axial	LVDT Partition-Grid Axial



BLOCK DIAGRAM

DYNAMIC TESTING INSTRUMENTATION & DATA PROCESSING [REF. 23]

FIGURE 4-1	NSF SPONSORED RESEARCH PROJECT DYNAMIC BEHAVIOR OF NON-STRUCTURAL BUILDING PARTITIONS & CEILING SYSTEMS DURING EARTHQUAKES PRINCIPAL INVESTIGATOR: DR. SAT RIHAL, ARCH. ENGR. DEPT.	PREPARED BY: DR. GARY GRANNEMAN, ET/EL DATE: 2-3-83 CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO, CALIFORNIA 93407

During each test a log sheet was kept showing all pertinent details of the dynamic test, measurement transducers, calibration of measuring instruments and recording devices. A typical sample of this log sheet is presented in Appendix F. Complete details of dynamic test control parameters for all specimens tested to date are presented in Table III.

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TABLE III: SUMMARY OF DYNAMIC TEST CONTROL PARAMETERS

SPECIMEN NO.	DESCRIPTION All Specimens 8'-0" Wide X 10'-0 High	FREQUENCY Hz.	NO. OF CYCLES	BLOCK CYCLIC TEST COMMAND PEAK DISPLACEMENT OF CYCLES - INCHES										
				±1/8	±1/4	±3/8	±1/2	±3/4	±1	±1-1/4	±1-1/2	±2	±2-1/2	±2.8
PD3-V Run No. 1	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side	0.50	5		X	X	X	X						
	No Holdowns	0.70	5		X	X	X	X						
PD3-V Run No. 2	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side	0.50	5	X	X	X	X	X	X	X	X			
	Simpson HD-2 Holdowns at Base at Each End	1.00	5	X	X	X	X	X	X	X	X			
PD3-H	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally Each Side	0.50	5	X	X	X	X	X	X	X	X	X	X	X
	Simpson HD-5 Holdowns at Base at Each End	1.00	5	X	X	X	X	X	X	X	X	X	X	X
PD-4	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally On One Side, and 3/8"	Run No. 1 0.5 Hz	5	X	X	X	X							
	Plywood Opposite Side Simpson HD-5 Holdowns at Base at Each End	Run No. 2 0.5 Hz	5			X	X	X	X	X	X	X	X	X

5. DYNAMIC TEST RESULTS

5.1 Summary of Test Results - Observed Behavior and Partition Performance

The behavior of each partition specimen was observed and recorded during each test sequence of the Block Cyclic Tests. In addition photographic record was kept of the specimen response and performance during each test sequence.

A detailed summary of observed partition damage level and corresponding motion parameters is presented in Table IV.

Photographic record of specimen performance on a specimen-by-specimen basis is presented in Appendix E (Figures 1-46).

5.2 Response Records of Dynamic Test Data

Measured time-history test data obtained by the load-cell, loading-grid LVDT, loading-grid accelerometer and strain-gages @ holdown bolts, during the dynamic tests, are presented in Appendix B (Figures 1-45). The original records of test data obtained from the Honeywell Visicorder could not be included in this report as reproduction of these records could not be made. The time-histories of dynamic test data presented in Appendix B (Figures 1-45) were obtained by playing back the analog data recorded on magnetic tape (using HP 3960A Tape Recorder) through a B & K strip chart recorder (Model 2309) two channels at a time. As described in the previous research report (23), because of the lack of appropriate software and interfacing difficulties between the HP

Tape Recorder and the Department's DEC Minicomputer, the analog tape data could not be digitized for transfer to disk storage and further processing.

This shortcoming is being corrected and an IBM-PC compatible microcomputer and all appropriate software (VIPAC System) is being acquired for automation of recording, displaying and processing of dynamic test data from further dynamic tests.

5.3 Peak Dynamic Responses

In the absence of any sophisticated signal processing equipment the available analog test data was manually analyzed using the time-histories of test data on Honeywell Visicorder rolls of paper.

For each block cyclic test, the peak responses of all transducer channels (e.g., load-cell, loading-grid LVDT, loading-grid accelerometer, etc.) were manually determined for each increment of control parameter, e.g., peak-command-displacement. The tables on pages 27-34 document the peak responses of all transducer channels for each test run for each partition test specimen. For every specimen tested, graphs are plotted between peak-load and peak-displacement of each block of cyclic motions.

In addition, plots of peak-command-displacement vs. measured peak-grid-displacement at top of the partition are presented for all test specimens.

Unique efforts to record behavior of typical holdown devices (30) under cyclic motions were successfully made. Peak values of measured holdown forces during each block cyclic test were successfully obtained for specimens PD-4 through the use of internally-gaged-threaded-studs made by Strainsert Corporation. Graphs between peak load-cell output and peak holdown forces were plotted.

These graphs of peak dynamic responses are presented in Appendix C (Figures 1-5).

From the cyclic load-displacement curves obtained for each block cyclic test for each specimen, an estimation of the modulus of rigidity was made as suggested by Freeman (10) as follows:

Ridigity = (Load/(Length X Thickness))/(Displacement/Height)

For all partition test specimens, graphs between the estimated rigidity and peak-command-displacement, for each block cyclic test are presented in Appendix C (Figure 6).

5.4 Summary of Test Results

Dynamic responses of the four partition test specimens were manually analyzed and a partial summary of test results is presented in Table V. For each partition test specimen, the maximum peak lateral load reached and the corresponding peak measured horizontal displacement at top of the partition during the block cyclic tests are summarized. The associated frequency of the imposed blocks of cycles of loading is also shown in Table V. The peak lateral shears defined as the peak lateral load divided by the width (8 feet) of the partitions, as well as the UBC allowable lateral design shears (34) are also presented in Table V.

A summary of peak measured holdown forces, corresponding peak loads reached and calculated holdown forces for partitions specimen PD-4 are presented in Table VI (Run No. 1) and Table VII (Run No. 2), for each block cyclic test. The calculated holdown forces are based on maximum peak load, dimensions of the partitions and principles of structural equilibrium.

For all partition test specimens the measured peak acceleration at center line of the loading grid, i.e., at top of the partitions varied between 0.006 g and 0.32 g. Measured peak horizontal displacement at top of partitions varied between ±0.05 inch (Specimen No. PD3-V Run No. 2, Test No. A-1, Peak Command Displacement ±1/8 inch) and ±1.55 inches (Specimen No. PD3-H, Test No. A-11, Peak Command Displacement ±2.8 inches) for all the block cyclic tests with frequencies of 0.5 Hz, 0.7 Hz and 1.0 Hz.

Relationship between motion parameters, i.e., frequency and amplitude of displacements, forces, etc., and level of partition damage is systematically presented in Table IV. Except for partition Specimen No. PD3-V Run No. 1, without any holdowns, initial partition damage appears to start at a peak horizontal displacement at top of the partition of ±0.20-0.25 inch @ frequency of 0.5 Hz. Severe partition damage takes place at peak horizontal displacement at top of partition of ±0.85-1.35 inches.

Figure 7 (Appendix C) shows the result of an effort to plot the relationship between partition damage level and peak measured horizontal displacement @ top of partition, for all test specimens.

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TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE

PARTITION SPECIMEN NO. **Ref. Table I**	**DAMAGE LEVEL**						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Damage @ Gypboard-Sill Plate Nailing-Crumbling of Gypboard Around Nail Heads	Noticeable Damage @ Gypboard-End Stud Nailing-Popping of Nail Heads	Noticeable Separation/Slippage Between Gypboard Panels and Stud Framing, Popping of Nail Heads	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Failure of Taped Joints Between Gypboard Panels
SPECIMEN PD3-V **Run No. 1** **No Holdowns**	First Signs of Damage @ Measured Top Displ. of · ±0.17 Inch @ · Freq. = 0.5 Hz · Load = ±550 lbs	Damage @ Measured Top Displ. of · ±0.22 Inch to ±0.30 Inch @ · Freq. = 0.5 Hz · Load = ±390 - 410 lbs.		Damage @ Measured Top Displ. of · ±0.35 Inch to ±0.55 Inch @ · Freq. = 0.70 Hz · Load = ±600 - 620 lbs.			

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE
(Cont'd)

PARTITION SPECIMEN NO. **Ref. Table I**	**DAMAGE LEVEL**						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Damage @ Gypboard-Sill Plate Nailing-Crumbling of Gypboard Around Nail Heads	Noticeable Damage @ Gypboard-End Stud Nailing-Popping of Nail Heads	Noticeable Separation/ Slippage Between Gypboard Panels and Stud Framing, Popping of Nail Heads	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Failure of Taped Joints Between Gypboard Panels
SPECIMEN PD3-V **Run No. 2** **HD-2 Holdowns** **(Cont'd)**			@ Measured Top Displ. of · ±0.25 Inch @ · Freq. = 0.5 Hz · Load = ±1600 lbs	@ Measured Top Displ. of · ±0.38 Inch @ · Freq. = 0.5 Hz · Load = ±1700 lbs	@ Measured Top Displ. of · ±0.55 Inch @ · Freq. = 0.5 Hz · Load = ±1950 lbs	@ Measured Top Displ. of · ±0.75 - ±1.2 Inches @ · Freq. = 0.5 Hz · Load = ±2100 - 2050 lbs	
			Continuation of Damage at · ±0.20 Inch @ · Freq. = 1.0 Hz · Load = ±300 lbs	Continuation of Damage at · ±0.28 Inch @ · Freq. = 1.0 Hz · Load = ±400 lbs	Continuation of Damage at · ±0.44 Inch @ · Freq. = 1.0 Hz · Load = ±500 lbs	Continuation of Damage at · ±0.58 - ±0.77 Inch @ · Freq. = 1.0 Hz · Load = ±550 - 750 lbs	

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE (Cont'd)

PARTITION SPECIMEN NO. **Ref. Table I**	**DAMAGE LEVEL**						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Damage @ Gypboard-Sill Plate Nailing-Crumbling of Gypboard Around Nail Heads	Noticeable Damage @ Gypboard-End Stud Nailing-Popping of Nail Heads	Noticeable Separation/ Slippage Between Gypboard Panels and Stud Framing, Popping of Nail Heads	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Failure of Taped Joints Between Gypboard Panels
SPECIMEN PD3-H **HD-5 Holdowns**			@ Measured Top Displ. of · ±0.36 Inch @ · Freq. = 0.5 Hz · Load = ±1800 LBS	Initial Damage @ Measured Top Displ. of · ±0.25 Inch · Freq. = 0.5 Hz · Load = ±1500 lbs	Initial Damage @ Measured Top Displ. of · ±0.55 - 0.73 Inch · Freq. = 0.5 Hz · Load = ±2200 - ±1900 lbs		Initial Damage: Crack Found on the Lower Rear Taped Joint @ Measured Top Displ. of · ±0.55 Inch @ · Freq. = 0.5 Hz · Load = ±2200 lbs
							Shear Failure @ Rear Taped Joint @ Measured Top Displ. of · ±0.95 Inch @ · Freq. = 0.5 Hz · Load = ±1800 lbs

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE (Cont'd)

PARTITION SPECIMEN NO. **Ref. Table I**	**DAMAGE LEVEL**						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Damage @ Gypboard-Sill Plate Nailing-Crumbling of Gypboard Around Nail Heads	Noticeable Damage @ Gypboard-End Stud Nailing-Popping of Nail Heads	Noticeable Separation/Slippage Between Gypboard Panels and Stud Framing, Popping of Nail Heads	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Failure of Taped Joints Between Gypboard Panels
SPECIMEN FD3-H **HD-5 Holdowns** **(Cont'd)**			Continuation of Damage @ Measured Top Displ. of • ±0.27 Inch @ • Freq. = 1.0 Hz • Load = ±170 lbs	Continuation of Damage @ • ±0.20 Inch • Freq. = 1.0 Hz • Load = ±140 lbs	Continuation of Damage @ Measured Top Displ. of • ±0.72 - 0.90 Inch • Freq. = 1.0 Hz • Load = ±370 - 400 lbs		Continued Damage @ Measured Top Displ. of • ±0.84 - 0.85 Inch • Freq. = 1.0 Hz • Load = ±360-380 lbs
			Continuation of This Type of Damage @ Measured Top Displ. of ±0.40 - 0.60 Inch @ Freq. = 1.0 Hz Load = ±200 - 350 lbs				

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE (Cont'd)

PARTITION SPECIMEN NO. Ref. Table I	DAMAGE LEVEL						
	I	II	III	IV	V	VI	VII
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Initial Damage-Slippage Between Facing Panels	Noticeable Damage @ Gypboard-End Stud and Sill-Plate Nailing. Noticeable Slippage Along Plywood Joints. Initial Damage of Plywood @ Edge Nailing	Noticeable Separation/ Slippage Between Gypboard Panels and Between Plywood Panels Popping of Nail Heads in Gypboard Panels	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Noticeable Nail-Pops in Gypboard, Failure of Taped Joints Between Gypboard Panels. Compression Failure of Plywood Panel, End Stud Splitting Failure
SPECIMEN PD-4 Run No. 1 HD-5 Holdowns			Initiation of Damage (Slippage @ Taped Joint in Gypboard Panels) @ Measured Top Displ. of • ±0.23 Inch @ • Frequency = 0.5 Hz • Load = ±1050 lbs.	Initial Damage of Gypboard @ Nail Heads @ End Studs @ Measured Top Displ. of • ±0.30 Inch • Frequency = 0.5 Hz • Load = ±1125 lbs.	Slippage (±1/8 Inch) Along Vertical Joint Between 3/8 Inch Plywood Panels @ Peak Command Displ. of • ±1 Inch • Frequency = 0.5 Hz • (Load Data not Available for this Test Run Due to Problem with Reaction Frame.)		Nail-Pop in Gypboard @ Sill-Plate @ Peak Command Displ. of • ±1-1/4 Inches • Frequency = 0.5 Hz • (Load Data Not Available for this Test Run Due to Problem with Reaction Frame.)

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE (Cont'd)

PARTITION SPECIMEN NO. **Ref. Table I**	DAMAGE LEVEL						
	I	II	III	IV	V	VI	VII
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Initial Damage-Slippage Between Facing Panels	Noticeable Damage @ Gypboard-End Stud and Sill-Plate Nailing. Noticeable Slippage Along Plywood Joints. Initial Damage of Plywood @ Edge Nailing	Noticeable Separation/Slippage Between Gypboard Panels and Between Plywood Panels Popping of Nail Heads in Gypboard Panels	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Noticeable Nail-Pops in Gypboard, Failure of Taped Joints Between Gypboard Panels. Compression Failure of Plywood Panel, End Stud Splitting Failure
SPECIMEN PD-4 **Run No. 2 HD-5 Holdowns** **(Cont'd)**							Crushing of Plywood @ Lower Front Corner @ Measured Top Displ. of · ±1.15-1.30 Inches · Frequency = 0.5 Hz · Load = ±2150-2350 lbs.

TABLE IV: SUMMARY OF DYNAMIC TEST RESULTS - OBSERVATIONS OF PARTITION PERFORMANCE
(Cont'd)

PARTITION SPECIMEN NO. **Ref. Table I**	**DAMAGE LEVEL**						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
	Failure of Edge Stud/Sill Plate Connection. Edge Stud Lifting Off Sill Plate	Uplifting of Sill Plate and Initiation of Damage Around Gypboard-Sill Plate Nailing and Gypboard-End Stud Nailing	Noticeable Initial Damage-Slippage Between Facing Panels	Noticeable Damage @ Gypboard-End Stud and Sill-Plate Nailing. Noticeable Slippage Along Plywood Joints. Initial Damage of Plywood @ Edge Nailing	Noticeable Separation/ Slippage Between Gypboard Panels and Between Plywood Panels Popping of Nail Heads in Gypboard Panels	Bending Deformation Noticeable @ Horizontal Plate Bracket of Holdown	Noticeable Nail-Pops in Gypboard, Failure of Taped Joints Between Gypboard Panels. Compression Failure of Plywood Panel, End Stud Splitting Failure
SPECIMEN PD-4 **Run No. 2** **HD-5 Holdowns**			Initial Slippage Between Facing Panels @ Measured Top Displ. of • ±0.39 Inch @ • Frequency = 0.5 Hz • Load = ±640 lbs.	Opening-Up of Horizontal Joint in 3/8 Inch Plywood and Damage of Plywood @ Nailing on Vertical Joint Between Plywood Panels @ Measured Top Displ. of • ±0.50 Inch @ • Frequency = 0.5 Hz • Load = ±950 lbs.	Popping of Nail Heads in Gypboard @ End Studs and @ Upper Portion of Panel @ Measured Top Displ. of • ±0.95 Inch • Frequency = 0.5 Hz • Load = ±1800 lbs.		Splitting Failure of Bottom Sill-Plate and Edge Stud @ Measured Displ. of • ±1.30-1.35 Inches • Frequency = 0.5 Hz • Load = ±2350-2380 lbs.

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO, CA 93407
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PRINCIPAL INVESTIGATOR: SAT RIHAL
FACULTY ASSOCIATE: GARY GRANNEMAN, ET/EL DEPARTMENT (TESTING AND INSTRUMENTATION)
STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD3-V DATE: 1/21/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum
I BLOCK CYCLIC TEST Run No. 1 Wall-Board Applied Vertically Each Side.
No Holdowns.

			MEASURING INSTRUMENTS		**COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)**										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES**	**CHANNEL NO.**	**TRANSDUCER**	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
A	0.5	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)		0	0	±0.03	±0.03						
			NO. 2	WIRE POTENTOMETER DISPL. TRANSDUCER LEFT (INCH)		±0.05	±0.1	±0.22	±0.37						
			NO. 3	WIRE POTENTOMETER DISPL. TRANSDUCER RIGHT (INCH)		±0.01	±0.02	±0.025	±0.05						
			NO. 4	LOAD-CELL (LBS.)		±420	±550	±600	±620						
			NO. 5	LVDT GRID-AXIAL (INCH)		±0.08	±0.17	±0.35	±0.55						
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)		0	0	0	±0.01						
			MAG-TAPE READING	INITIAL	000										
				FINAL					064						

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PRINCIPAL INVESTIGATOR: SAT RIHAL
FACULTY ASSOCIATE: GARY GRANNEMAN, ET/EL DEPARTMENT (TESTING AND INSTRUMENTATION)
STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD3-V DATE: 1/21/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side. No Holdowns.
I BLOCK CYCLIC TEST Run No. 1

			MEASURING INSTRUMENTS		COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)										
RUN NO.	FIXED FREQ. Hz	NO. OF CYCLES.	CHANNEL NO.	TRANSDUCER	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
B	0.70	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)		0	±0.015	±0.04	±0.04						
			NO. 2	WIRE POTENTOMETER DISPL. TRANSDUCER LEFT (INCH)		±0.1	±0.15	±0.20	+0.020						
			NO. 3	WIRE POTENTOMETER DISPL. TRANSDUCER RIGHT (INCH)		±0.02	±0.025	±0.03	±0.003						
			NO. 4	LOAD-CELL (LBS.)		±300	±390	±410	±410						
			NO. 5	LVDT GRID-AXIAL (INCH)		±0.15	±0.22	±0.30	±0.30						
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)		0	0	0	0						
			MAG-TAPE READING	INITIAL		064									
				FINAL					172						

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STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD3-V DATE: 2/4/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Woods Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side. Simpson HD-2 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST Run No. 2

			MEASURING INSTRUMENTS		**COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)**										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES.**	**CHANNEL NO.**	**TRANSDUCER**	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
A	0.5	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)	0	0	0	0.1	0.01	0.01	0.02	0.025			
			NO. 2	STRAIN GAGE @ LEFT HOLDOWN BOLT-FORCE (LBS.)	±250#	±800#	±1000#	±1100#	±1330#	±1500#	±1450#	±1560#			
			NO. 3	STRAIN GAGE @ RIGHT HOLDOWN BOLT-FORCE (LBS.)	±50#	±300#	±400#	±470#	±600#	±600#	±630#	±600#			
			NO. 4	LOAD-CELL (LBS.)	±900	±1400	±1600	±1700	±1950	±2100	±2200	±2050			
			NO. 5	LVDT GRID-AXIAL (INCH)	±0.05	±0.18	±0.25	±0.38	±0.55	±0.75	±0.93	±1.20			
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)	0	0	0	0	±0.01	±0.025	±0.06	±0.06			
			MAG-TAPE READING	INITIAL	0175	231	256	282	308	336	360	383			
				FINAL	0231	236	282	308	336	360	383				

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STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD3-V DATE: 2/4/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Woods Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side. Simpson HD-2 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST Run No. 2

			MEASURING INSTRUMENTS		COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES.**	**CHANNEL NO.**	**TRANSDUCER**	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
C	1.0	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)	0	0.01	0.04	0.05	0.06	0.07	0.08	0.09			
			NO. 2	STRAIN GAGE @ LEFT HOLDOWN BOLT-FORCE (LBS.)	±300#	±450#	±600#	±800#	±850#	±1050#	±950#	±1100#			
			NO. 3	STRAIN GAGE @ RIGHT HOLDOWN BOLT-FORCE (LBS.)	±50#	±110#	±120#	±200#	±300#	±350#	±220#	±325#			
			NO. 4	LOAD-CELL (LBS.)	±150	±220	±300	±400	±500	±550	±680	±750			
			NO. 5	LVDT GRID-AXIAL (INCH)	±0.06	±0.11	±0.20	±0.28	±0.44	±0.58	±0.70	±0.77			
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)	0	0	0	0	0	0	±0.02	±0.04			
			MAG-TAPE READING	INITIAL		423	438	451	466	480	493	506			
				FINAL	423	438	451	466	480	493	506	522			

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STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD 3-H DATE: 2/22/85 TIME: 8:00 A.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally Each Side. Simpson HD-5 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST

			MEASURING INSTRUMENTS		COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)										
RUN NO.	FIXED FREQ. Hz	NO. OF CYCLES.	CHANNEL NO.	TRANSDUCER	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
A	0.5	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)	0	0	0	±0.03	±0.04	±0.07	±0.07	±0.08	±0.12	±0.14	±0.18
			NO. 2	STRAIN GAGE @ LEFT HOLDOWN BOLT-FORCE (LBS.)	±100#	±150#	±175#	±200#	±200#	±220#	±200#	±150#	±500#	±400#	±400#
			NO. 3	STRAIN GAGE @ RIGHT HOLDOWN BOLT-FORCE (LBS.)	±100#	±200#	±300#	±320#	±420#	±500#	±550#	±550#	±750#	±680#	±500#
			NO. 4	LOAD-CELL (LBS.)	±620	±1040	±1500	±1800	±2200	±1900	±1800	±1500	±1240	±1230	±800
			NO. 5	LVDT GRID-AXIAL (INCH)	±0.07	±0.17	±0.25	±0.36	±0.55	±0.73	±0.95	±1.14	±1.34	±1.48	±1.55
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)	0	0	0	0	0	0	0	0	0.02	0.03	0.04
			MAG-TAPE READING	INITIAL	538	557	578	600	621	641	660	677	836	854	871
				FINAL	557	578	600	621	641	660	677	697	854	871	889

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STUDENT ASSISTANTS: TONG CHEUNG, M. ARCH STUDENT, SAED TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD 3-H DATE: 2/22/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally Each Side. Simpson HD-5 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST

			MEASURING INSTRUMENTS		**COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)**										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES.**	**CHANNEL NO.**	**TRANSDUCER**	**1 ±1/8**	**2 ±1/4**	**3 ±3/8**	**4 ±1/2**	**5 ±3/4**	**6 ±1**	**7 ±1-1/4**	**8 ±1-1/2**	**9 ±2**	**10 ±2-1/2**	**11 ±2.8**
C	1.0	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)	0	±0.03	±0.04	±0.06	±0.11	±0.12	±0.14	±0.19	±0.24	±0.28	±0.32
			NO. 2	STRAIN GAGE @ LEFT HOLDOWN BOLT-FORCE (LBS.)	±950#	±1500#	±1580#	±1700#	±1700#	±1250#	±900#	±800#	±220#	±200#	±350#
			NO. 3	STRAIN GAGE @ RIGHT HOLDOWN BOLT-FORCE (LBS.)	±40#	±380#	±400#	±700#	±1200#	±1400#	±1200#	±900#	±500#	±550#	±500#
			NO. 4	LOAD-CELL (LBS.)	±120	±140	±140	±170	±200	±250	±350	±370	±400	±360	±380
			NO. 5	LVDT GRID-AXIAL (INCH)	±0.06	±0.13	±0.20	±0.27	±0.40	±0.53	±0.60	±0.72	±0.9	±0.84	±0.85
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)	0	0	0	0	0	0	0	0	0	0	0.01
			MAG-TAPE READING	INITIAL	699	711	724	735	747	759	770	784	797	811	823
				FINAL	711	724	735	747	759	770	784	797	811	823	836

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PRINCIPAL INVESTIGATOR: SAT RIHAL
FACULTY ASSOCIATE: GARY GRANNEMAN, ET/EL DEPARTMENT (TESTING AND INSTRUMENTATION)
STUDENT ASSISTANTS: STEPHEN DEJESSE AND SPENCER BURROUGHS, ARCE DEPARTMENT TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.: PD-4 DATE: 6/24/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally On One Side, and 3/8" Plywood Opposite Side. Simpson HD-5 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST Run No. 1

			MEASURING INSTRUMENTS		**COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)**										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES.**	**CHANNEL NO.**	**TRANSDUCER**	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
A	0.5	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)	0	0	0	0							
			NO. 2	S. G. @ LEFT HOLDOWN BOLT (in./in.) FORCE - (LBS.)	± 50 ±293	±100 ±586	±170 ±996	± 215 ±1259							
			NO. 3	S. G. @ RIGHT HOLDOWN BOLT (in./in.) FORCE - (LBS.)	± 40 ±234	± 90 ±527	±150 ±879	± 180 ±1054							
			NO. 4	LOAD-CELL (LBS.)	±500	±875	±1050	±1125							
			NO. 5	LVDT GRID-AXIAL (INCH)	±0.065	±0.13	±0.23	±0.30							
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)	0	0	0	0							
			MAG-TAPE READING	INITIAL	1011	1023	1038	1053							
				FINAL	1023	1038	1053	1069							

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO, CA 93407
ARCHITECTURAL ENGINEERING DEPARTMENT - HIGH BAY LAB

NSF SPONSORED RESEARCH PROJECT: DYNAMIC TESTING OF BUILDING PARTITIONS - PEAK RESPONSE DATA

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TEST SCHEDULE: SPECIMEN NO.: PD-4 DATE: 7/12/85 TIME: 3:00 P.M. DESCRIPTION: 2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally On One Side, and 3/8" Plywood Opposite Side. Simpson HD-5 Holdowns at Base at Each End.
I BLOCK CYCLIC TEST Run No. 2

			MEASURING INSTRUMENTS		**COMMAND PEAK DISPLACEMENT OF CYCLES (Inches)**										
RUN NO.	**FIXED FREQ. Hz**	**NO. OF CYCLES.**	**CHANNEL NO.**	**TRANSDUCER**	1 ±1/8	2 ±1/4	3 ±3/8	4 ±1/2	5 ±3/4	6 ±1	7 ±1-1/4	8 ±1-1/2	9 ±2	10 ±2-1/2	11 ±2.8
A	0.5	5	NO. 1	ACCELEROMETER GRID-AXIAL (g's)			±0.006	±0.009	±0.013	±0.021	±0.020	±0.025	±0.03	±0.033	±0.035
			NO. 2	S. G. @ LEFT HOLDOWN BOLT (in./in.) FORCE - (LBS)			± 120 ± 702	± 175 _1025	± 270 ±1581	± 700 ±4099	± 540 ±3160	± 570 ±3340	± 550 ±3221	± 440 ±2578	± 360 ±2110
			NO. 3	S. G. @ RIGHT HOLDOWN BOLT (in./in.) FORCE - (LBS.)			± 135 ± 790	± 175 ±1025	± 270 ±1581	± 600 ±3500	± 540 ±3160	± 600 ±3500	± 640 ±3750	± 670 ±3925	± 640 ±3750
			NO. 4	LOAD-CELL (LBS.)			±440	±640	±950	±1475	±1550	±1800	±2150	±2350	±2380
			NO. 5	LVDT GRID-AXIAL (INCH)			±0.24	±0.39	±0.50	±0.82	±0.80	±0.95	±1.15	±1.30	±1.35
			NO. 6	LVDT PARTITION-GRID-AXIAL (INCH)			0	±0.02	±0.02	±0.045	±0.04	±0.05	±0.07	±0.07	±0.08
			MAG-TAPE READING	INITIAL			1204	1218	1233	1112	1248	1265	1280	1295	1311
				FINAL			1218	1233	1248	1204	1265	1280	1295	1311	1327

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TABLE V: SUMMARY OF DYANMIC TEST RESULTS

SPECIMEN NO.	DESCRIPTION All Specimens 8'-0" Wide X 10'-0" High	FREQUENCY (Hz)	PEAK LATERAL LOAD LBS.	PEAK LATERAL DISPLACEMENT INCHES	PEAK LATERAL SHEAR LBS./LIN. FT.	UBC ALLOWABLE DESIGN SHEAR LBS./LIN. FT.
PD3-V Run No. 1	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side No Holdowns	0.5	±620	±0.55	77.5	200 (Table 47-I)
PD3-V Run No. 2	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Vertically Each Side Simpson HD-2 Holdowns at Base at Each End	0.5	±2200	±1.20	275.0	200 (Table 47-I)
PD3-H	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally Each Side Simpson HD-5 Holdowns at Base at Each End	0.5	±2200	±1.55	275.0	200 (Table 47-I)
PD-4 Run No. 1 Run No. 2	2 X 4 Wood Studs at 16" O.C. 1/2" Gypsum Wall-Board Applied Horizontally On Side and 3/8" Opposite Side Simpson HD-5 Holdowns at Base at Each End	0.5	±2380	±1.35	297.5	264 (Table 25-K)

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TABLE VI: SUMMARY OF MEASURED AND CALCULATED HOLDOWN FORCES - TEST SPECIMEN PD-4, RUN NO. 1

TEST RUN	PEAK COMMAND DISPL. OF CYCLES INCHES	PEAK LOAD POUNDS	PEAK HOLDOWN FORCE - MEASURED LEFT POUNDS	RIGHT POUNDS	CALCULATED HOLDOWN FORCE - BASED ON PEAK LOAD POUNDS
A-1	±1/8	500	293	234	329
A-2	±1/4	875	586	527	794
A-3	±3/8	1050	996	879	1012
A-4	±1/2	1125	1259	1054	1105

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TABLE VII: SUMMARY OF MEASURED AND CALCULATED HOLDOWN FORCES - TEST SPECIMEN PD-4, RUN NO. 2

TEST RUN	PEAK COMMAND DISPL. OF CYCLES INCHES	PEAK LOAD POUNDS	PEAK HOLDOWN FORCE - MEASURED		CALCULATED HOLDOWN FORCE - BASED ON PEAK LOAD POUNDS
			LEFT POUNDS	RIGHT POUNDS	
A-3	±3/8	440	702	790	255
A-4	±1/2	640	1025	1025	503
A-5	±3/4	950	1581	1581	888
A-6	±1	1475	4099	3500	1539
A-7	±1-1/4	1550	3160	3160	1632
A-8	±1-1/2	1800	3340	3500	1943
A-9	±2	2150	3221	3750	2377
A-10	±2-1/2	2350	2579	3925	2625
A-11	±2.8	2380	2110	3750	2663

6. SOURCES OF ERROR

One possible source of error that became known during one of these partition tests is the stiffness of the reaction frame and its connections @ base @ actuator end. During the test of Specimen PD-4, Run No. 1, in test no. A-5 (peak command displacement ±3/4 inch), the rear left column of the reaction frame was observed to be undergoing large displacements as sequence of block cyclic displacements were applied. This problem was identified and immediately corrected before the test of Specimen PD-4, Run No. 2.

Manual reduction of recorded dynamic test data is a possible source of error. Other sources of error are the limitation and characteristics of the MTS electro-hydraulic closed-loop system, as shown by the graph between the peak command displacements and peak grid displacement (measured) at varying amplitudes and frequencies of block cyclic tests (Appendix C, Figures 3-4).

The effect of friction between the wheels and the bottom flanges of steel tie-beams of the reaction frame, under the weight of the loading grid is also a possible source of error. Lastly human error inherent in observation and interpretation of test data of specimen performance is also a source of error.

7. DISCUSSION OF TEST RESULTS AND CONCLUSIONS

I. Results of dynamic tests to-date have shown that the behavior and performance of building partitions is influenced by motion parameters, e.g., magnitude and frequency of block cyclic displacement levels, and number of cycles in each test sequence.

II. The relationships between partition damage level and peak measured horizontal displacement @ top of partition, for all test specimens is presented graphically in Appendix C (Figure 7).

The damage levels shown may be further condensed into three classifications:

Low/Minor Damage - Level I-III

Moderate Damage - Level III-V

Severe Damage - Level V-VII

Detailed descriptions of damage levels are documented in Table IV. In all test specimens the damage is initiated @ ends of the partition and edges of facing panels, e.g., crumbling of gypboard around nail-heads. Eventually through working of the nails under cyclic motions, the facing panels start slipping relative to the stud framing and become loose, at which point popping of nail-heads is clearly visible. Severe damage consists of failure of taped joints in gypboard and further crumbling of gypboard around nail-heads. In the partition with 3/8 inch plywood on one face (Specimen PD-4), damage on the plywood face essentially consisted of slippage @ edges of plywood panels, damage of plywood @ nail-heads and eventual crushing of plywood @ bottom left corner of panel. In all partition specimens the shot-ins connecting the bottom sill-plate to precast concrete base, performed really well without damage. Under large cyclic displacements, severe partition damage also consisted of tearing of edge studs and the ends of the bottom sill-plate.

In could be reasoned that a good part of this damage is repairable damage. Studies need to be carried out to investigate effectiveness of techniques of repairing earthquake damage to these building components.

III. Comparison of the test results for Specimen PD3-V, Run No. 1, without any holdowns with all other test specimens (PD3-V, Run No. 2, PD3-H, PD-4, Run No. 1/Run No. 2) which had holdowns clearly showed that without holdowns failure takes place very early in the initial few cycles of motion @ lower ends of the partition as documented in Table IV.

It can be clearly concluded that without holdowns or equivalent restraints, partition components cannot have dynamic stability under the severe motions that can be expected during earthquakes. Therefore earthquake resistance of wood-framed building partitions can be relied upon, provided dynamic stability is provided for, through the use of holdowns or equivalent devices.

IV. A study of the graph between peak loads and peak grid displacements for all partition specimens (Appendix C, Fig. 2) shows that the peak load-level reached for every test is definitely related to the frequency of the block cyclic displacements applied. Load-levels for test runs @ 0.5 Hz are significantly higher than those for test runs @ 0.7 Hz and 1.0 Hz. The maximum peak load for specimens with gypboard applied on both sides (PD3-V, Run No. 2 and PD3-H) does not seem to be affected by orientation (vertical or horizontal application) of the gypboard.

A comparison of the cyclic load-displacement curves for each test run presented in Appendix D (Figures 1-19), shows that the energy absorption capacities of the partition specimens will be influenced by the orientation of facing panels and layout of fasteners.

V. A study of the graph between rigidity and the peak-command-displacement (Appendix C, Fig. 6) shows that in general, the rigidity keeps on decreasing with increasing peak amplitudes of blocks of cyclic displacements. Furthermore, the partition rigidities seem to be lower at frequencies of block cyclic displacements of 0.7 Hz and 1.0 Hz as compared to those for block cyclic tests @ frequency of 0.5 Hz.

VI. A review of the dynamic test results of peak lateral loads, peak lateral displacements and peak lateral shears shows the following (Ref. Table V):

- The maximum loads and shears were reached at block cyclic displacements with frequency of 0.5 Hz.
- Except for Specimen PD3-V, Run No. 1, without any holdowns, the maximum peak lateral shears reached for all other specimens were greater than those allowed by the Uniform Building Code.

- Among all test specimens, the highest peak lateral load was reached for Specimen PD-4 (with 3/8 inch plywood on one side and 1/2 inch gypboard on opposite side and with holdowns). Actually, peak loads of much higher magnitudes were expected for this test specimen (PD-4, Run No. 2) which was tested after the sudden relaxation of the reaction frame encountered in the previous test (PD-4, Run No. 1) was corrected. The reason for this was that because of operator error, this partition test started with a sequence of large peak command displacements (Test No. A-6, ±1 inch @ 0.5 Hz), which immediately induced damage in the specimen with resulting loss of rigidity. This action may also explain the reason for the nature of cyclic load displacement curves for this partition specimen (Appendix D, Figures 13-19).

VII. It can be stated that for the first time the dynamic behavior of holdowns typically used in wood-framed buildings has been documented as one useful product of this pilot testing program. 5/8 inch diameter holdown bolts anchored to the precast concrete base with drilled inserts typical of standard construction practice (18), (21) were subjected to cyclic loads with peak values up to approximately 4100 pounds @ frequencies of 0.5 Hz.

The peak holdown forces (left and right) measured successfully during test of Specimen No. PD-4 (Run No. 2) as well as the corresponding peak loads-reached during each test sequence are presented in Table VII. The calculated holdown forces, determined from the peak loads-reached, dimensions of the partition, and laws of structural equilibrium are found to be much lower than the measured peak holdown forces and this needs further investigation. This peak response test data is plotted in Figure 5 (Appendix C) in the form of a graph between peak-load and peak-holdown force for this dynamic test.

VIII. A review of the time-history plots of measured holdown forces (Specimen PD-4, Run No. 1/Run No. 2), as presented in Figures 34-45 (Appendix B) shows that after undergoing a certain number of blocks of cyclic motions, the holdown assembly functions in tension only, with the nut connecting the holdown bracket and holdown bolt, eventually becoming loose, so that it can be turned very easily by hand. This behavior was observed in all specimens with holdowns.

In conclusion it can be stated that the earthquake resistance of wood-framed building partitions can be relied-upon in the seismic analysis and design of wood-framed building systems, provided sound practices of detailing (e.g., holdowns, fastener layout etc.) and construction are implemented.

In conclusion, studies should be carried out to investigate and compare the factors of safety for walls/partitions obtained through dynamic racking tests with those obtained through static racking tests. It should be noted that allowable lateral shears found in most regulatory codes are based on static racking tests only.

8. SUGGESTIONS FOR FURTHER RESEARCH

Unique dynamic pilot tests of full-height building partitions have been carried out, thresholds of damage have been determined and effectiveness of provisions of the Uniform Building Code has been investigated.

It is suggested that further work be continued to:

1. Investigate the dynamic behavior and earthquake resistance of other important configurations of wood-framed walls/partitions.
    a. Height to width ratios as per provisions of the regulatory codes.
    b. Improved methods of detailing (e.g., location of edge studs, nailing and other methods of fastening).
    c. Facing materials, e.g., stucco, with/without plywood on one side and gypboard on the opposite side.
    d. Holdowns with double-nut arrangement @ holdown bolts @ each end.
2. Investigate the modelling assumptions used to calculate holdown forces in walls/partitions based on the overturning actions of design earthquake forces.
3. Develop guidelines for the planning, analytical modelling, design, detailing and installation of building partition and suspended ceiling systems in seismic areas, incorporating results of recent research in this field.

4. In conclusion it is suggested that an ongoing data-base of static and dynamic test results (for building partition and suspended ceiling systems), as they become available, be developed in such a form so as to be of practical value to the building design professionals, building officials, research workers and others interested in mitigation of earthquake hazards in buildings.

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APPENDIX A

DRAWINGS OF TEST SET-UP AND BUILDING PARTITION TEST SPECIMENS

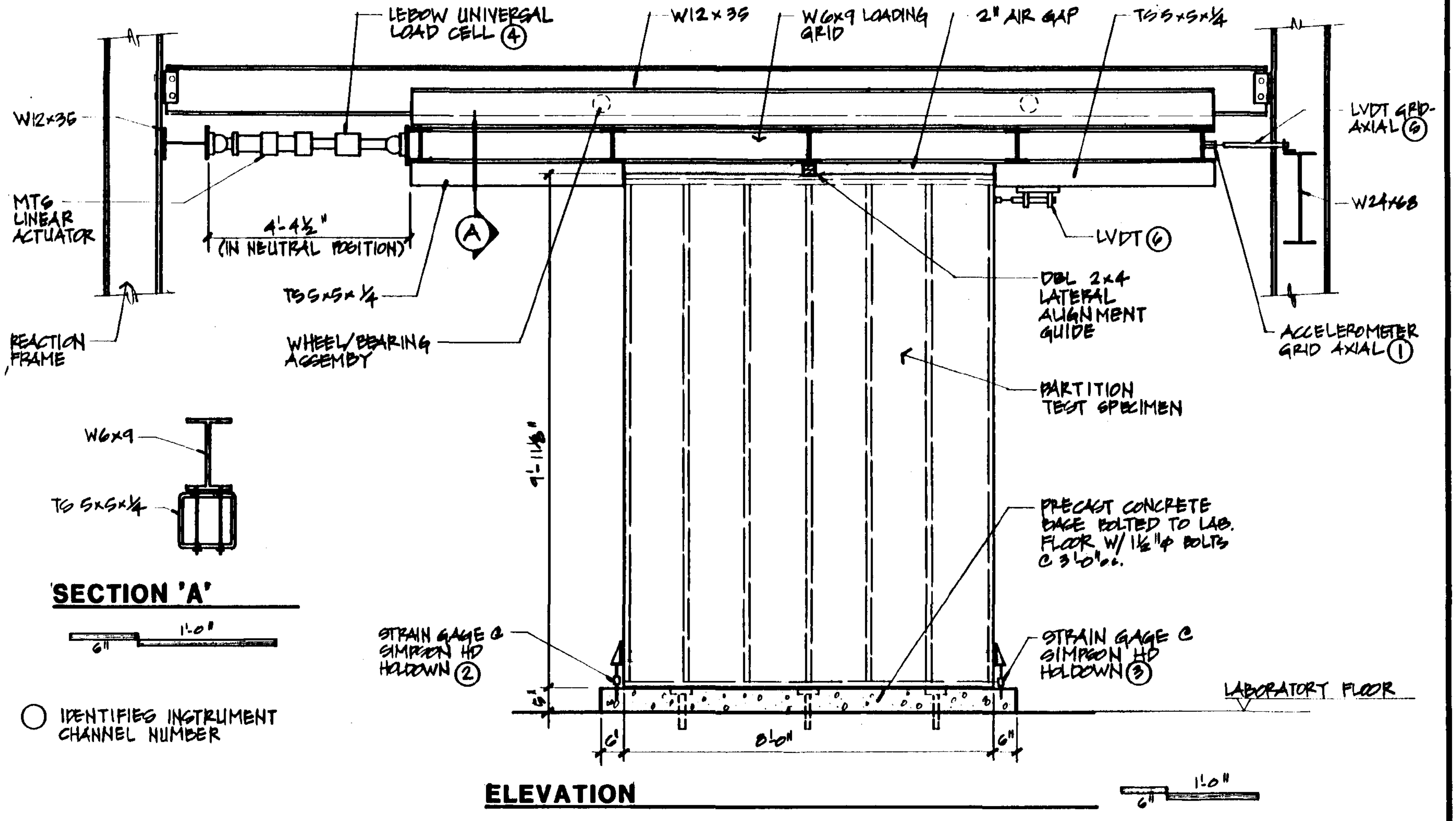

FIGURE	NSF SPONSORED RESEARCH PROJECT	TEST SET-UP	DRAWN BY: T.C.	DATE: 3/85
1	DYNAMIC TESTING OF BUILDING PARTITIONS	MEASUREMENT TRANSDUCERS– LOCATION AND ORIENTATION	CHECKED BY: S.R.	DATE: 7/85
			REVISED BY: C.I.L.	DATE: 7/85
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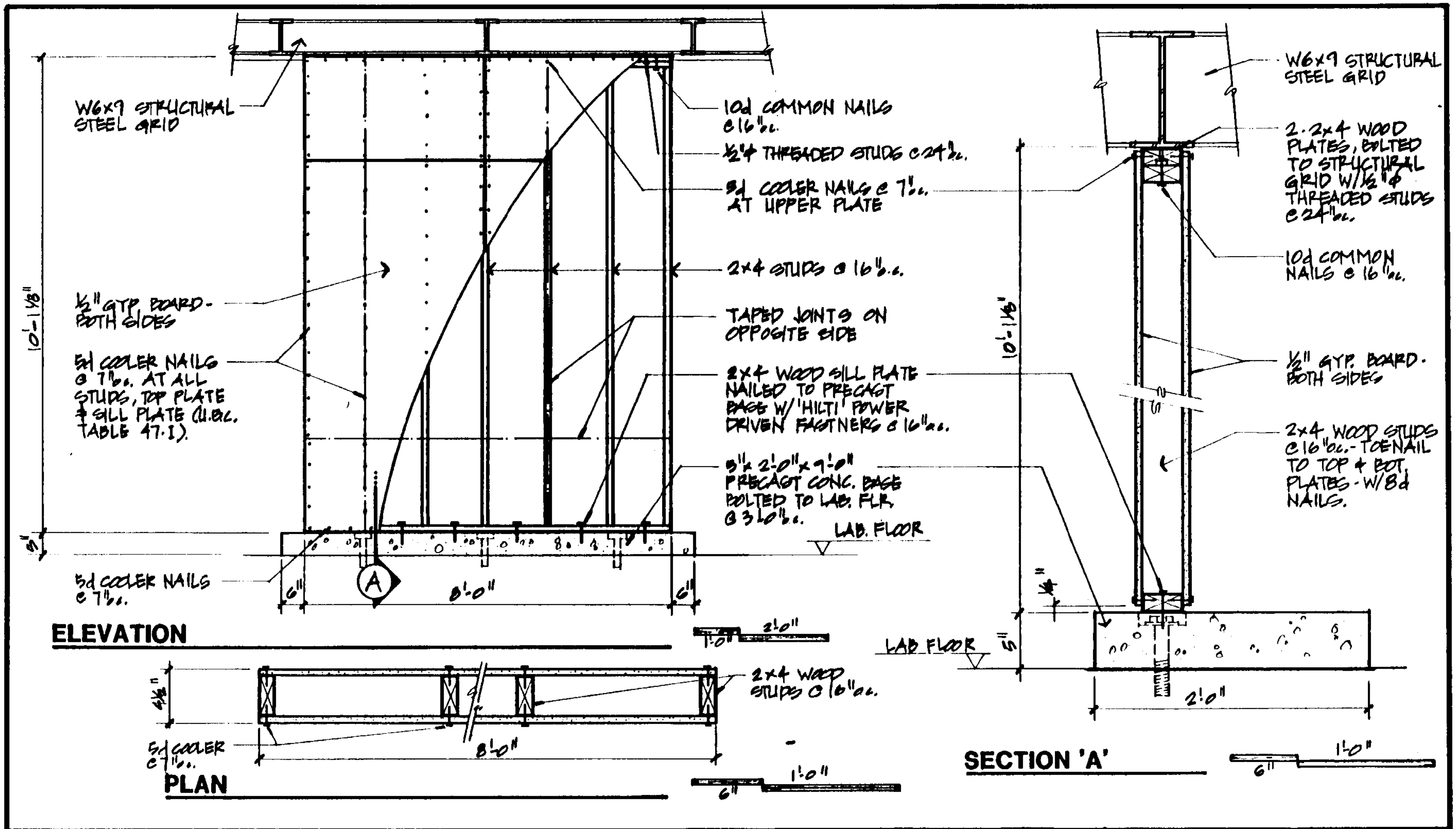

FIGURE 2

NSF SPONSORED RESEARCH PROJECT

DYNAMIC TESTING OF BUILDING PARTITIONS

PARTITION TEST SPECIMEN NO. PD-3V, RUN NO. 1

2 x 4 WOOD STUDS AT 16"o.c.-1/2" GYP. BOARD EACH SIDE, FACING PANELS APPLIED VERTICALLY

DRAWN BY: T.C. DATE: 2/85
CHECKED BY: S.R. DATE: 7/85
REVISED BY: C.I.L. DATE: 7/85

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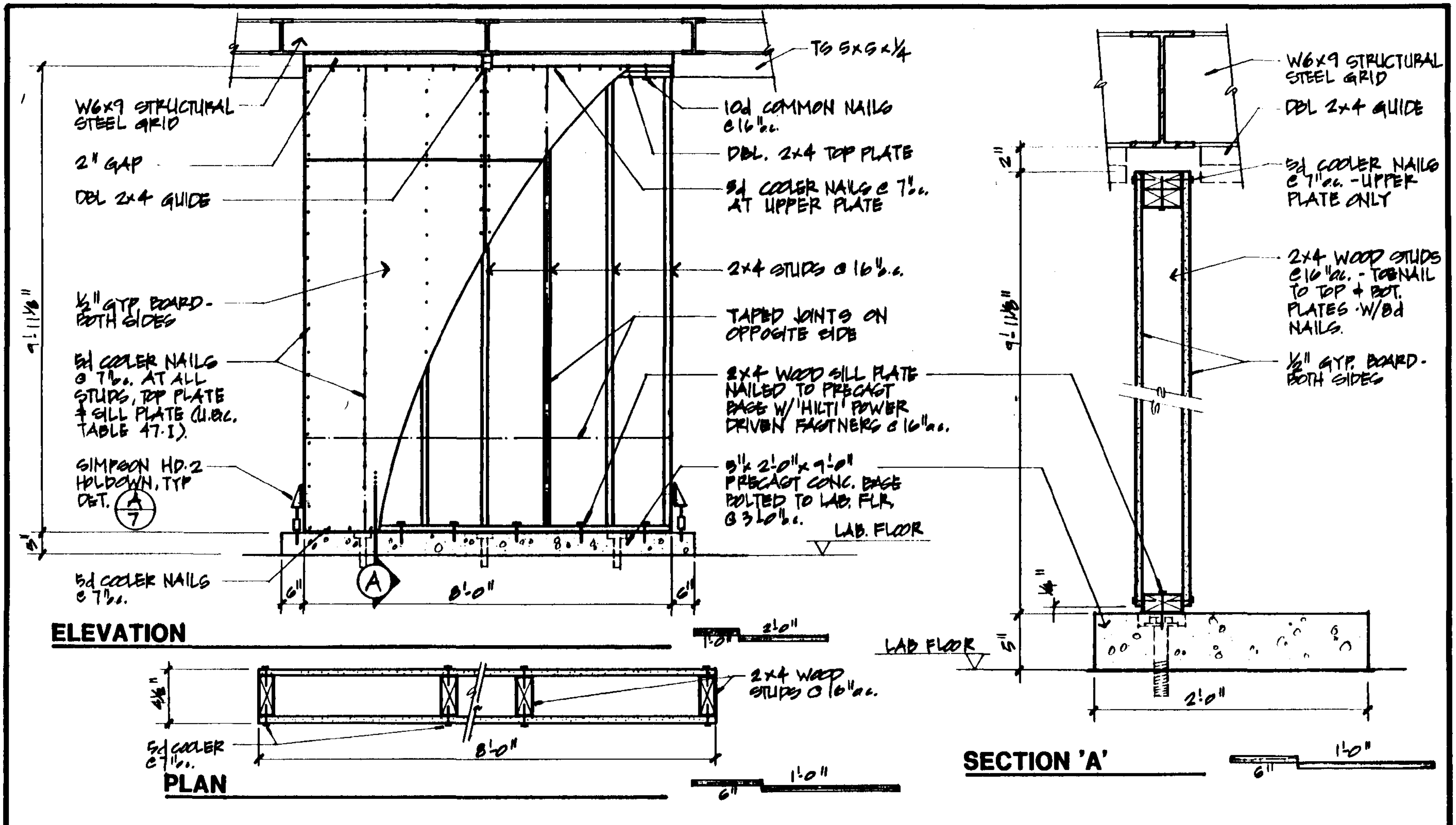

FIGURE
3

NSF SPONSORED RESEARCH PROJECT
DYNAMIC TESTING OF BUILDING PARTITIONS

PARTITION TEST SPECIMEN NO. PD-3V, RUN NO. 2
2 x 4 WOOD STUDS AT 16"o.c.-1/2" GYP. BOARD EACH SIDE, FACING PANELS APPLIED VERTICALLY-SIMPSON HD-2 HOLDOWNS AT EACH END

DRAWN BY: T.C. **DATE:** 2/85
CHECKED BY: G.R. **DATE:** 7/85
REVISED BY: C.I.L. **DATE:** 7/85
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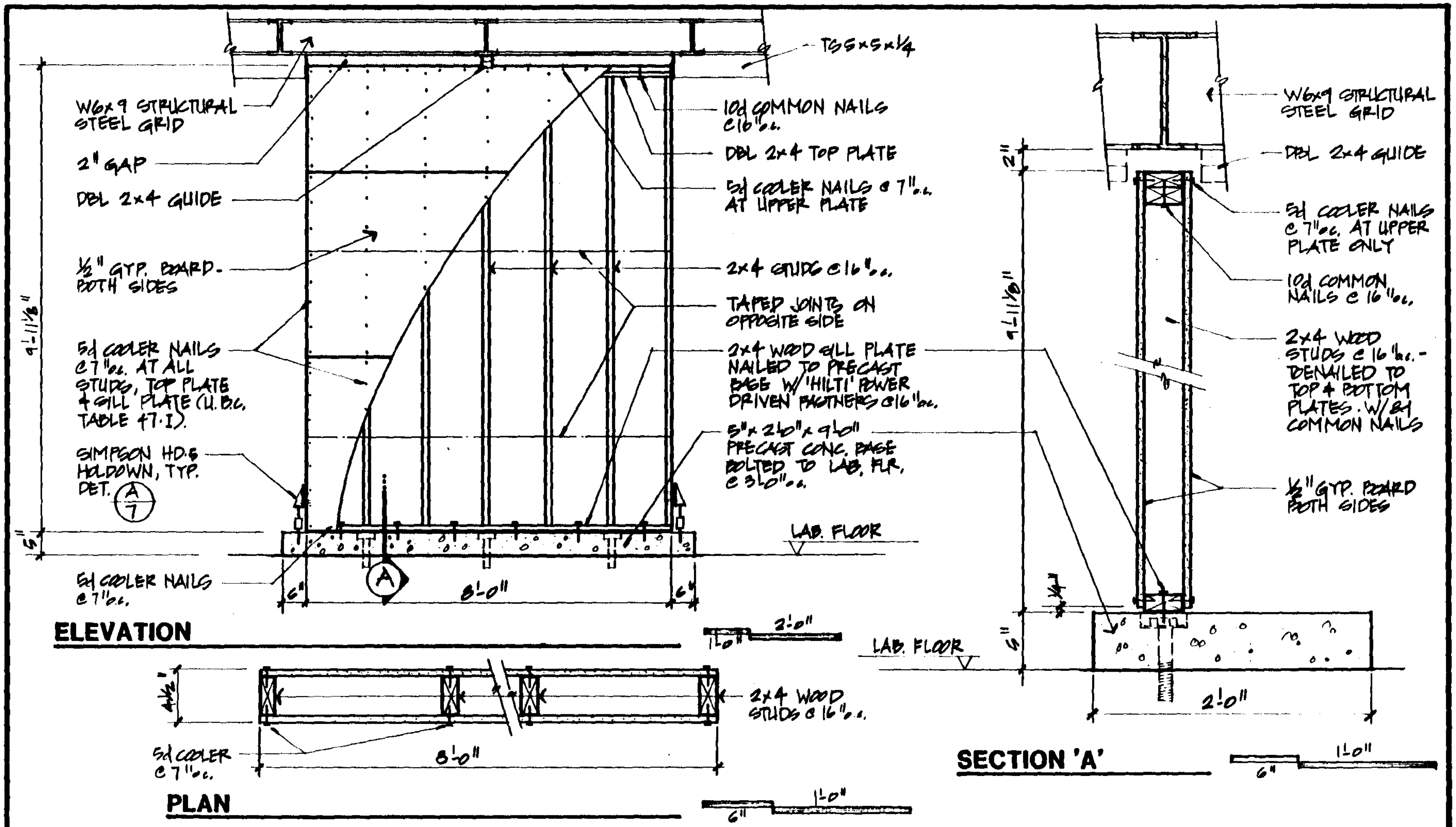

FIGURE
4

NSF SPONSORED RESEARCH PROJECT

DYNAMIC TESTING OF BUILDING PARTITIONS

PARTITION TEST SPECIMEN NO. PD-3H

2 x 4 WOOD STUDS AT 16"o.c.-1/2" GYP. BOARD EACH SIDE, FACING PANELS APPLIED HORIZONTALLY-SIMPSON HD-5 HOLDOWNS AT EACH END

DRAWN BY: T.C. DATE: 3/89
CHECKED BY: S.R. DATE: 7/85
REVISED BY: C.I.L. DATE: 7/85

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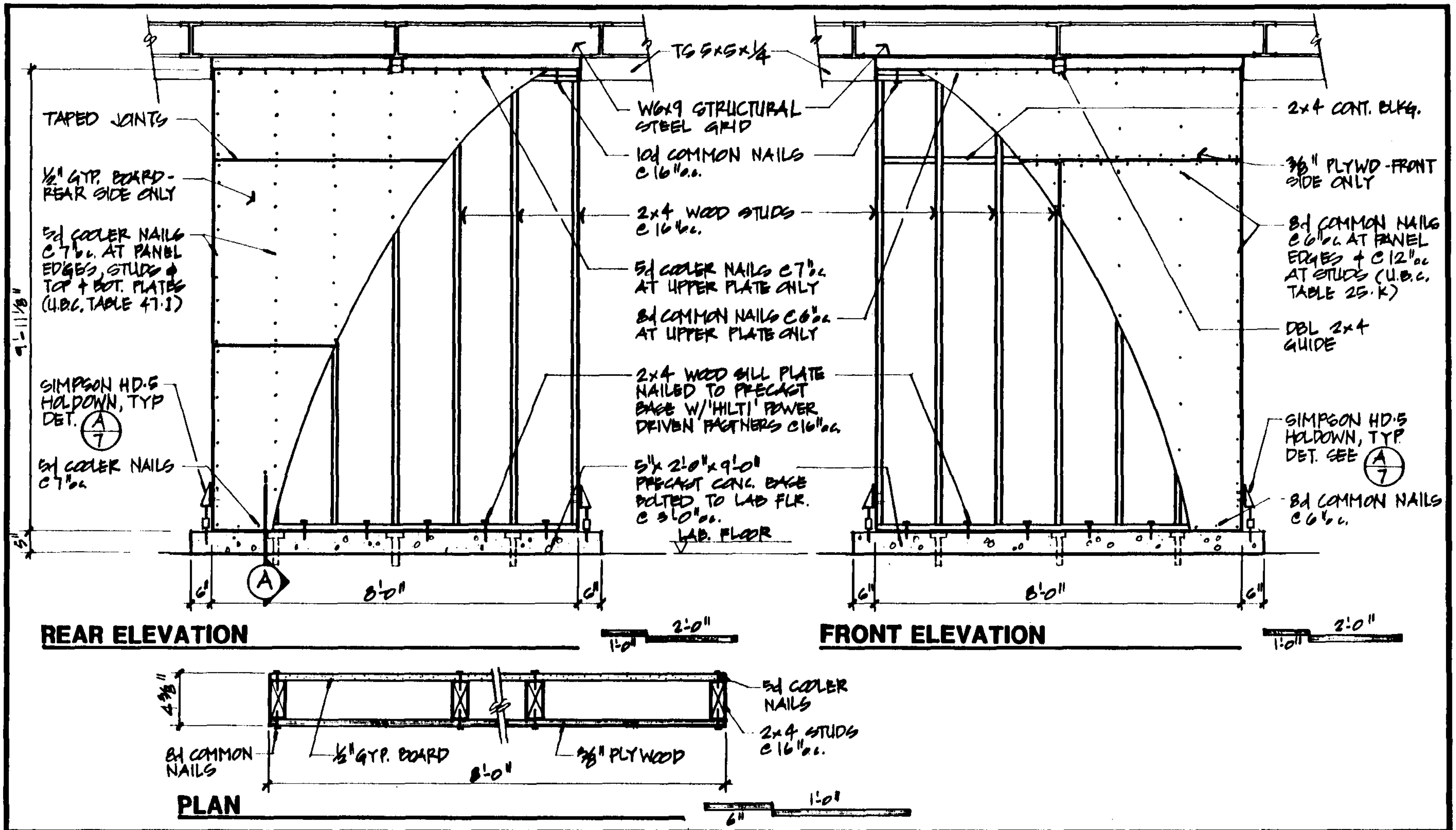
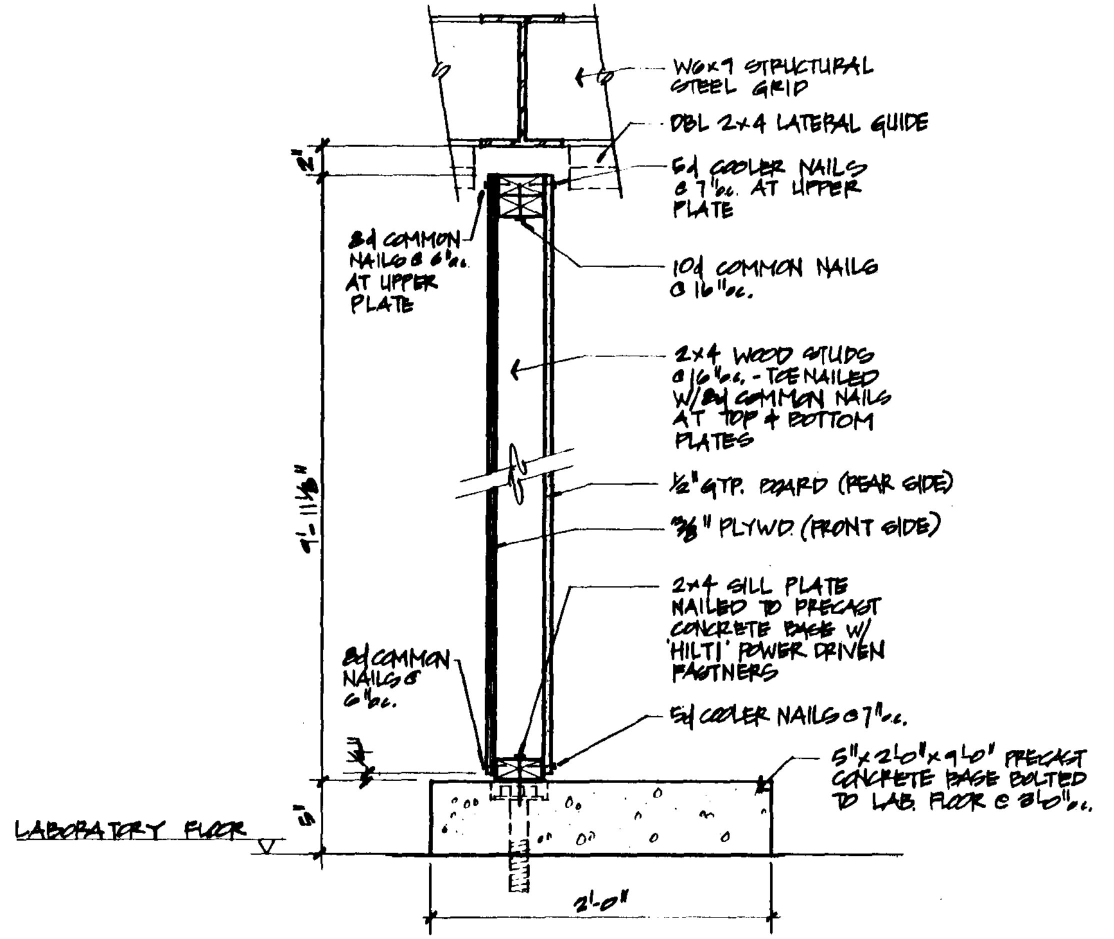
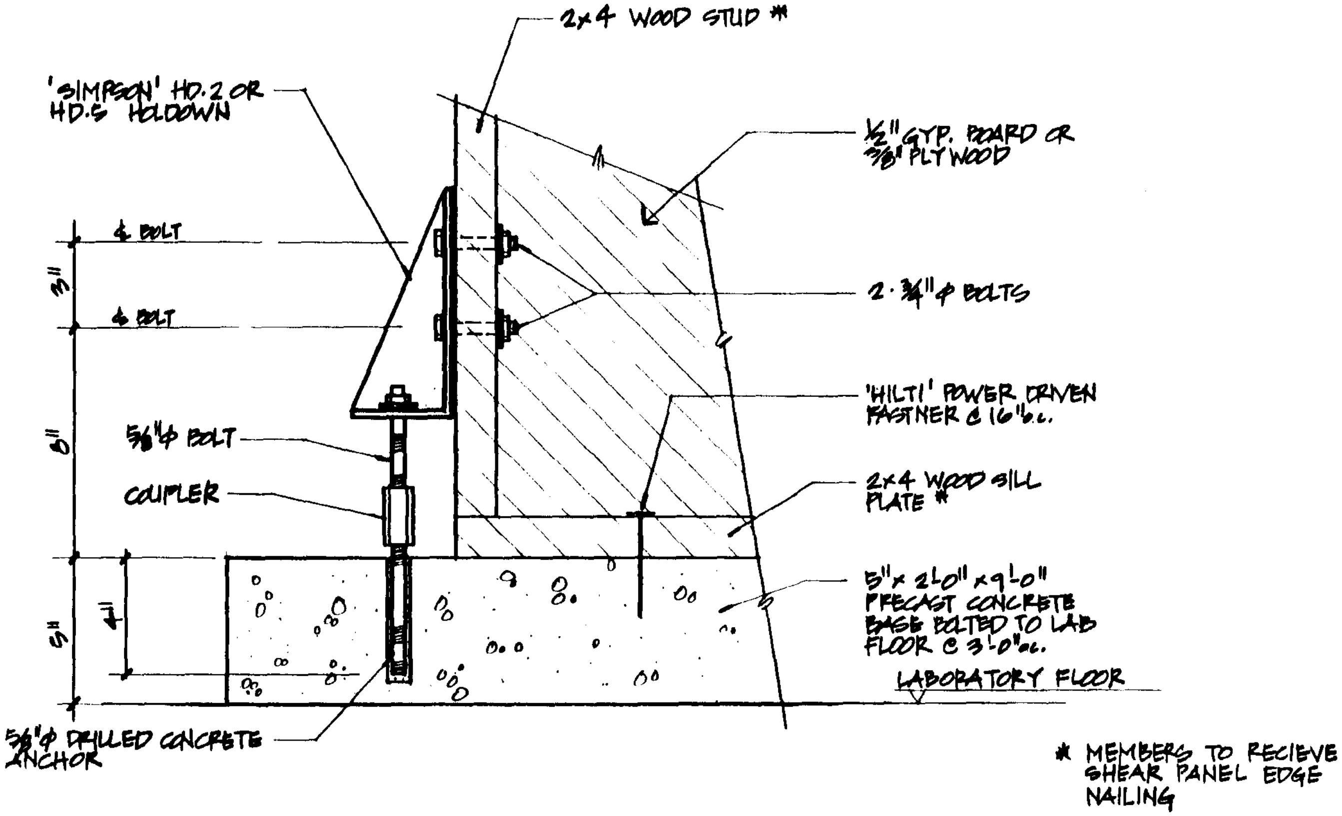


FIGURE	NSF SPONSORED RESEARCH PROJECT	PARTITION TEST SPECIMEN NO. PD-4 RUN NO. 1, 2	DRAWN BY: T.C.	DATE: 2/86
5	DYNAMIC TESTING OF BUILDING PARTITIONS	2 x 4 WOOD STUDS AT 16"o.c.-1/2" GYP. BOARD; ONE SIDE APPLIED HORIZONTALLY, 3/8" PLYWOOD OPPOSITE SIDE APPLIED VERTICALLY-HD-5 HOLDOWNS	CHECKED BY: G.R.	DATE: 1/85
			REVISED BY: C.I.L.	DATE: 1/85
			CALIFORNIA POLYTECHNIC STATE UNIVERSITY SAN LUIS OBISPO,CA	



SECTION 'A'

FIGURE 6	**NSF SPONSORED RESEARCH PROJECT** DYNAMIC TESTING OF BUILDING PARTITIONS	PARTITION TEST SPECIMEN NO. PD-4 RUN NO. 1, 2 2 x 4 WOOD STUDS AT 16"o.c.-1/2" GYP. BOARD ONE SIDE APPLIED HORIZONTALLY, 3/8" PLYWOOD OPPOSITE SIDE APPLIED VERTICALLY-HD-5 HOLDOWNS	DRAWN BY: T.C. DATE: 2/85 CHECKED BY: S.R. DATE: 7/85 REVISED BY: C.I.L. DATE: 7/85 CALIFORNIA POLYTECHNIC STATE UNIVERSITY SAN LUIS OBISPO, CA



* MEMBERS TO RECIEVE SHEAR PANEL EDGE NAILING

TYPICAL HOLDOWN DETAIL (A)

6" 1'-0"

FIGURE 7

NSF SPONSORED RESEARCH PROJECT

DYNAMIC TESTING OF BUILDING PARTITIONS

TYPICAL HOLDOWN DETAIL

TEST SPECIMEN: NO. PD-3V RUN NO. 2
NO. PD-3H
NO. PD-4 RUN NO. 1, 2

DRAWN BY: T.C. DATE: 2/85
CHECKED BY: S.R. DATE: 7/85
REVISED BY: C.I.L. DATE: 7/85

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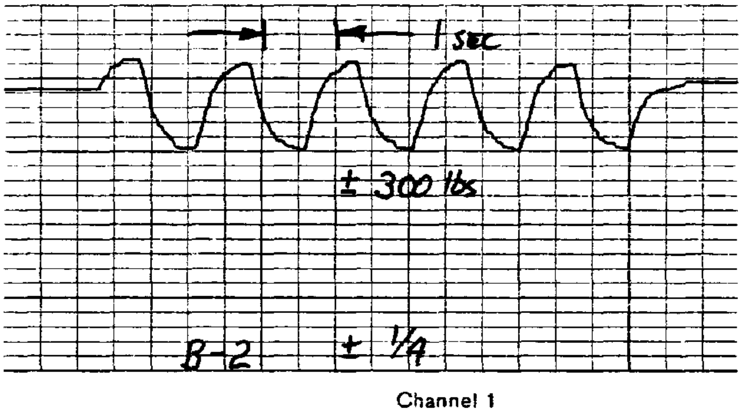
APPENDIX B

DYNAMIC TEST RESPONSE DATA



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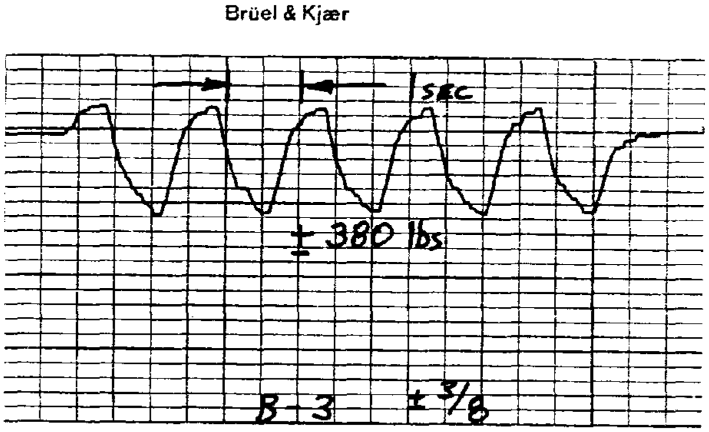
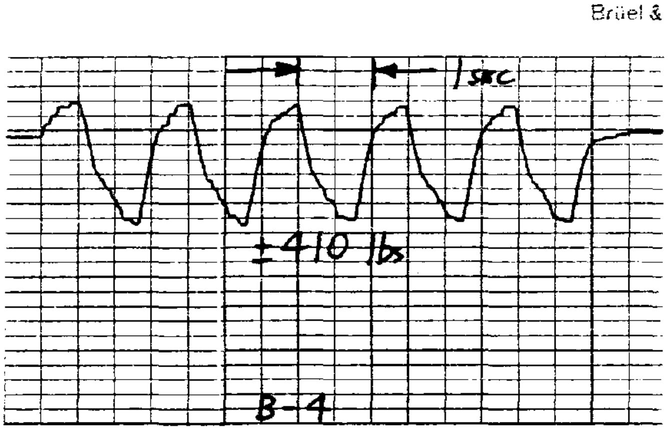
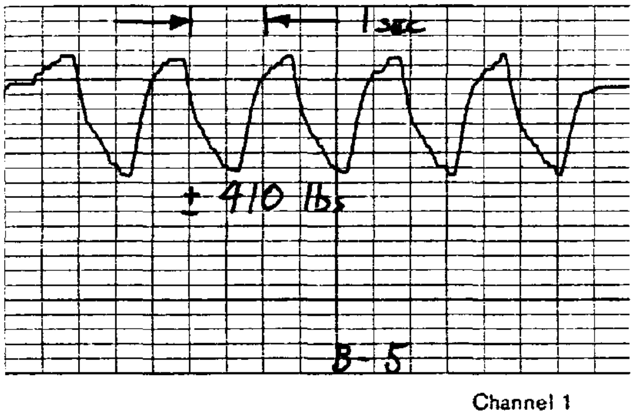


LOAD-CELL

FIGURE 1: TEST SPECIMEN PD3-V RUN NO. 1
BLOCK CYCLIC TEST
TEST NO. B-2 (PEAK COMMAND DISPLACEMENT ±1/4 INCH)
TEST NO. B-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 0.7 HZ.

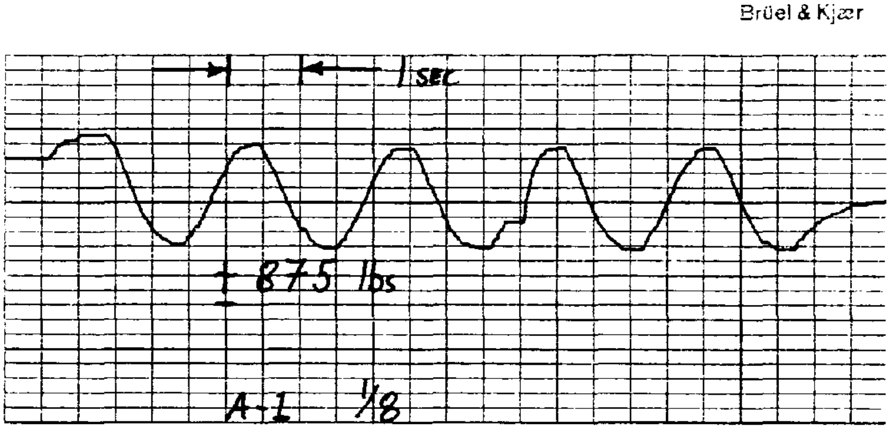


LOAD-CELL

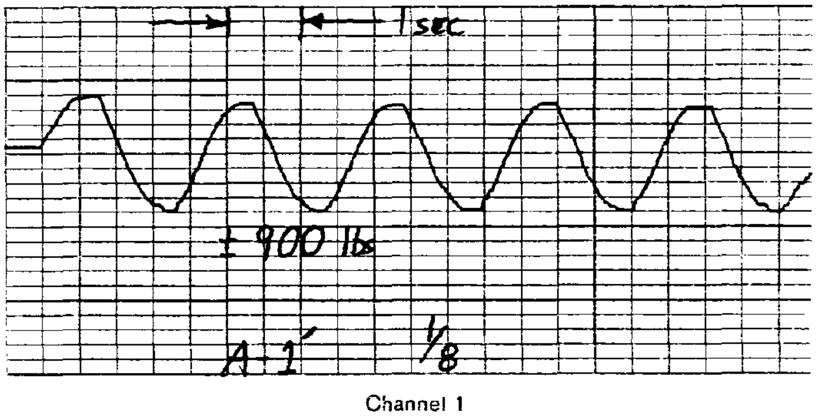


LOAD-CELL

FIGURE 2: TEST SPECIMEN PD3-V RUN NO. 1
BLOCK CYCLIC TEST
TEST NO. B-4 (PEAK COMMAND DISPLACEMENT ±1/2)
TEST NO. B-5 (PEAK COMMAND DISPLACEMENT ±3/4)
FREQUENCY - 0.5 HZ.

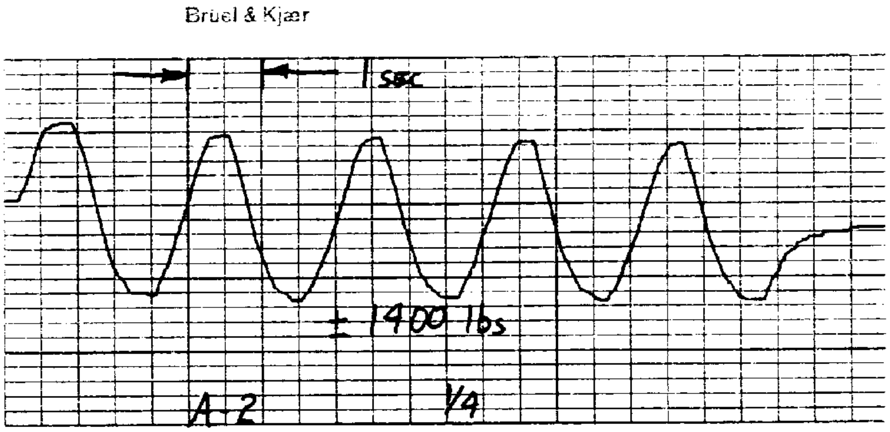


LOAD-CELL



LOAD-CELL

FIGURE 3: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-1, A-1' (PEAK COMMAND DISPLACEMENT ±1/8 INCH)
FREQUENCY = 0.5 HZ.



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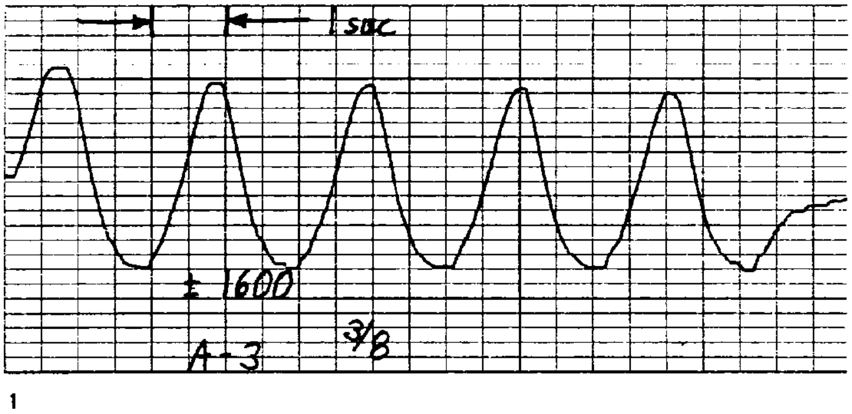
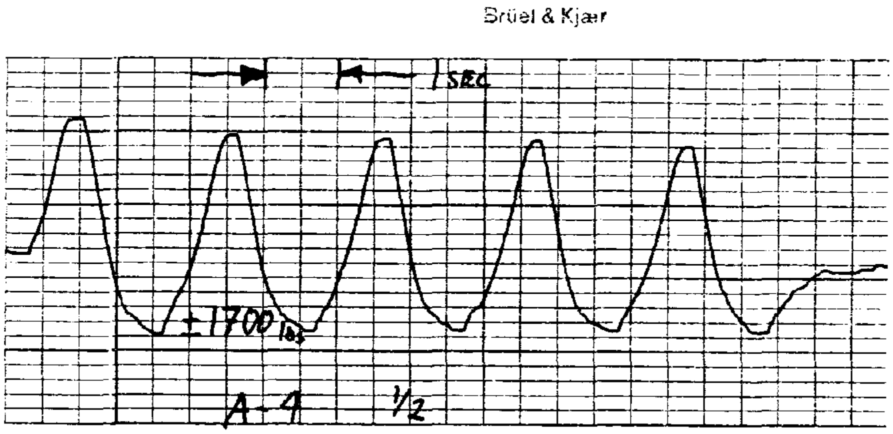


LOAD-CELL

FIGURE 4: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-2 (PEAK COMMAND DISPLACEMENT ±1/4 INCH)
TEST NO. A-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 0.5 HZ.



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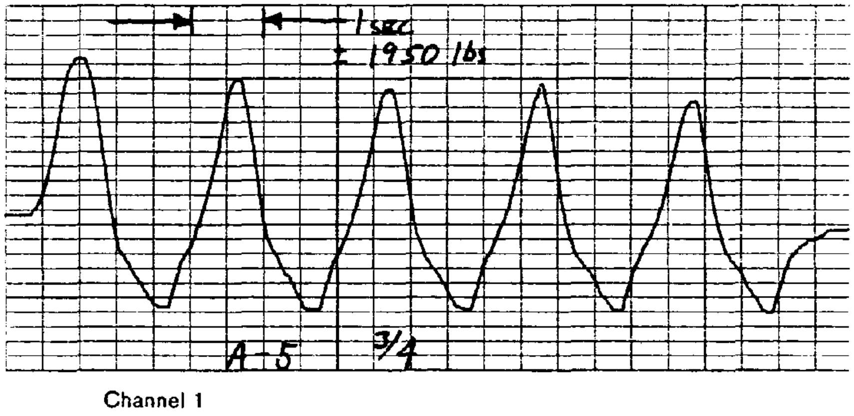
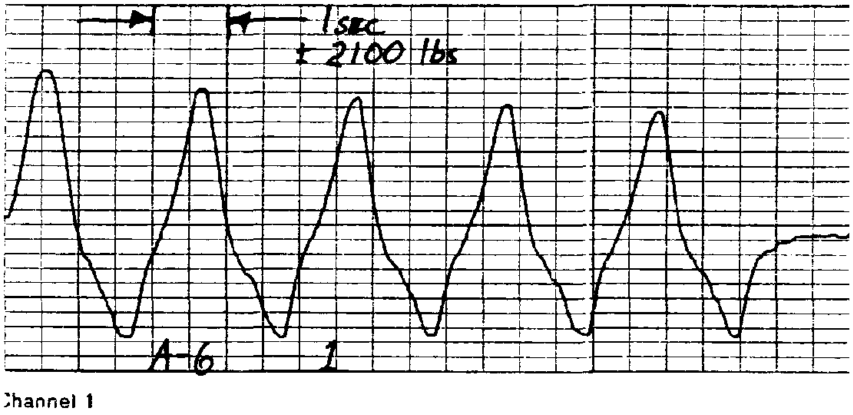


LOAD-CELL

FIGURE 5: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
TEST NO. A-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
FREQUENCY = 0.5 HZ.



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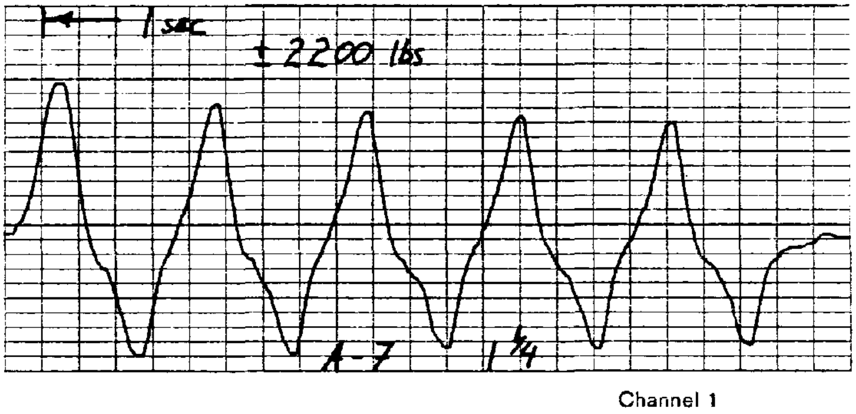

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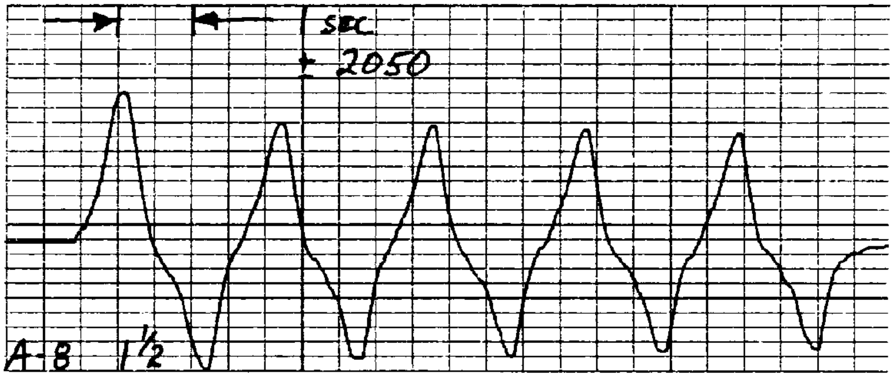
FIGURE 6: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-6 (PEAK COMMAND DISPLACEMENT ±1 INCH)
TEST NO. A-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCH)
FREQUENCY = 0.5 HZ.



Channel 1

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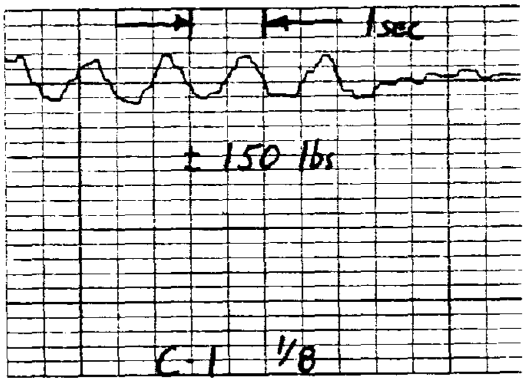
FIGURE 7: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCH)
FREQUENCY = 0.50 HZ.



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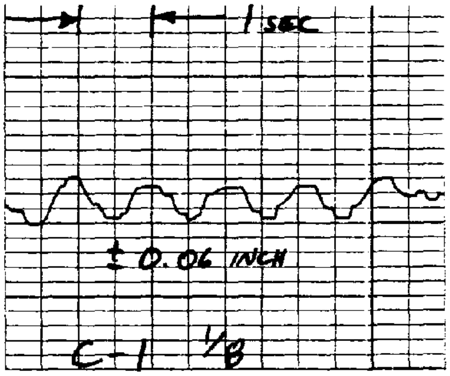
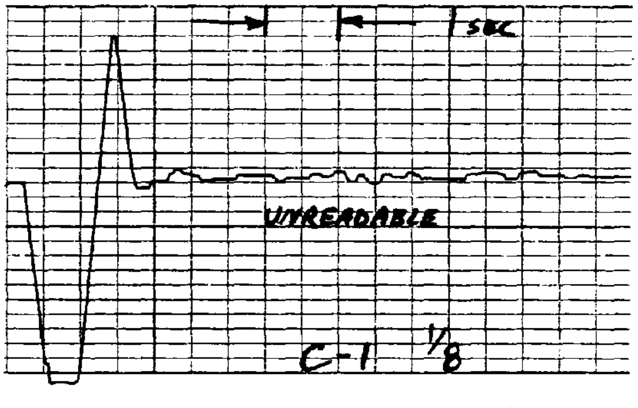
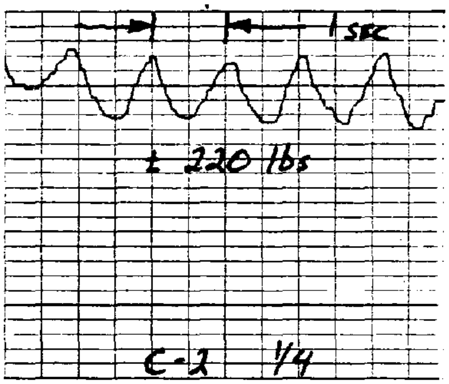


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 8: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-1 (PEAK COMMAND DISPLACEMENT ±1/8 INCH)
FREQUENCY = 1.0 HZ.



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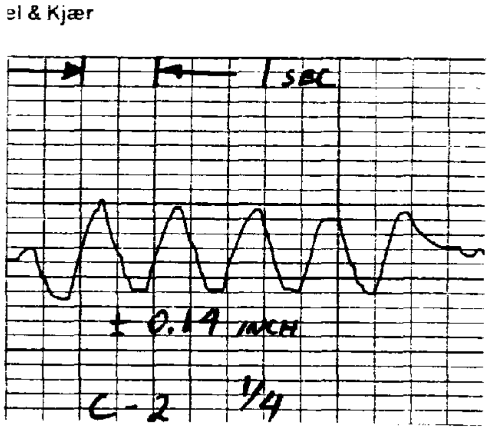
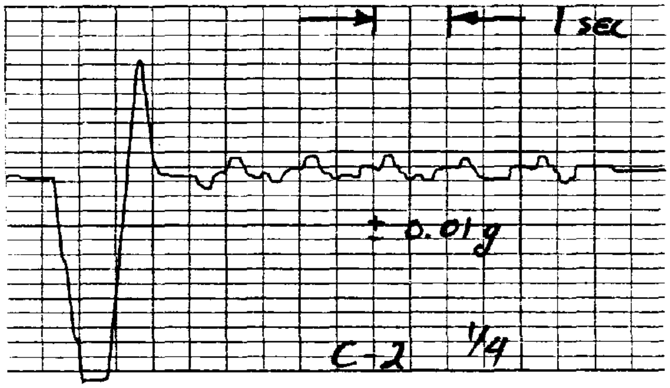
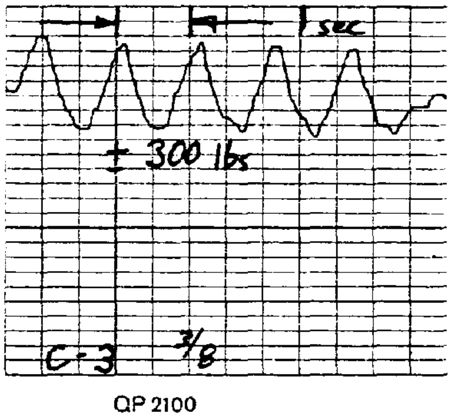


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 9: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-2 (PEAK COMMAND DISPLACEMENT ±1/4 INCH)
FREQUENCY = 1.0 HZ.



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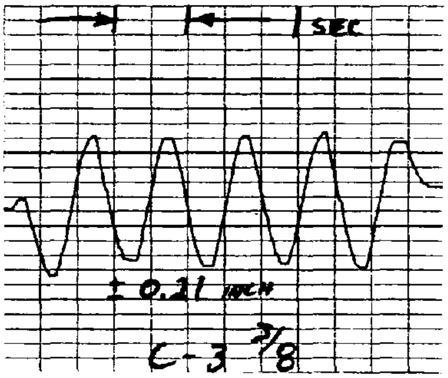
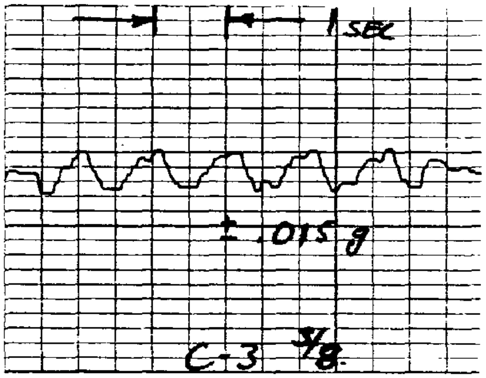
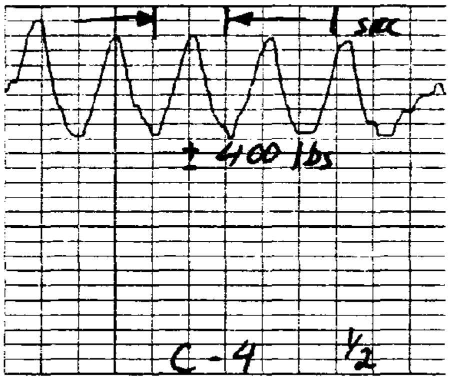


DISPLACEMENT (GRID LVDT)



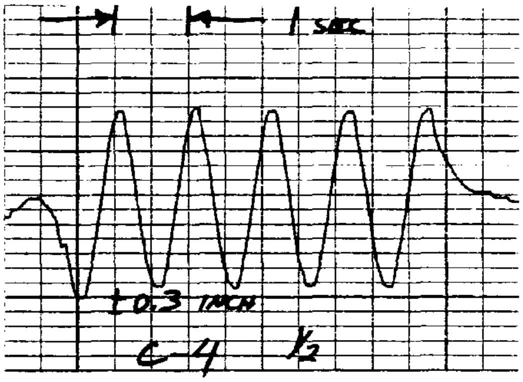
ACCELEROMETER (GRID-AXIAL)

FIGURE 10: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 1.0 HZ.

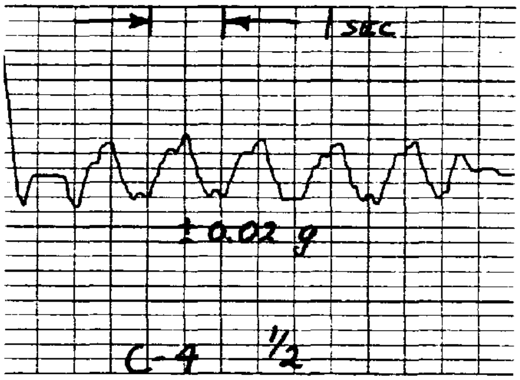


Channel 2

LOAD-CELL

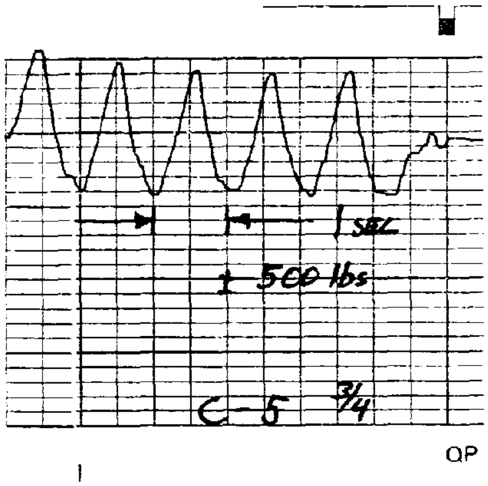


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 11: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
FREQUENCY = 1.0 HZ.



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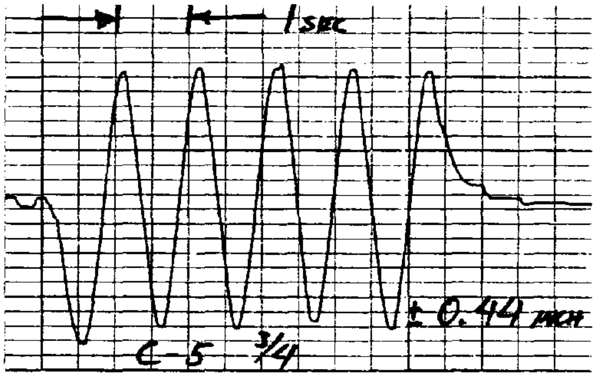

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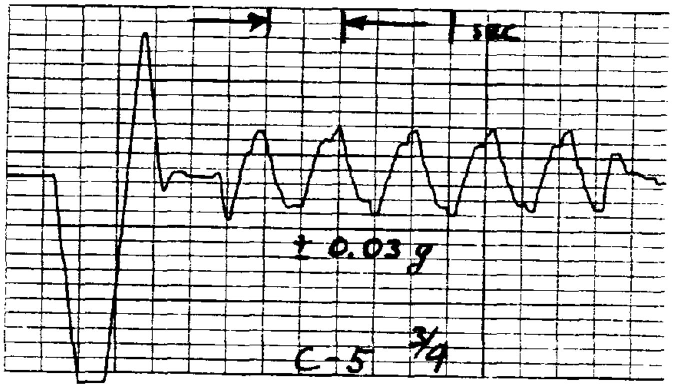
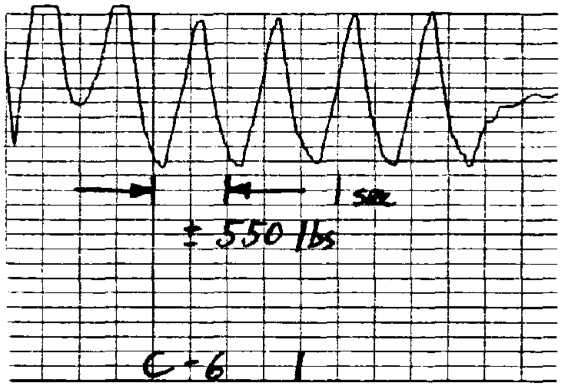


ACCELEROMETER (GRID-AXIAL)

FIGURE 12: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
FREQUENCY = 1.0 HZ.



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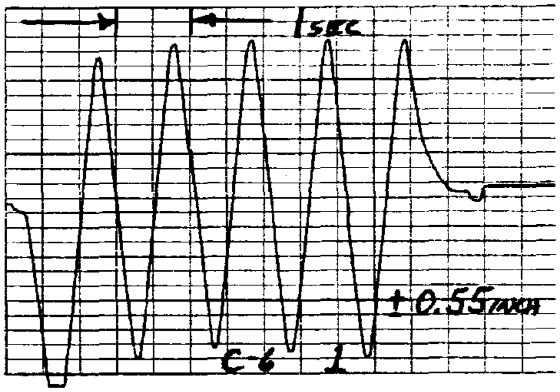

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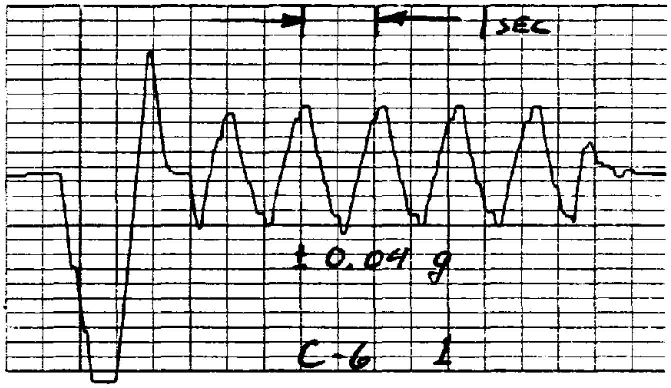
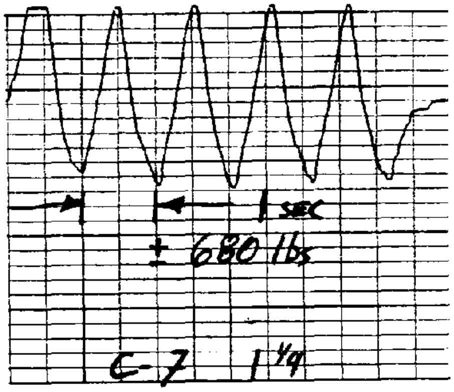


ACCELEROMETER (GRID-AXIAL)

FIGURE 13: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-6 (PEAK COMMAND DISPLACEMENT ±1 INCH)
FREQUENCY = 1.0 HZ.



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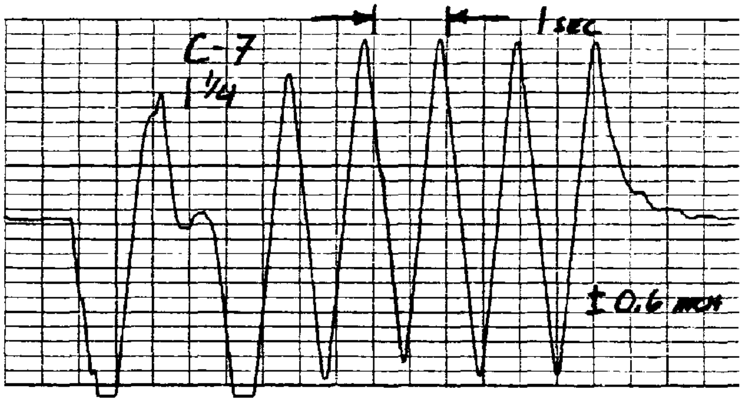

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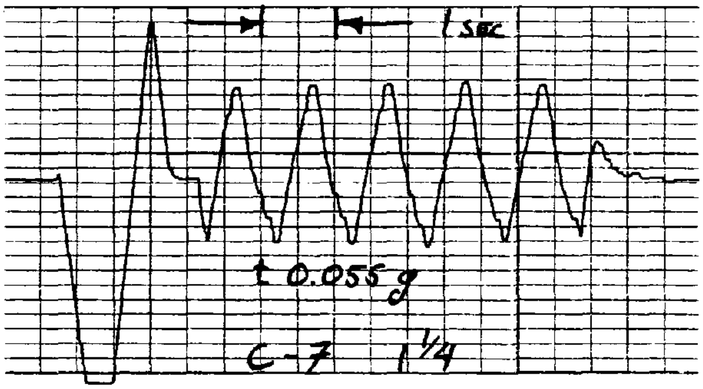
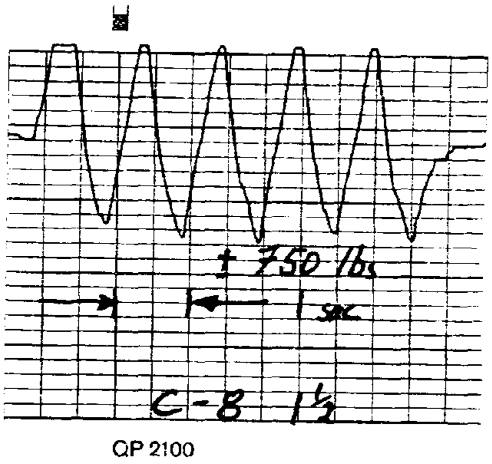


ACCELEROMETER (GRID-AXIAL)

FIGURE 14: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCH)
FREQUENCY = 1.0 HZ.



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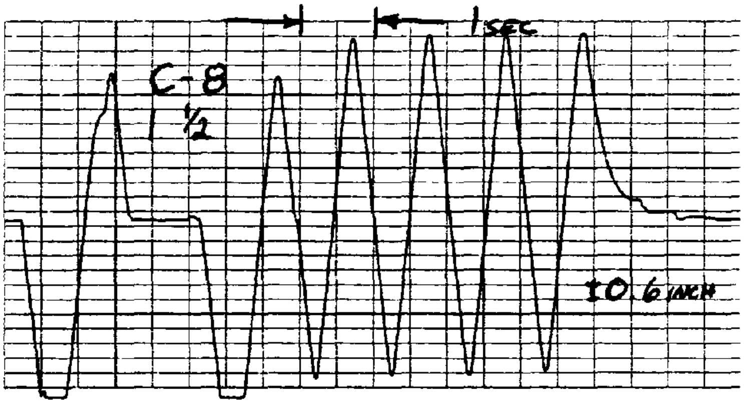
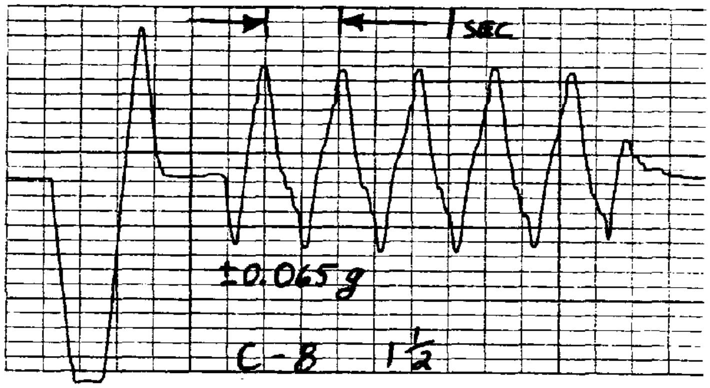
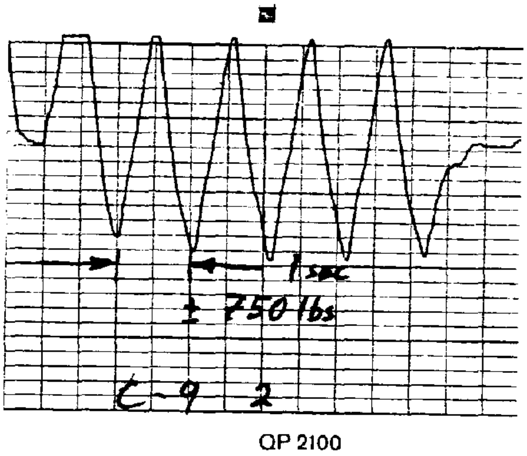


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 15: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCH)
FREQUENCY = 1.0 HZ.



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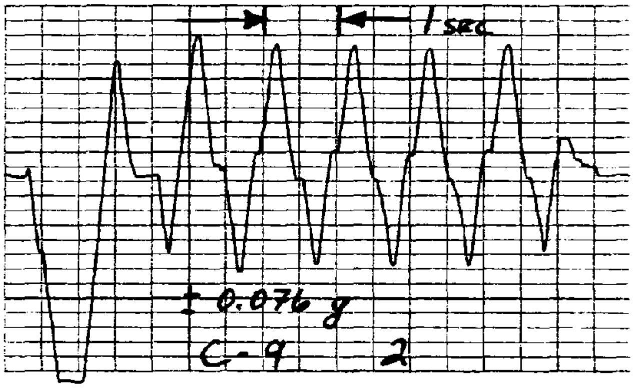
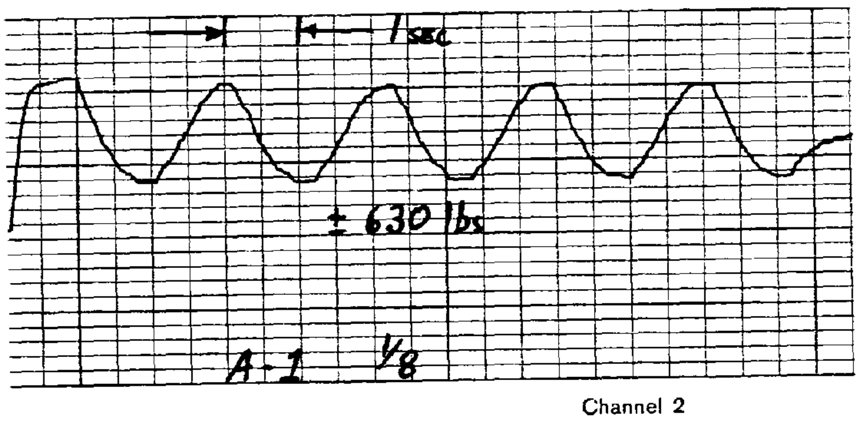
DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 16: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-9 (PEAK COMMAND DISPLACEMENT ±2 INCHES)
FREQUENCY = 1.0 HZ.



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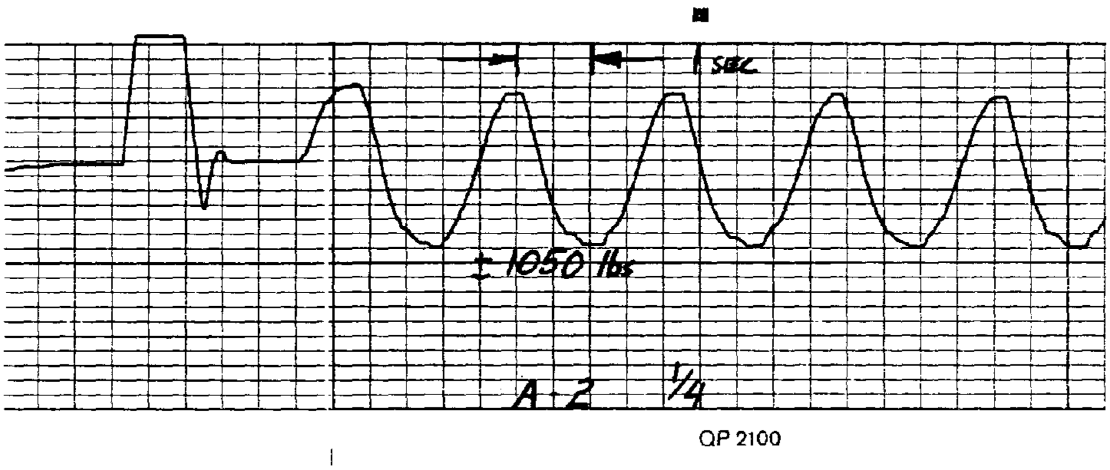
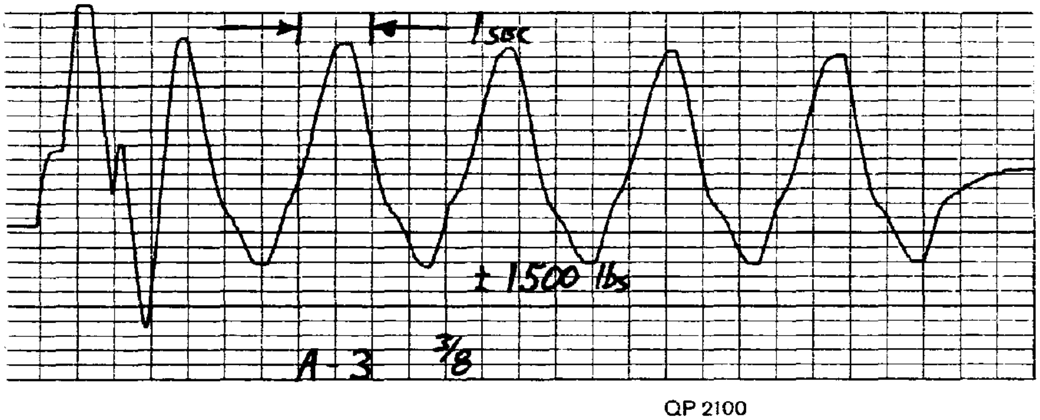


LOAD-CELL

FIGURE 17: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-1 (PEAK COMMAND DISPLACEMENT ±1/8 INCH)
TEST NO. A-2 (PEAK COMMAND DISPLACEMENT ±1/4 INCH)
FREQUENCY = 0.50 HZ.



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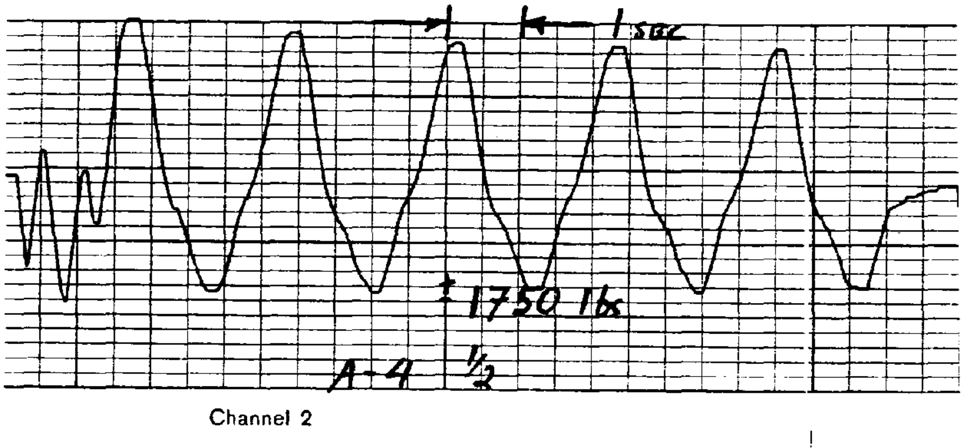
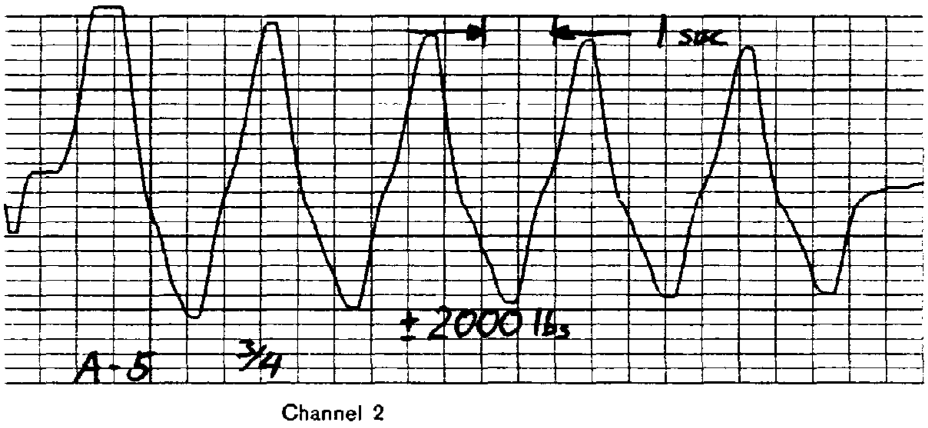


LOAD-CELL

FIGURE 18: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
TEST NO. A-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
FREQUENCY = 0.50 HZ.



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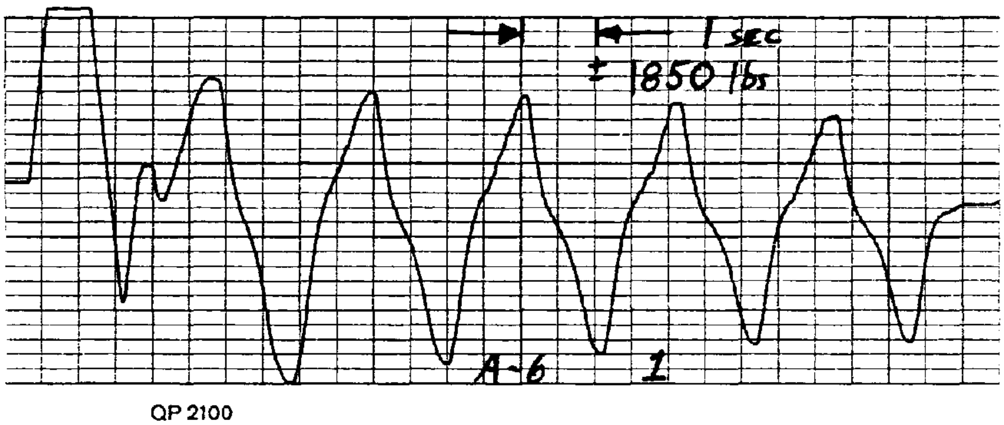
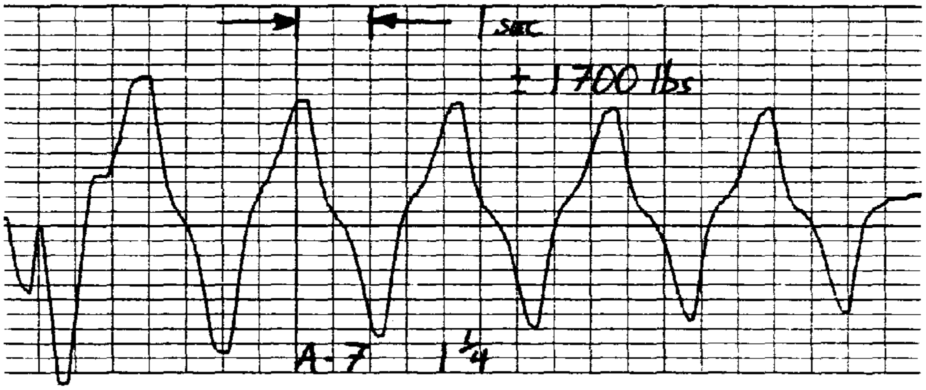


LOAD-CELL

FIGURE 19: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
TEST NO. A-6 (PEAK COMMAND DISPLACEMENT ±1 INCH)
FREQUENCY = 0.50 HZ.



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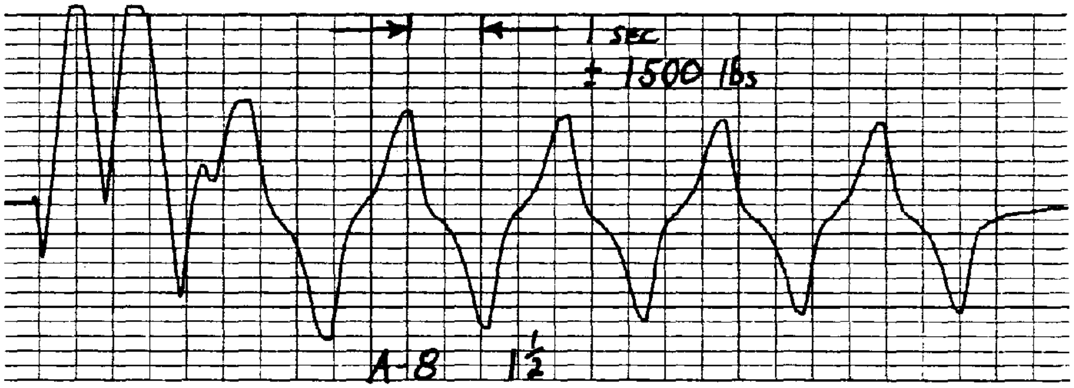

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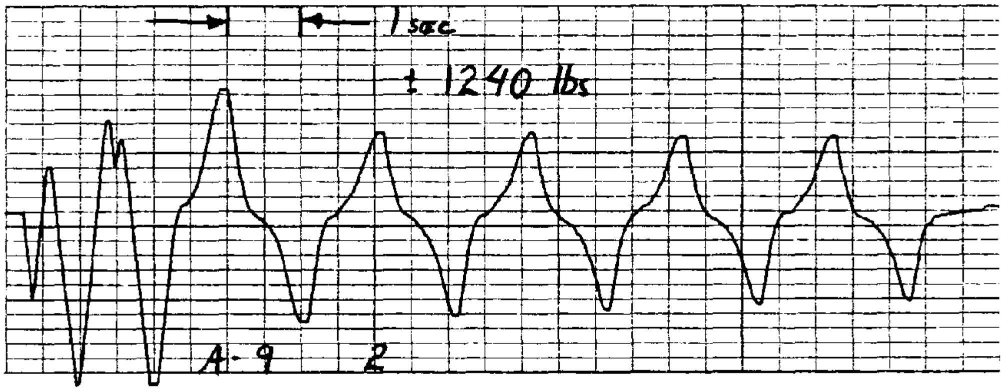
FIGURE 20: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCH)
TEST NO. A-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCH)
FREQUENCY = 0.50 HZ.



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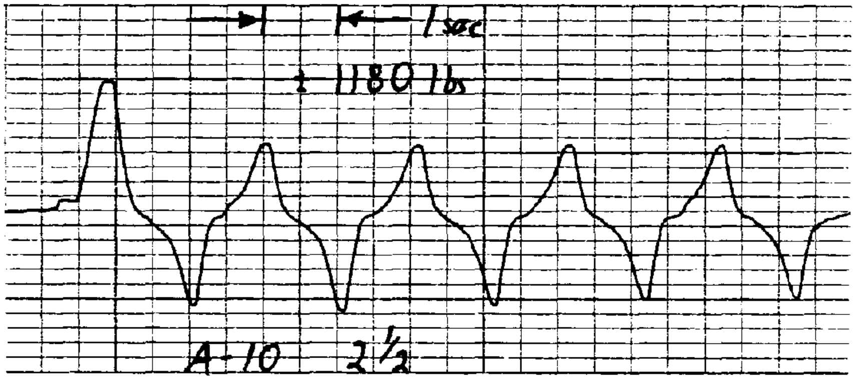

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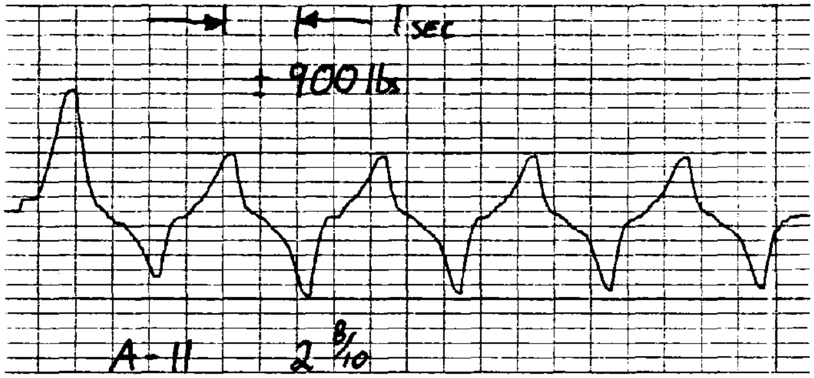
FIGURE 21: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-9 (PEAK COMMAND DISPLACEMENT ±2 INCH)
TEST NO. A-10 (PEAK COMMAND DISPLACEMENT ±2-1/2 INCH)
FREQUENCY = 0.50 HZ.



Channel 2

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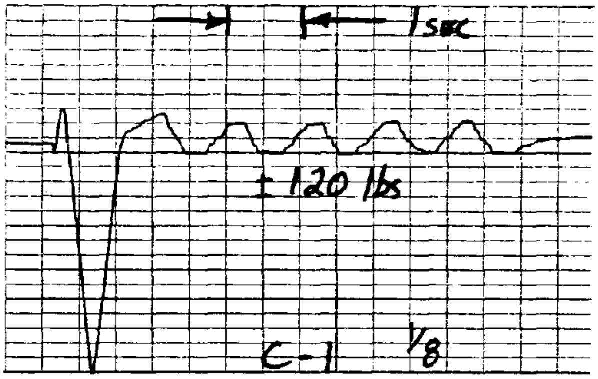
FIGURE 22: TEST SPECIMEN PD-3H
BLOCK CYCLIC TEST
TEST NO. A-11 (PEAK COMMAND DISPLACEMENT ±2.8 INCH)
FREQUENCY = 0.50 HZ.



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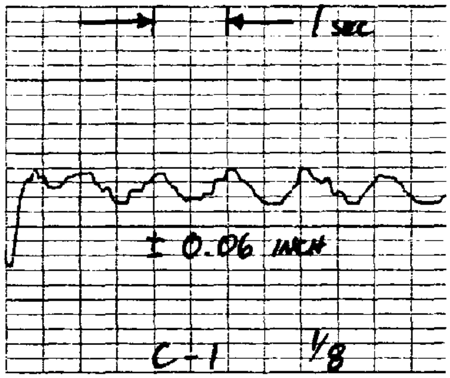
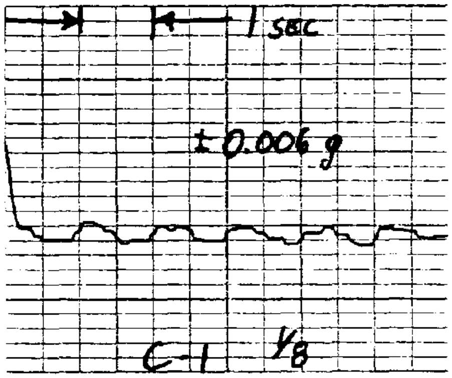
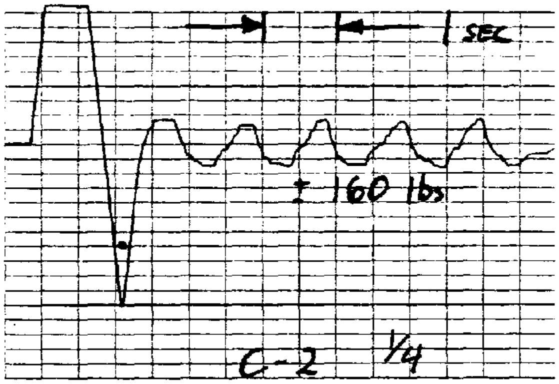


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 23: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-1 (PEAK COMMAND DISPLACEMENT ±1/8 INCH)
FREQUENCY = 1.0 HZ.



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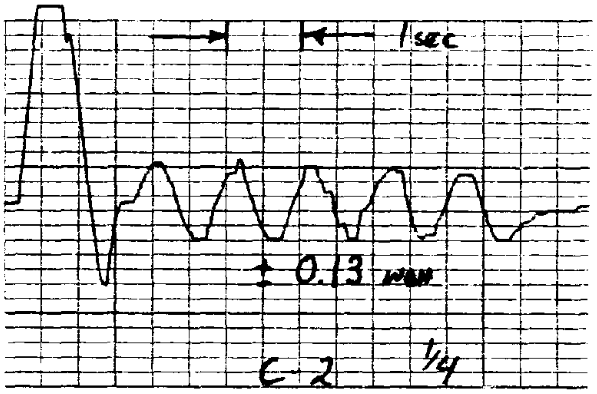
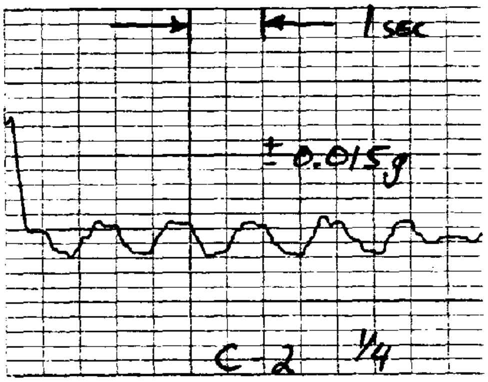
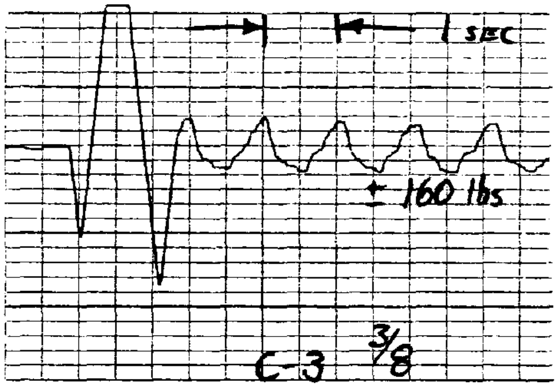


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 24: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-2 (PEAK COMMAND DISPLACEMENT ±1/4 INCH)
FREQUENCY = 1.0 HZ.



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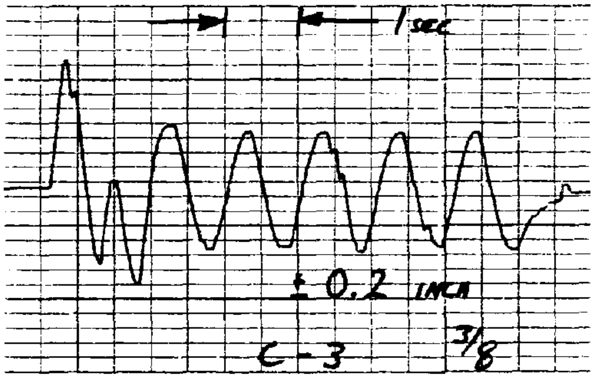
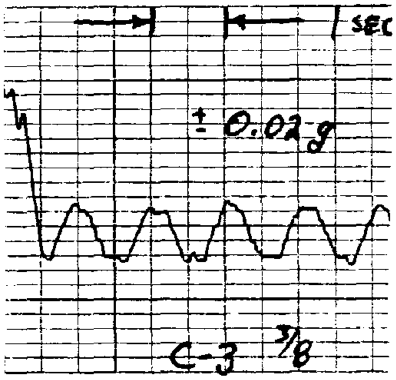
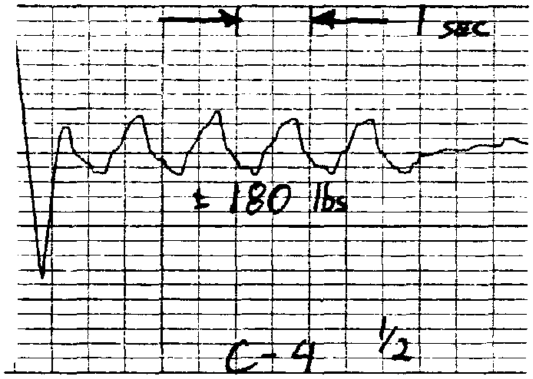


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 25: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 1.0 HZ.



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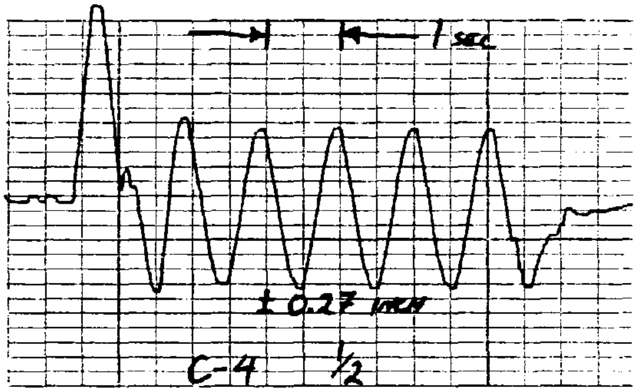
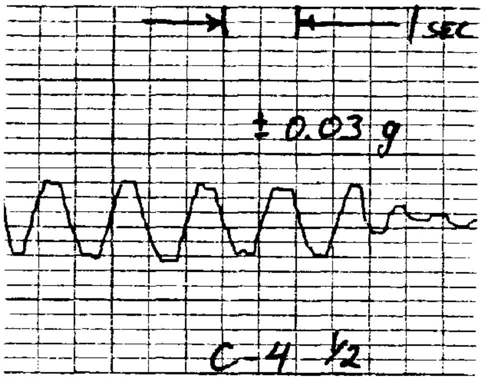
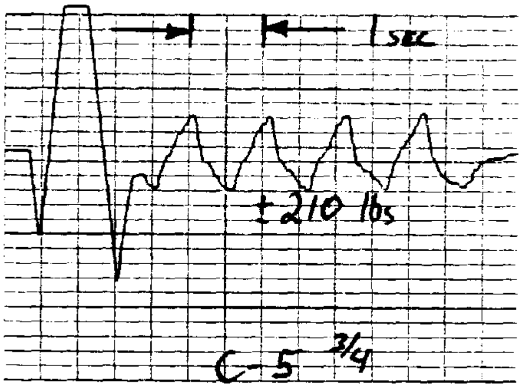


DISPLACEMENT (GRID LVDT)

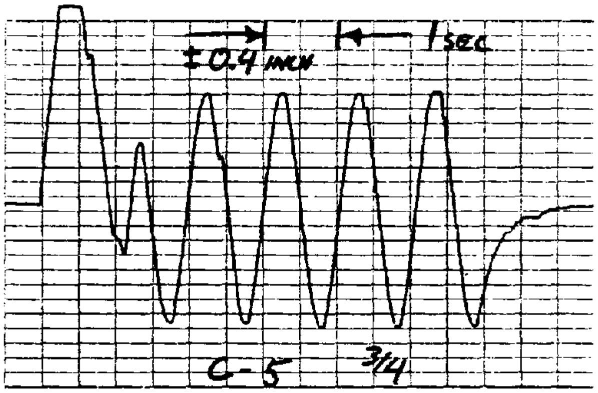


ACCELEROMETER (GRID-AXIAL)

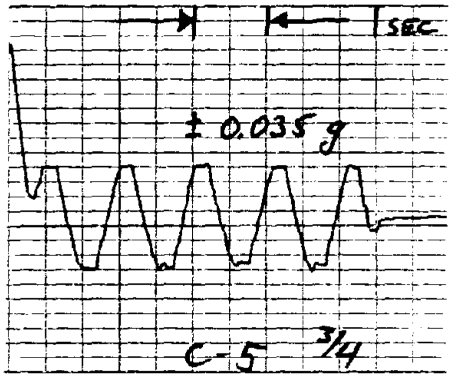
FIGURE 26: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
FREQUENCY = 1.0 HZ.



LOAD-CELL

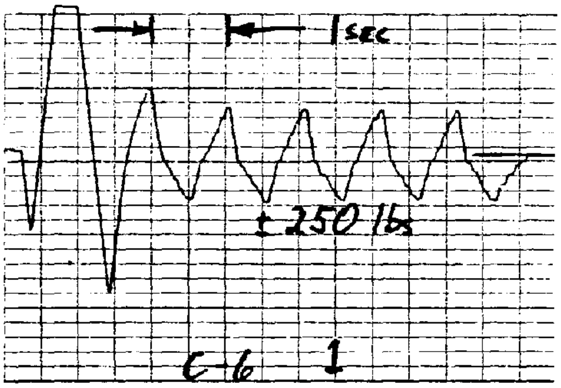


DISPLACEMENT (GRID LVDT)

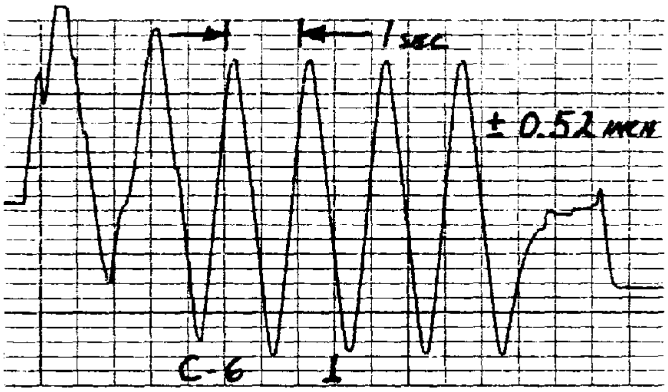


ACCELEROMETER (GRID-AXIAL)

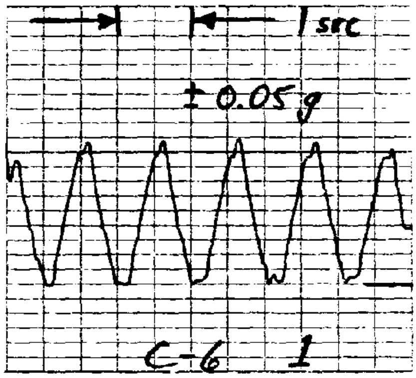
FIGURE 27: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
FREQUENCY = 1.0 HZ.



LOAD-CELL

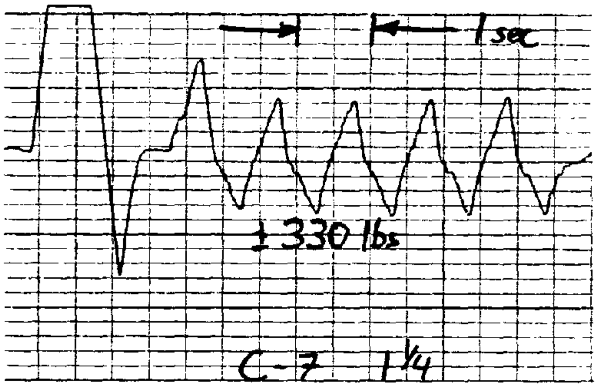


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 28: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-6 (PEAK COMMAND DISPLACEMENT ±1.0 INCH)
FREQUENCY = 1.0 HZ.



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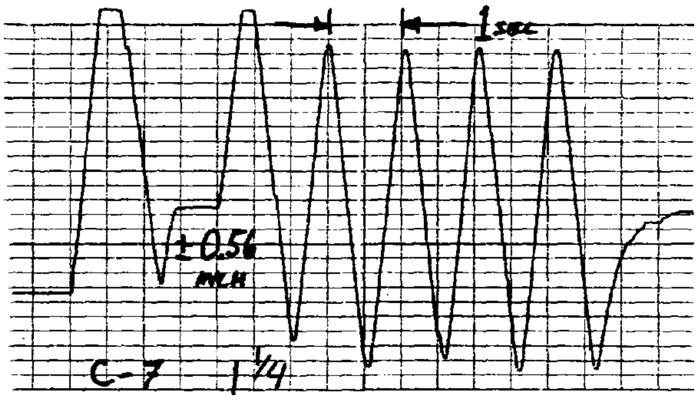
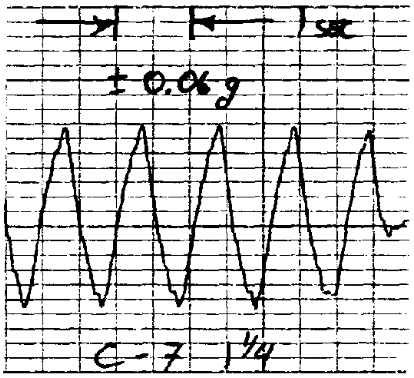
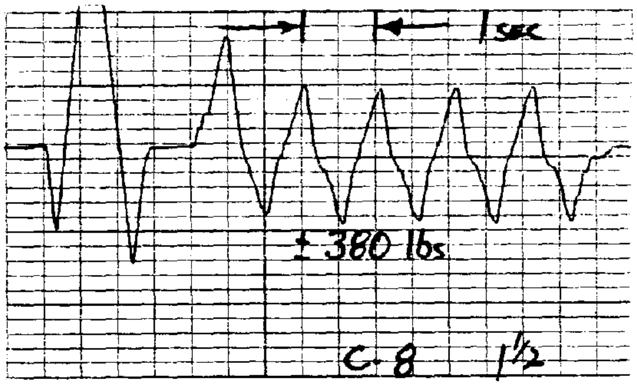


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 29: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCHES)
FREQUENCY = 1.0 HZ.



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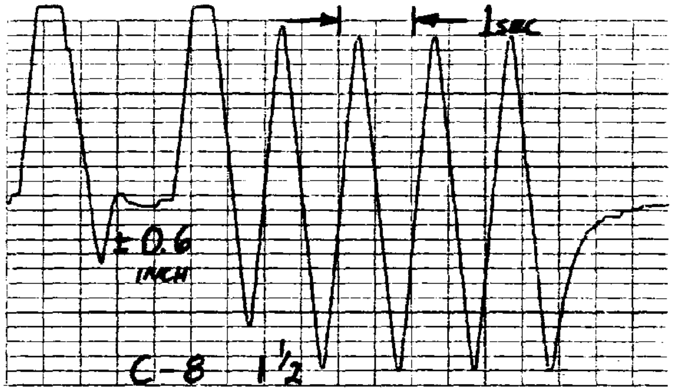
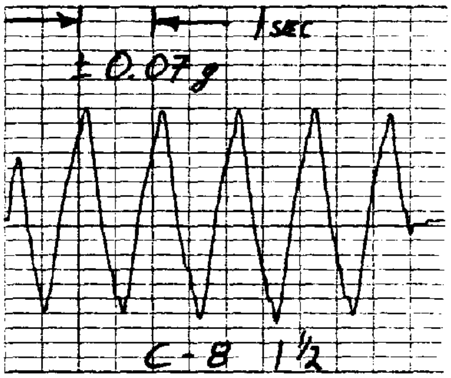
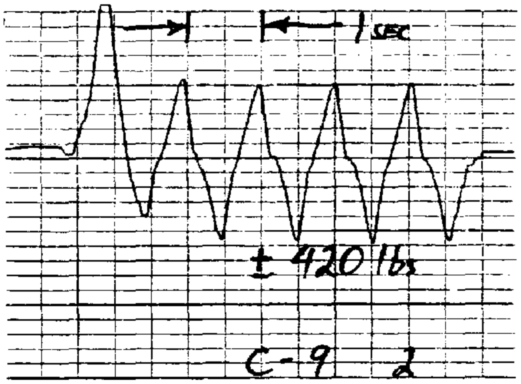


DISPLACEMENT (GRID LVDT)

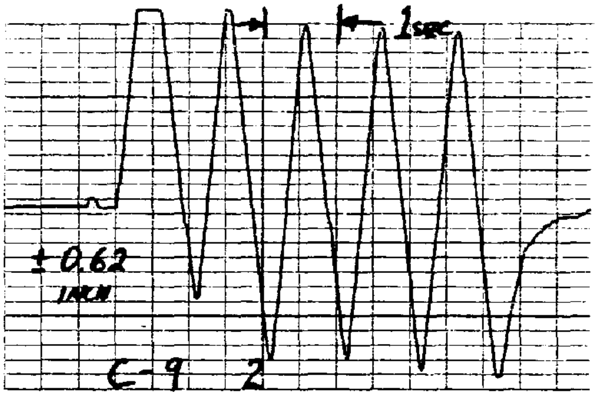


ACCELEROMETER (GRID-AXIAL)

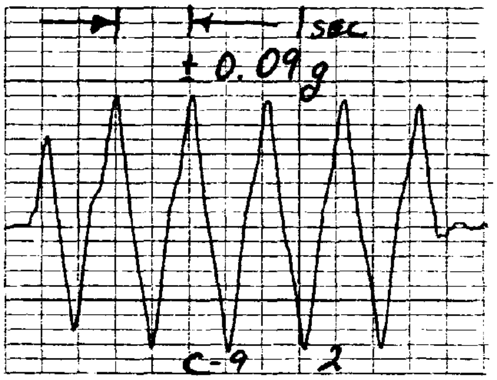
FIGURE 30: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCHES)
FREQUENCY = 1.0 HZ.



LOAD-CELL

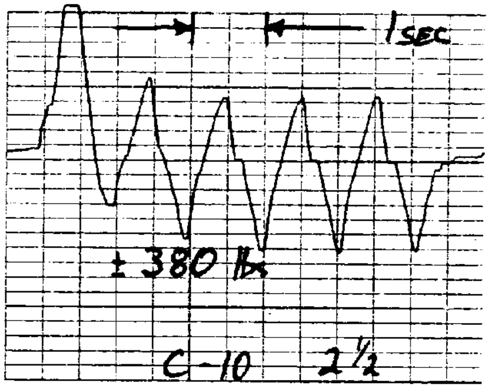


DISPLACEMENT (GRID LVDT)

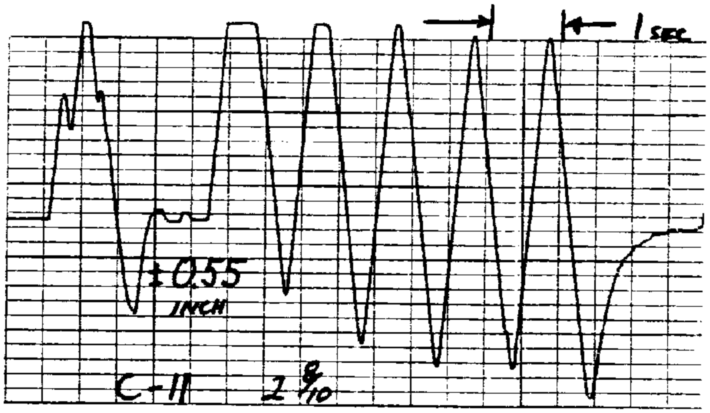


ACCELEROMETER (GRID-AXIAL)

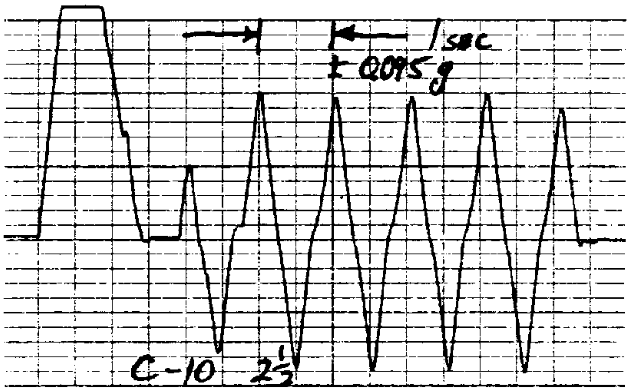
FIGURE 31: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-9 (PEAK COMMAND DISPLACEMENT ±2 INCHES)
FREQUENCY = 1.0 HZ.



LOAD-CELL

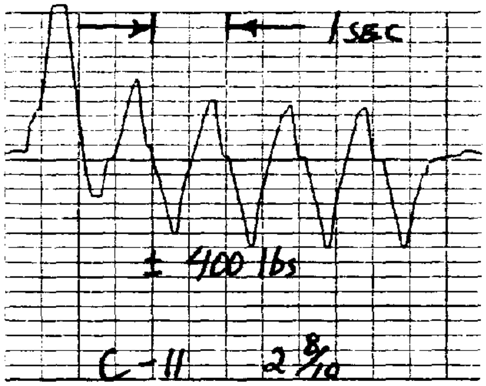


DISPLACEMENT (GRID LVDT)

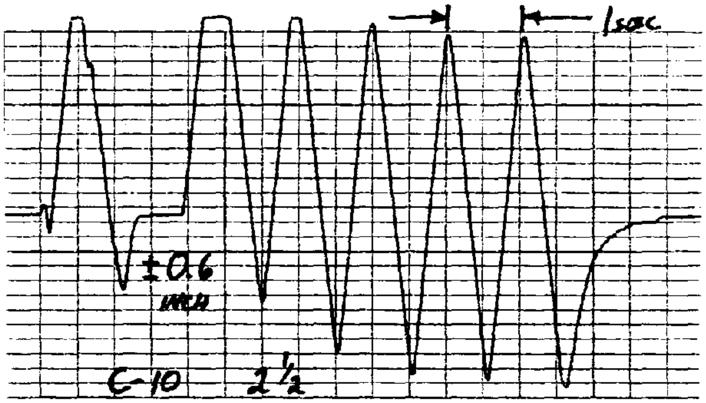


ACCELEROMETER (GRID-AXIAL)

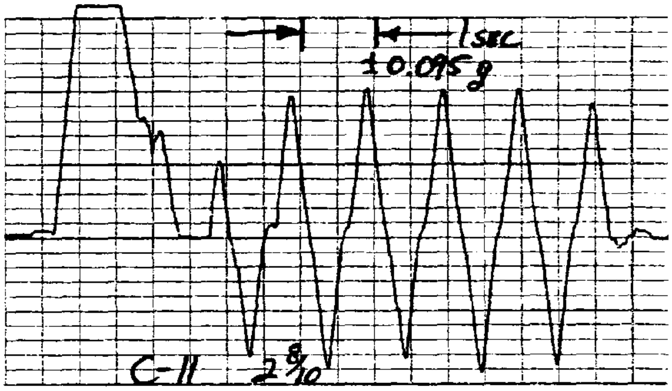
FIGURE 32: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-10 (PEAK COMMAND DISPLACEMENT ±2-1/2 INCHES)
FREQUENCY = 1.0 HZ.



LOAD-CELL

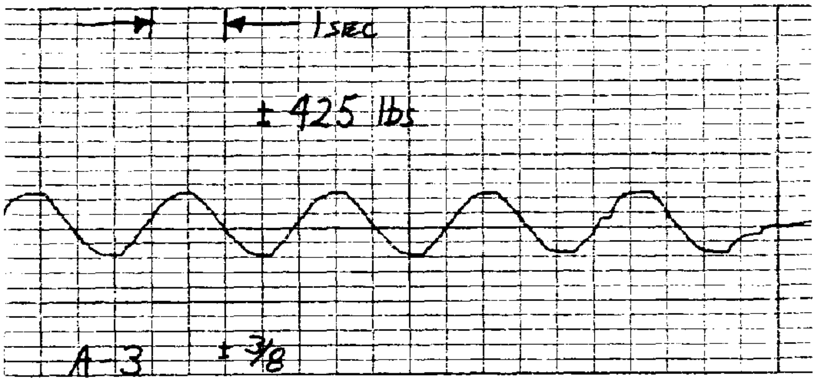


DISPLACEMENT (GRID LVDT)



ACCELEROMETER (GRID-AXIAL)

FIGURE 33: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. C-11 (PEAK COMMAND DISPLACEMENT ±2.8 INCHES)
FREQUENCY = 1.0 HZ.



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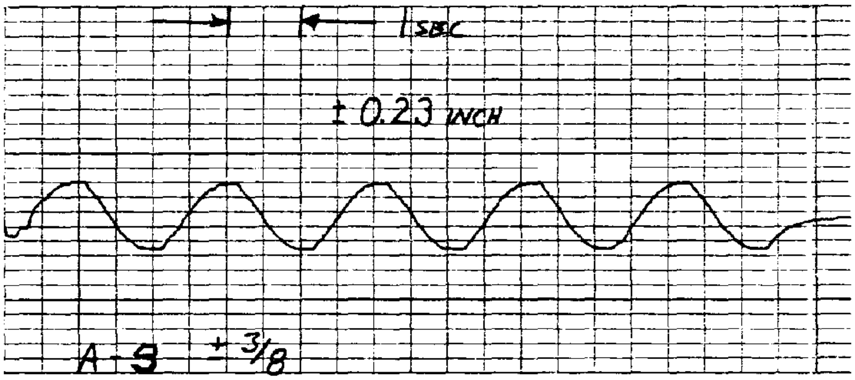
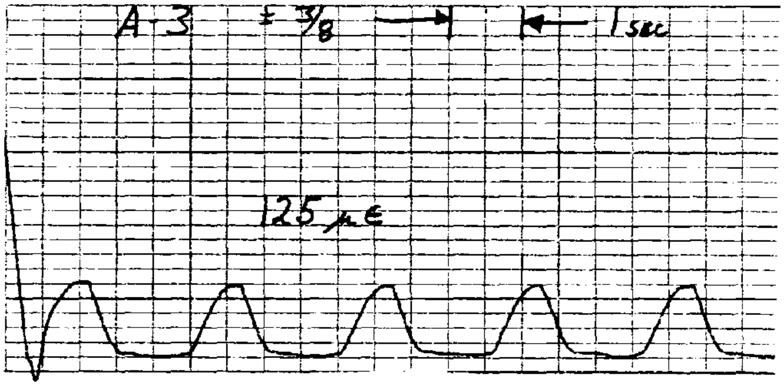
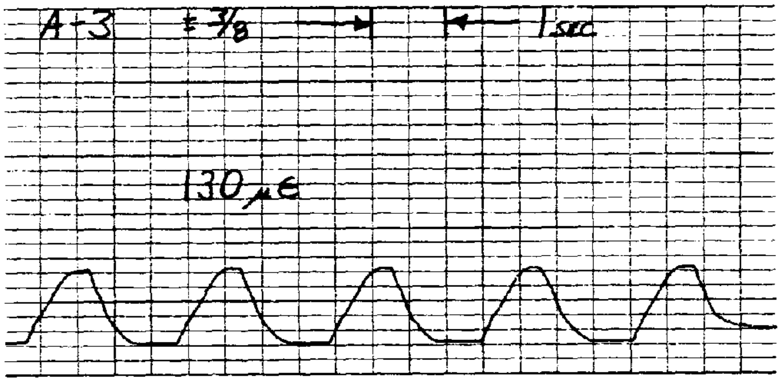


DISPLACEMENT (GRID LVDT)

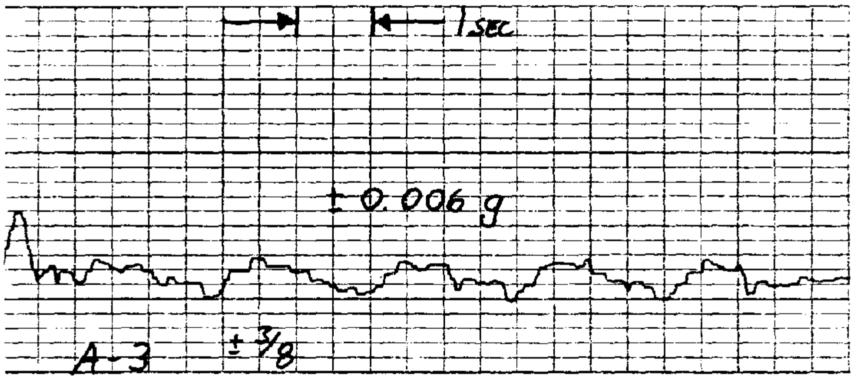


STRAIN GAGE @ LEFT HOLDOWN BOLT

FIGURE 34: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 0.5 HZ.

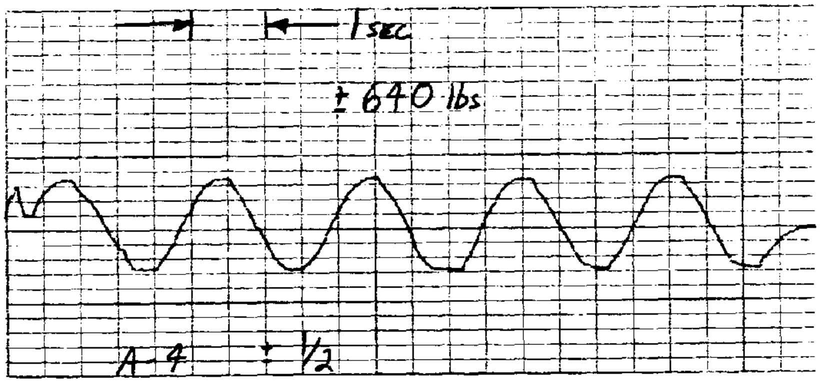


STRAIN GAGE @ RIGHT HOLDOWN BOLT



ACCELEROMETER (GRID-AXIAL)

FIGURE 35: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-3 (PEAK COMMAND DISPLACEMENT ±3/8 INCH)
FREQUENCY = 0.5 HZ.



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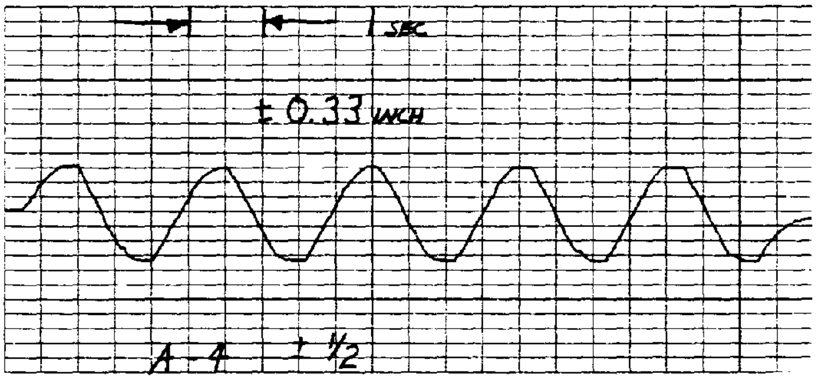
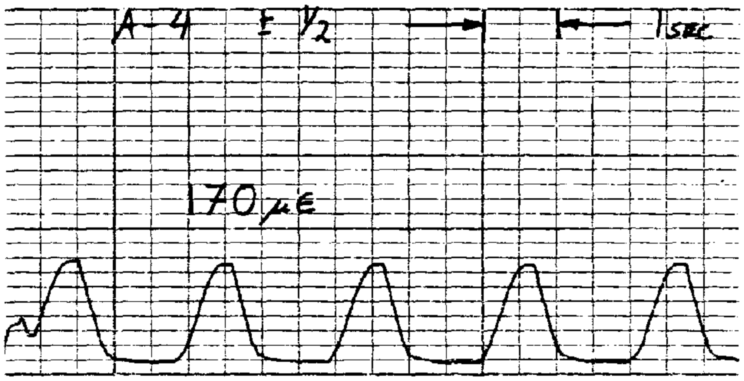
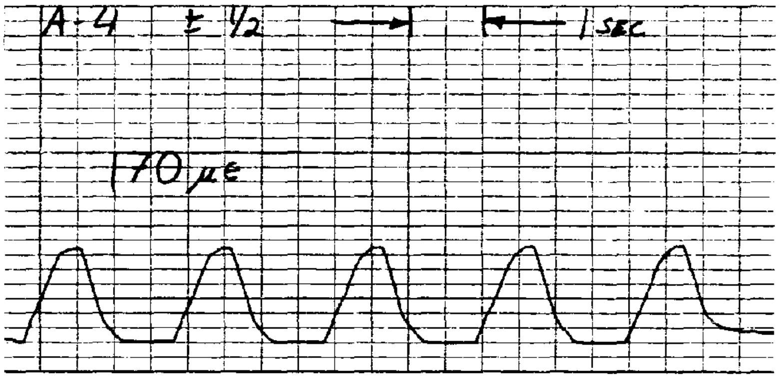


DISPLACEMENT (GRID LVDT)

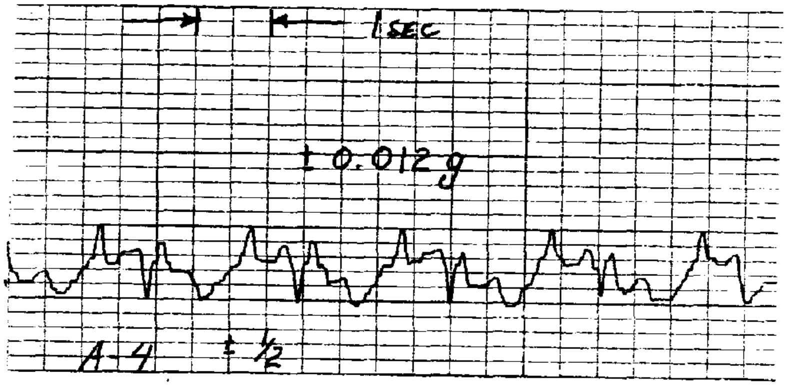


STRAIN GAGE @ LEFT HOLDOWN BOLT

FIGURE 36: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
FREQUENCY = 0.5 HZ.

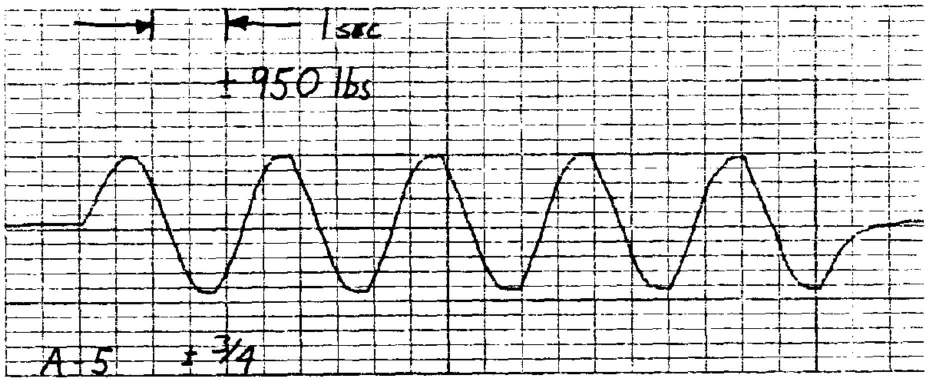


STRAIN GAGE @ RIGHT HOLDOWN BOLT



ACCELEROMETER (GRID-AXIAL)

FIGURE 37: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-4 (PEAK COMMAND DISPLACEMENT ±1/2 INCH)
FREQUENCY = 0.5 HZ.



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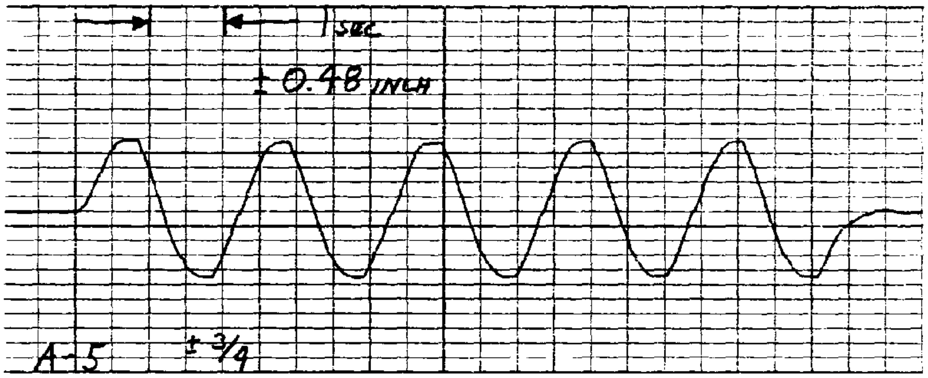
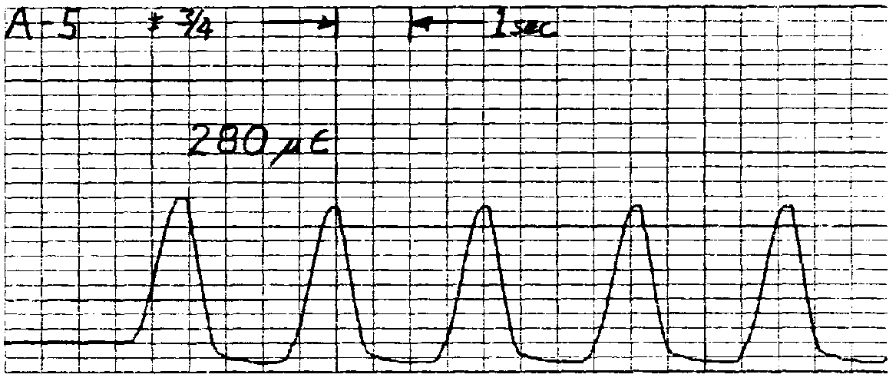
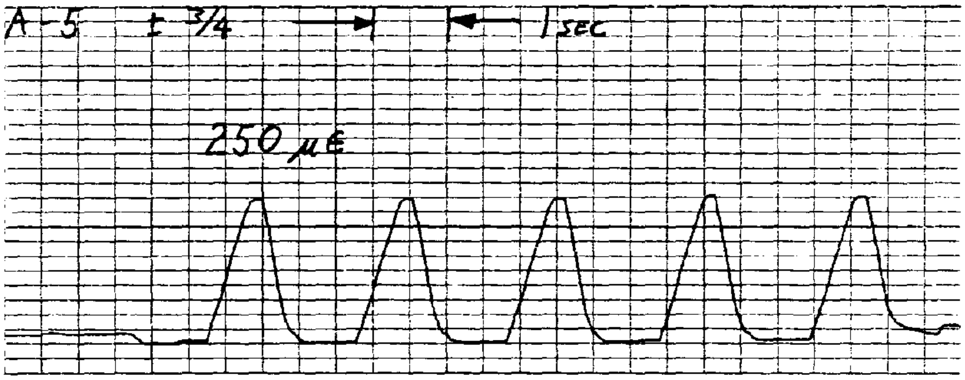


DISPLACEMENT (GRID LVDT)

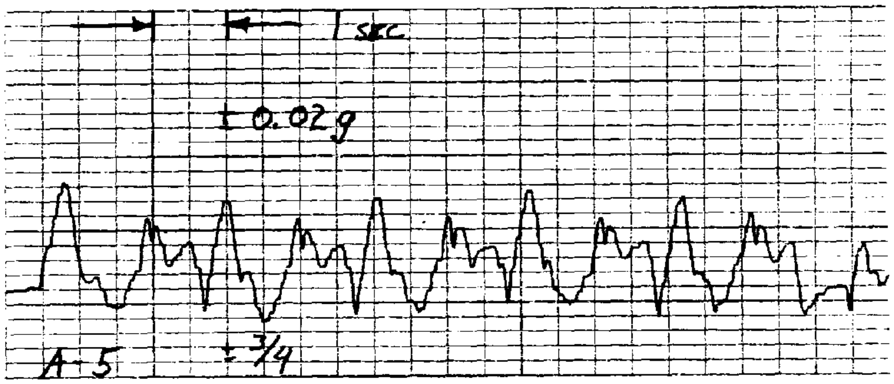


STRAIN GAGE @ LEFT HOLDOWN BOLT

FIGURE 38: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
FREQUENCY = 0.5 HZ.

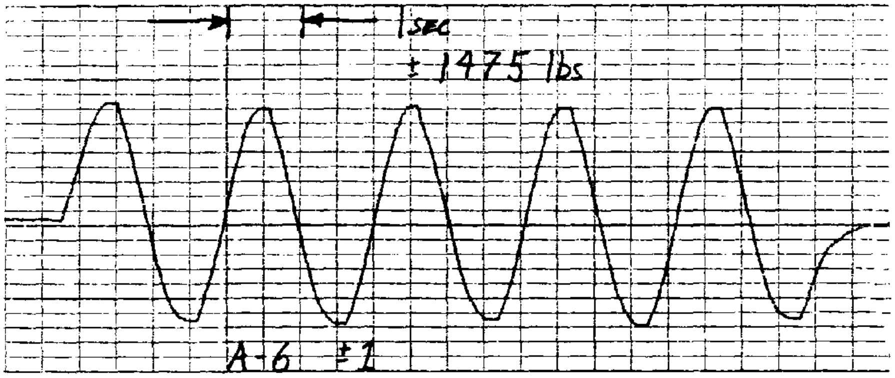


STRAIN GAGE @ RIGHT HOLDOWN BOLT

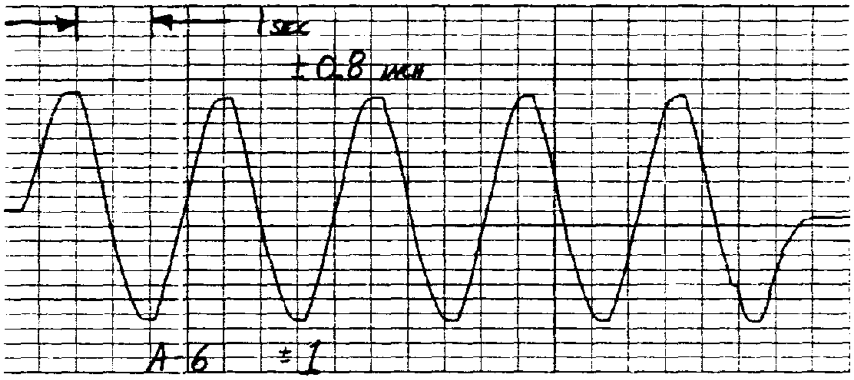


ACCELEROMETER (GRID-AXIAL)

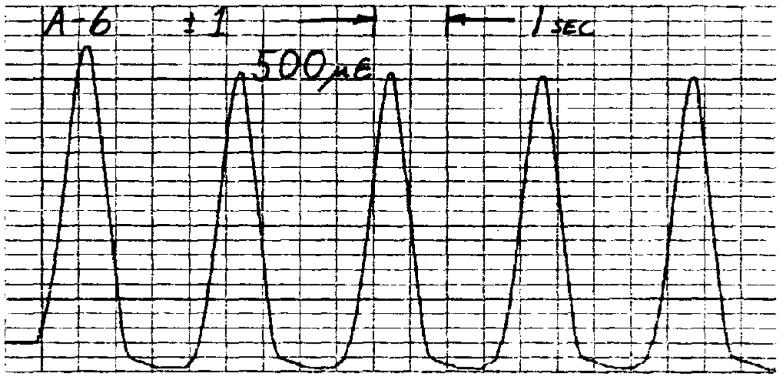
FIGURE 39: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-5 (PEAK COMMAND DISPLACEMENT ±3/4 INCH)
FREQUENCY = 0.5 HZ.



LOAD-CELL

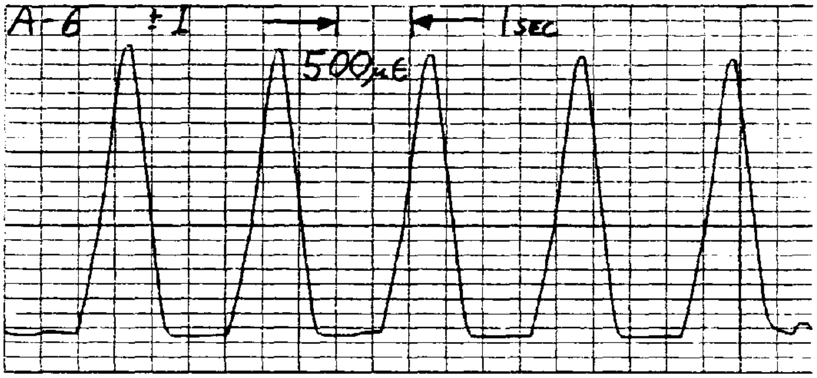


DISPLACEMENT (GRID LVDT)

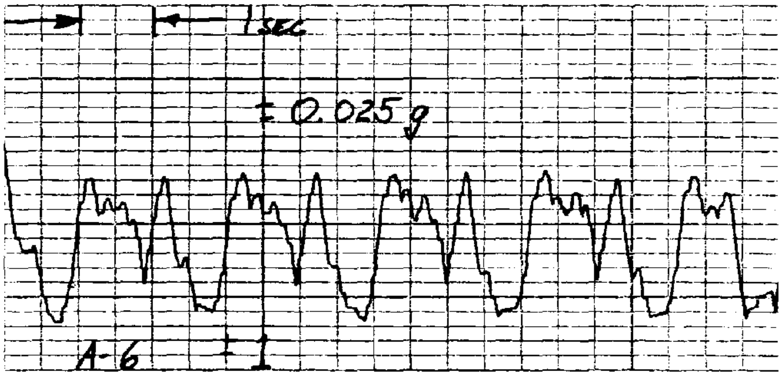


STRAIN GAGE @ LEFT HOLDOWN BOLT

FIGURE 40: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-6 (PEAK COMMAND DISPLACEMENT ±1 INCH)
FREQUENCY = 0.5 HZ.

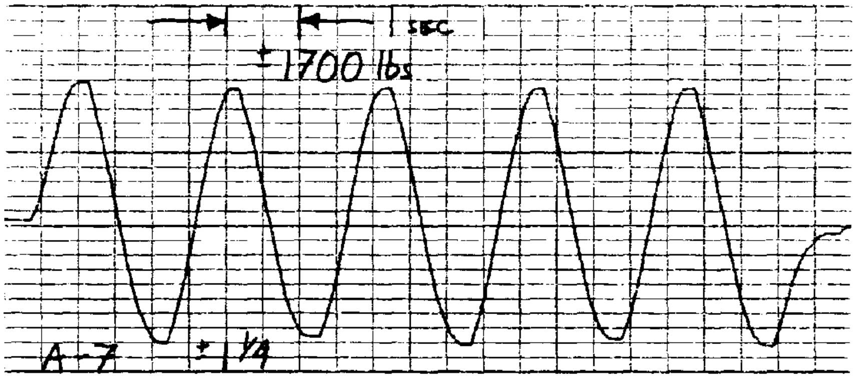


STRAIN GAGE @ RIGHT HOLDOWN BOLT

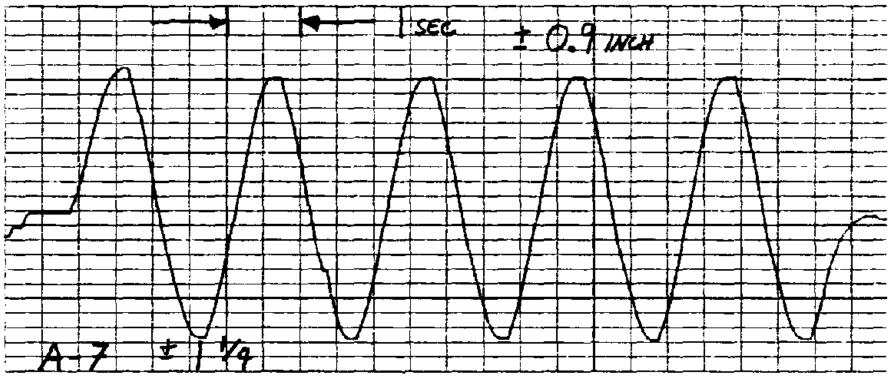


ACCELEROMETER (GRID-AXIAL)

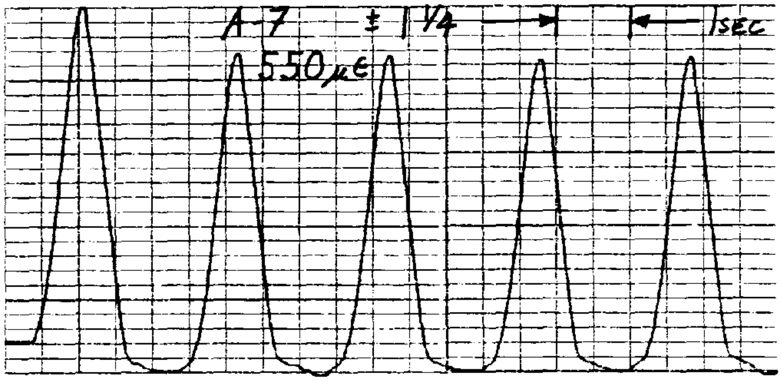
FIGURE 41: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-6 (PEAK COMMAND DISPLACEMENT ±1 INCH)
FREQUENCY = 0.5 HZ.



LOAD-CELL



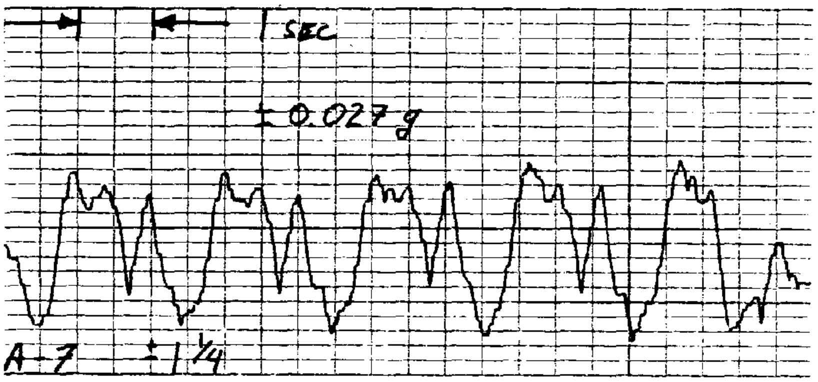
DISPLACEMENT (GRID LVDT)



STRAIN GAGE @ LEFT HOLDOWN BOLT

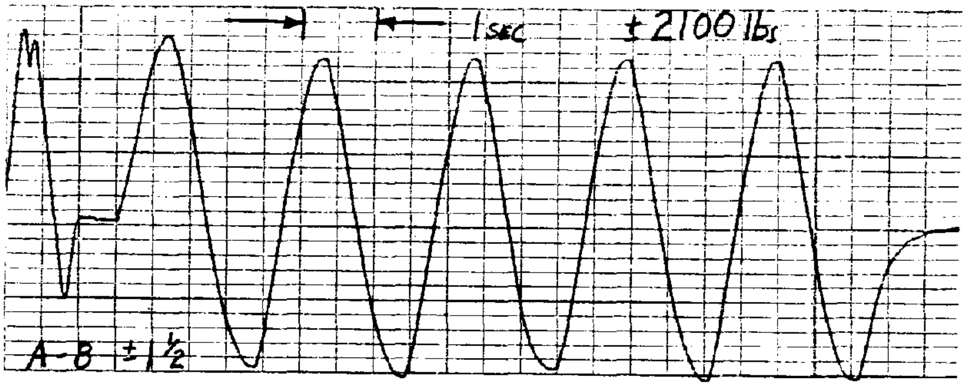
FIGURE 42: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCHES)
FREQUENCY = 0.5 HZ.

STRAIN GAGE @ RIGHT HOLDOWN BOLT

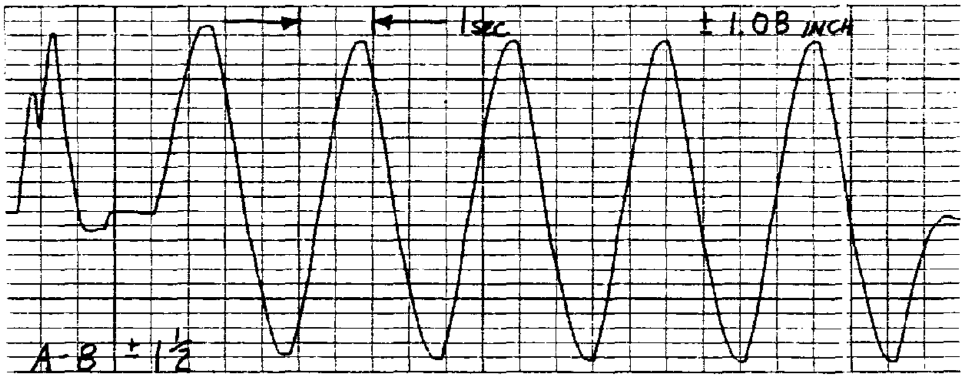


ACCELEROMETER (GRID-AXIAL)

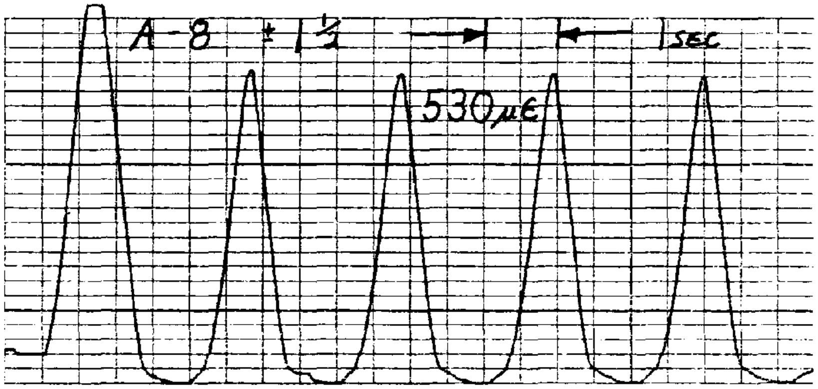
FIGURE 43: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-7 (PEAK COMMAND DISPLACEMENT ±1-1/4 INCHES)
FREQUENCY = 0.5 HZ.



LOAD-CELL

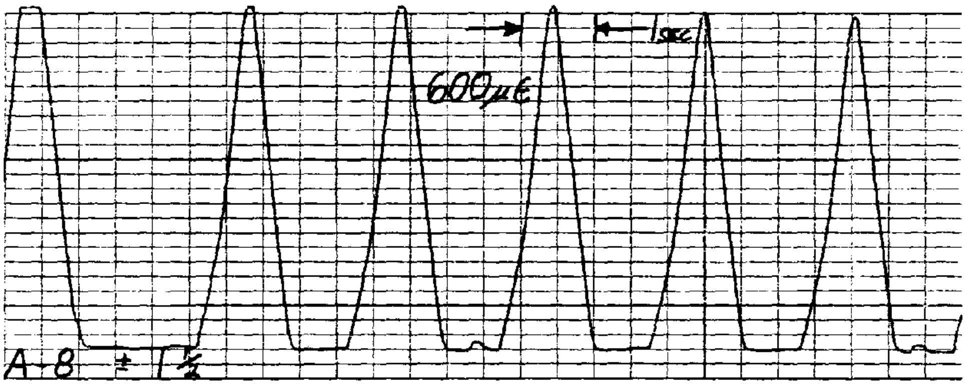


DISPLACEMENT (GRID LVDT)

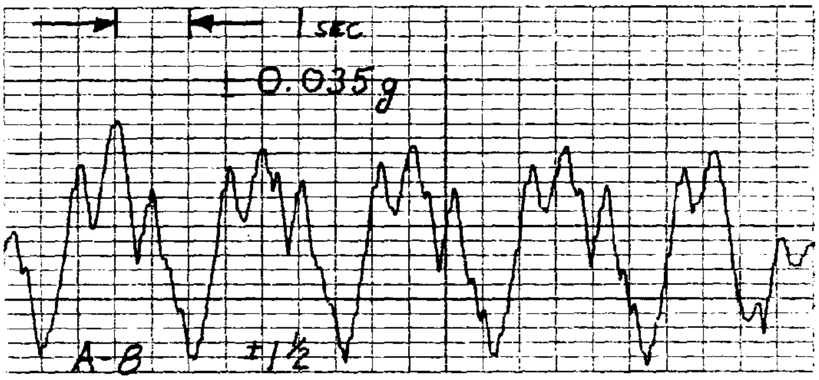


STRAIN GAGE @ LEFT HOLDOWN BOLT

FIGURE 44: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCHES)
FREQUENCY = 0.5 HZ.



STRAIN GAGE @ RIGHT HOLDOWN BOLT

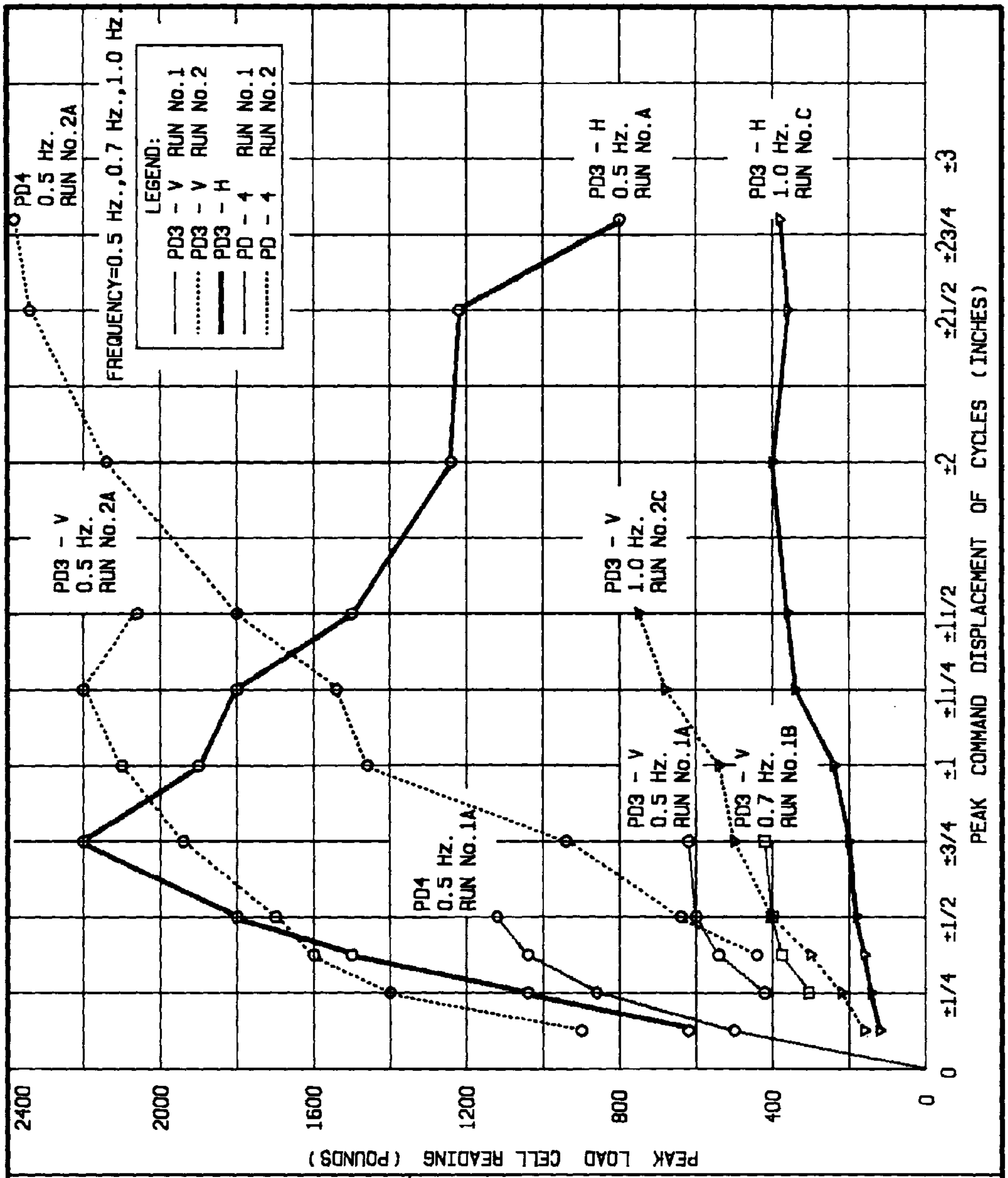


ACCELEROMETER (GRID-AXIAL)

FIGURE 45: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-8 (PEAK COMMAND DISPLACEMENT ±1-1/2 INCHES)
FREQUENCY = 0.5 HZ.

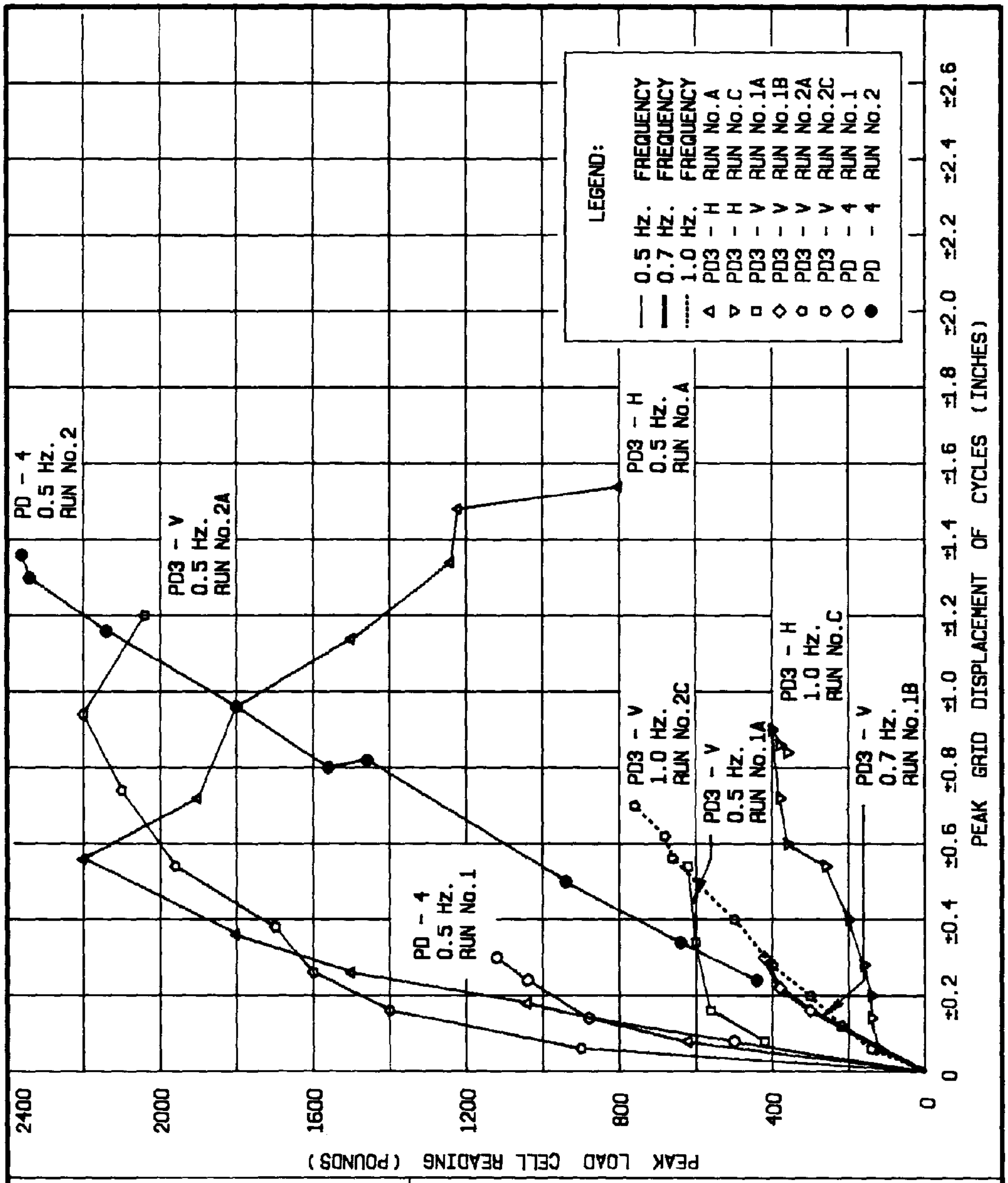
APPENDIX C

DYNAMIC TEST RESULTS - PLOTS OF PEAK LOADS AND PEAK DISPLACEMENTS, RIGIDITIES AND DAMAGE LEVELS



SPECIMEN PD3-V (RUN No.1) SPECIMEN PD3-V (RUN No.2) SPECIMEN PD3-H SPECIMEN PD-4 (RUN No.1/RUN No.2)	N.S.F. SPONSORED RESEARCH PROJECT DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 1	BLOCK CYCLIC TEST PEAK LOAD vs. PEAK COMMAND DISPLACEMENT.	DRAWN BY: R.O. DATE:7/85 CHECKED BY:S.R. DATE:7/85 CALIFORNIA POLYTECHNIC STATE UNIVERSITY,S.L.O.,CA.



SPECIMEN PD3-V (RUN No.1)
SPECIMEN PD3-V (RUN No.2)
SPECIMEN PD3-H
SPECIMEN PD-4 (RUN No.1/RUN No.2)

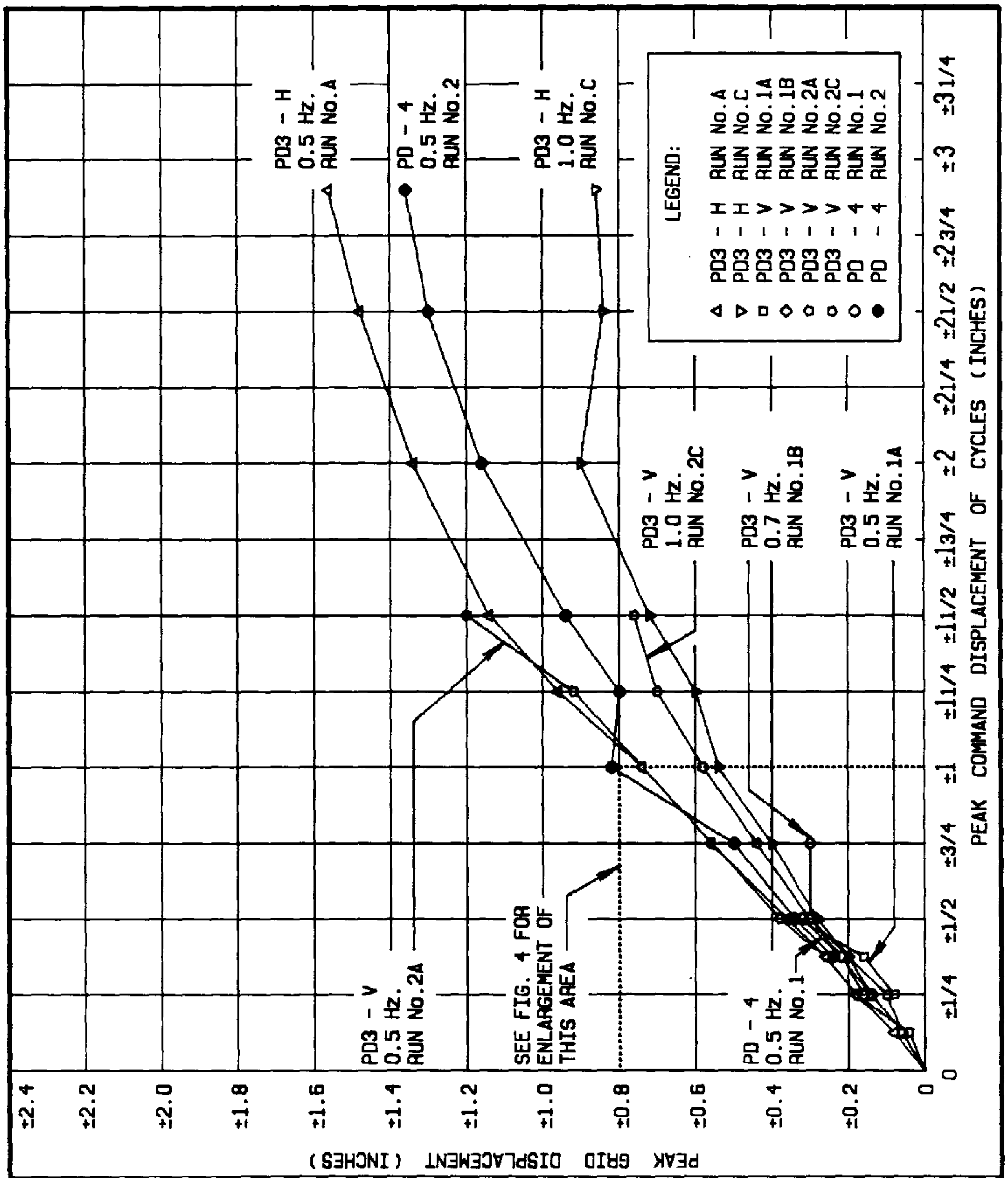
N.S.F. SPONSORED RESEARCH PROJECT

DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 2

BLOCK CYCLIC TEST
PEAK LOAD vs.
PEAK GRID DISPLACEMENT.

DRAWN BY: R.O. DATE: 7/85
CHECKED BY: S.R. DATE: 7/85
CALIFORNIA POLYTECHNIC STATE UNIVERSITY, S.L.O., CA.



SPECIMEN PD3-V (RUN No.1)
SPECIMEN PD3-V (RUN No.2)
SPECIMEN PD3-H
SPECIMEN PD-4 (RUN No.1/RUN No.2)

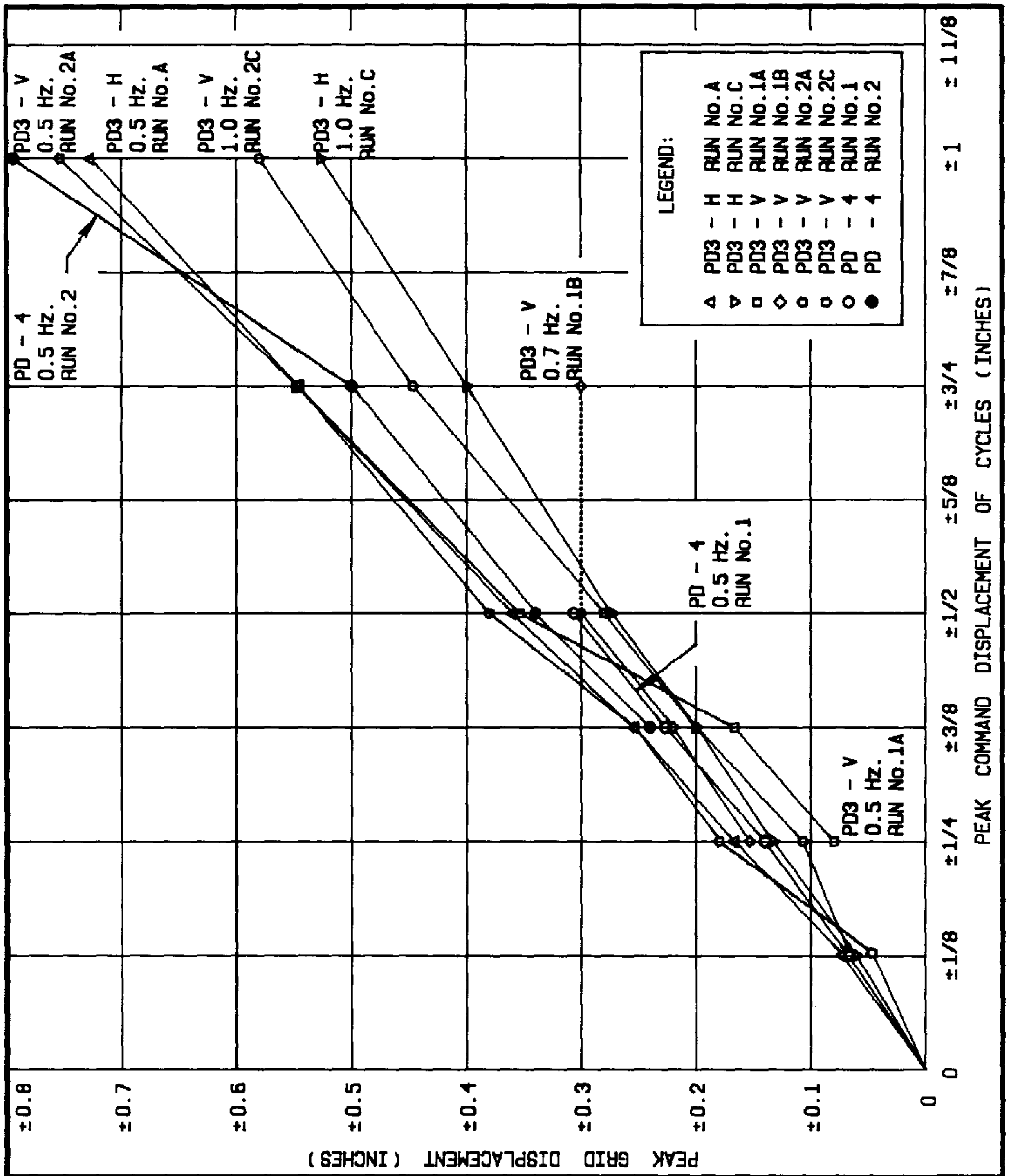
N.S.F. SPONSORED RESEARCH PROJECT

DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 3

BLOCK CYCLIC TEST
PEAK GRID DISPLACEMENT vs.
PEAK COMMAND DISPLACEMENT

DRAWN BY: R.O. DATE:7/85
CHECKED BY:S.R. DATE:7/85
CALIFORNIA POLYTECHNIC STATE UNIVERSITY,S.L.O.,CA.



SPECIMEN PD3-V (RUN No.1)
SPECIMEN PD3-V (RUN No.2)
SPECIMEN PD3-H
SPECIMEN PD-4 (RUN No.1/RUN No.2)

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DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 4

BLOCK CYCLIC TEST
PEAK GRID DISPLACEMENT vs.
PEAK COMMAND DISPLACEMENT.

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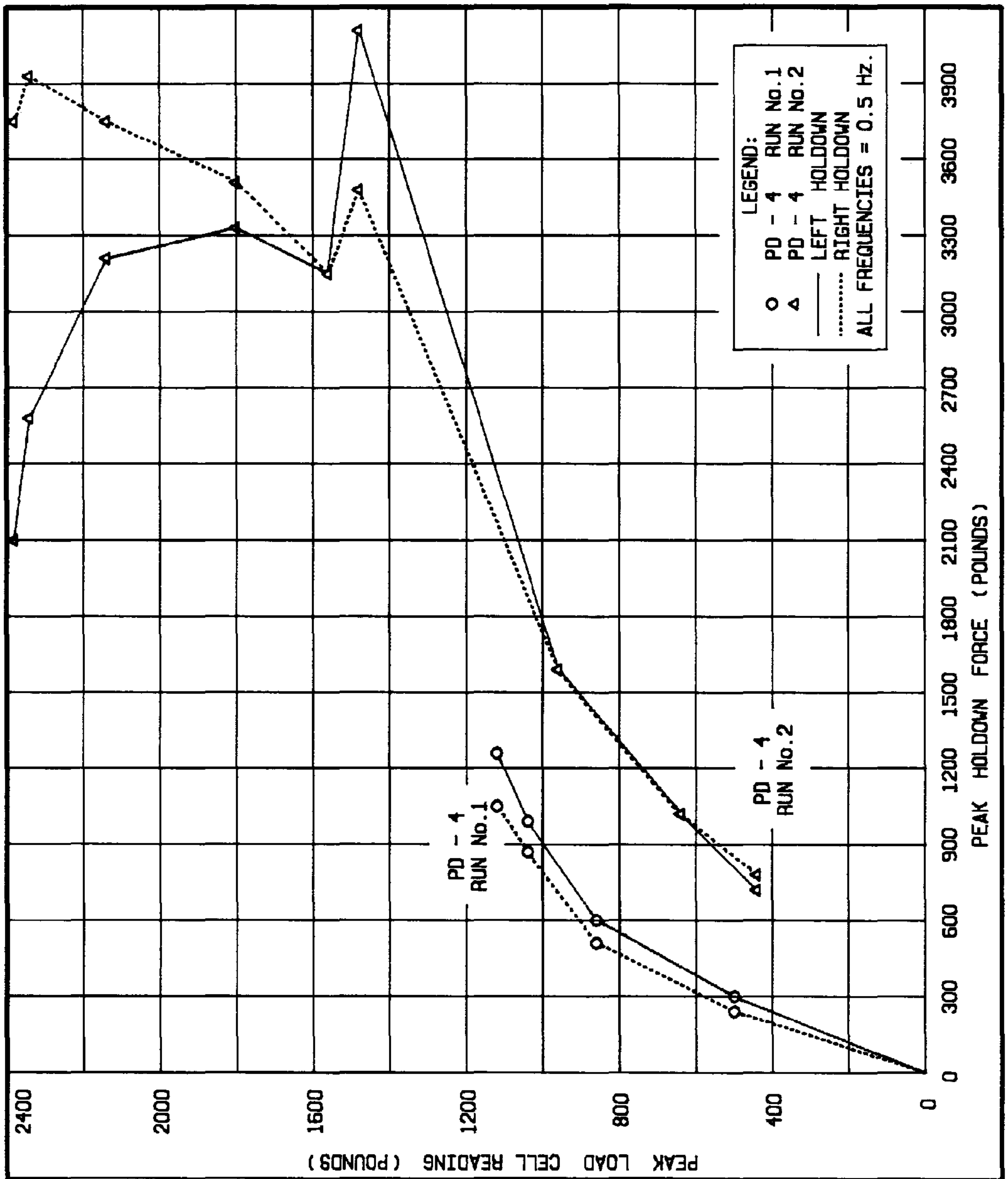
CHECKED BY: S.R. DATE: 7/85
CALIFORNIA POLYTECHNIC STATE UNIVERSITY, S.L.O., CA.



SPECIMEN PD - 4
(RUN No.1/RUN No.2)

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DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 5

BLOCK CYCLIC TEST
PEAK LOAD vs.
PEAK HOLDOWN FORCE.

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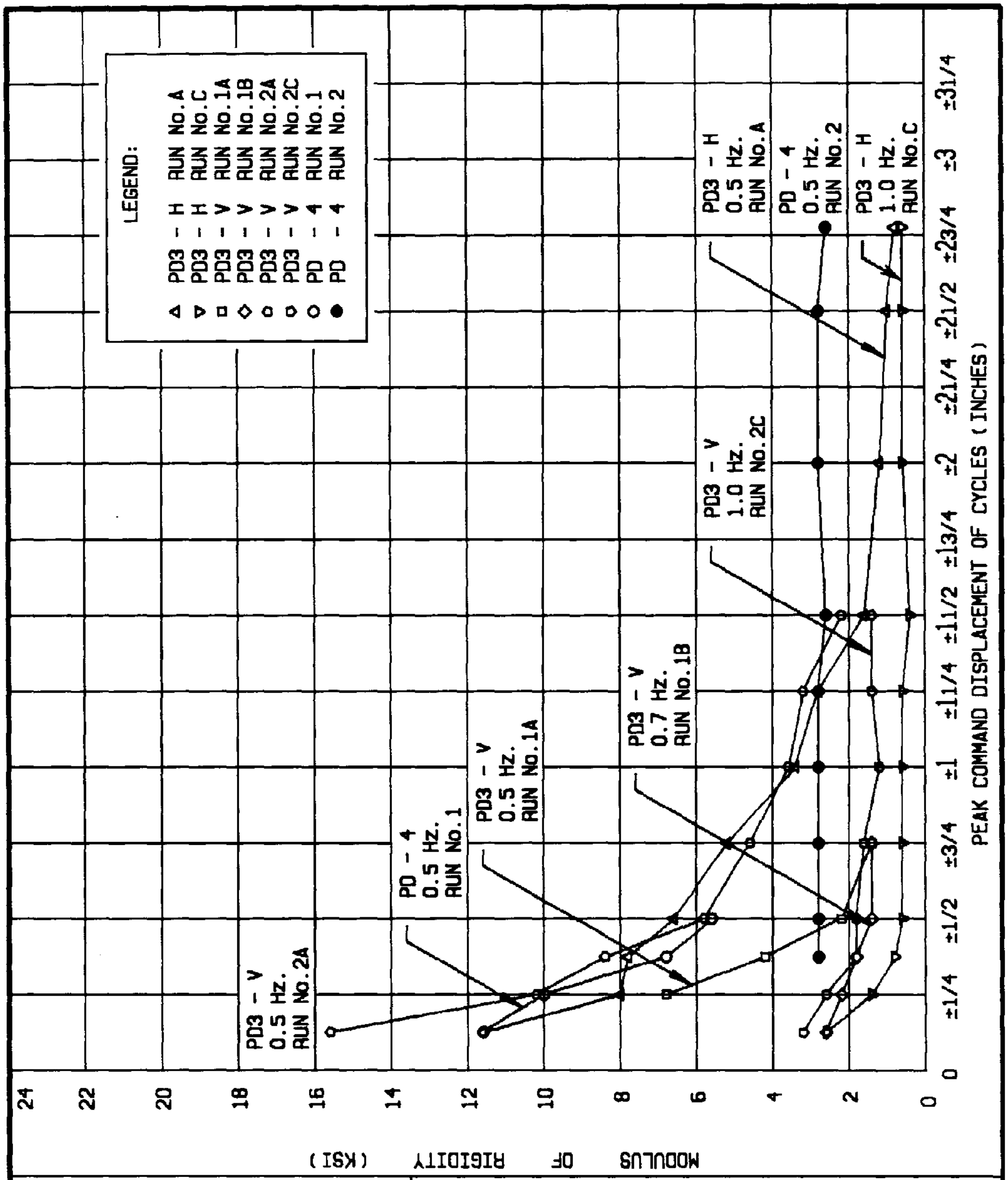

SPECIMEN PD3-V (RUN No.1)
SPECIMEN PD3-V (RUN No.2)
SPECIMEN PD3-H
SPECIMEN PD-4 (RUN No.1/RUN No.2)

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FIG. 5

BLOCK CYCLIC TEST
MODULUS OF RIGIDITY vs.
PEAK COMMAND DISPLACEMENT.

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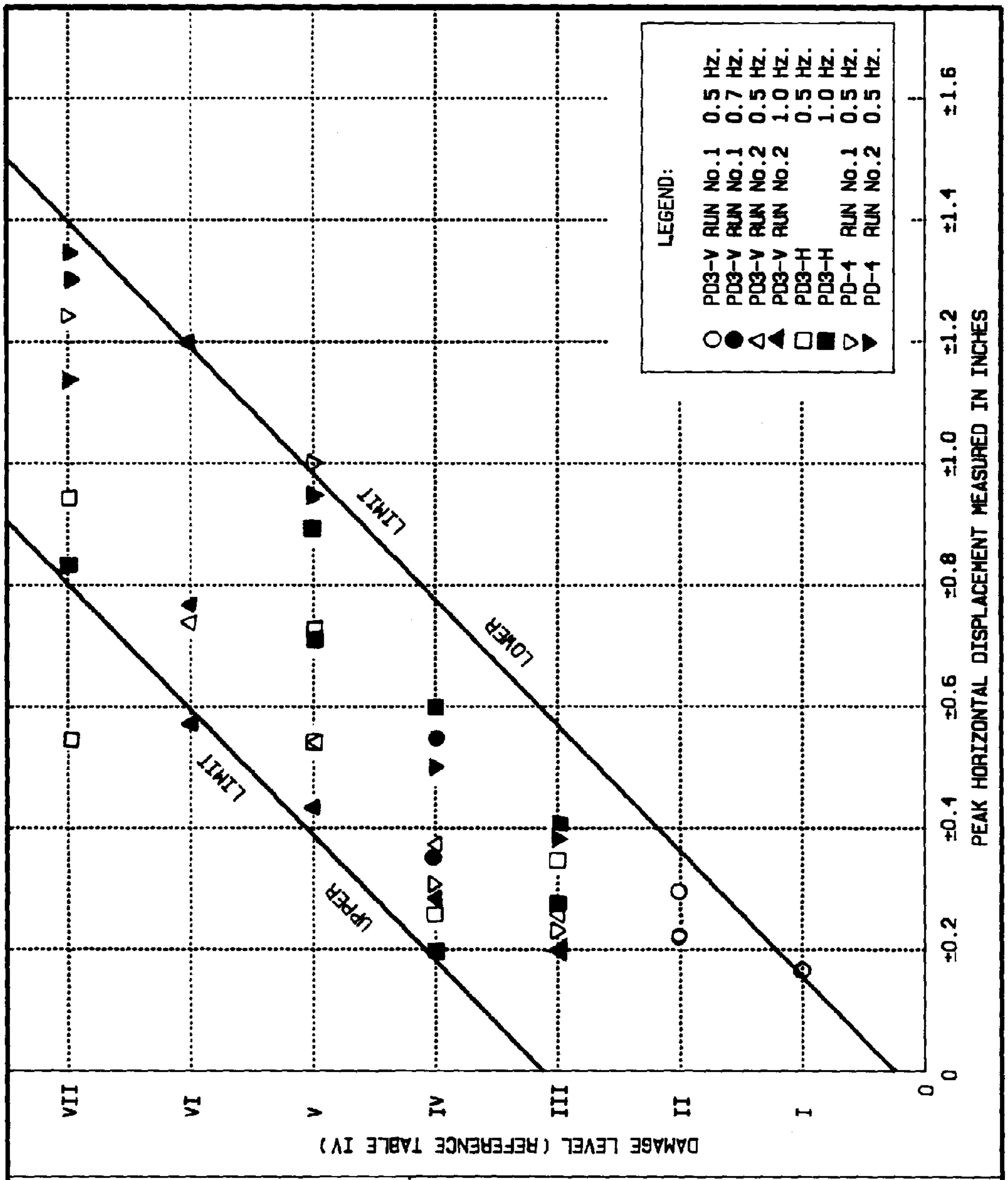

SPECIMEN PD3-V (RUN No.1)
SPECIMEN PD3-V (RUN No.2)
SPECIMEN PD3-H
SPECIMEN PD-4 (RUN No.1/RUN No.2)

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DYNAMIC TESTING OF BUILDING PARTITIONS

FIG. 7 PLOT OF DAMAGE LEVEL vs. PEAK HORIZONTAL DISPLACEMENT

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CHECKED BY: S.R. DATE: 7/85
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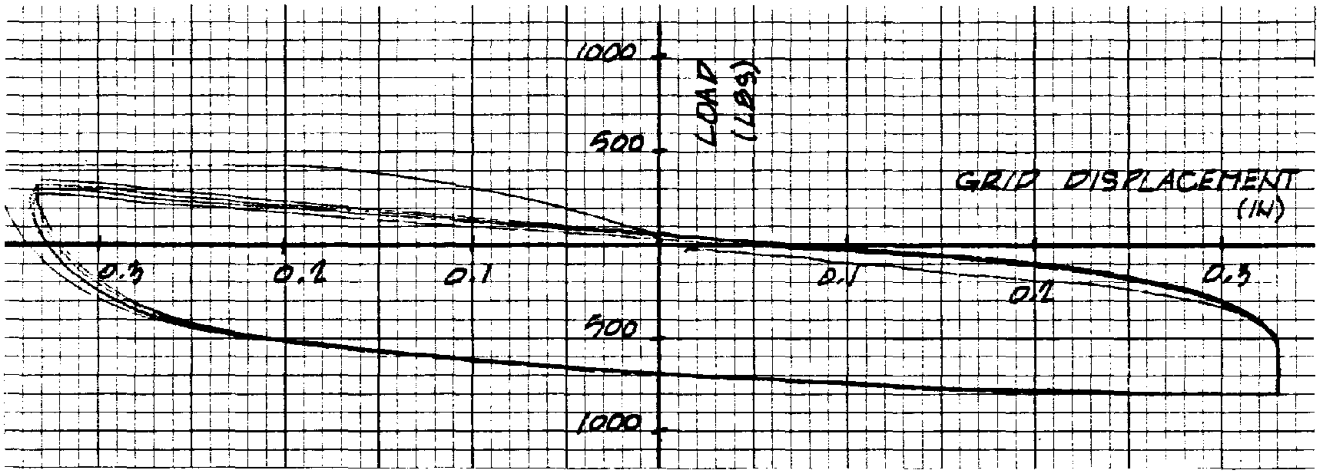
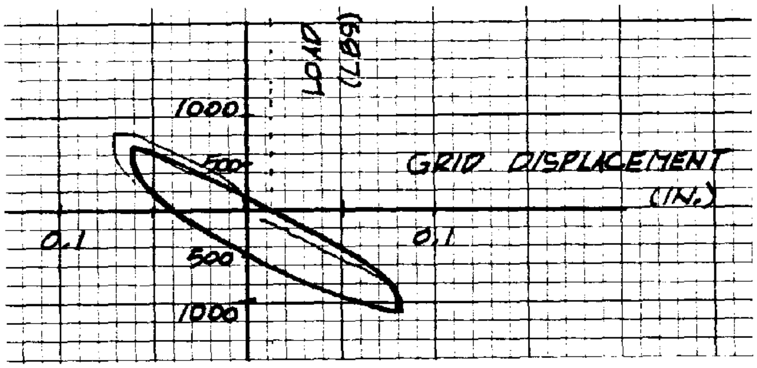
APPENDIX D

CYCLIC LOAD - DISPLACEMENT CURVES

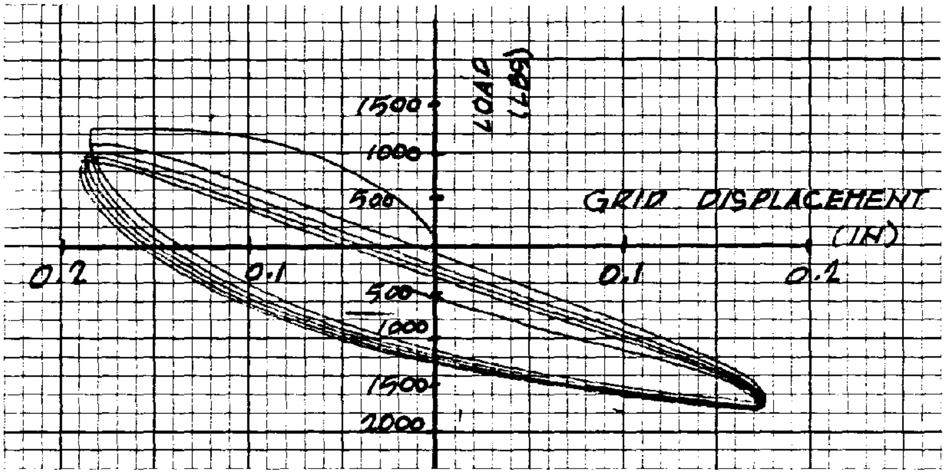


TEST NO. A-4
PEAK COMMAND DISPLACEMENT = ±1/2 INCH
FREQUENCY = 0.5 HZ.

FIGURE 1: TEST SPECIMEN PD3-V RUN NO. 1
BLOCK CYCLIC TEST
LOAD VS. DISPLACEMENT CURVES

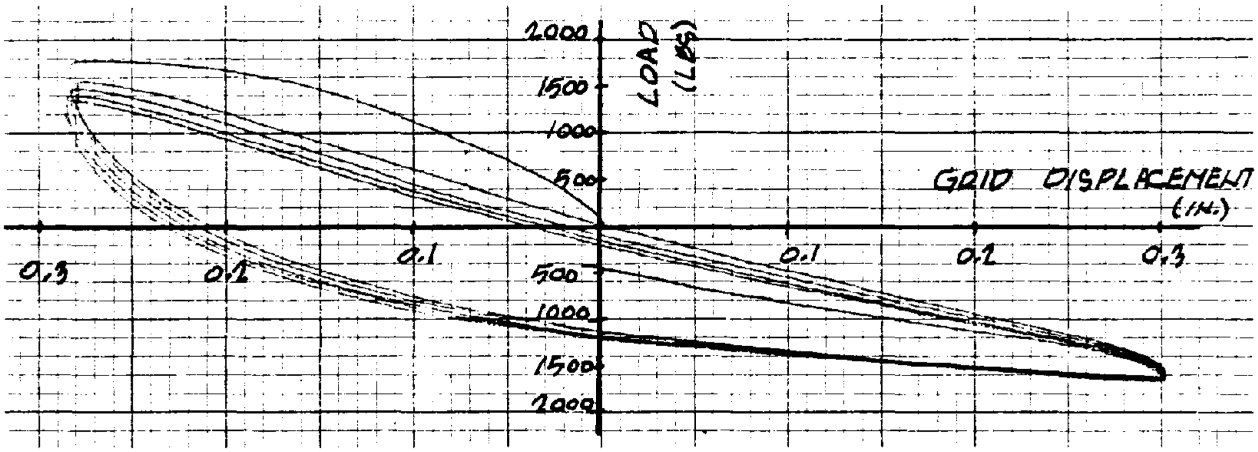


TEST NO. A-1
PEAK COMMAND DISPLACEMENT = ±1/8 INCH
FREQUENCY = 0.5 HZ.

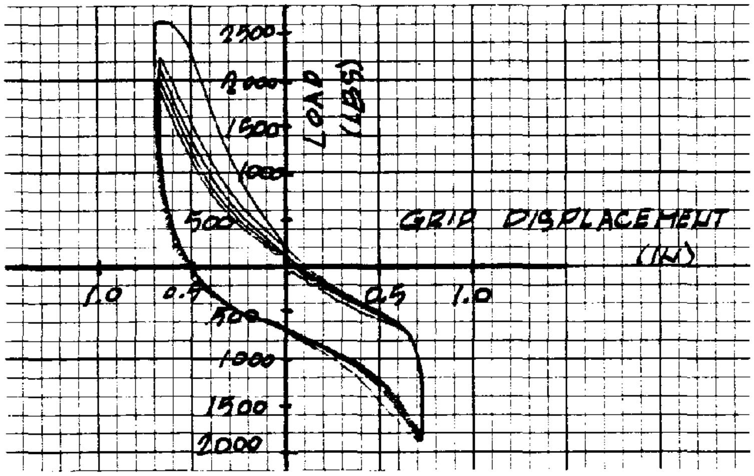


TEST NO. A-2
PEAK COMMAND DISPLACEMENT = ±1/4 INCH
FREQUENCY = 0.5 HZ.

FIGURE 2: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-1, A-2
LOAD VS. DISPLACEMENT CURVES

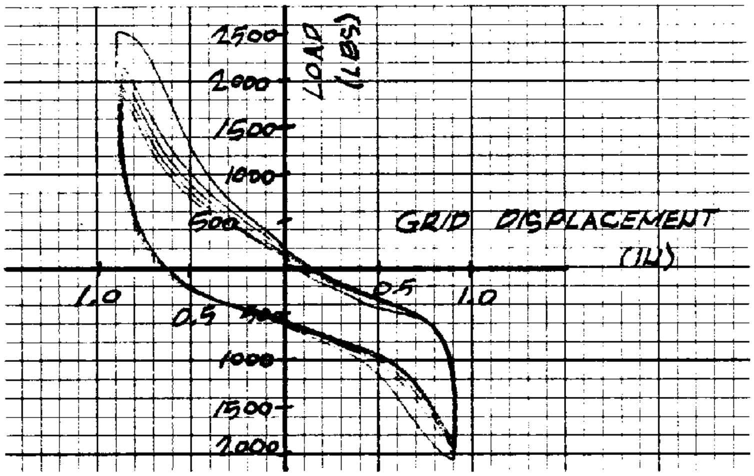


TEST NO. A-3
PEAK COMMAND DISPLACEMENT = ±3/8 INCH
FREQUENCY = 0.5 HZ.

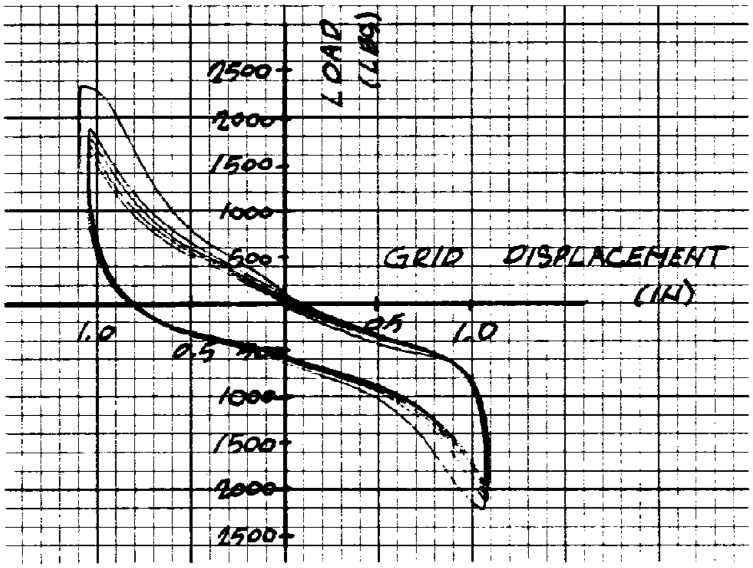


TEST NO. A-6
PEAK COMMAND DISPLACEMENT = ±1 INCH
FREQUENCY = 0.5 HZ.

FIGURE 3: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-3, A-6
LOAD VS. DISPLACEMENT CURVES

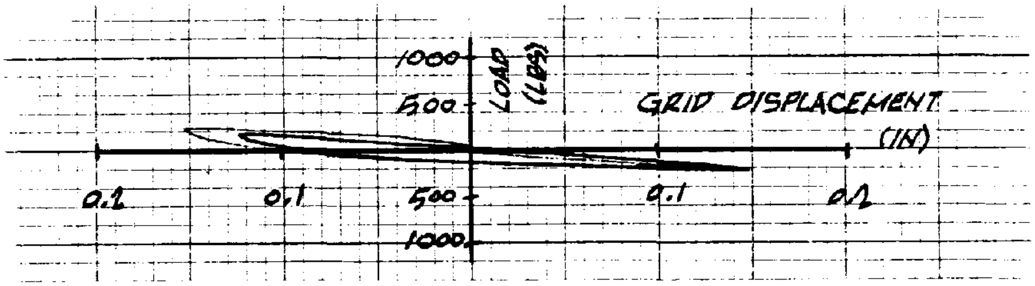


TEST NO. A-7
PEAK COMMAND DISPLACEMENT = ±1-1/4 INCHES
FREQUENCY = 0.5 HZ.

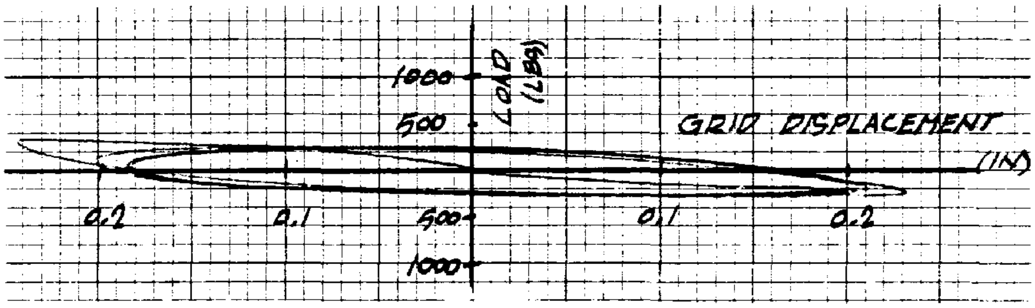


TEST NO. A-8
PEAK COMMAND DISPLACEMENT = ±1-1/2 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 4: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-7, A-8
LOAD VS. DISPLACEMENT CURVES

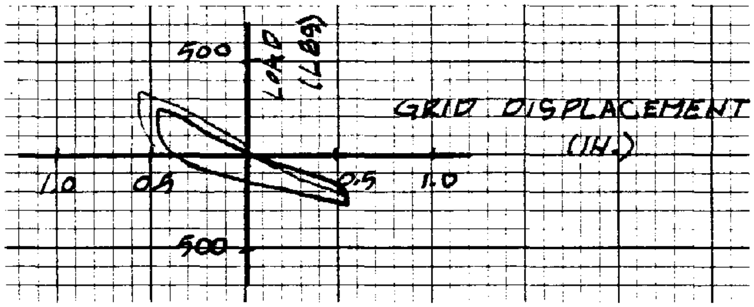


TEST NO. C-2
PEAK COMMAND DISPLACEMENT = ±1/4 INCH
FREQUENCY = 1.0 HZ.

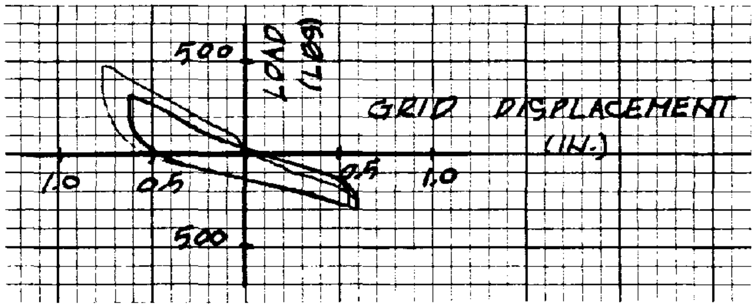


TEST NO. C-3
PEAK COMMAND DISPLACEMENT = ±3/8 INCH
FREQUENCY = 1.0 HZ.

FIGURE 5: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-2, C-3
LOAD VS. DISPLACEMENT CURVES

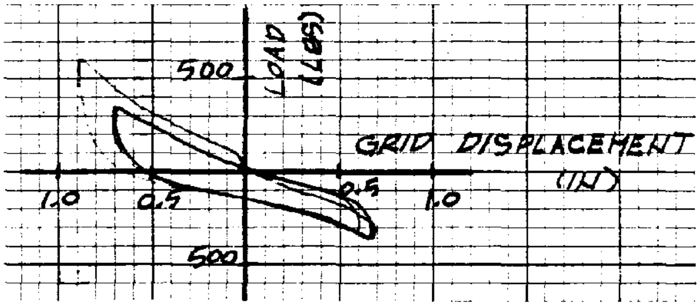


TEST NO. C-5
PEAK COMMAND DISPLACEMENT = ±3/4 INCH
FREQUENCY = 1.0 HZ.

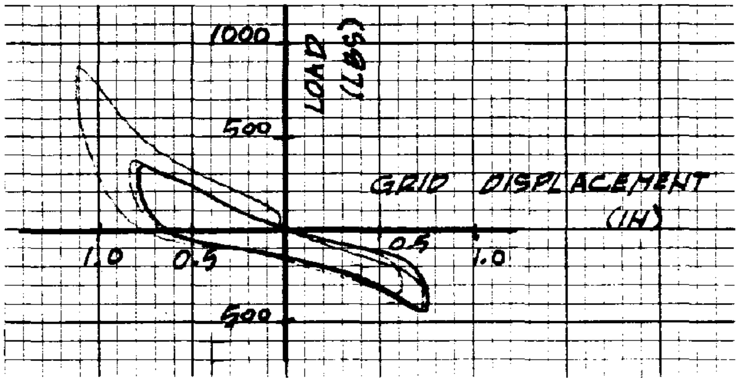


TEST NO. C-6
PEAK COMMAND DISPLACEMENT = ±1 INCH
FREQUENCY = 1.0 HZ.

FIGURE 6: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-5, C-6
LOAD VS. DISPLACEMENT CURVES

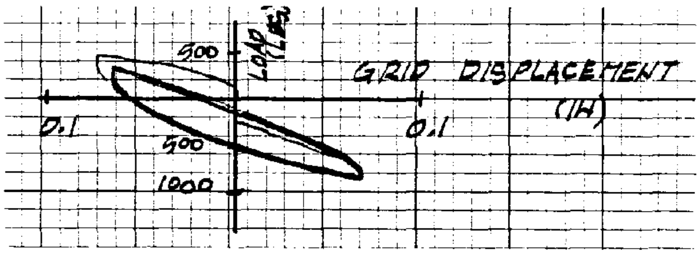


TEST NO. C-7
PEAK COMMAND DISPLACEMENT = ±1-1/4 INCHES
FREQUENCY = 1.0 HZ.

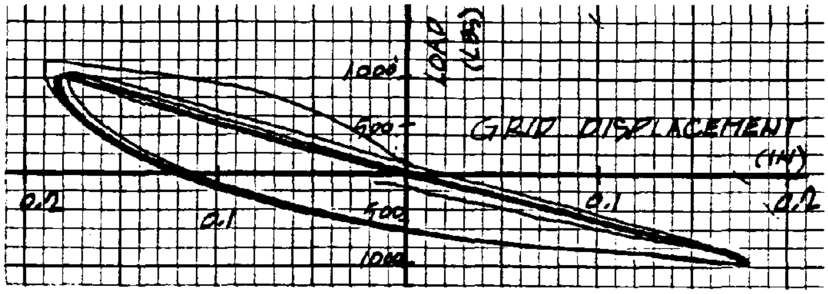


TEST NO. C-8
PEAK COMMAND DISPLACEMENT = ±1-1/2 INCHES
FREQUENCY = 1.0 HZ.

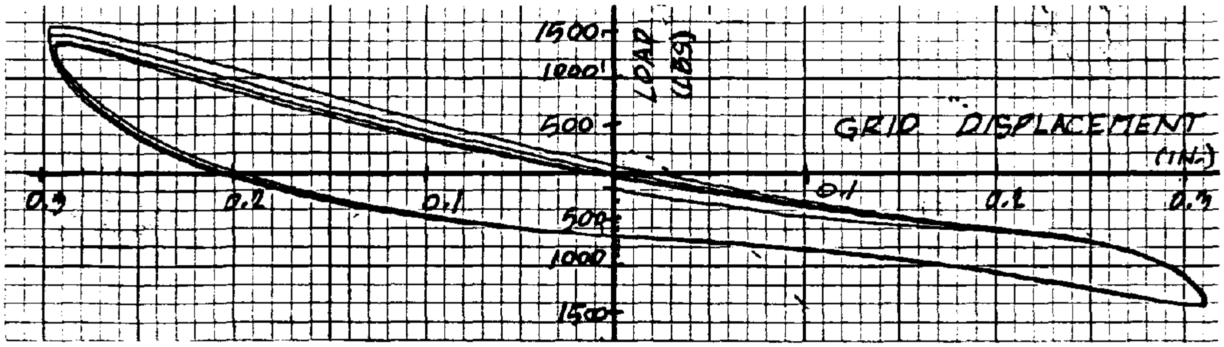
FIGURE 7: TEST SPECIMEN PD3-V RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. C-7, C-8
LOAD VS. DISPLACEMENT CURVES



TEST NO. A-1
PEAK COMMAND DISPLACEMENT = ±1/8 INCH
FREQUENCY = 0.5 HZ.

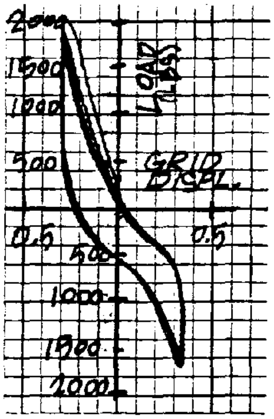


TEST NO. A-2
PEAK COMMAND DISPLACEMENT = ±1/4 INCH
FREQUENCY = 0.5 HZ.

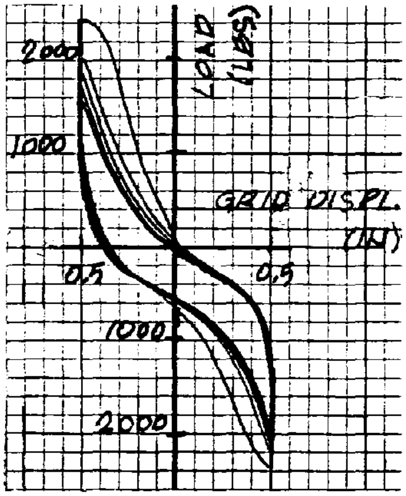


TEST NO. A-3
PEAK COMMAND DISPLACEMENT = ±3/8 INCH
FREQUENCY = 0.5 HZ.

FIGURE 8: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. A-1, A-2, A-3
LOAD VS. DISPLACEMENT CURVES

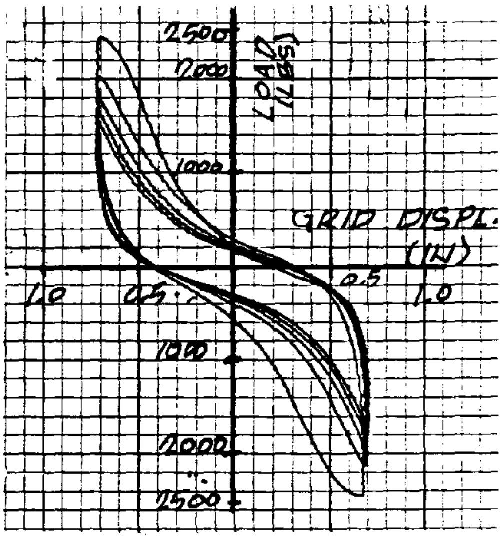


TEST NO. A-4
PEAK COMMAND DISPLACEMENT = ±1/2 INCH
FREQUENCY = 0.5 HZ.

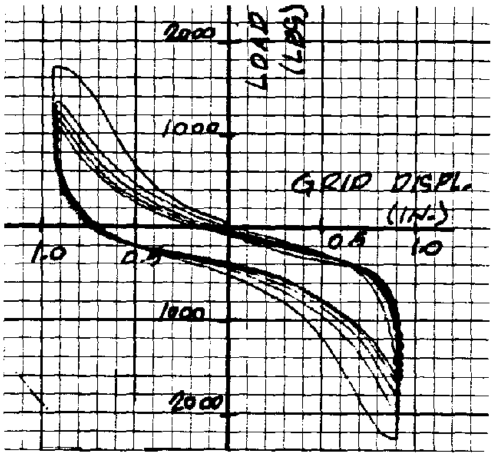


TEST NO. A-5
PEAK COMMAND DISPLACEMENT = ±3/4 INCH
FREQUENCY = 0.5 HZ.

FIGURE 9: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. A-4, A-5
LOAD VS. DISPLACEMENT CURVES

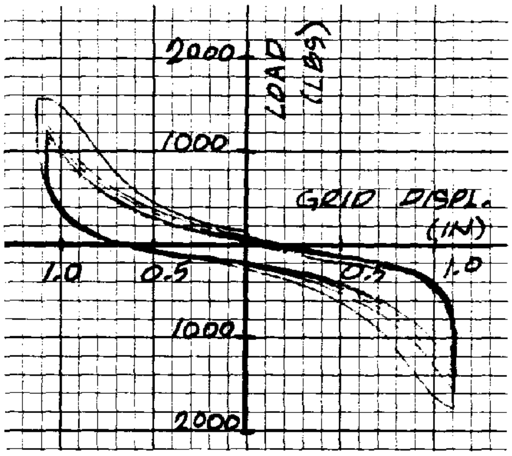


TEST NO. A-6
PEAK COMMAND DISPLACEMENT = ±1 INCH
FREQUENCY = 0.5 HZ.

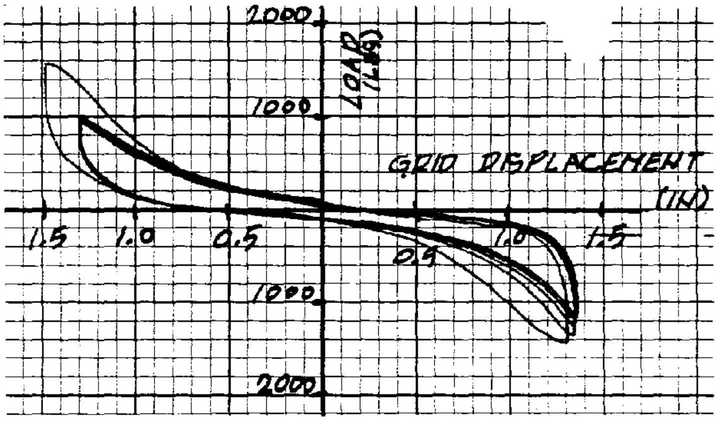


TEST NO. A-7
PEAK COMMAND DISPLACEMENT = ±1-1/4 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 10: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. A-6, A-7
LOAD VS. DISPLACEMENT CURVES

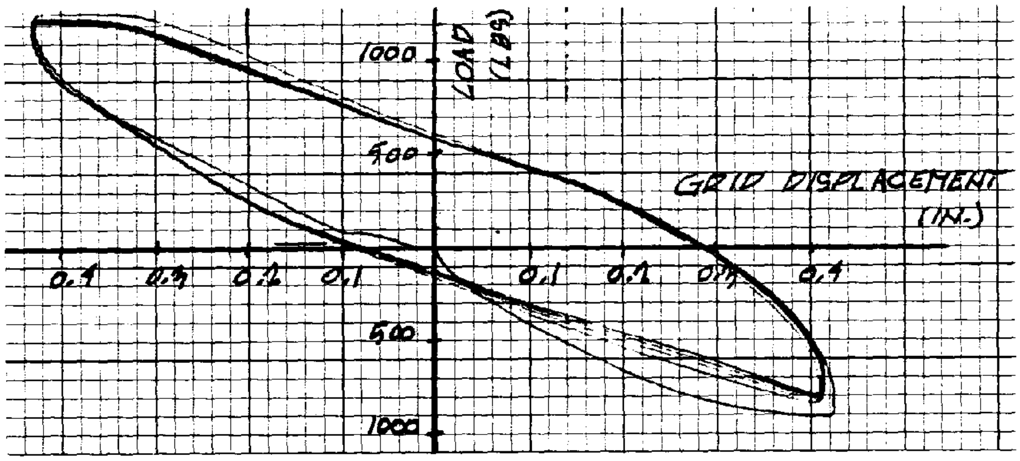


TEST NO. A-8
PEAK COMMAND DISPLACEMENT = ±1-1/2 INCHES
FREQUENCY = 0.5 HZ.

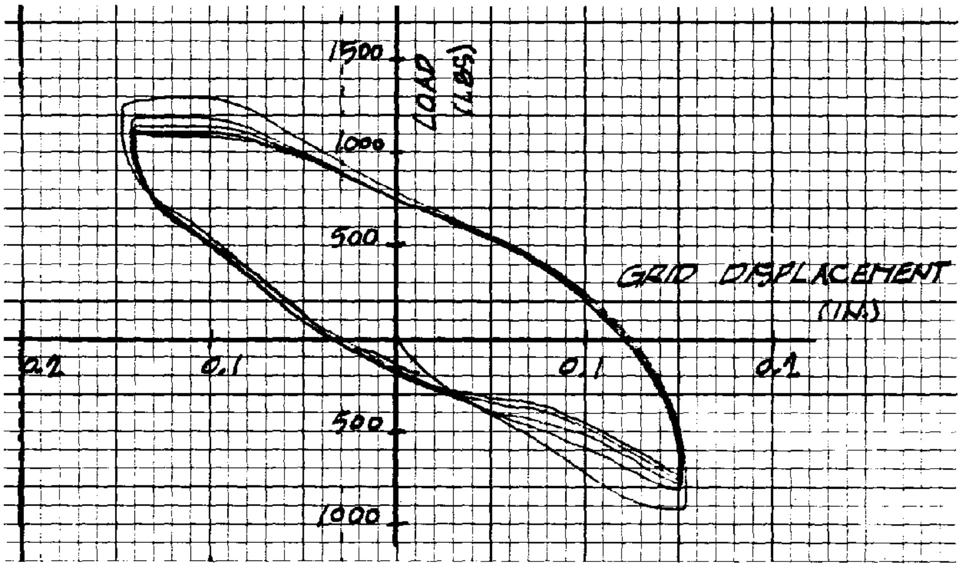


TEST NO. A-9
PEAK COMMAND DISPLACEMENT = ±2 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 11: TEST SPECIMEN PD3-H
BLOCK CYCLIC TEST
TEST NO. A-8, A-9
LOAD VS. DISPLACEMENT CURVES

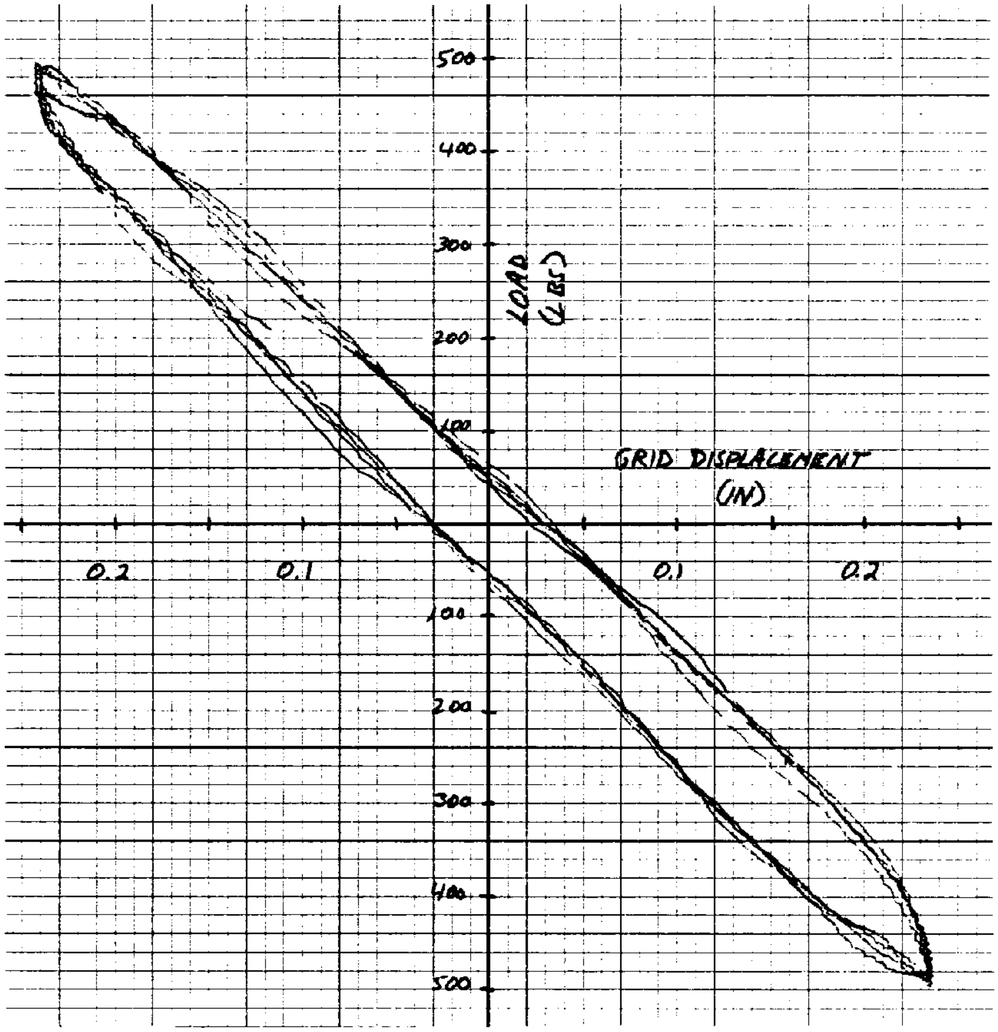


TEST NO. A-3
PEAK COMMAND DISPLACEMENT = ±3/8 INCH
FREQUENCY = 0.5 HZ.



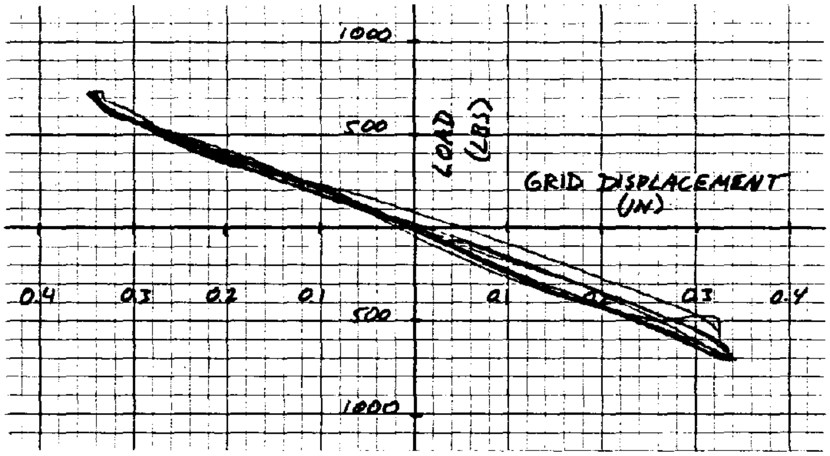
TEST NO. A-4
PEAK COMMAND DISPLACEMENT = ±1/2 INCH
FREQUENCY = 0.5 HZ.

FIGURE 12: TEST SPECIMEN PD-4 RUN NO. 1
BLOCK CYCLIC TEST
TEST NO. A-3, A-4
LOAD VS. DISPLACEMENT CURVES



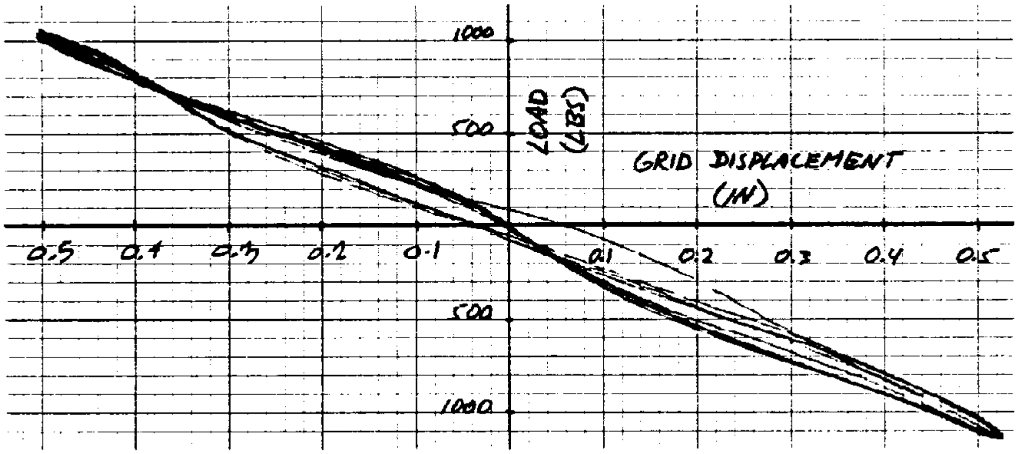
TEST NO. A-3
PEAK COMMAND DISPLACEMENT = ±3/8 INCH
FREQUENCY = 0.5 HZ.

FIGURE 13: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-3
LOAD VS. DISPLACEMENT CURVES

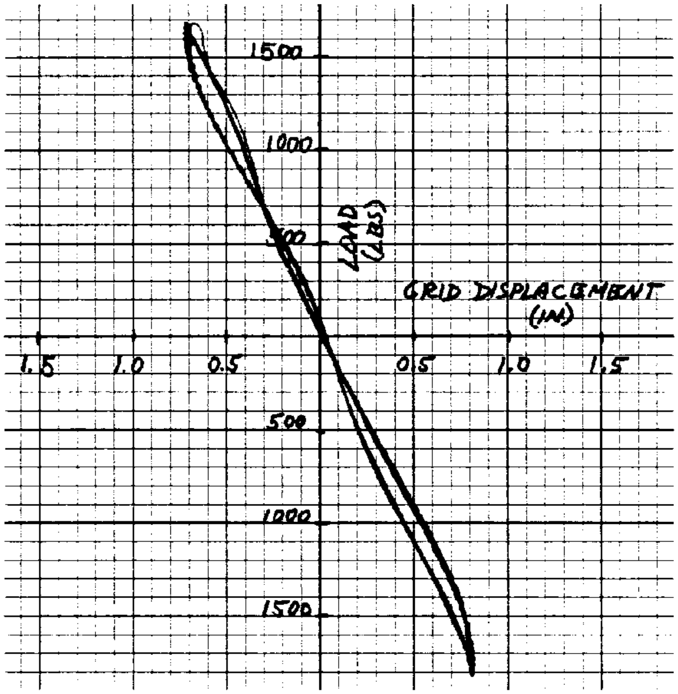


TEST NO. A-4
PEAK COMMAND DISPLACEMENT = ±1/2 INCH
FREQUENCY = 0.5 HZ.

FIGURE 14: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-4
LOAD VS. DISPLACEMENT CURVES

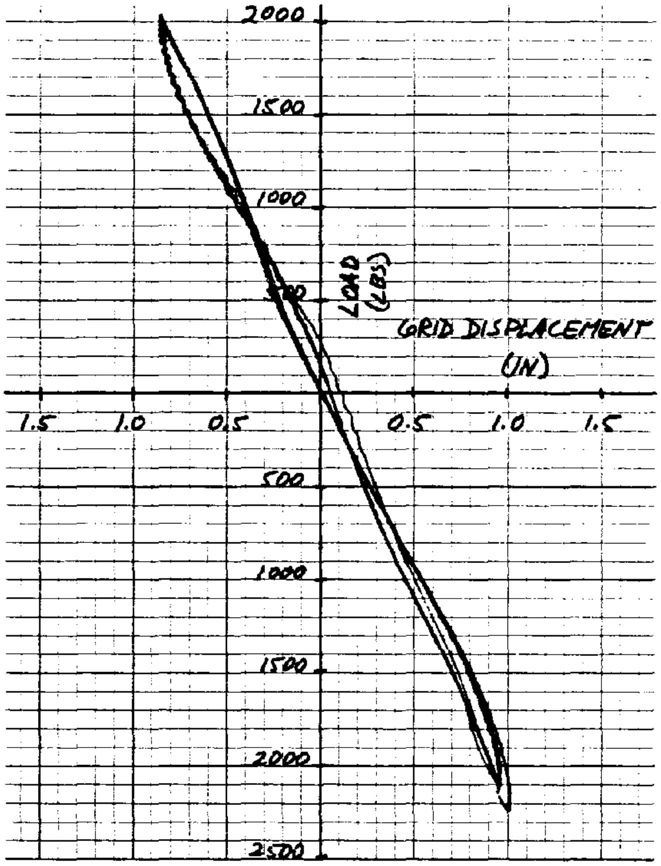


TEST NO. A-5
PEAK COMMAND DISPLACEMENT = ±3/4 INCH
FREQUENCY = 0.5 HZ.



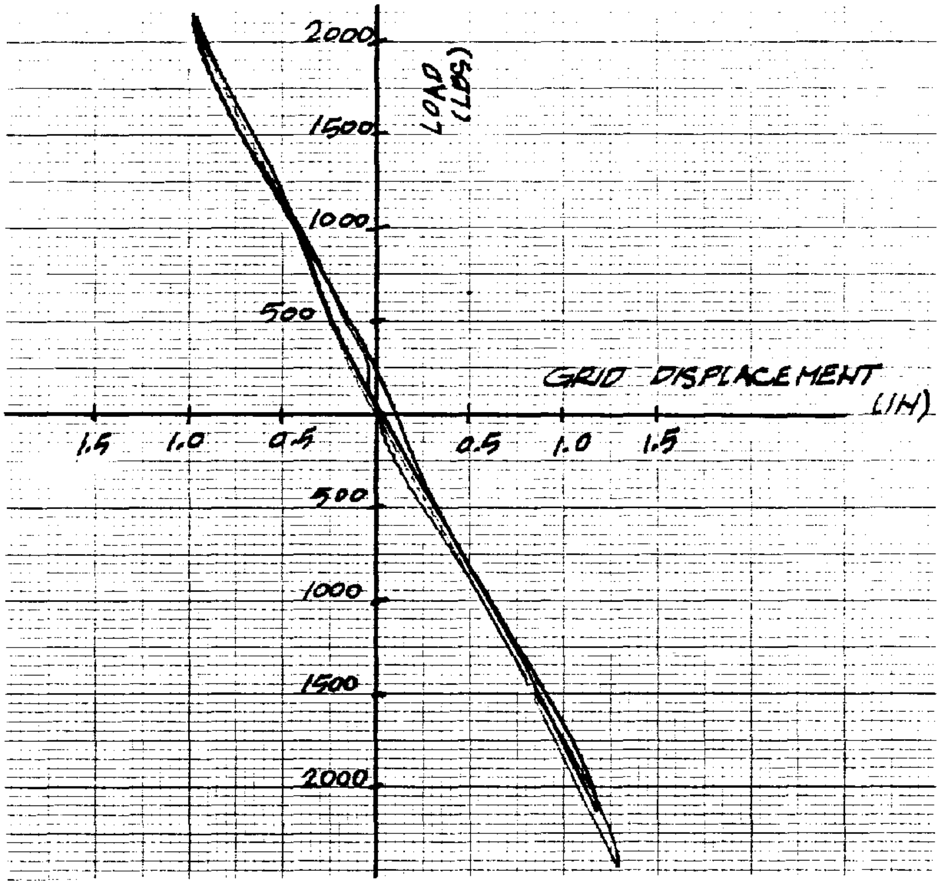
TEST NO. A-7
PEAK COMMAND DISPLACEMENT = ±1-1/4 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 15: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-5, A-7
LOAD VS. DISPLACEMENT CURVES



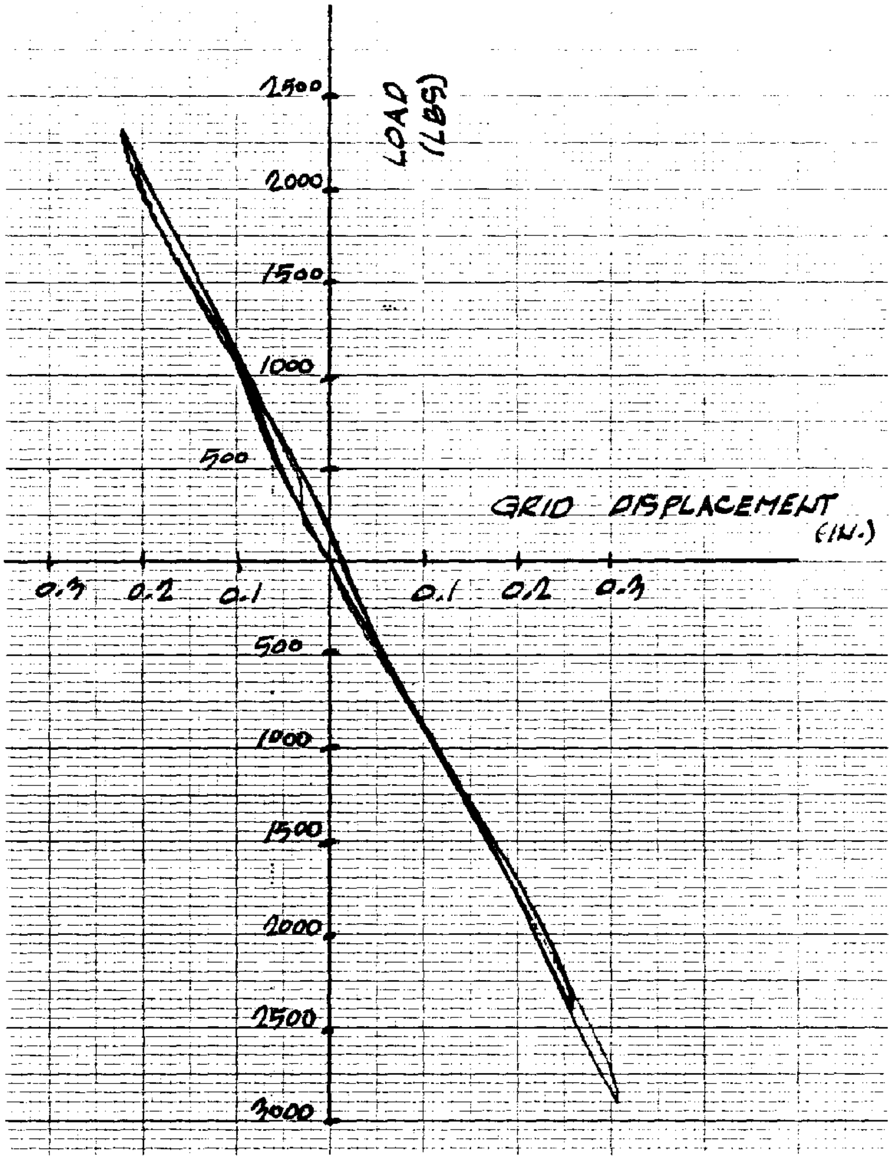
TEST NO. A-8
PEAK COMMAND DISPLACEMENT = ±1-1/2 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 16: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-8
LOAD VS. DISPLACEMENT CURVES



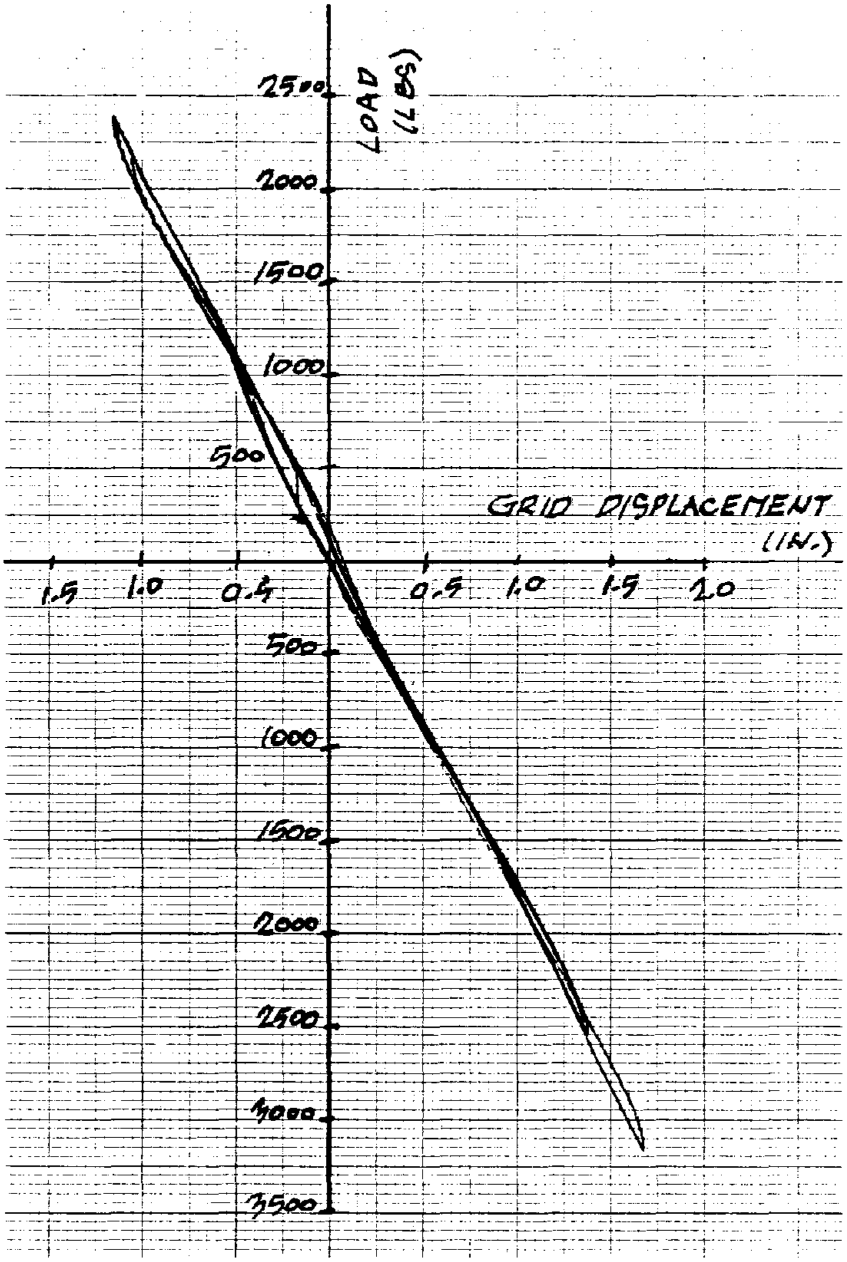
TEST NO. A-9
PEAK COMMAND DISPLACEMENT = ±2 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 17: TEST SPECIMEN PD-4 RUN NO.
BLOCK CYCLIC TEST
TEST NO. A-9
LOAD VS. DISPLACEMENT CURVES



TEST NO. A-10
PEAK COMMAND DISPLACEMENT = ±2-1/2 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 18: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-10
LOAD VS. DISPLACEMENT CURVES



TEST NO. A-11
PEAK COMMAND DISPLACEMENT = ±2.8 INCHES
FREQUENCY = 0.5 HZ.

FIGURE 19: TEST SPECIMEN PD-4 RUN NO. 2
BLOCK CYCLIC TEST
TEST NO. A-11
LOAD VS. DISPLACEMENT CURVES

APPENDIX E

PHOTOGRAPHS - BEHAVIOR OF PARTITION TEST SPECIMENS

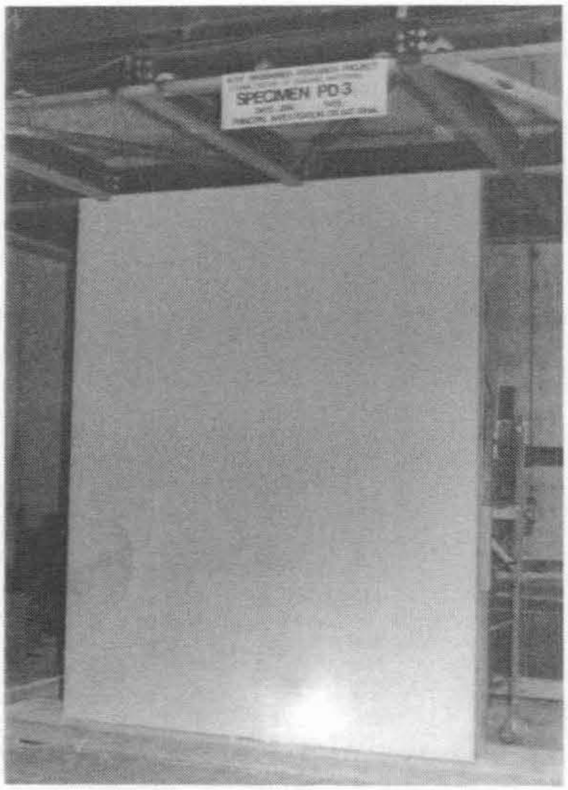


Figure 1: Specimen PD3-V Run No. 1
Before Test

Figure 1A: Specimen PD3-V Run No. 1
Installation in Progress

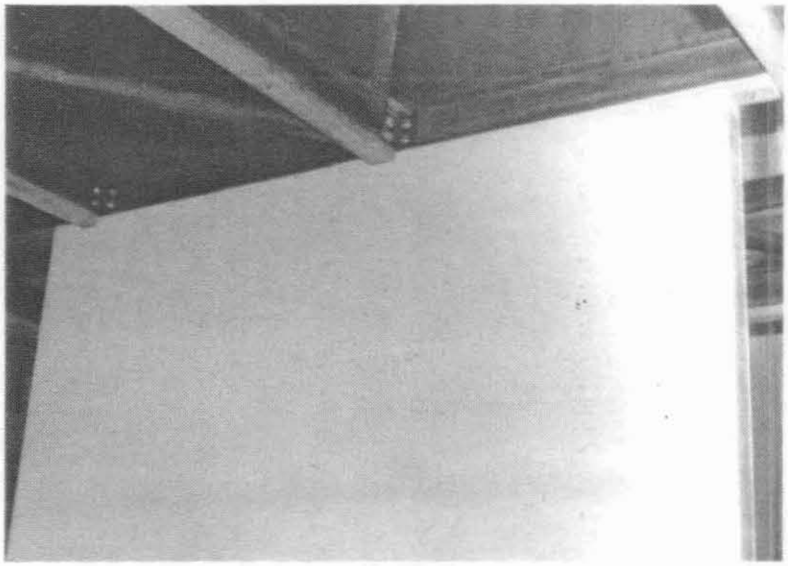


Figure 2: Specimen PD3-V Run No. 1
Close-Up Showing Nail Layout

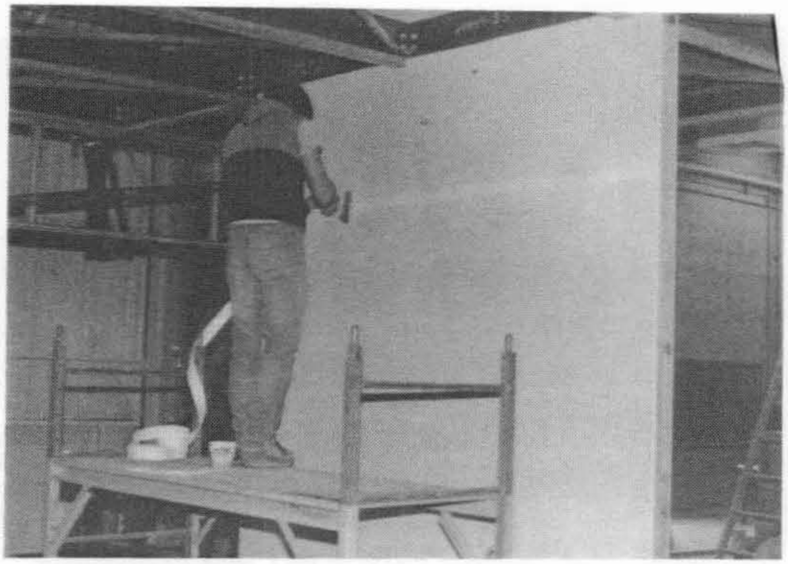


Figure 3: Specimen PD3-V Run No. 1
Installation in Progress

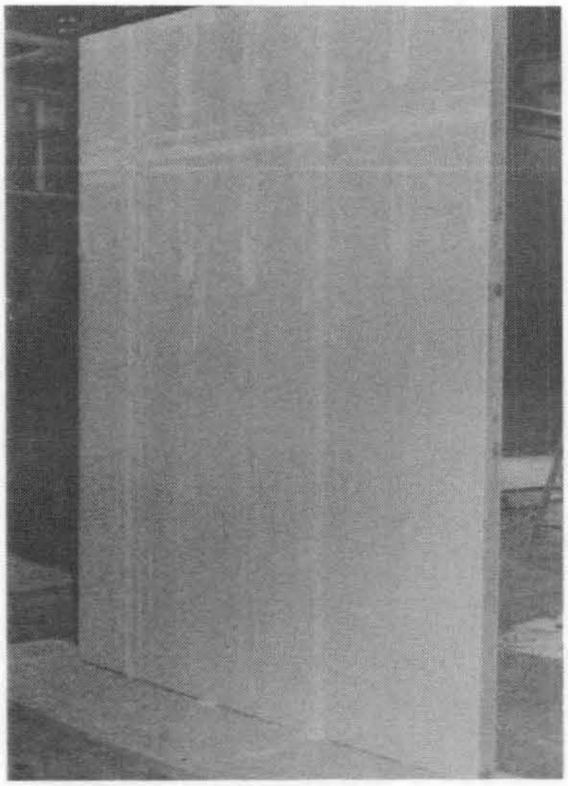


Figure 4: Specimen PD3-V Run No. 1
Finished Specimen

Figure 4A: Specimen PD3-V Run No. 1
Test No. A-2, Frequency = 0.5 Hz
Peak Command Displacement ±1/4 Inch
Damage - Loosening of Bottom Line of Nails

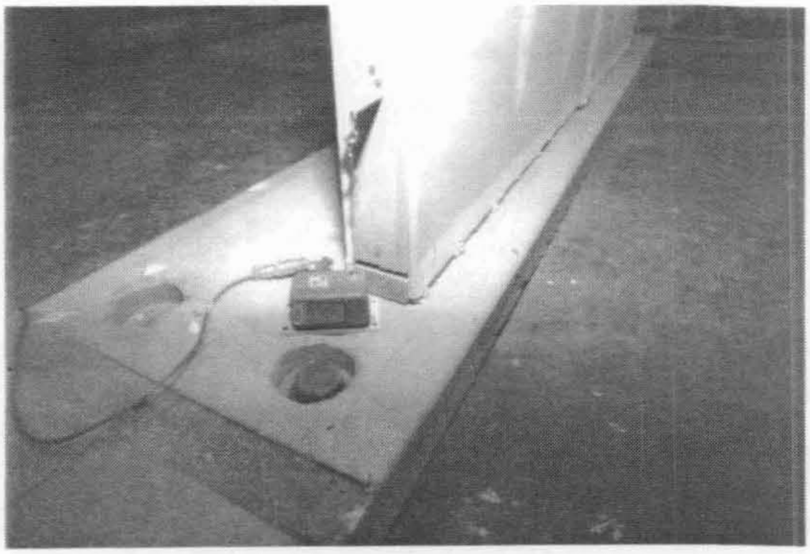


Figure 5: Specimen PD3-V Run No. 1
Test No. A-4, Frequency = 0.5 Hz
Peak Command Displacement = ±1/2 Inch
Typical Damage @ Bottom Nailing and
Uplift of Edge Stud from Sill Plate.
Also Shown is Houston Scientific
Vertical Displacement Transducer

Figure 6: Specimen PD3-V Run No. 1
Test No. A-3, Frequency = 0.5 Hz
Peak Command Displacement = ±3/8 Inch
Typical Damage @ Bottom Edge Nailing
Crumbling of Gypboard Around Nail Heads

Figure 7: Specimen PD3-V Run No. 2
Before Test

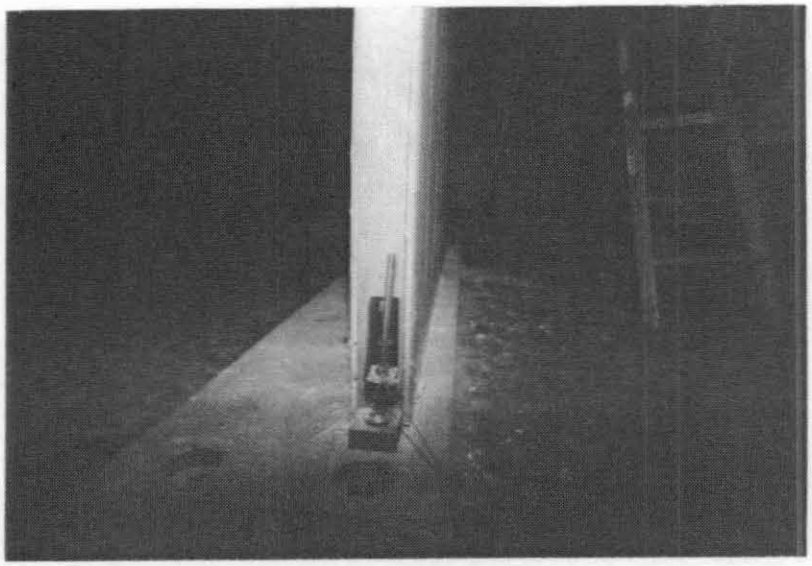


Figure 8: Specimen PD3-V Run No. 2
Test No. A-3, Frequency = 0.5 Hz
Peak Command Displacement = ±3/8 Inch
Typical Damage - Separation of Gypboard from Wood-Studs

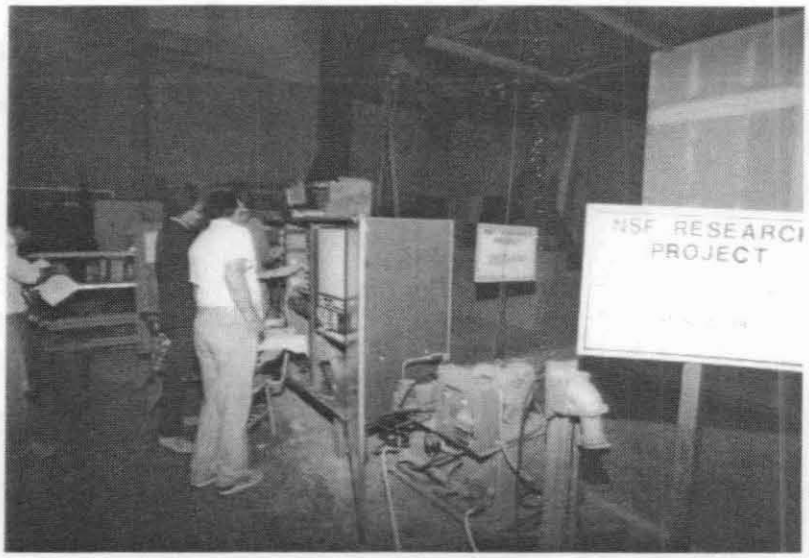


Figure 9: Specimen PD3-V Run No. 2
Testing in Progress

Figure 10: Specimen PD3-V Run No. 2
Simpson HD-5 Holdown @ South End
Typical Damage Consists of Crumbling
of Gypboard @ End Studs Through
Working of Nails

Figure 11: Specimen PD3-V Run No. 2
Close-Up of Simpson HD-5 Holdown
Including Strain-Gage Mounted on Sleeve

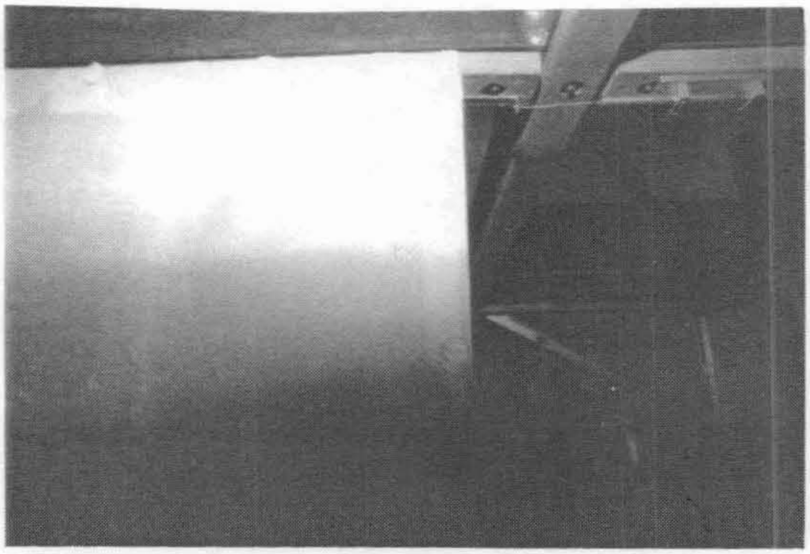


Figure 12: Specimen PD3-V Run No. 2
Test No. A-3, Frequency = 0.5 Hz
Peak Command Displacement = ±3/8 Inch
Popping of Nail-Heads @ Top Plate and Edge Studs

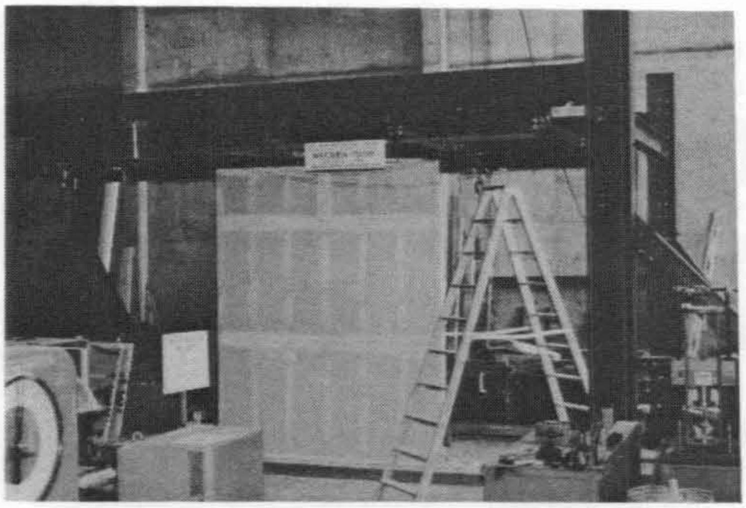


Figure 13: Specimen PD3-H
Overall View

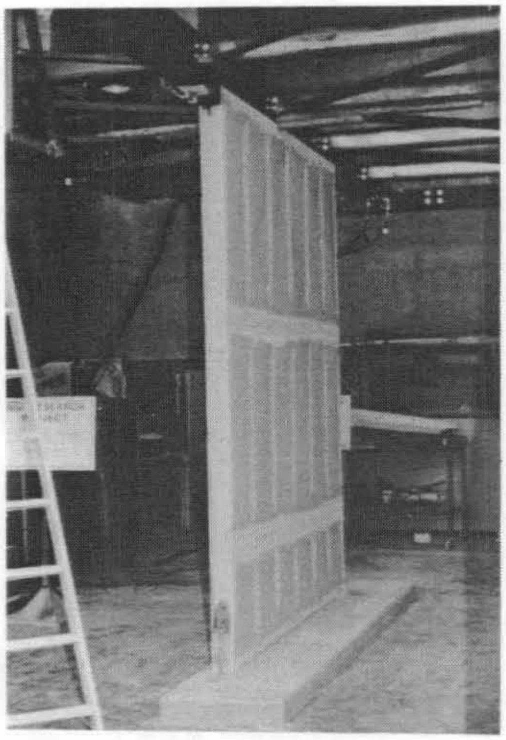


Figure 14: Specimen PD3-H
Overall View - Before Test

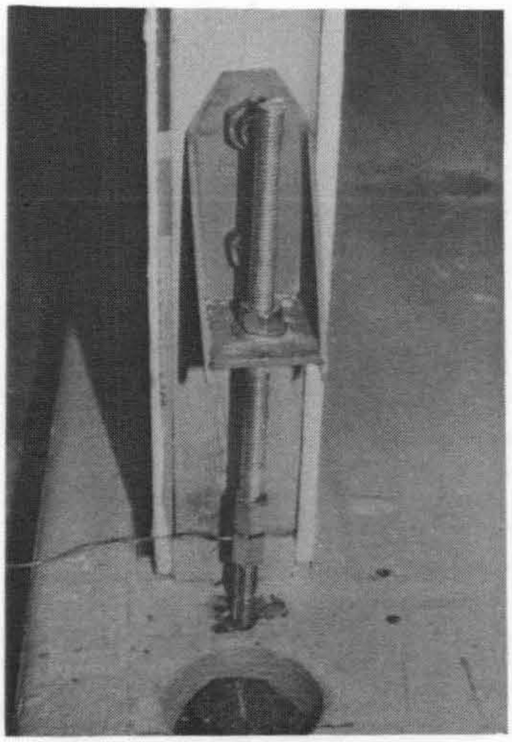


Figure 15: Specimen PD3-H
Before Test - Close-Up View of Holdown

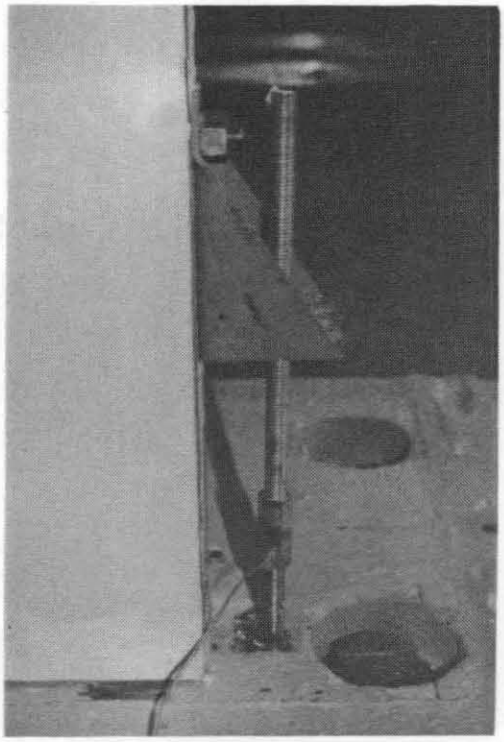


Figure 16: Specimen PD3-H
Before Test - Close-Up View of Holdown

Figure 17: Specimen PD3-H
Rear View of Bottom Lower Left - Close-Up of Holdown

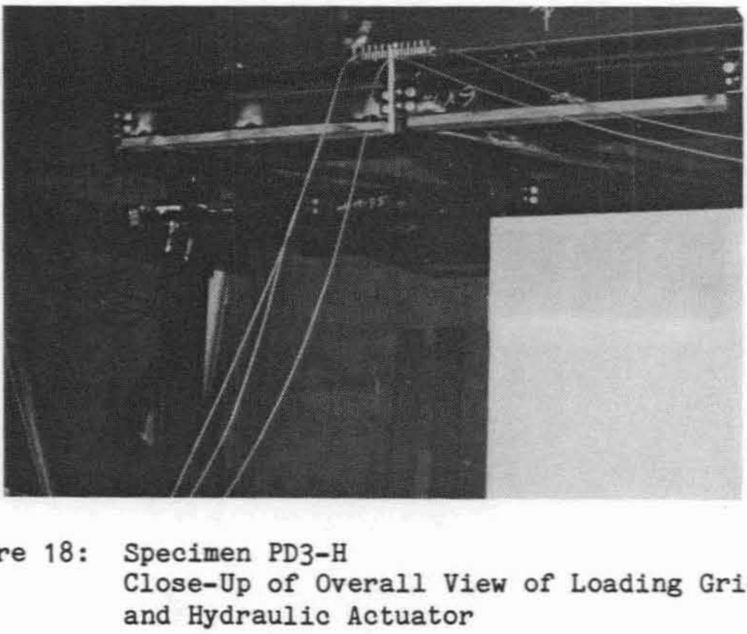


Figure 18: Specimen PD3-H
Close-Up of Overall View of Loading Grid
and Hydraulic Actuator

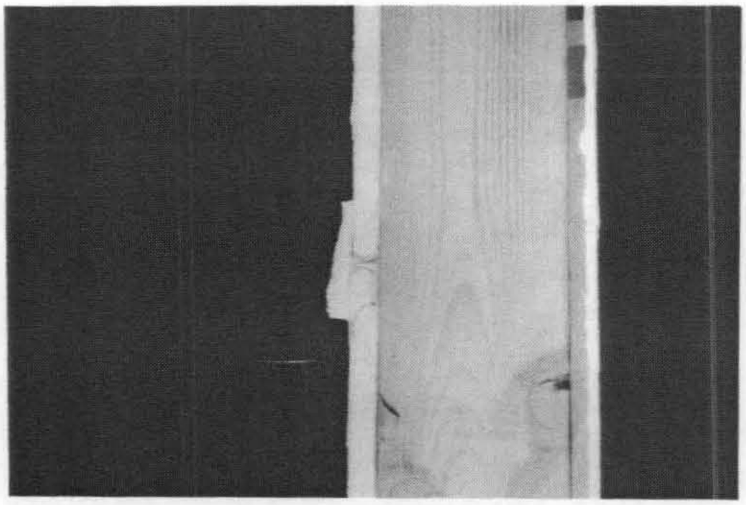


Figure 19: Specimen PD3-H
End View of Damage of Taped Joint of Gypboard Panels
Test No. A-5, Frequency = 0.5 Hz
Peak Command Displacement = ±3/4 Inch

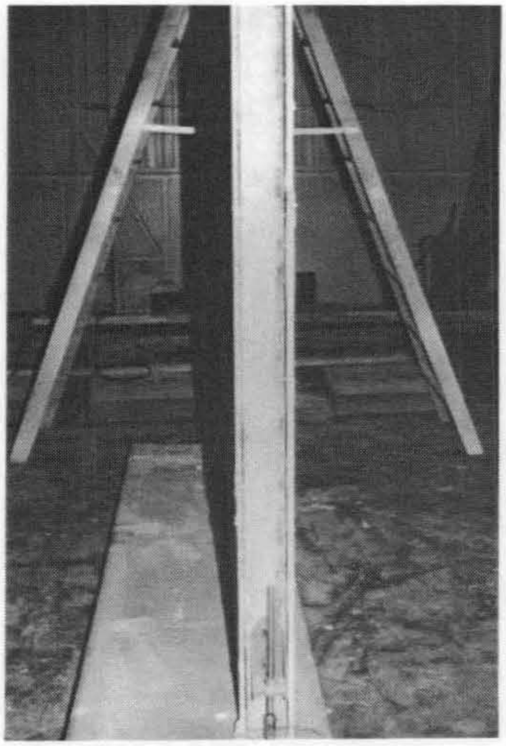


Figure 20: Specimen PD3-H
Typical Separation Between Gypboard and Wood-Stud Framing

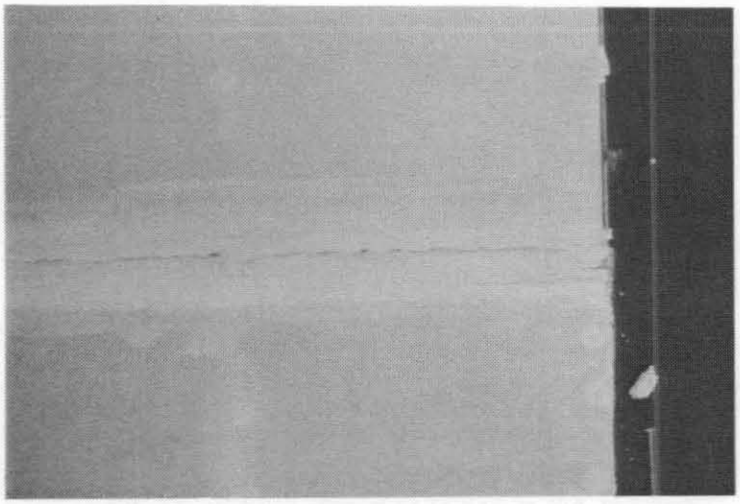


Figure 21: Specimen PD3-H
Typical Damage of Horizontal Taped Joint
of Gypboard Panels
Test No. A-7, Frequency = 0.5 Hz
Peak Command Displacement = ±1-1/4 Inches

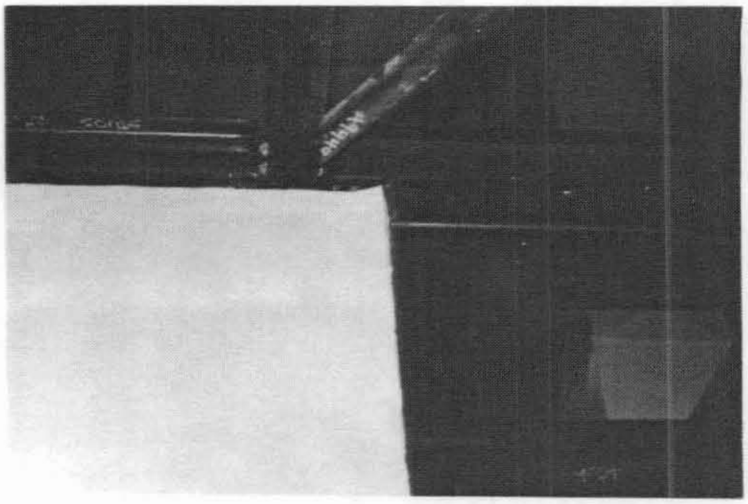


Figure 22: Specimen PD3-H
Local Crushing of Gypboard @ Steel Tubing

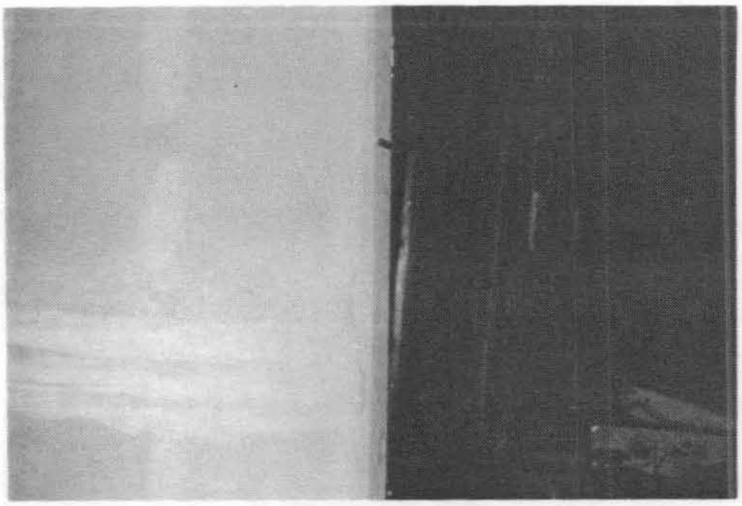


Figure 23: Specimen PD3-H
Damage - Front View of Separation (Approx. 3/4 Inch) Between Gypboard and End-Studs

Figure 24: Specimen PD3-H
Damage @ Left Holdown and @ Sill-Plate - Separation Between Gypboard and End Studs and Crumbling of Gypboard Around Nail Heads @ Sill-Plate

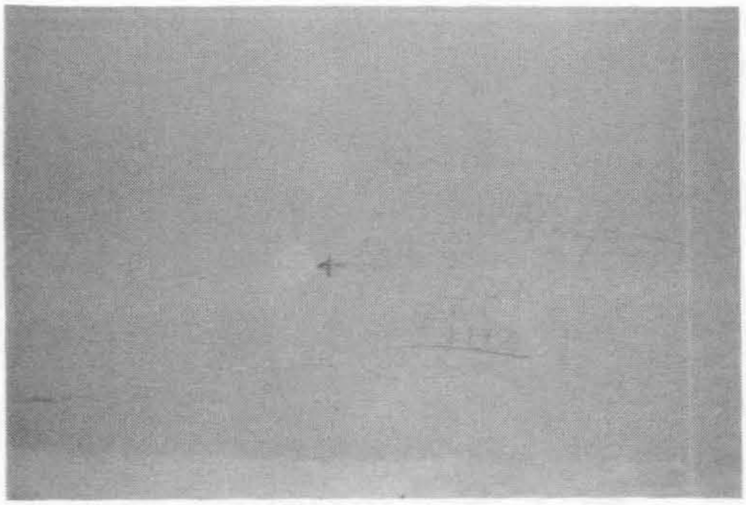


Figure 25: Specimen PD3-H
Typical Damage - Nail-Pop in Gypboard
Test No. C-11, Frequency = 1.0 Hz
Peak Command Displacement = ±0.9 Inch

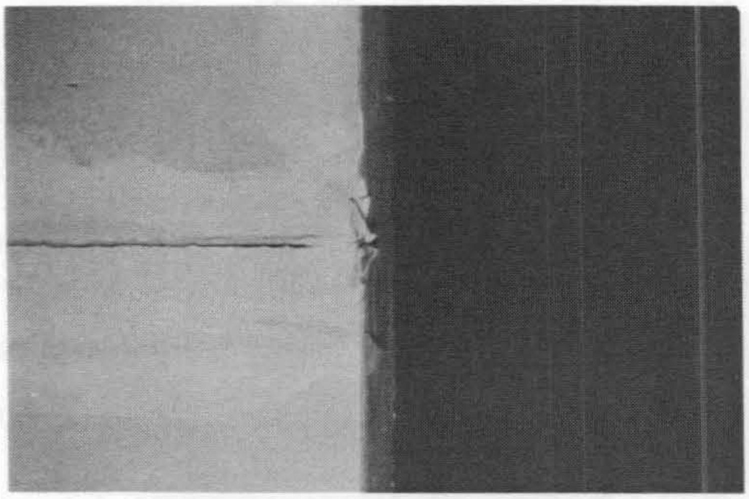


Figure 26: Specimen PD3-H
Typical Damage - Separation Between Gypboard and Stud Framing, Failure of Taped Joint of Gypboard Panels
Test No. A-10, Frequency = 0.5 Hz
Peak Command Displacement = ±2-1/2 Inches

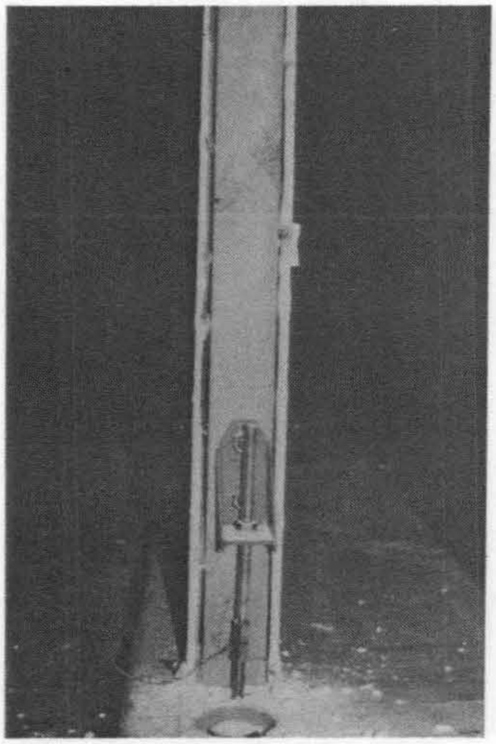


Figure 27: Specimen PD3-H
Typical Damage @ North End - Separation Between Gypboard and End Stud, Crumbling of Gypboard @ Edge Nailing and Damage of Gypboard @ Taped-Joint Between Panels

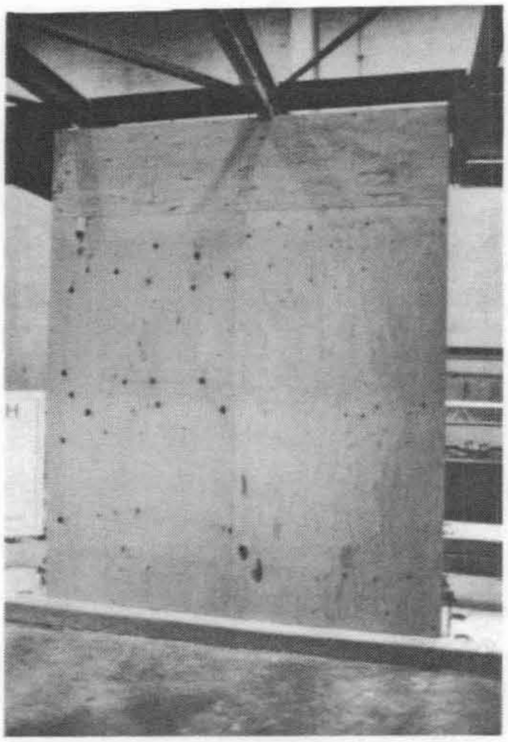


Figure 28: Specimen PD-4 Run No. 1
Front View - 3/8 Inch Plywood and Holdown Before Test

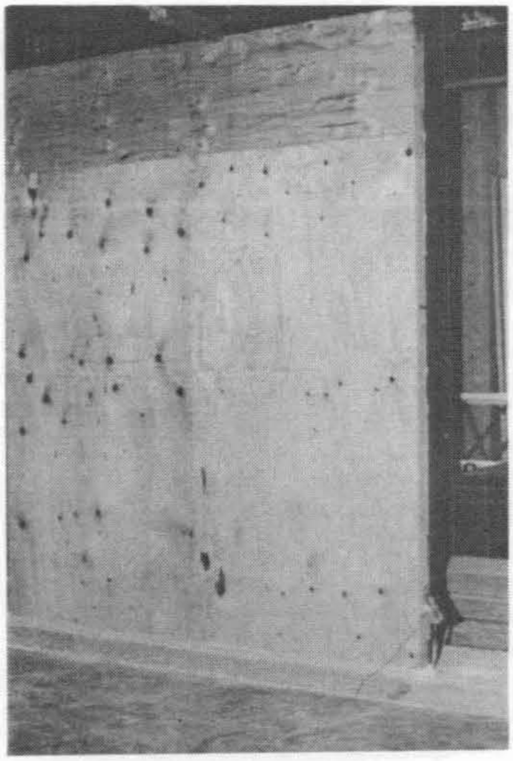


Figure 29: Specimen PD-4 Run No. 1
Front View - 3/8 Inch Plywood and Holdown Before Test

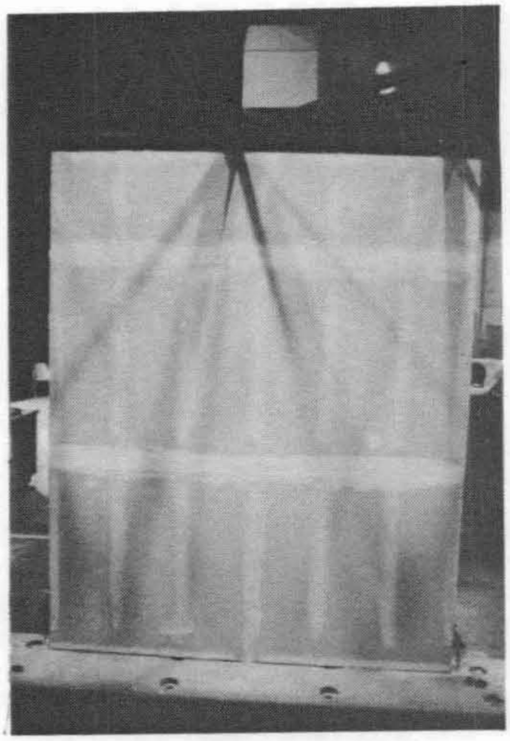


Figure 30: Specimen PD-4 Run No. 1
Rear View - 1/2 Inch Gypboard Panels Applied Horizontally

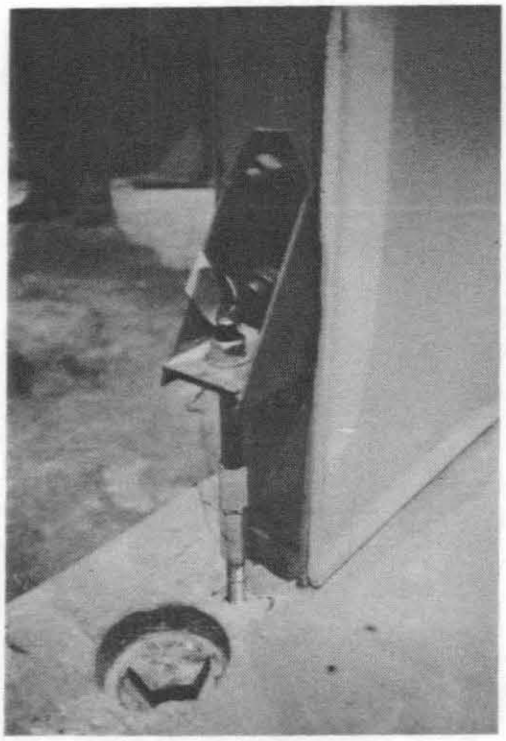


Figure 31: Specimen PD-4 Run No. 1
Close-Up View of Holdown @ North End Before Test

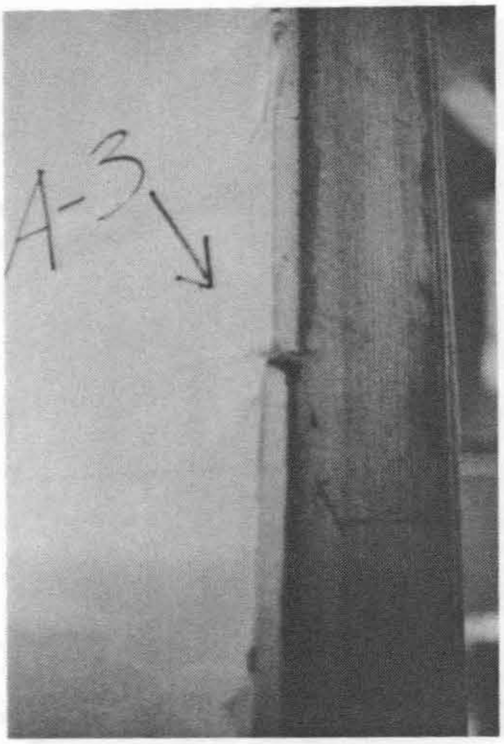


Figure 32: Specimen PD-4 Run No. 1
Initial Slippage (±1/8-3/16 Inch) @ Taped Joint in Gypboard Panels
Test No. A-3, Frequency = 0.5 Hz
Peak Command Displacement = ±3/8 Inch

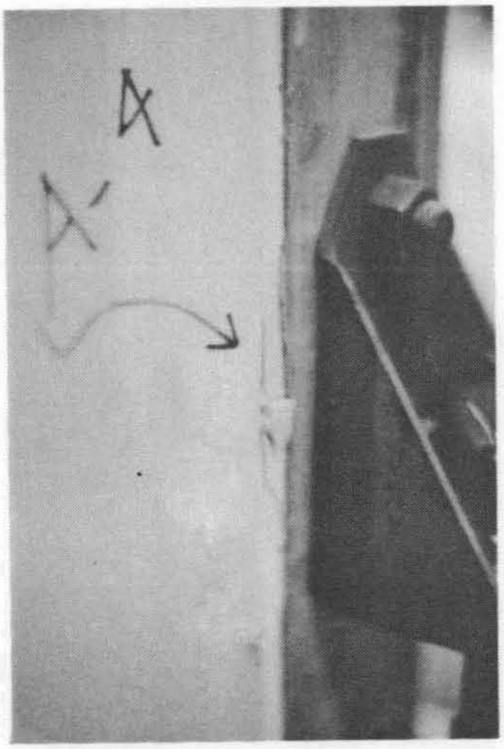


Figure 33: Specimen PD-4 Run No. 1
Initial Damage of Gypboard @ Nail Heads @ South End
Test No. A-4, Frequency = 0.5 Hz
Peak Command Displacement = ±1/2 Inch

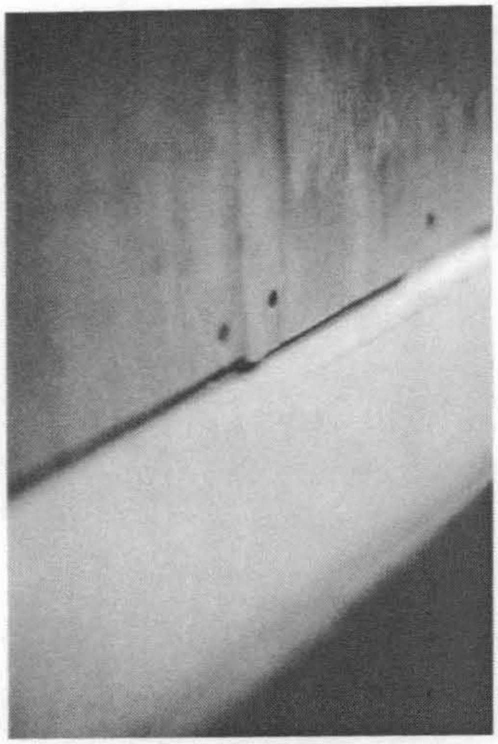


Figure 34: Specimen PD-4 Run No. 1
Slippage (±1/8 Inch) Along Vertical Joint
Between 3/8 Inch Plywood Panels
Test No. A-6, Frequency = 0.5 Hz
Peak Command Displacement = ±1 Inch

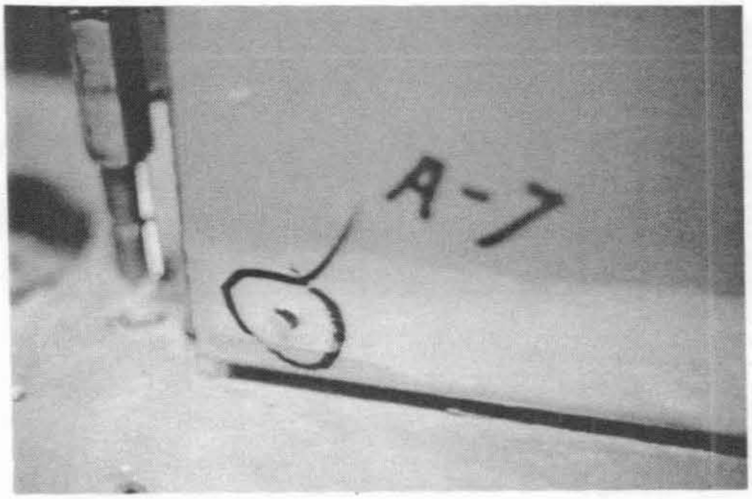


Figure 35: Specimen PD-4 Run No. 1
Nail-Pop in Gypboard @ Sill-Plate
Test No. A-7, Frequency = 0.5 Hz
Peak Command Displacement = ±1-1/4 Inches

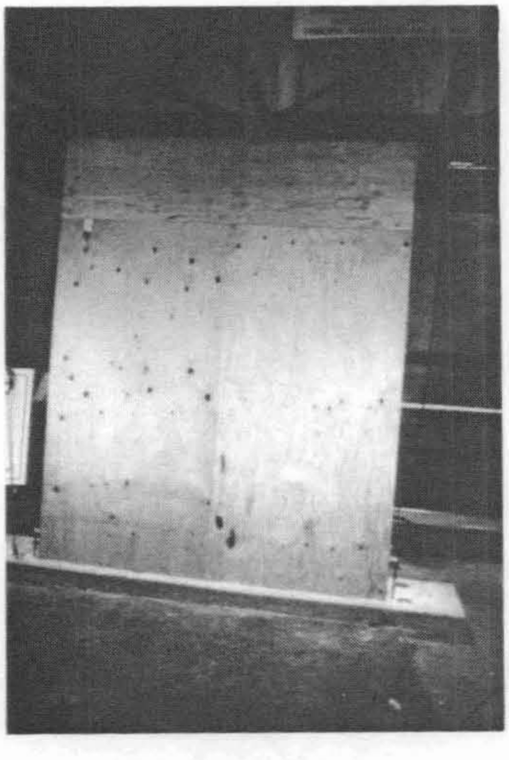


Figure 36: Specimen PD-4 Run No. 2
Overall Front View - Before Test

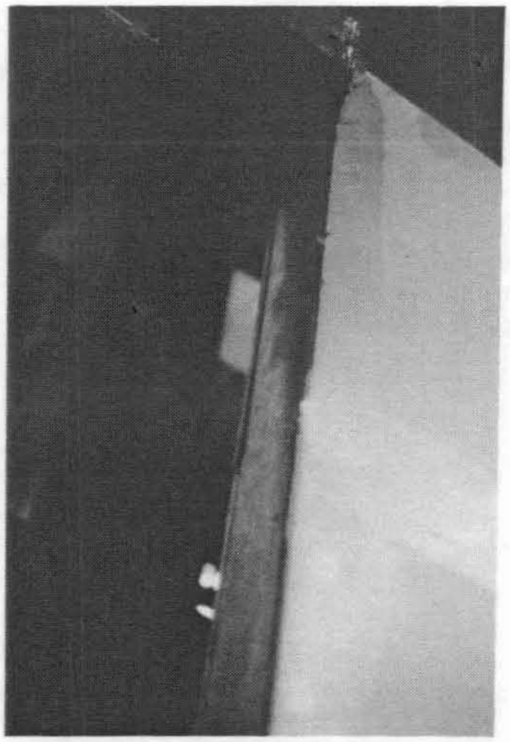


Figure 37: Specimen PD-4 Run No. 2
Initial Slippage Between Facing Panels
Test No. A-4, Frequency = 0.5 Hz
Peak Command Displacement = ±1/2 Inch

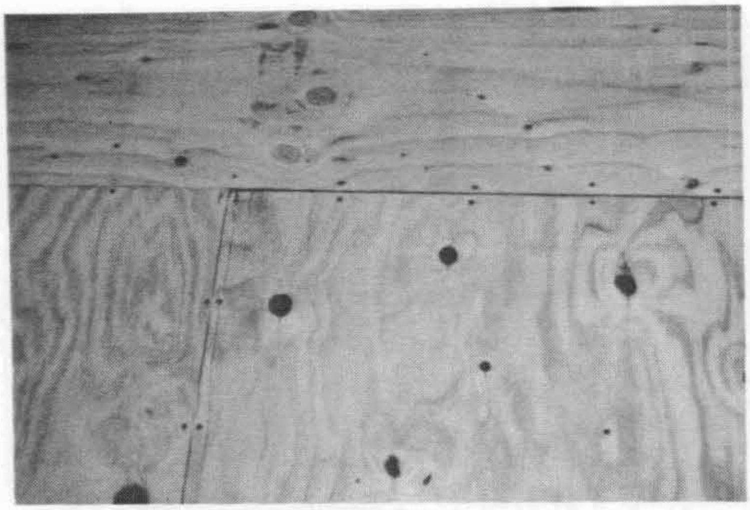


Figure 38: Specimen PD-4 Run No. 2
Opening-Up of Horizontal Joint in 3/8 Inch Plywood
Test No. A-5, Frequency = 0.5 Hz
Peak Command Displacement = ±3/4 Inch

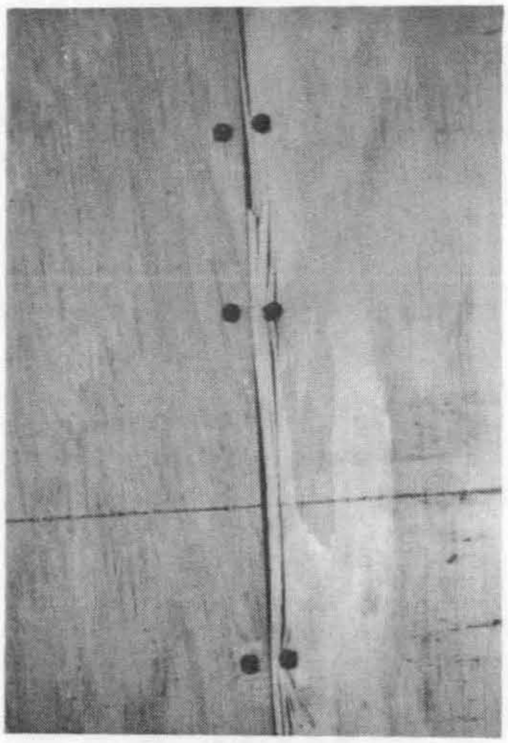


Figure 39: Specimen PD-4 Run No. 2
Damage of 3/8 Inch Plywood @ Nailing on
Vertical Joint Between Plywood Panels
Test No. A-5, Frequency = 0.5 Hz
Peak Command Displacement = ±3/4 Inch

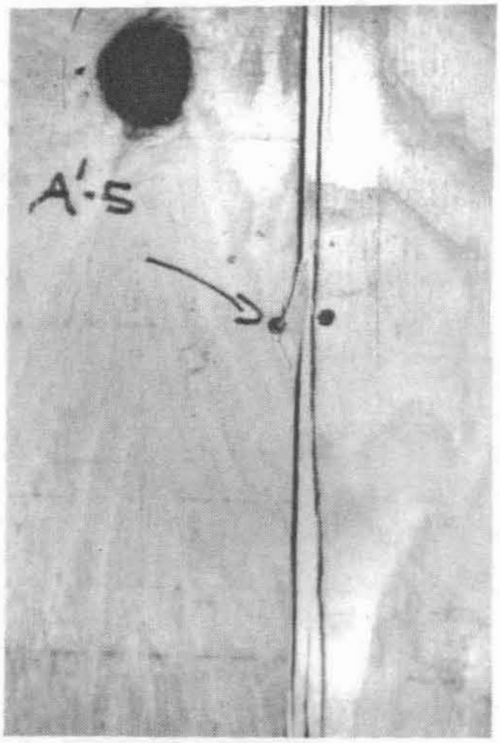


Figure 40: Specimen PD-4 Run No. 2
Damage of 3/8 Inch Plywood @ Nailing on
Vertical Joint Between Plywood Panels
Test No. A-5, Frequency = 0.5 Hz
Peak Command Displacement = ±3/4 Inch

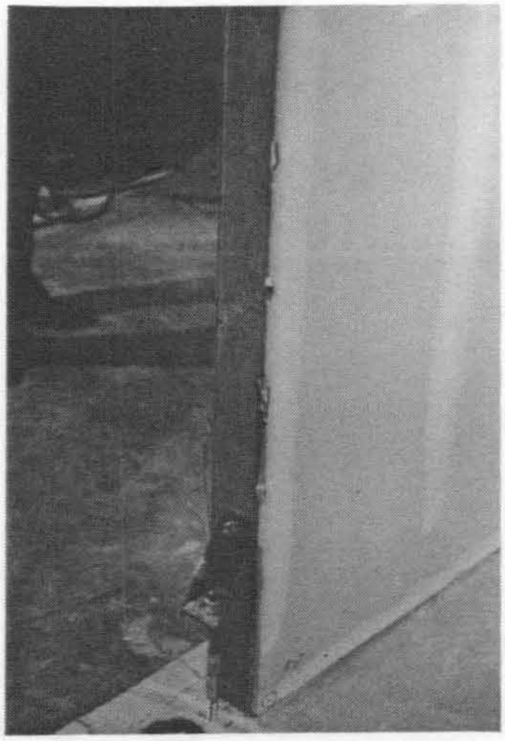


Figure 41: Specimen PD-4 Run No. 2
Popping of Nail-Heads in Gypboard @ End Studs
Test No. A-8, Frequency = 0.5 Hz
Peak Command Displacement = ±1-1/2 Inches

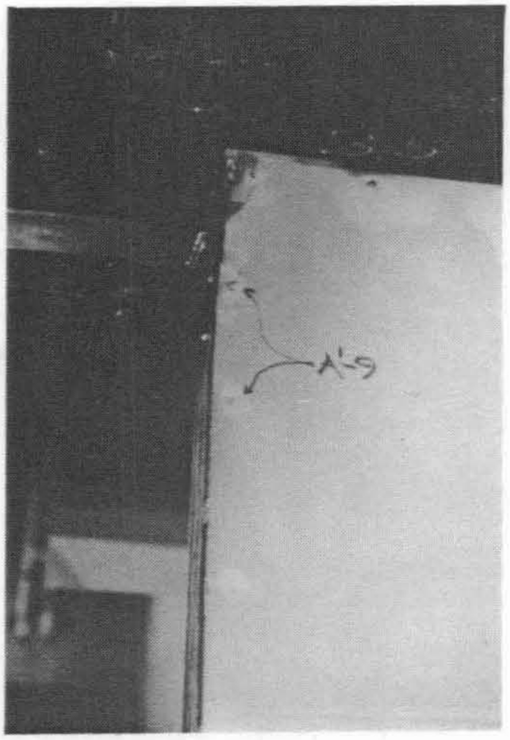


Figure 42: Specimen PD-4 Run No. 2
Popping of Nail-Heads in Gypboard @ Upper Part of the Panel
Test No. A-9, Frequency = 0.5 Hz
Peak Command Displacement = ±2 Inches

Figure 43: Specimen PD-4 Run No. 2
Crumbling of Plywood @ Lower Front Corner
Test No. A-9, A-10, Frequency = 0.5 Hz
Peak Command Displacement = ±2 Inches, ±2-1/2 Inches

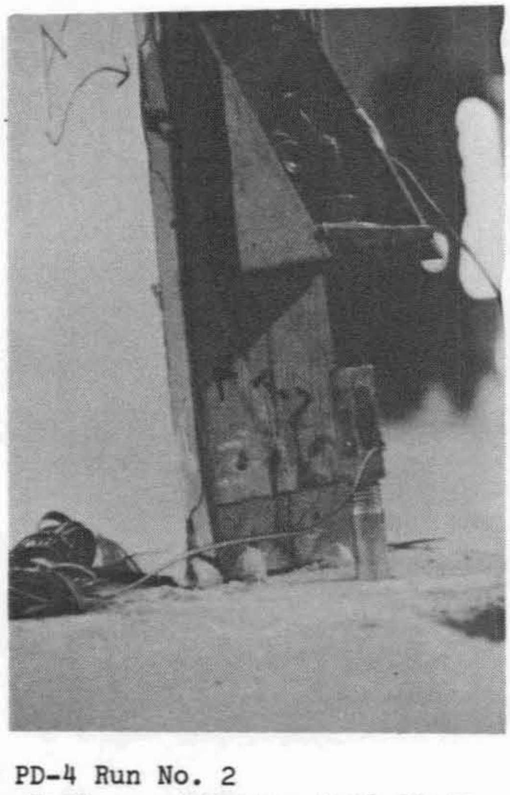


Figure 44: Specimen PD-4 Run No. 2
Splitting Failure of Bottom Sill-Plate and Edge-Stud
Test No. A-10, A-11, Frequency = 0.5 Hz
Peak Command Displacement = ±2-1/2 Inches, ±2.8 Inches

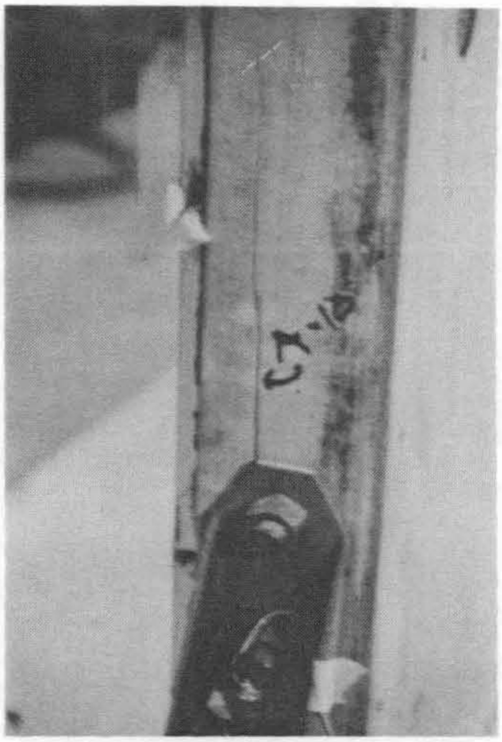


Figure 45: Specimen PD-4 Run No. 2
Splitting Failure of End Wood Stud
Test No. A-10, Frequency = 0.5 Hz
Peak Command Displacement = ±2-1/2 Inches

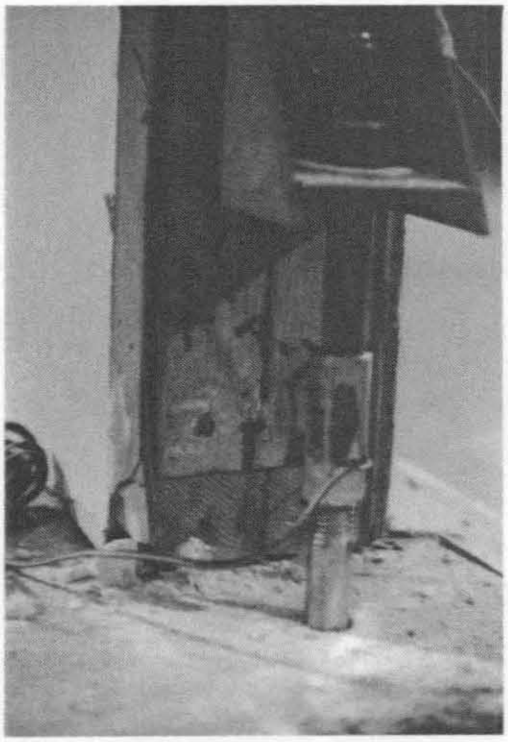


Figure 46: Specimen PD-4 Run No. 2
Splitting Failure of Bottom Sill-Plate and End Stud
Test No. A-11, Frequency = 0.5 Hz
Peak Command Displacement = ±2.8 Inches

APPENDIX F

SAMPLE DYNAMIC TEST LOG SHEET

CALIFORNIA POLYTECHNIC STATE UNIVERSITY SAN LUIS OBISPO, CA. 93407
ARCHITECTURAL ENGINEERING DEPARTMENT – HIGH BAY LAB

DYNAMIC TESTING OF BUILDING PARTITIONS

PRINCIPAL INVESTIGATOR: SAT RIHAL
FACULTY ASSOCIATE: GARY GRANNEMAN ET/EL DEPT. (TESTING & INSTRUMENTATION)
STUDENT ASSISTANT: TONG CHEUNG M ARCH STUDENT SAED
TECHNICIAN: BOB MEYERS

TEST SCHEDULE: SPECIMEN NO.:________ DATE:________ TIME:________ DESCRIPTION:________
I BLOCK CYCLIC TEST

RUN NO	FIXED FREQUENCY (Hz)	NO. OF CYCLES				COMMAND PEAK DISPLACEMENT OF CYCLES (INCHES)							
						1	2	3	4	5	6	7	8
						± 1/8	± 1/4	± 3/8	± 1/2	± 3/4	± 1	± 1 1/4	± 1 1/2
			REMARK										
			X-Y RECORDER		X								
					Y								
			MAG-TAPE READING		INITIAL								
					FINAL								
			TRANSDUCERS NO.		ACCELEROMETER GRID – AXIAL								
					STRAIN GAGE TRANSDUCER HOLDDOWN BOLT (LEFT)								
					STRAIN GAGE TRANSDUCER HOLDDOWN BOLT (RIGHT)								
					LOAD – CELL								
					LVDT GRID – AXIAL								
					LVDT PARTITION – GRID AXIAL								