PB93-198299

NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH

State University of New York at Buffalo

Seismic Testing of Installation Methods for Computers and Data Processing Equipment

by

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Technical Report NCEER-93-0007

April 12, 1993

This research was conducted at the State University of New York at Buffalo, IBM and Florida Atlantic University and was partially supported by the National Science Foundation under Grant No. BCS 90-25010 and the New York State Science and Technology Foundation under Grant No. NEC-91029.

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NCEER Project Numbers 91-5221 and 92-5201

NSF Master Contract Number BCS 90-25010
and
NYSSTF Grant Number NEC-91029

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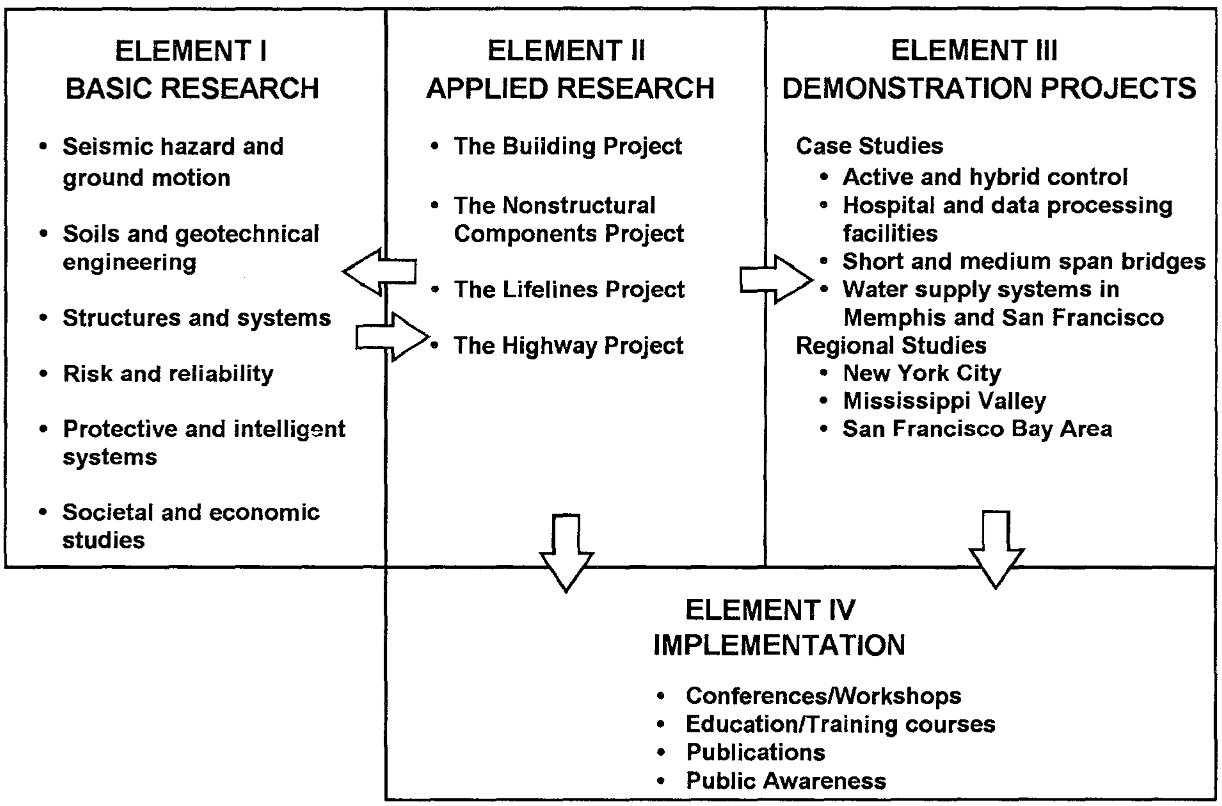
PREFACE

The National Center for Earthquake Engineering Research (NCEER) was established to expand and disseminate knowledge about earthquakes, improve earthquake-resistant design, and implement seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures in the eastern and central United States and lifelines throughout the country that are found in zones of low, moderate, and high seismicity.

NCEER's research and implementation plan in years six through ten (1991-1996) comprises four interlocked elements, as shown in the figure below. Element I, Basic Research, is carried out to support projects in the Applied Research area. Element II, Applied Research, is the major focus of work for years six through ten. Element III, Demonstration Projects, have been planned to support Applied Research projects, and will be either case studies or regional studies. Element IV, Implementation, will result from activity in the four Applied Research projects, and from Demonstration Projects.



Research tasks in the **Nonstructural Components Project** focus on analytical and experimental investigations of seismic behavior of secondary systems, investigating hazard mitigation through optimization and protection, and developing rational criteria and procedures for seismic design and performance evaluation. Specifically, tasks are being performed to: (1) provide a risk analysis of a selected group of nonstructural elements; (2) improve simplified analysis so that research results can be readily used by practicing engineers; (3) protect sensitive equipment and critical subsystems using passive, active or hybrid systems; and (4) develop design and performance evaluation guidelines.

The end product of the **Nonstructural Components Project** will be a set of simple guidelines for design, performance evaluation, support design, and protection and mitigation measures in the form of handbooks or computer codes, and software and hardware associated with innovative protection technology.

This report addresses seismic safety of computers and data processing systems. Under a joint research program with IBM, seismic tests on a variety of computer systems using a wide spectrum of installation methods were conducted in order to assess their effectiveness in mitigating damaging effects to these systems in a seismic environment. Results from three two-week test sessions are presented and analyzed in this report and the performances of several installation methods are evaluated.

ABSTRACT

The basic objective of the test program described in this report was to investigate seismic response of computers and data processing equipment and to evaluate a variety of possible earthquake resistant installation methods ranging from those currently in use to more advanced designs using energy absorbing materials. This report documents results and assesses their significant based on three two-week test sessions performed jointly by NCEER and IBM investigators from June, 1991 through June, 1992.

These tests were conducted on different mainframe systems utilizing a variety of earthquake inputs and different installation methods. The equipment response to the earthquake inputs is analyzed to enable a quantitative evaluation of the installation methods. Discussions and conclusions regarding the equipment sensitivity to earthquakes and the performance of selected installation methods are presented.

ACKNOWLEDGEMENTS

This work was supported in part by the National Center for Earthquake Engineering Research under Grant Nos. NCEER-91-5221 and NCEER-92-5201C and by the IBM Corporation under the NCEER/IBM Joint Research Program on Seismic Performance and Safety Enhancement of Computers and Data Processing Equipment. The 3M Company provided the viscoelastic dampers used in this study. Aeroflex International and SVP Inc. contributed the wire ropes. Their contributions are gratefully acknowledged.

The authors are indebted to the following individuals who participated and contributed to this test program:

The 3M Company: Dr. M.L. Lai and Dr. E.J. Nielsen

IBM: Mr. R.A. Frey, Mr. G.N. Nikolsky, Mr. K. Larsen, and Mr. E. Caukin

The State University of New York at Buffalo: Dr. M.C. Constantinou, Mr. G.F. Demetriades, Mr. M. Pitman, Mr. D. Walch, Mr. P. Pattarroyo, and Mr. R. Cizdziel

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SECTION 1

INTRODUCTION AND TEST OBJECTIVES

Equipment such as computers and data processing systems play a vital role in modern society. Industries and business concerns rely on computing centers for data processing, process control, communications, research and other functions. Any interruption or failure in the operation of these systems due to earthquakes and other vibrational effects can lead to total chaos and substantial economic loss. Moreover, life safety can be a serious concern when these systems are tied to life saving operations such as those performed in a hospital.

Since the advent of sophisticated data processing facilities, there has been limited opportunity to evaluate the impact of earthquakes upon their design and function. Most information on seismic damage to computer equipment is obtained from reconnaissance reports and inspections following earthquake occurrences. While no quantitative damage measures can be cited, observations after recent earthquakes point to the importance of earthquake hazard mitigation measures for computer and data processing systems (Gates and Scawthorn, 1982; Green and Frey, 1990).

The choice of an appropriate method of installation plays a key role in insuring seismic safety of computers. As one part of a joint NCEER/IBM research program, seismic tests on a variety of data processing equipment using a wide spectrum of installation methods were conducted in order to assess their effectiveness in preventing or minimizing damaging effects to these equipment in a seismic environment. The methods of installation selected represented a cross section of restraining techniques and covered the range from free casters to innovative energy dissipation devices.

The seismic tests described in this report encompass three two-week test sessions conducted in June, 1991; August, 1991; and June, 1992. The major test objective was to evaluate different installation methods applied to typical and functional data processing equipment, and to gain insight into and assess their suitability for use in a given seismic region. Another objective was to include several different test inputs in the program with the hope that the test results would lead to reductions and improved efficiency in future seismic tests.

It is noted that some parts of these test series have been described in other publications. For example, the performance of wire ropes during the June 1991 test is discussed in Demetriodes et al. (1992), and some of the test results and their implications are described in Frey (1992), Frey and Nikolsky (1992), and Holung and Lin (1993). This report provides comprehensive test results obtained from all three test series and an overall assessment of their significance.

SECTION 2

TEST SET-UP

2.1 The Earthquake Simulator

The three test series were carried out on the shaking table at the State University of New York at Buffalo, which provided the base motion to the equipment being tested. The shaking table has a dimension of 3.66 m×3.66 m (12 ft×12 ft) with a capacity of 50 mtons (110 kips) and an advanced control system. It has five degrees of freedom (DOF) actively controlled, with three DOF's programmable directions (horizontal, vertical, and roll) and the other two DOF's corrected for cross coupling only. The sixth degree of freedom horizontal-transverse) is restrained by hydrostatic bearings which provide free sliding with lateral displacement/force control.

The system has two horizontal actuators with a capacity of 32 mtons (70 kips), which can provide a horizontal acceleration of 0.625 g with maximum payload. Four vertical actuators with a total capacity of 100 mtons (220 kips) can accelerate the system with 1.05 g at maximum payload. With lighter payloads, the system can produce larger accelerations (up to 4.0g horizontally and 8.0g vertically). A schematic sketch of the system is shown in Fig. 2-1.

2.2 Raised Floor

All the tests were conducted on a 6 ft×6 ft raised floor surface that was constructed on top of a concrete slab attached to the shaking table. The installation details, as shown in Fig. 2-2, conform to standards normally applied to earthquake installations (FIMS, 1987). Additional braces were provided at the ends to simulate the added support of building walls and cut-outs in the raised floor surface to accommodate signal and power cable attachments. A photograph of the completed raised floor assembly is shown in Fig. 2-3.

2.3 Instrumentation

Horizontal and vertical acceleration measurements using accelerometers were made at many locations on the shaking table, the raised floor, and the equipment being tested. The placements and designations for the accelerometers attached to the equipment are shown in Fig. 2-4, although not all of the instruments were used in every test. A complete listing of accelerometer locations and designations is provided in Table 2-1. For all measurements, the sampling rate was set at 100 samples/second.

The horizontal displacements of the equipment were measured by means of permanent markers attached to the front and rear surfaces, as shown in Fig. 2-5. For some of the early tests, Temposonic displacement transducers were attached to the shaking table and to the equipment although they were not used in many of the later tests due to attachment difficulties in some cases and excessive sliding motion of the equipment in some other cases. The locations of the Temposonic transducers attached to the equipment are shown in Fig. 2-6, and a complete listing is also given in Table 2-1.

2.4 Input Accelerations

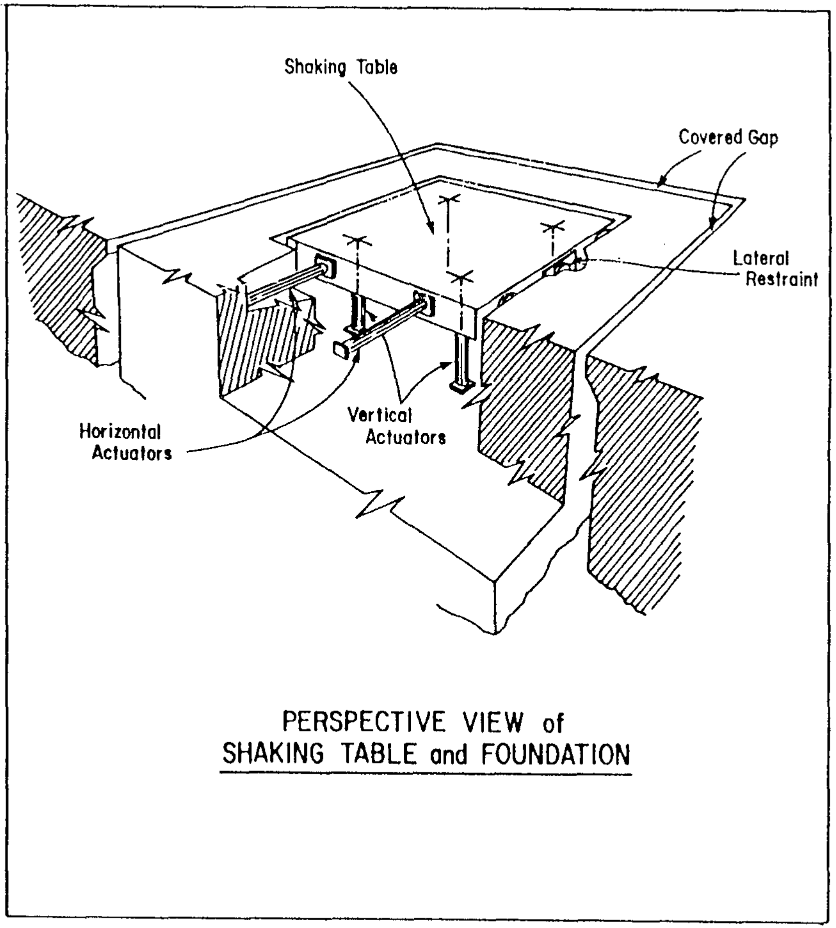
Several types of input accelerations representing some typical past earthquakes and simulated test response spectra were used in the test program. In addition, simulated earthquake inputs at different floor levels of a seven-story reinforced concrete (RC) building were generated. The particular earthquake inputs selected were those of El Centro (1940, lateral component = S00E), and Taft (1952, lateral component = N21E). The notation "EL C RC-X" or "TAFT RC-X" refers to the lateral or horizontal component of a simulated motion that would be experienced at story level X of the 7-story reinforced concrete building with El Centro or Taft ground input. This short-hand notation is abbreviated even more in certain sections of this report for convenience.

A test input proposed by Bellcore (Bellcore, 1988) for the upper stories in Zone 4 earthquakes, and two IBM developed inputs (IBM, 1991), were also used. The IBM inputs, denoted by IBM1 and IBM2, represent two functional test levels. At the first level, the machine is expected to operate normally, and at the second level, also referred to as the structural/safety level, gross structural failures should not occur although the machine may not remain functional. The acceleration response spectra of these inputs are shown in Fig. 2-7, from which time histories were generated as input accelerations from the shaking table. The duration of IBM inputs was initially set at 40 seconds, consistent with the total recording time for the other inputs, but was shortened to 20 seconds later in the test program. Also, the IBM1 input was only used in a limited number of the early tests until it was observed that the machine could in fact withstand the IBM2 test level while operating.

In some test runs, the actual recorded ground vertical accelerations for the El Centro and Taft earthquakes were used instead of the 1/3-scaled amplitude of the lateral component used in most cases. Also, in one test trial, the lateral and vertical components of the Pacoima earthquake were also used. These exceptions are marked accordingly in Sec. 4 when the test matrices and test results are discussed. A sample of the test inputs as measured on the raised floor surface is shown in Figs. 2-8 through 2-10.

Table 2-1 Accelerometer and Displacement Transducer Locations and Designations

SHAKING TABLE	
ALAT	reference accel. lateral direction (X-axis)
AVRT	reference accel. vertical direction (Z-axis)
DLAT	displ. lateral direction
DVRT	displ. vertical direction
CONCRETE SLAB	
ASEX	accel. slab east x-direction
ASWX	accel. slab west x-direction
ASCZ	accel. slab center z-direction
RAISED FLOOR	
AFEX	accel. floor east x-direction
AFCZ	accel. floor center z-direction
AFEZ	accel. floor east z-direction
AFWX	accel. floor west x-direction
AFWZ	accel. floor west z-direction
EQUIPMENT	
LRFX	accel. lower right front x-direction
LRRX	accel. lower right rear x-direction
TRFX	accel. top right front x-direction
TRRX	accel. top right rear x-direction
LRRZ	accel. lower right rear z-direction
LRRY	accel. lower right rear y-direction
TRFZ	accel. top right front z-direction
TRRZ	accel. top right rear z-direction
TLEZ	accel. top left front z-direction
TLRZ	accel. top left rear z-direction
DSDX	accel. DASD (IBM 9332) x-direction
DSDY	accel. DASD (IBM 9332) y-direction
DSDZ	accel. DASD (IBM 9332) z-direction
DNEX	displ. north east x-direction
DNWX	displ. north west x-direction
DNWY	displ. north west y-direction
DSWY	displ. south west y-direction



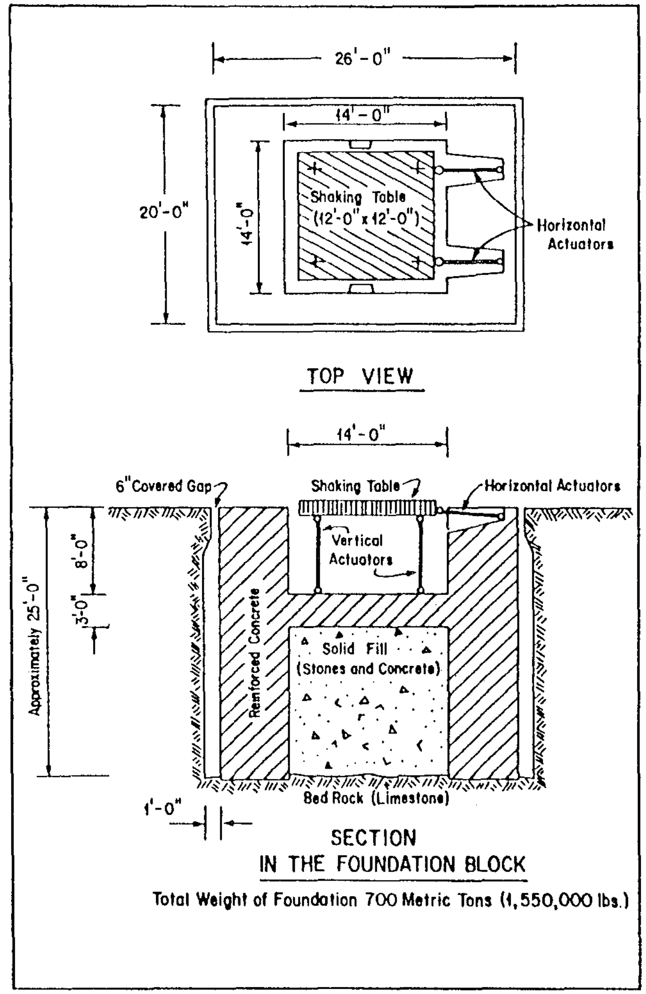


Fig. 2-1 Schematic Sketch of the Shaking Table

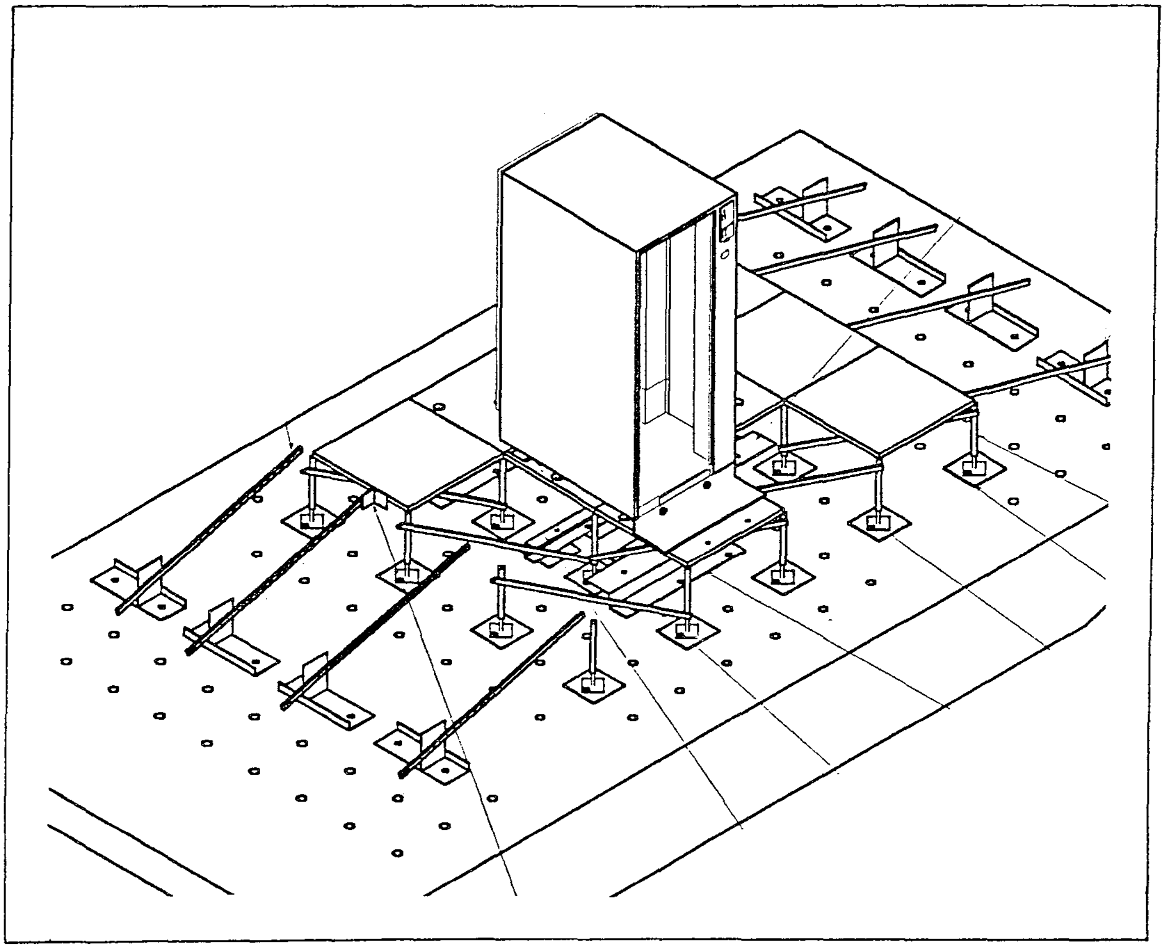


Fig. 2-2 Installation Details of Raised Floor

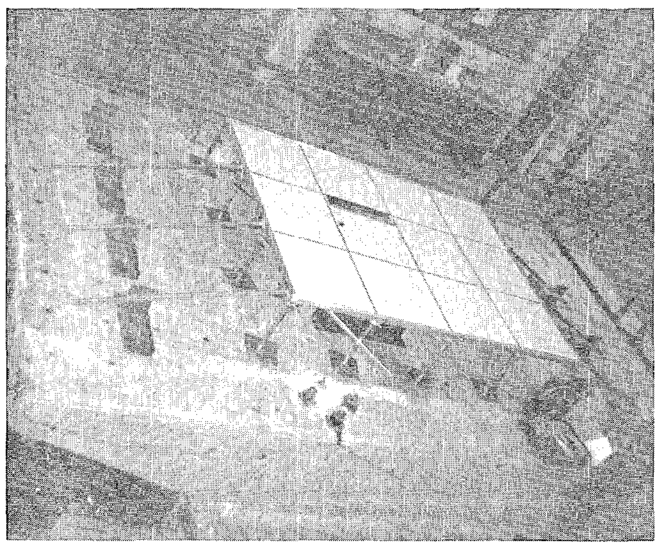


Fig. 2-3 Fully Assembled Raised Floor

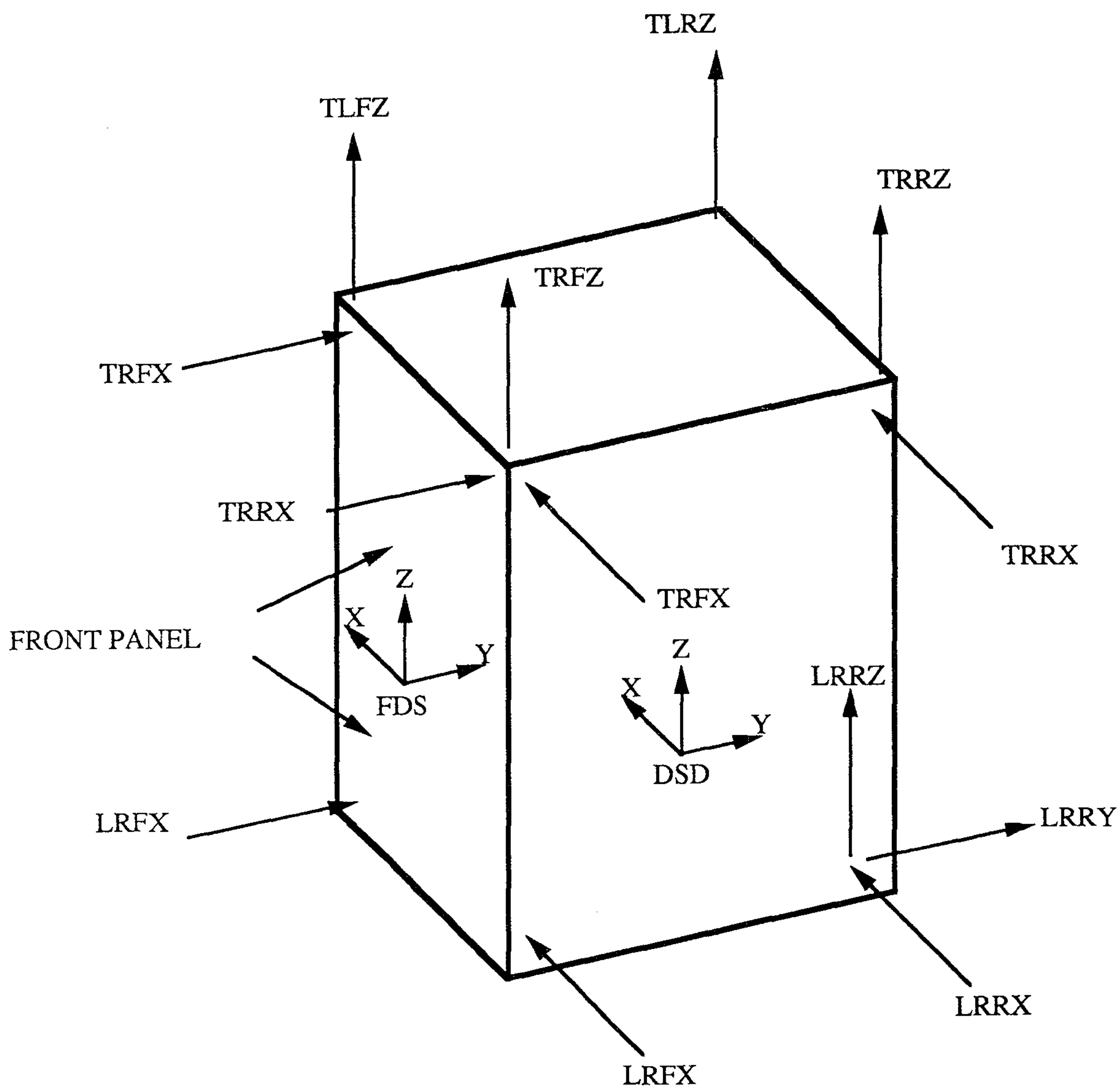


Fig. 2-4 Accelerometer Locations

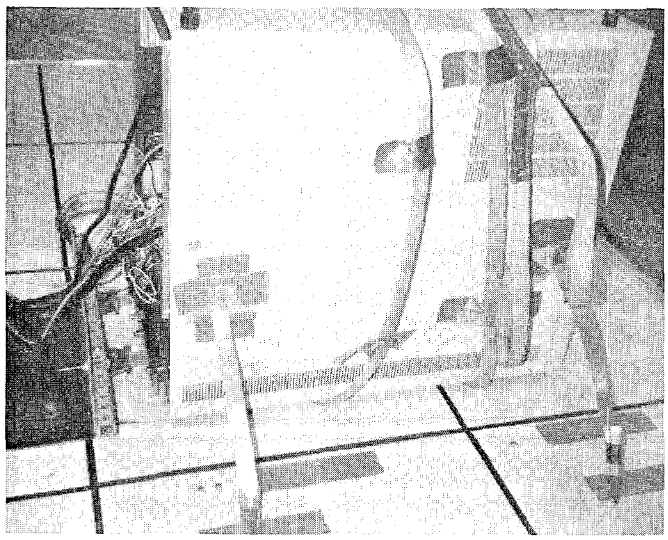


Fig. 2-5 Location of Markers

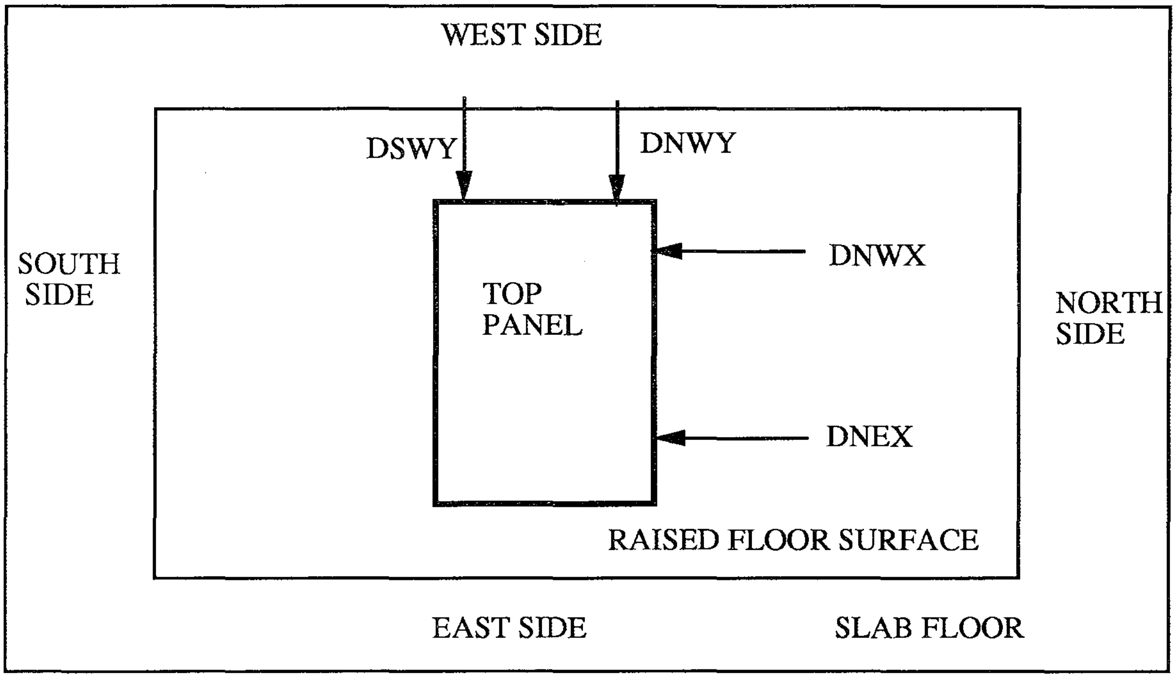


Fig. 2-6 Temposonic Transducer Locations

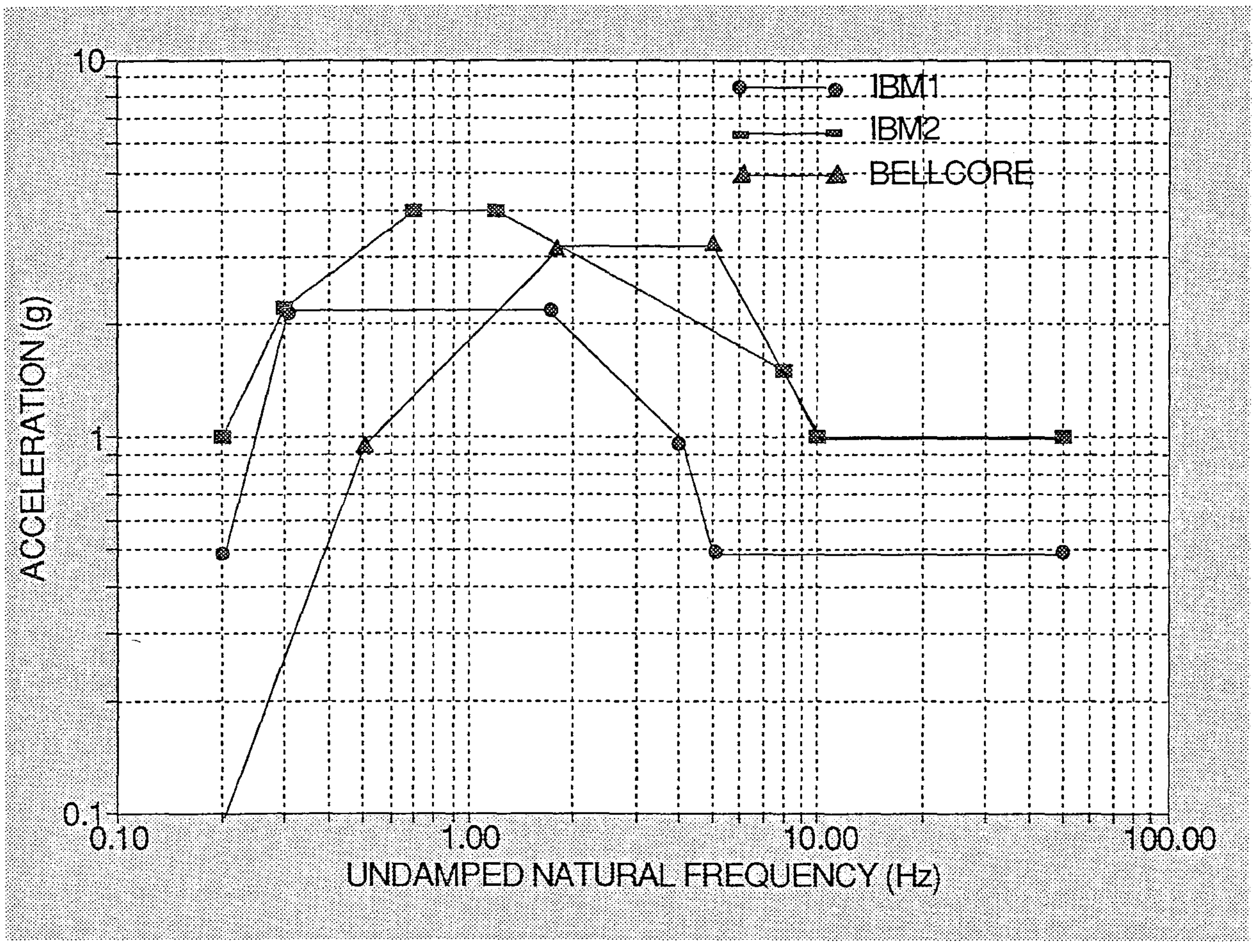


Fig. 2-7 Acceleration Response Spectra for IBM1, IBM2, and Bellcore Inputs

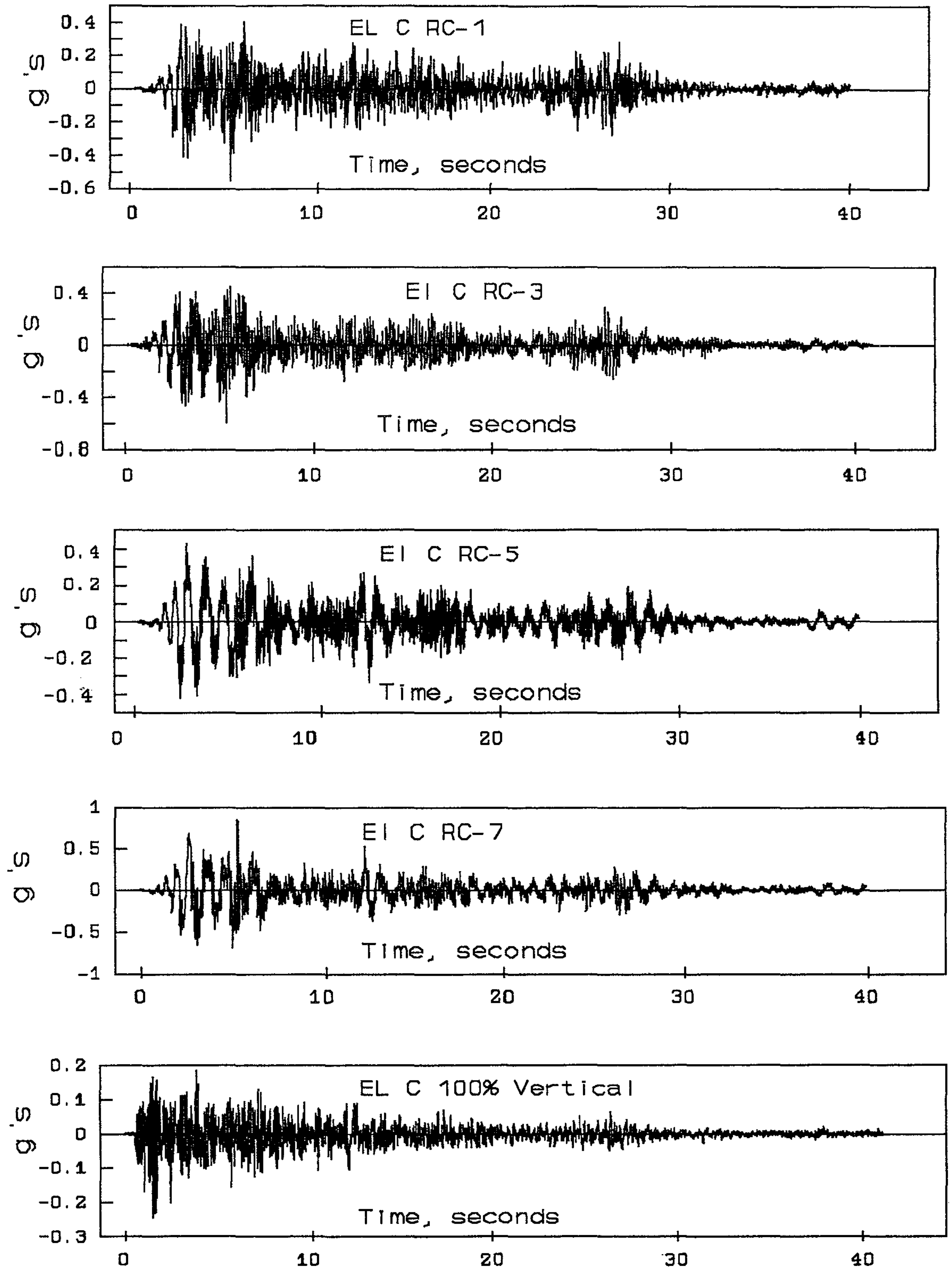


Fig. 2-8 Raised-floor Input Accelerations: El Centro Earthquake

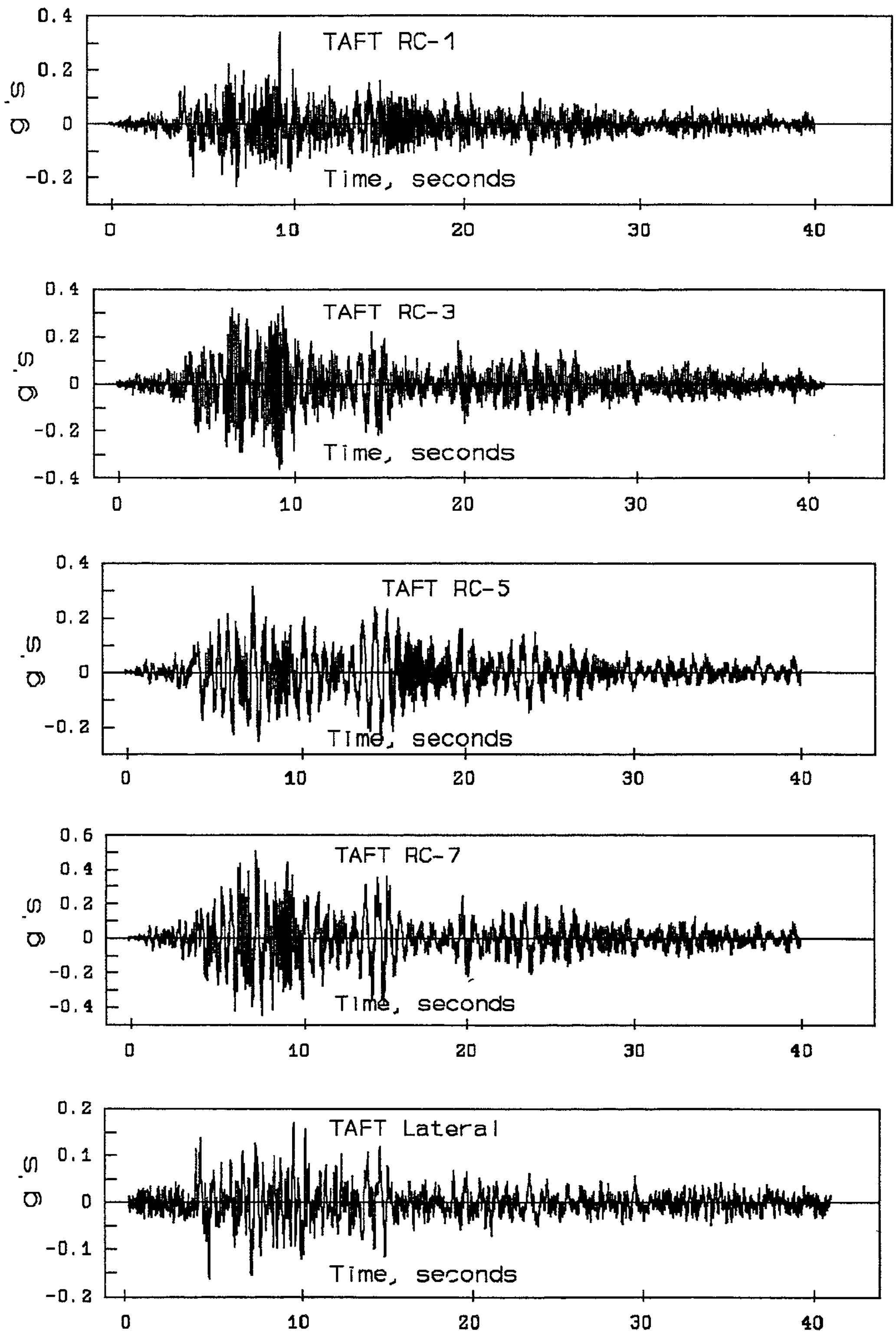


Fig. 2-9 Raised-floor Input Accelerations: Taft Earthquake

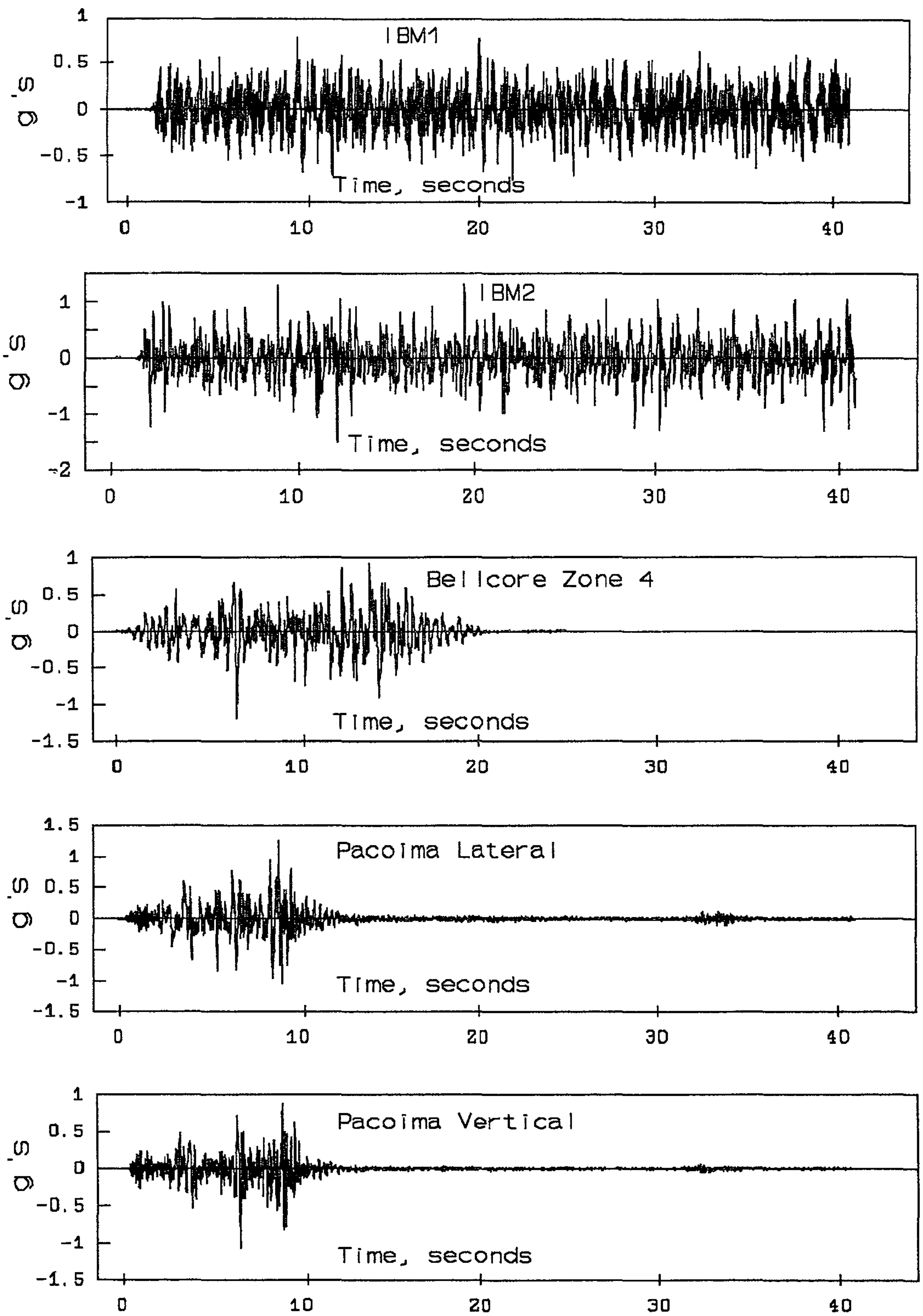


Fig. 2-10 Raised-floor Input Accelerations: IBM, Bellcore and Pacoima

SECTION 3

TEST EQUIPMENT AND INSTALLATION METHODS

3.1 Test Equipment

A wide variety of IBM mainframe computer systems and peripheral equipment were tested in the three test series. A description of the test equipment tested in each series is given below.

3.1.1 June 1991 Test

The test equipment for this series consisted of two IBM mainframe computer systems: An IBM 9370 system, with DASD and tape drive units, and a fully configured IBM 9371 system. Both systems were configured with devices commonly found in data processing facilities and were fully operational.

The overall sizes and weights of these two mainframe computer systems, shown in Fig. 3-1, are given in Table 3-1. In addition to the size differences, the two systems also differ in base style. The IBM 9370 system base consists of four casters, two in the front and two in the back. The two in the back are free to swivel, but the two in the front are not. Moreover, there is a stabilizing foot in the front as shown in Fig. 3-2, the purpose of which is to stabilize the body from tipping forward.

The IBM 9371 system base consists of four glides, these are round in shape like a cylinder and about 1.0m in height.

3.1.2 August 1991 Test

The equipment tested in this series consisted of two mainframe computer systems, a printer and some miscellaneous stand alone computer periphery. One of the mainframe systems was a fully functional IBM 9221 system with a 9348 tape drive, 9336 DASD, a CEC processor and a 5020 Beach "B" box; the other was a nonfunctional IBM 9221 system consisting of two 9335 A units and four 9335 B units. The printer tested was a 6252 printer unit. Only test results from the mainframe computer systems are considered here. The overall sizes and weights of these two mainframe computer systems can also be found in Table 3-1.

Both units are similar in base style to the IBM 9370 system, and both are designed to accommodate a stabilizer foot. However, the foot was not used during the test.

3.1.3 June 1992 Test

The equipment used for this test consisted of three mainframe computer systems: A half-frame Frame-8 computer system, a full-frame Frame-1 computer system, and a non-operational Endicott frame computer system (Fig. 3-3). The overall sizes and weights of these three mainframe computer systems are included in Table 3-1.

3.2 Installation Methods

A large variety of installation methods as described below were used in the three test series, representing a cross-section of typical installations as well as innovative passive energy dissipation devices.

3.2.1 IBM 9370, June 1991

Locked Casters. The casters were locked into position with thumb screws. The system was otherwise free to swivel and slide on the surface of the raised floor.

This is a more typical installation, although it may not be entirely suitable if large sliding motion is expected. Less sliding motion is expected in the case of locked casters than that of free casters due to the additional frictional restraining force at the caster-floor interface.

Free Casters. The casters were not locked into position and the system was free to roll on the surface of the raised floor without any external restraint.

For this case, unrestrained motion of the system relative to the floor would be possible except where limited by attachment power or signal cables which now acts as an (unintended) tether. This free-rolling installation approach is not typical. In practice, however, it may occur following service, installation, or when machines are moved from one location to another and the casters are mistakenly left in the unlocked position.

Testing this free-rolling configuration required more care than most of the other methods because larger sliding motion was expected and the behavior of the system was unpredictable. For this reason, the input test levels were initially selected at a much reduced level and then gradually increased while observing the response of the system.

The final test level attained was one-third of the level used for the other installation methods.

Bungee Cords (with tethers). Bungee cords, attached to eye bolts on each side of the rear casters, were secured through two-inch diameter cut-out holes in the raised floor to eye bolts attached to steel plates which, in turn, were bolted to the shaking table. The bungee cords were 14 inches in length and had metal hooks at each end as shown in Fig. 3-4.

One of the purposes of evaluating the performance of bungee cords, as well as the spring restraints, was to examine the general feasibility of using tethers as a viable installation approach. The advantages of tethers are low cost, and the simplicity and adaptability it affords to a variety of field installations.

Spring Restraints. Two springs, stretched to an estimated preload of 128 lbs in each spring, were secured from eye bolts in the floor to eye bolts on either side of the casters via steel cables through the two-inch cut-out holes in the floor. This arrangement is shown in Fig. 3-5(a). Following tests on the two-spring installation, it was augmented with two more springs for a single test. This arrangement is shown in Fig. 3-5(b).

Toggle Bars. The toggle bar installation (Foss and Nikolakopoulou, 1980) was essentially an adjustable threaded steel rod in tension. Four threaded rods, with turnbuckle adjustment, were attached from the base of the IBM 9370 near the casters through two-inch diameter clearance holes in the raised floor. The ends of the toggle bars were attached with steel hooks to eye bolts firmly attached to the floor. In use, the turnbuckles were adjusted to relieve all play in the rods.

This installation approximates a fixed base condition, although some limited motion between the equipment and the base is possible because of the clearance hole. Two of the toggle bars can be seen in the photograph shown in Fig. 3-6.

Viscoelastic Dampers. Four viscoelastic dampers, supplied by the 3M Company, were used to secure the system to the surface of the raised floor. The design of these dampers allowed direct attachment to the machine. During these tests, the casters were locked with the locking thumb screws.

Two different designs were tested: One denoted as a 2-Hz, "type F" damper, and the other denoted as a 5-Hz, "type D" damper. These dampers were secured by brackets bolted to the machine and to the floor, as shown in Fig. 3-7.

Wire Ropes. Four coiled wire rope dampers were bolted directly to the IBM 9370 base and the raised floor. The casters were also locked into place during the tests.

A photograph of this restraint system installed on the IBM 9370 machine is shown in Fig. 3-8, where the foot-plate brace attached to the front of the machine had been removed to permit viewing.

Fixed Base: The base of the IBM 9370 system was bolted directly to the raised floor by means of brackets mounted adjacent to the base of the casters.

3.2.2 IBM 9371, June 1991

While the majority of the tests were conducted on the IBM 9370 system, four different installation approaches were tested on the IBM 9371 machine. These are described below.

Glides. The IBM 9371 system was placed on the raised floor and was not restrained in any manner. The system was supported at the base on glides and can slide freely on the raised floor, as shown in Fig. 3-1(b).

Viscoelastic Dampers in Rear. Two viscoelastic dampers, similar to those used for the IBM 9370 tests, but designated as 0.5 Hz, "type E" damper, were used to secure the rear of the system to a bracket on the raised floor. The front end of the machine was not secured.

Fixed in Rear. The two type E viscoelastic dampers as mentioned above were removed and replaced with threaded rods which were used to bolt the rear of the machine to the bracket on the raised floor. The front of the machine was unrestrained.

Fixed Base. The system was bolted directly to the slab through the cut-out holes in the raised floor using two threaded rods. The threaded rods were positioned at two diagonal corners of the system as shown in Fig. 3-9.

3.2.3 IBM 9221, August 1991

The installation methods used on the IBM 9221 mainframe computer system consisted of the following:

Locked Casters. Same as described in Sec. 3.2.1.

Free Casters. Same as described in Sec. 3.2.1.

Toggle Bars. Same as described in Sec. 3.2.1, but with 40 and 80 durometer grommets used at the floor interface.

Fixed Base. Same as described in Sec. 3.2.1, except that the front and back were fixed. In some tests, the sides were fixed as well.

Viscoelastic Dampers - Case 1. Four viscoelastic dampers were mounted vertically from the eye bolts on the bottom of the mainframe to the shaking table. This is a very soft mounting system due to flexibility of the viscoelastic dampers.

Viscoelastic Dampers - Case 2. Viscoelastic dampers in this case were mounted in a criss-cross configuration, between the eye bolts of the computer system and the shaking table, at the front and back sides of the computer system.

Viscoelastic Dampers - Case 3. Two viscoelastic dampers in this case were mounted vertically between the middle eye bolts of the front and back side of the computer system and the shaking table.

3.2.4 Frame 1, Frame 8 and Endicott Frame, June 1992

Toggle Bars. Same as described in Sec. 3.2.1. In this installation, the lateral displacement was controlled using bushings fitted into the raised floor surface. The bushings used during these tests consisted of two sets: An 80-durometer neoprene set and an aluminum set.

Wire Cables. Either 3/16-in or 5/32-in wire cables were connected between the eyebolts in the floor and the computer system. A schematic of a typical installation is shown in Fig. 3-10 (Frey and Nikolsky, 1992). The bushings used here to control lateral displacements also consisted of two sets: An 80-durometer neoprene set and a Teflon set.

Springs. Simple extension springs with spring constants of 570 lb/in and 290 lb/in were used. They were attached to respective eyebolts using wire cables. A schematic of a typical installation is shown in Fig. 3-11 (Frey and Nikolsky, 1992). Teflon bushings were used to limit the lateral displacements of the computer systems.

Fixed Base. The computer system was bolted directly to the concrete floor without the raised floor surface in between. These tests were for cases where there was no raised floor surfaces.

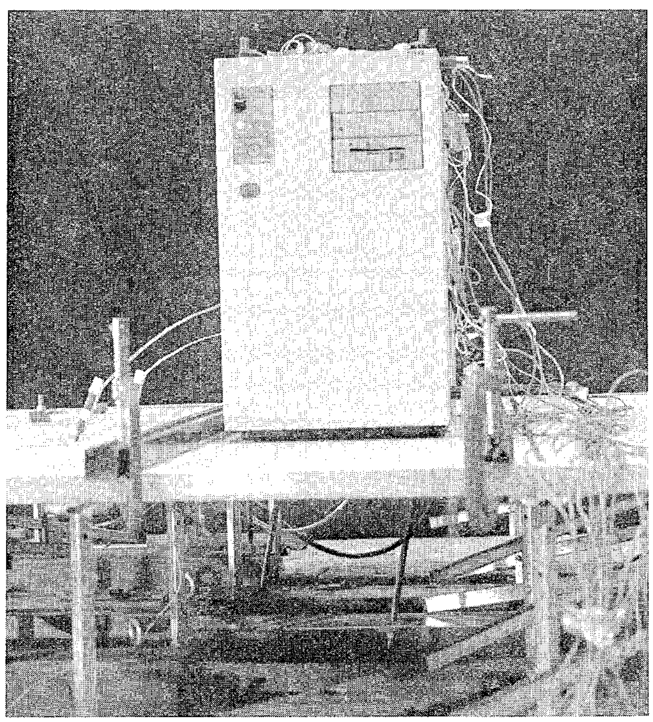
Levelers. The types of levelers used during these tests consisted of two types. One type, referred to as the normal leveler, was obtainable off the shelf. It consisted of a round foot with a plastic coating on it. This leveler could be adjusted to raise the casters off the floor.

The other type, referred to as the NTT leveler, had an M20 tapped hole on the bottom of its foot. This hole was used for attaching either a toggle bar or a wire cable type anchoring device to the concrete floor surface. A schematic of a typical installation is shown in Fig. 3-12 (Frey and Nikolsky, 1992).

Table 3-1 Sizes and Dimensions of Test Equipment.

Unit	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
9370	884	650	1503	375.8
9371	787	381	546	87.7
9221 (Functional)	884	650	1600	395.3
9221 (Non-Functional)	884	650	1575	426.5
Frame-8	870	830	1775	420
Frame-1	1640	835	1775	900
Endicott	1067	749	1765	408

(a) IBM 9370 System



(b) IBM 9371 System

Fig. 3-1 IBM 9370 and 9371 Systems

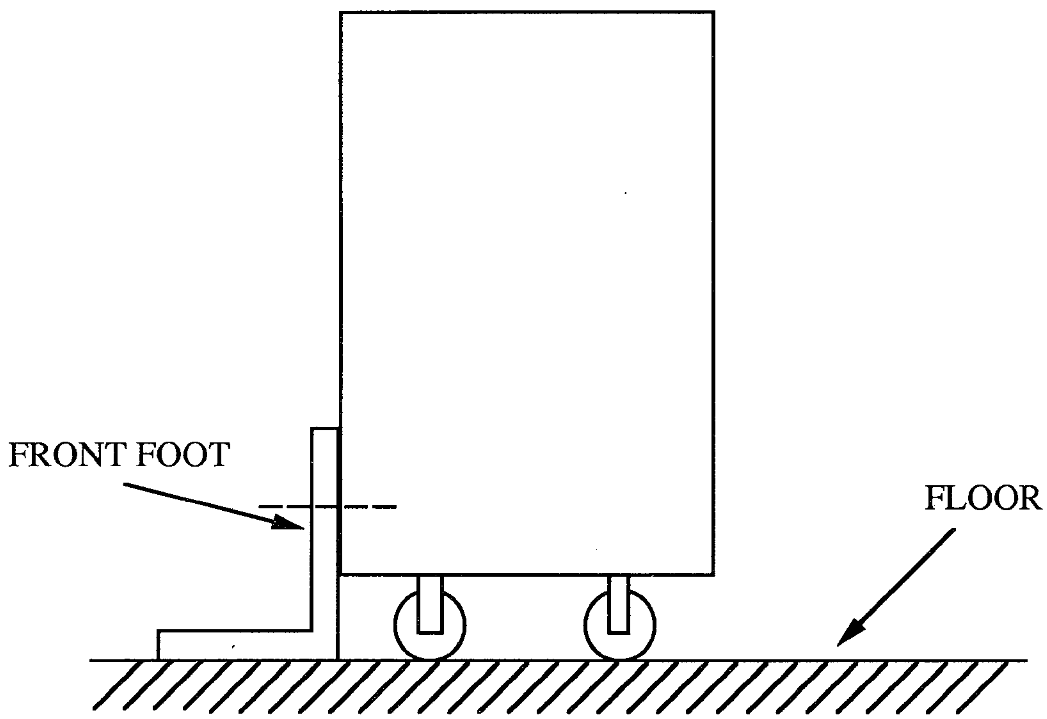
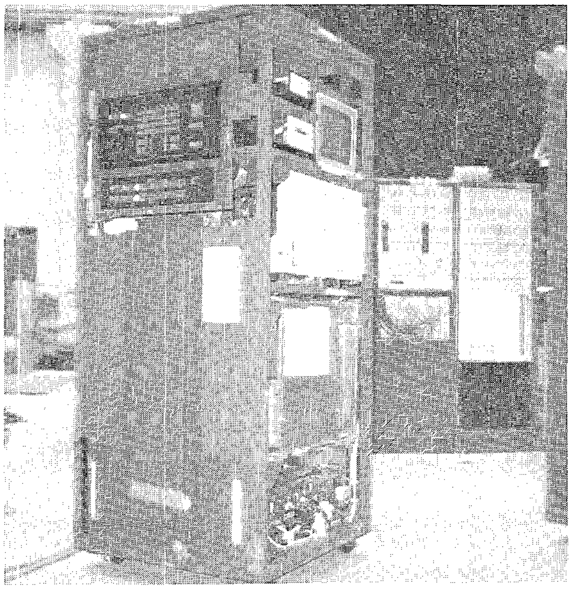
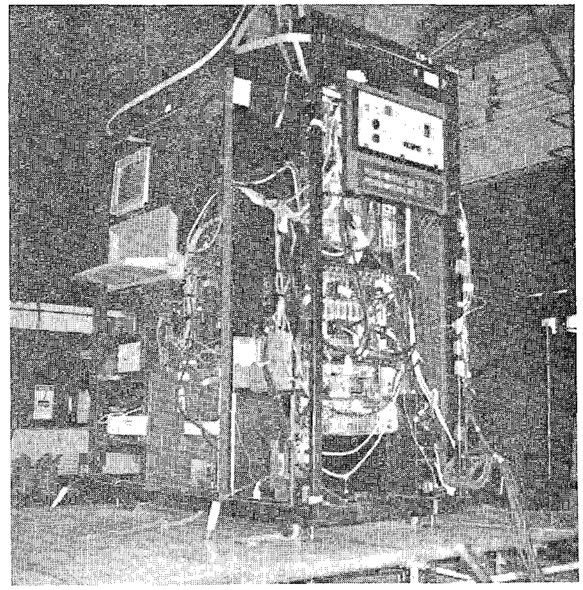


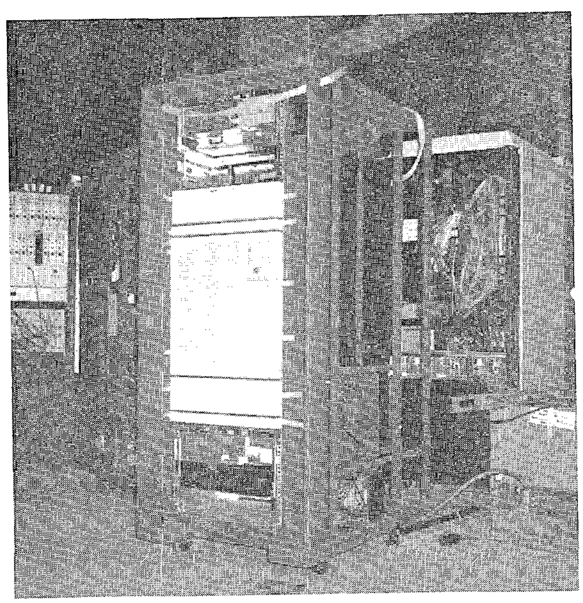
Fig. 3-2 Stabilizing Foot



(a) Frame-8



(b) Frame-1



(c) Endicott Frame

Fig. 3-3 Frame-8, Frame-1, and Endicott Frame

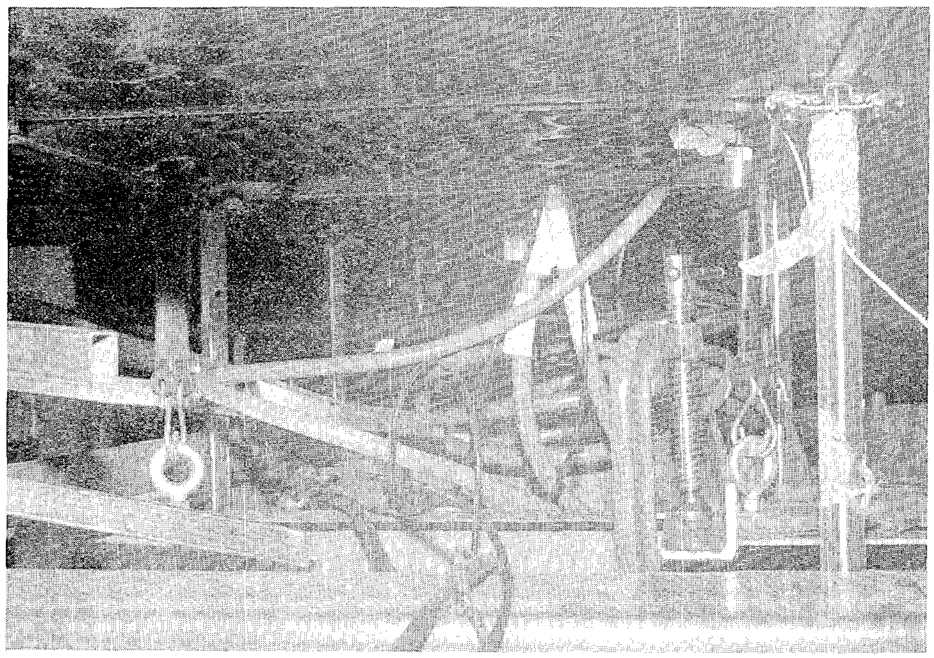
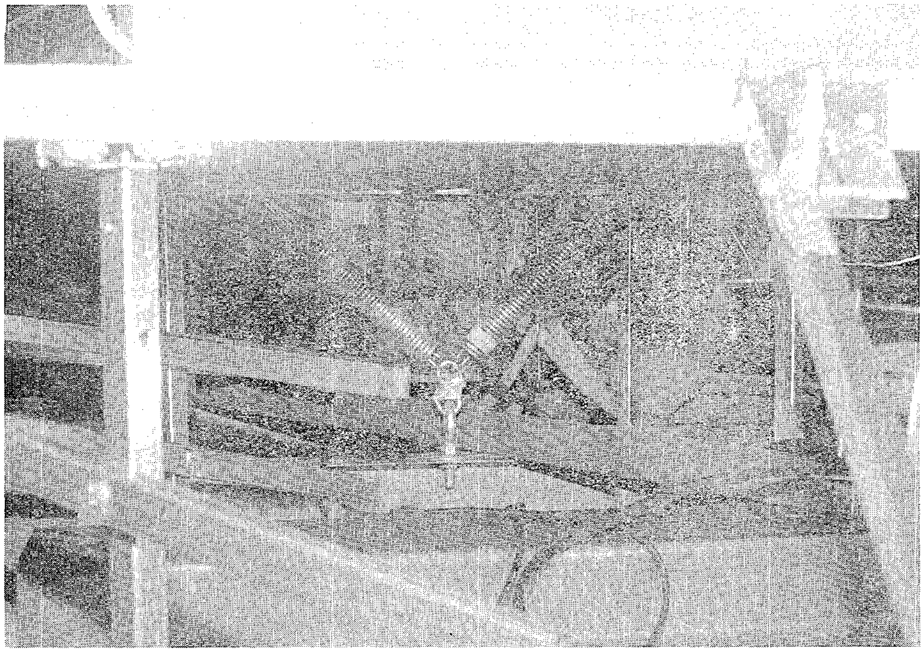
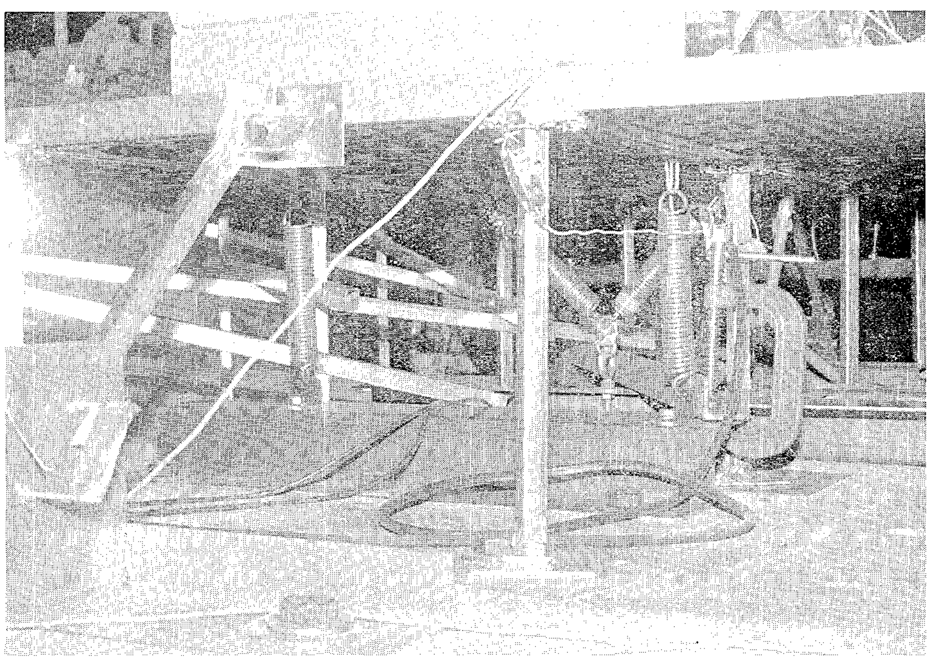


Fig. 3-4 Bungee Cord Installation



(a) Two Spring Installation



(b) Four Spring Installation

Fig. 3-5 Spring Installations

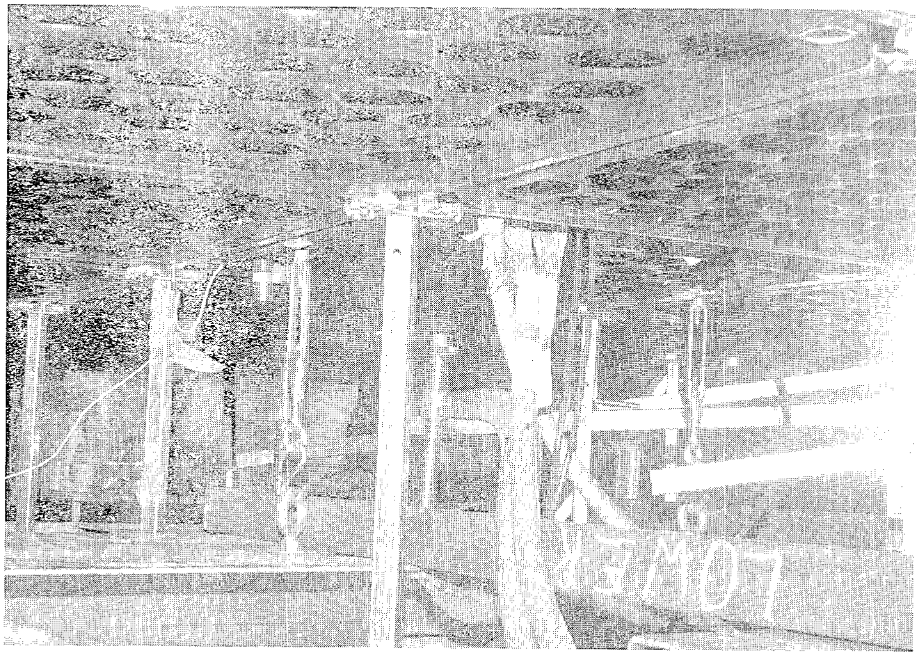


Fig. 3-6 Toggle Bar Installation

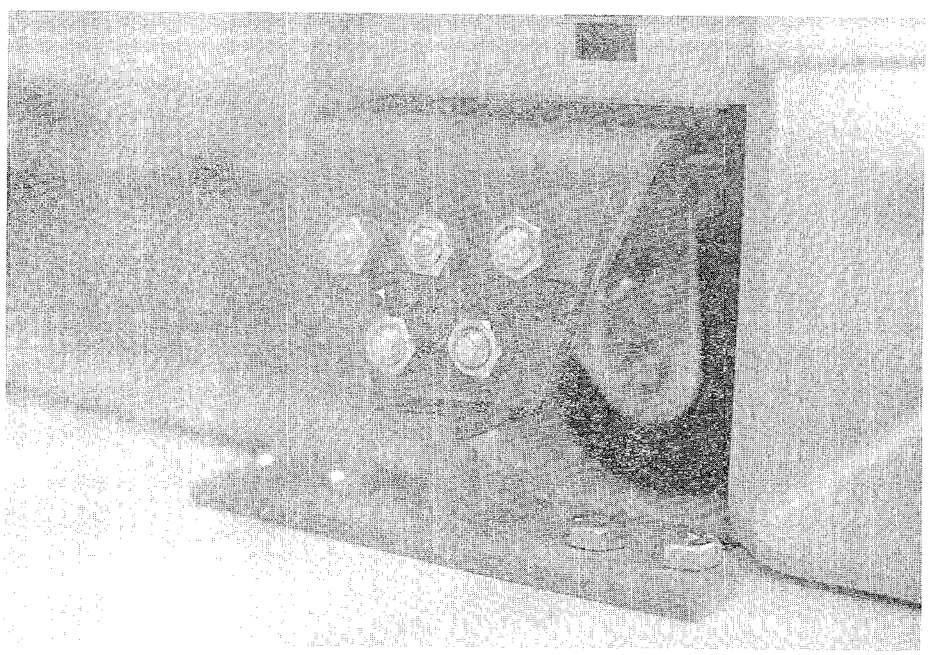


Fig. 3-7 Viscoelastic Damper Installation

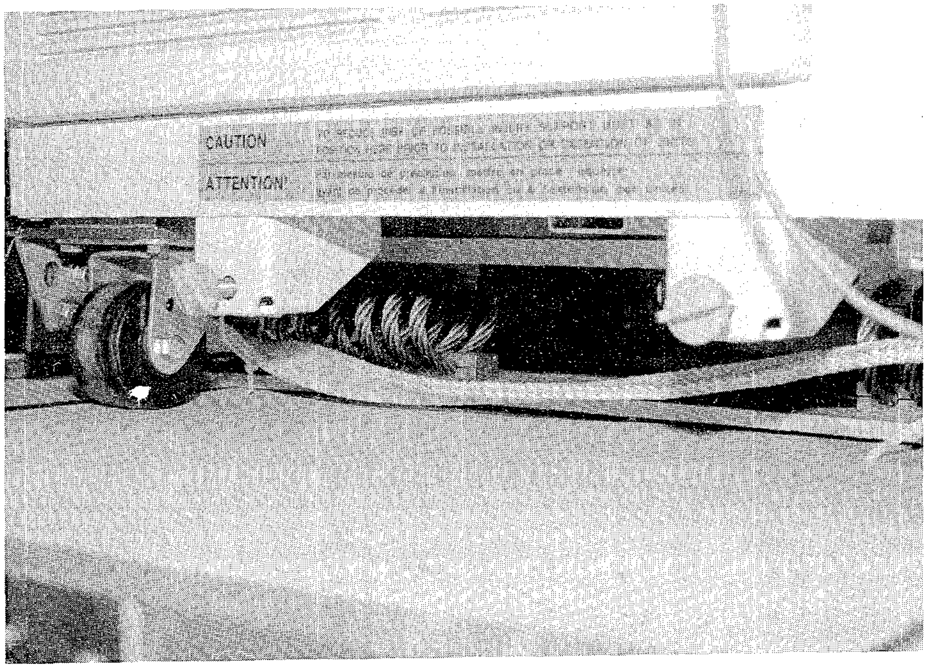


Fig. 3-8 Wire Rope Installation

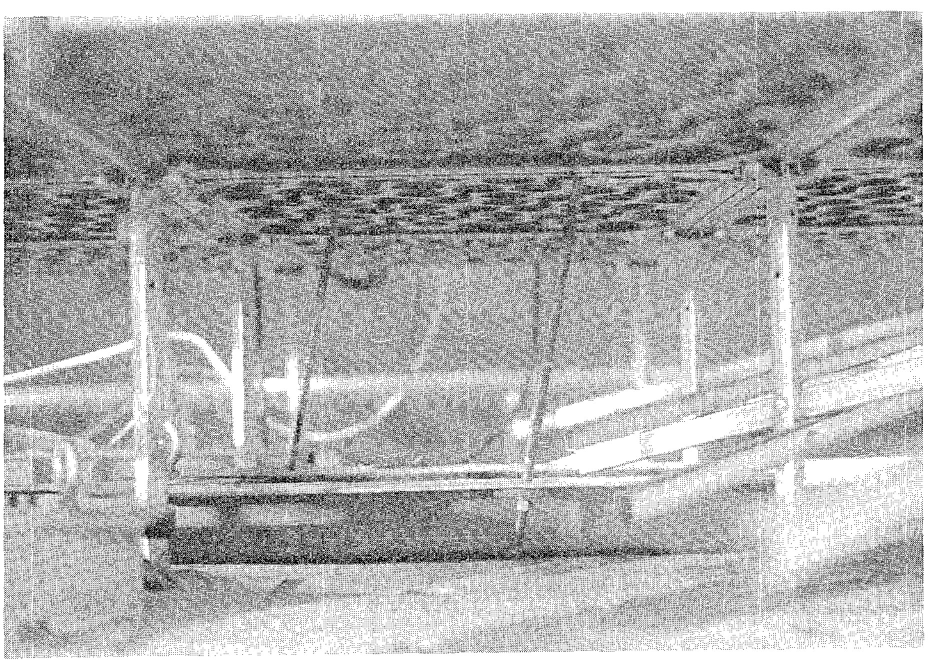


Fig. 3-9 Fixed Base Installation

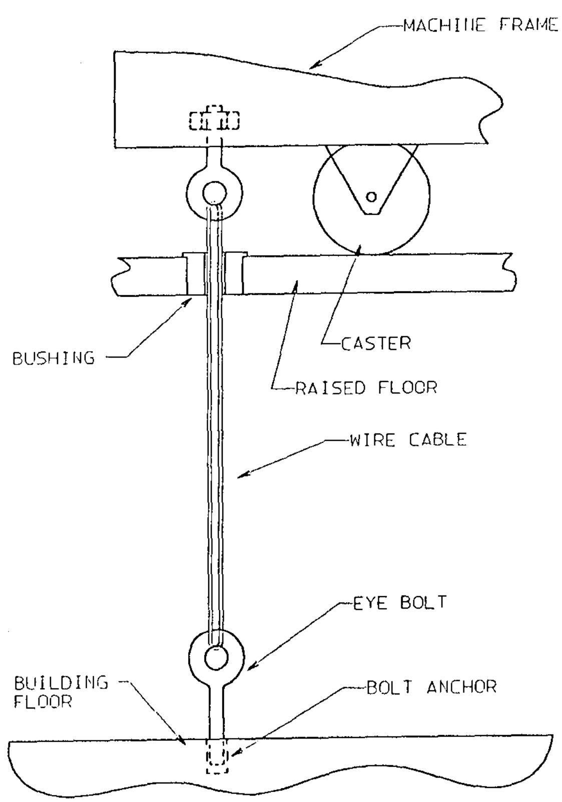


Fig. 3-10 Wire Cable Installation
(Frey and Nikolsky, 1992)

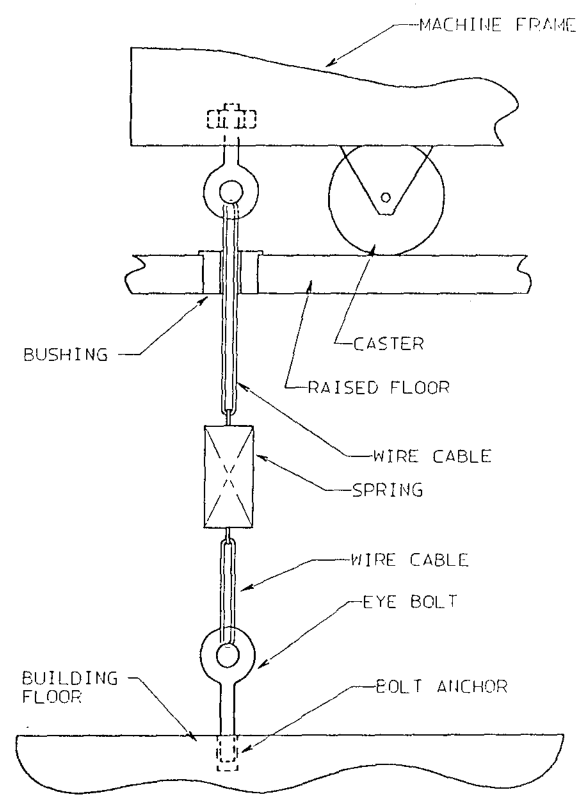


Fig. 3-11 Spring Installation
(Frey and Nikolsky, 1992)

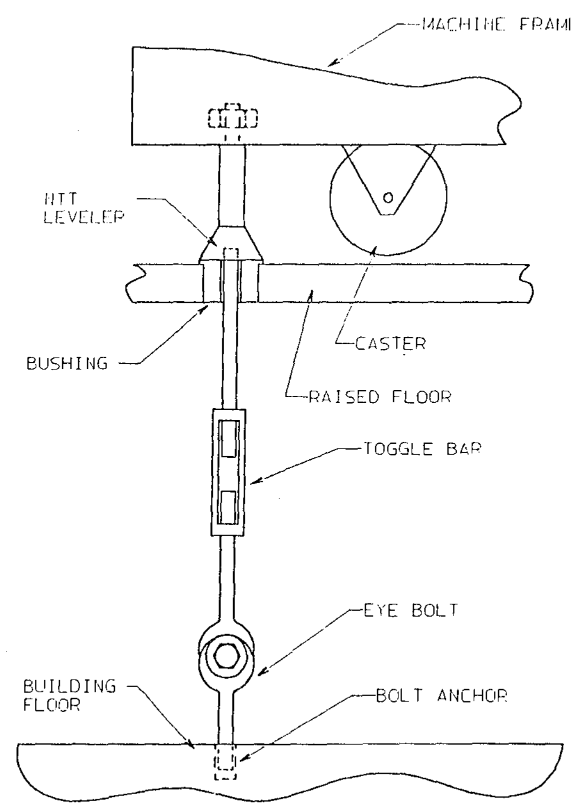


Fig. 3-12 Toggle Bar Installation with NTT Leveler
(Frey and Nikolsky, 1992)

SECTION 4

TEST MATRICES AND TEST RESULTS

4.1 Test Matrices

A comprehensive test program was conducted over the three test periods in order to assess the performance of various installation methods as described in Sec. 3 under a wider spectrum of seismic input accelerations as described in Sec. 2. Due to practical constraints, not all installation methods were tested on every computer system and not all seismic inputs were used in every test. In addition, test objectives for different computer systems required different scale factors to be assigned to the seismic inputs.

The most convenient way of describing the types of tests conducted for each computer system is to construct a test matrix for each case.

4.1.1 June 1991 Test

The complete test matrices for this test series are given in Tables 4-1 and 4-2. The maximum input acceleration levels are summarized in Table 4-3.

4.1.2 August 1991 Test

The complete test matrix for this test series is given in Table 4-4. The maximum input acceleration levels are summarized in Tabel 4-5.

4.1.3 June 1992 Test

The complete test matrices for the test series are given in Tables 4-6 to 4-8. The maximum input acceleration levels are summarized in Table 4-9.

4.2 Test Results

Test results of most practical interest are the maximum absolute acceleration level experienced by the computer system and its maximum lateral displacement. A selected set of these values for each installation method and for each mainframe computer system is given in the appendix.

Figures 4-1 through 4-22 show performance comparisons of the installation methods for a selected series of test runs in terms of maximum absolute accelerations and lateral displacements. The plots of only the best-case installation methods are shown, which are chosen on the basis of smallest lateral displacements and lowest maximum acceleration levels. In these plots, the maximum value at each accelerometer location is plotted on the y-axis with respect to the accelerometer location on the x-axis.

Table 4-1 Test Matrix For IBM-9370, June 1991

9370	SIMULATION RUNS								
INSTAL. TYPE	EC-1	EC-5	EC-7	Taft 1	Taft 5	Taft 7	BELL CORE	IBM 1	IBM 2
Locked Casters	X	X	X	X	X	X	X	X	X
Free Casters			33%			33%	33%		33%
Bungee Cords F.C.			X			X	X		X
Bungee Cords L.C.			X						
Two Springs			X			X	X	X	
Four Springs			X			X	X	X	
Four Toggle Bars								X	
F VE Dampers			X			X			
D VE Dampers	50%		X			X	50%		50%
2-Hz Wire Ropes			X			X			
4-Hz Wire Ropes			X			X	X		
Fixed Base			X			X	X		X

Table 4-2 Test Matrix For IBM-9371, June 1991

IBM-9371	SIMULATION RUNS			
INSTALATION TYPE	EC-7	Taft-7	BELLCORE	IBM-2
Glides	X	X	X	X
E VE Dampers	X	X	X	X
Fixed to Rear Wall	X	X	X	X
Fixed Base	X	X	X	X

Table 4-3 Maximum Acceleration Levels for June 1991

Maximum Acceleration Values	Slab X-Axis (g's)	Floor Z-Axis (g's)	Floor X-Axis (g's)
El Centro RC-7	0.66	0.24	0.71
Taft RC-7	0.20	0.19	0.62
IBM-1	0.68	0.24	0.71
IBM-2	1.02	0.33	1.02
Bellcore	1.02	0.51	0.72

Table 4-4 Test Matrix For IBM-9221, August 1991

IBM-9221	SIMULATION RUNS				
INSTALLATION TYPE	EC-1	EC-3	EC-7	IBM 1	IBM 2
Locked Casters	X	X	X		X
Locked Casters Rotated 90 Deg.	X	X			
Four Toggle Bars Free Casters 40-Dur. Bushings	X		X		X
Four Toggle Bars Free Casters 80-Dur. Bushings			X		X
Front & Back Fixed		X	X		X
Sides Fixed		X	X		X
Two Console Series Fixed Front & Back	X	X	X		X
Two Console Series Toggle Bars	X	X	X		X
Two Console Series Locked Casters	X	X	X		
VE Dampers, Case-1	X	X	X		
VE Dampers, Case-2	X	X	X		
VE Dampers, Case-3	X	X	X		

Table 4-5 Maximum Acceleration Levels for August 1991

Maximum Acceleration Values	Slab X-Axis (g's)	Slab Z-Axis (g's)	Floor X-Axis (g's)
El Centro RC-1	0.45	0.24	0.53
El Centro RC-3	0.50	0.24	0.57
El Centro RC-7	0.82	0.23	1.15
IBM-2	1.83	0.34	2.04

Table 4-6 Test Matrix for Frame-8, June 1992

FRAME-8	SIMULATION RUNS							
INSTALLATION TYPE	EC-1	EC-3	EC-5	EC-7	EC-1.5	IBM 1	IBM 2	BELL CORE
Toggle Bars 80-Durometer		X		X	X	X	X	X
3/16 Wire Cable, 80-Durometer		X		X	X	X	X	X
3/16 Wire Cable, Teflon Bush.		X		X				
Springs K=570 lb/in Teflon Bush.		X		X	X	X	X	
5/32 Wire Cable Teflon Bush.		X		X	X	X		
Toggle Bars Alum. Bush.		X		X	X	X	X	X
Toggle Bars Loose, Alum. Bush.						X	X	
Normal Lev. X-Axis	X	X	X	X		X		
Normal Lev. Y-Axis		X		X		X	X	

Table 4-7 Test Matrix for Frame-1, June 1992

FRAME-1	SIMULATION RUNS							
INSTALLATION TYPE	EC-1	EC-3	EC-5	EC-7	EC 1.5	IBM 1	IBM 2	BELL CORE
Casters	X	X						
NTT Levelers	X	X	X	X				
Normal lev.	X	X	X	X				
Toggle Bars 80-Durometer		X		X	X	X	X	X
Toggle Bars Alum. Bush.		X		X	X	X	X	X
5/32 Wire Cable Teflon Bush.		X		X	X	X	X	X
NTT Levelers Toggle Bars Alum. Bush.		X	X	X	X	X	X	X
NTT Levelers 3/16 Wire Cable Alum. Bush.		X		X	X	X	X	X
3/16 Wire Cable Teflon Bush.		X		X	X	X	X	X
Springs K=570 lb/in.		X		X	X	X		
Springs K=290 lb/in.		X						
Fixed X-Axis		X		X	X	X	X	X
Fixed Y-Axis		X		X	X	X	X	X
Fixed 1-Bolt X-Axis		X		X	X	X	X	X

Table 4-8 Test Matrix for Endicott Frame, June 1992

ENDICOTT FRAME	SIMULATION RUNS							
INSTALLATION TYPE	EC-1	EC-3	EC-5	EC-7	EC 1.5	IBM 1	IBM 2	BELL CORE
Normal Lev. X-Axis		X		X		X	X	X
Toggle Bars 80-Durometer		X		X		X	X	X
NTT Levelers Toggle Bars 80-Durometer		X		X		X	X	X
Toggle Bars Alum. Bush.		X		X		X	X	X
NTT levelers Toggle Bars Alum. Bush.		X		X		X	X	X
Toggle Bars Loose Alum. Bush.						X	X	

Table 4-9 Maximum Acceleration Levels for June 1992

Maximum Acceleration Values	Slab X-Axis (g's)	Slab Z-Axis (g's)	Floor X-Axis (g's)
El Centro RC-3	0.48	0.16	0.54
El Centro RC-7	0.70	0.16	0.73
IBM-1	0.78	0.30	0.91
IBM-2	0.97	0.31	1.80
Bellcore	0.81	0.35	1.35

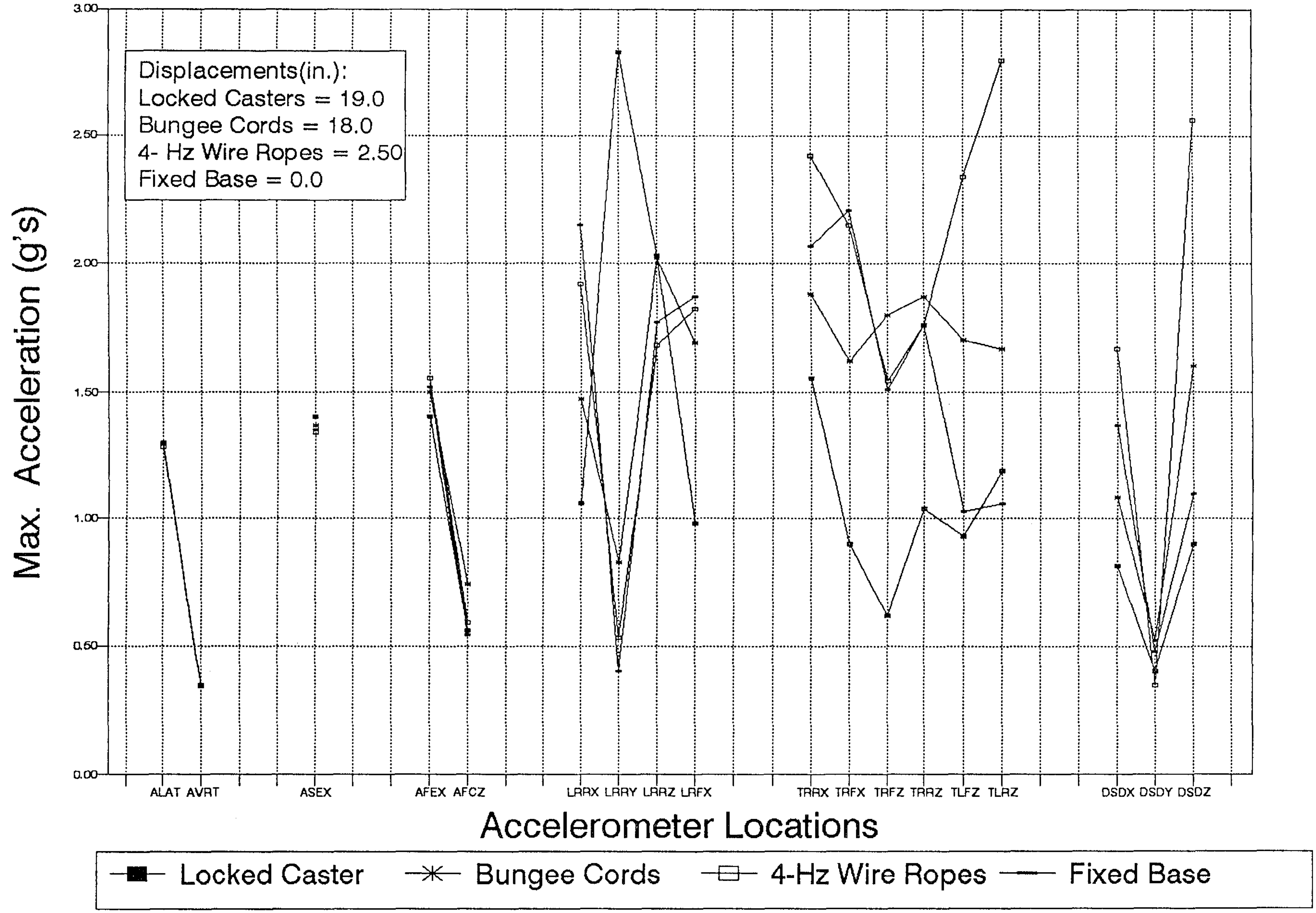


Fig. 4-1 IBM 9370, IBM2 Input

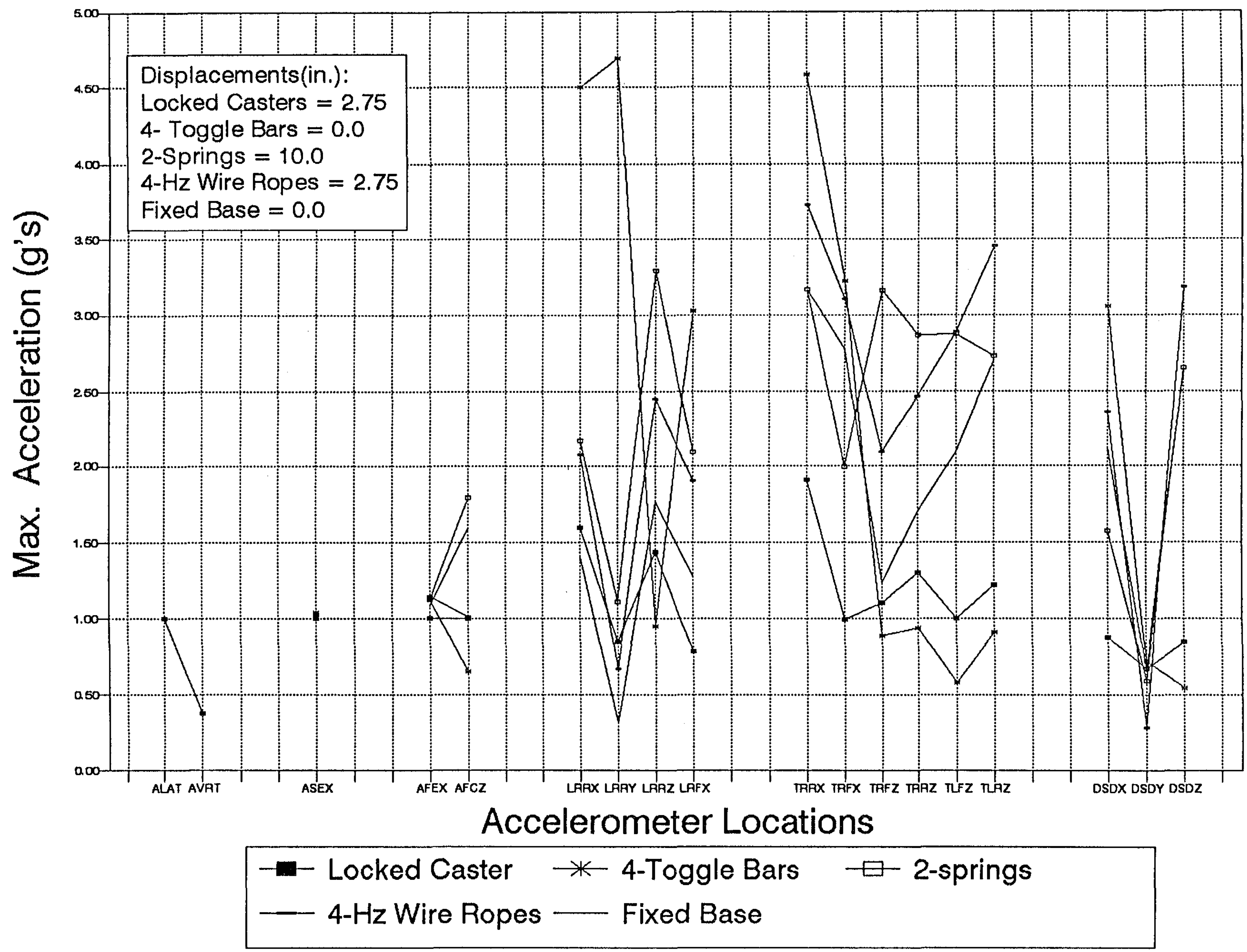


Fig. 4-2 IBM 9370, Bellcore Input

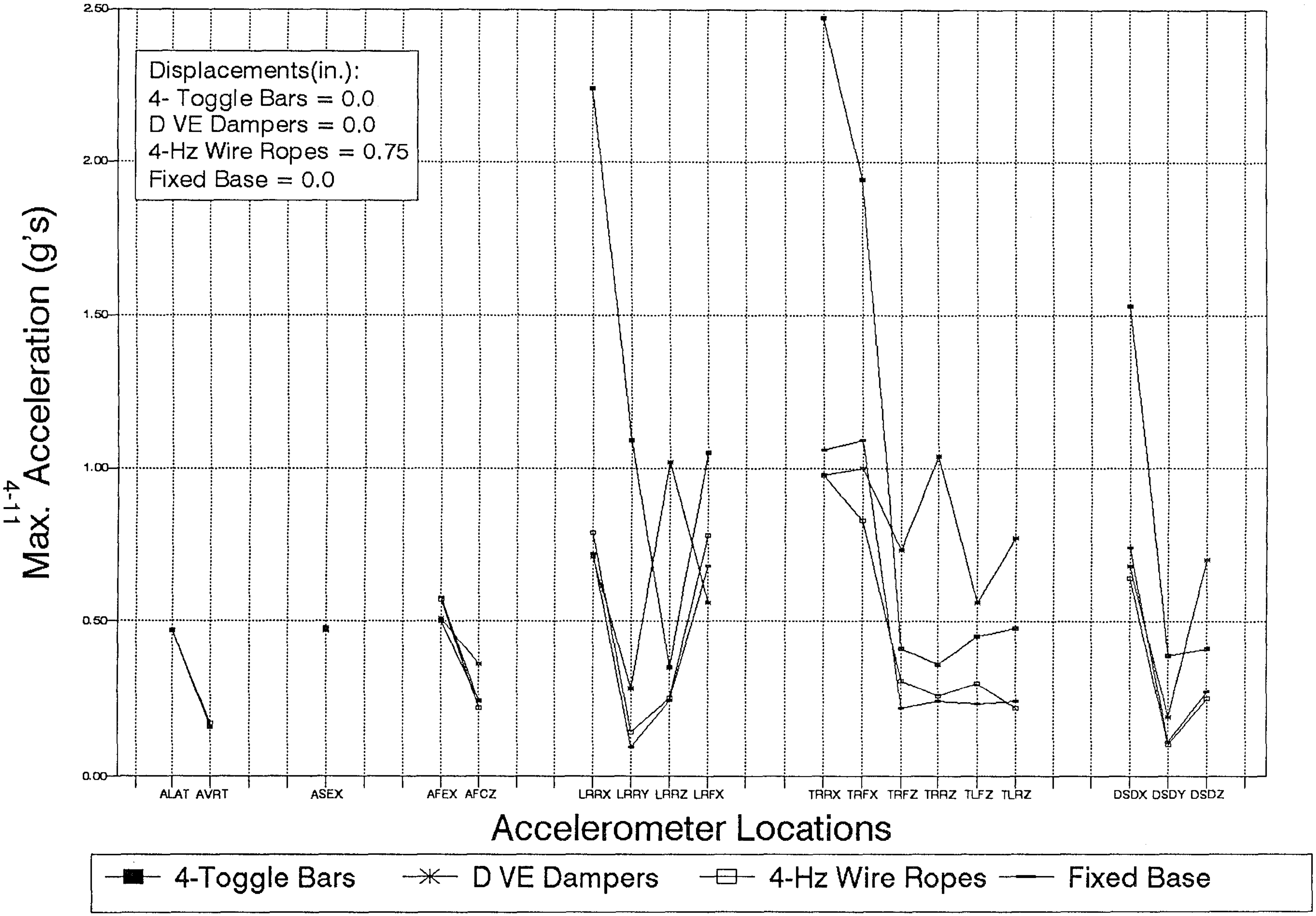


Fig. 4-3 IBM 9370, Taft RC-7 Input

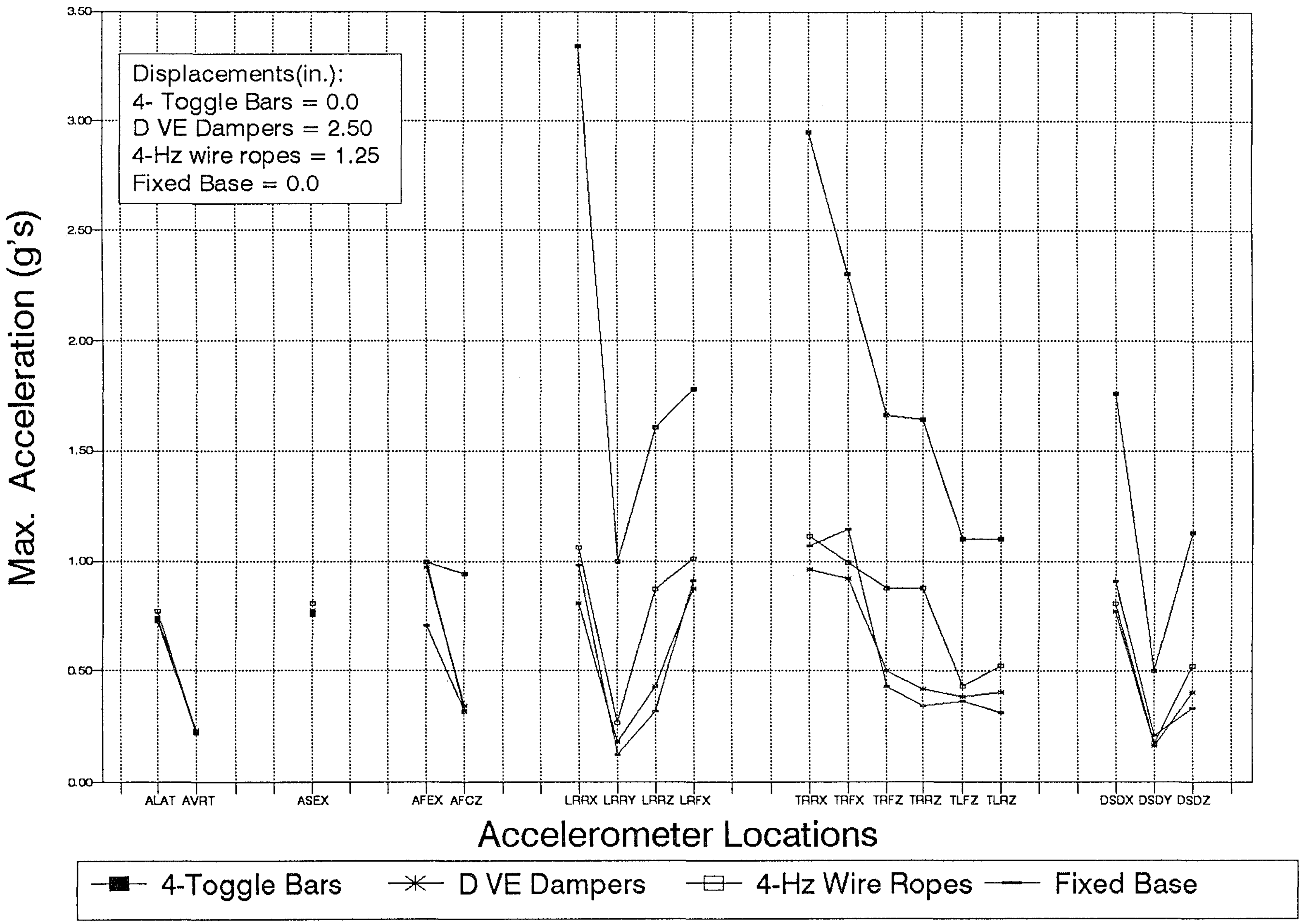


Fig. 4-4 IBM 9370, El Centro RC-7 Input

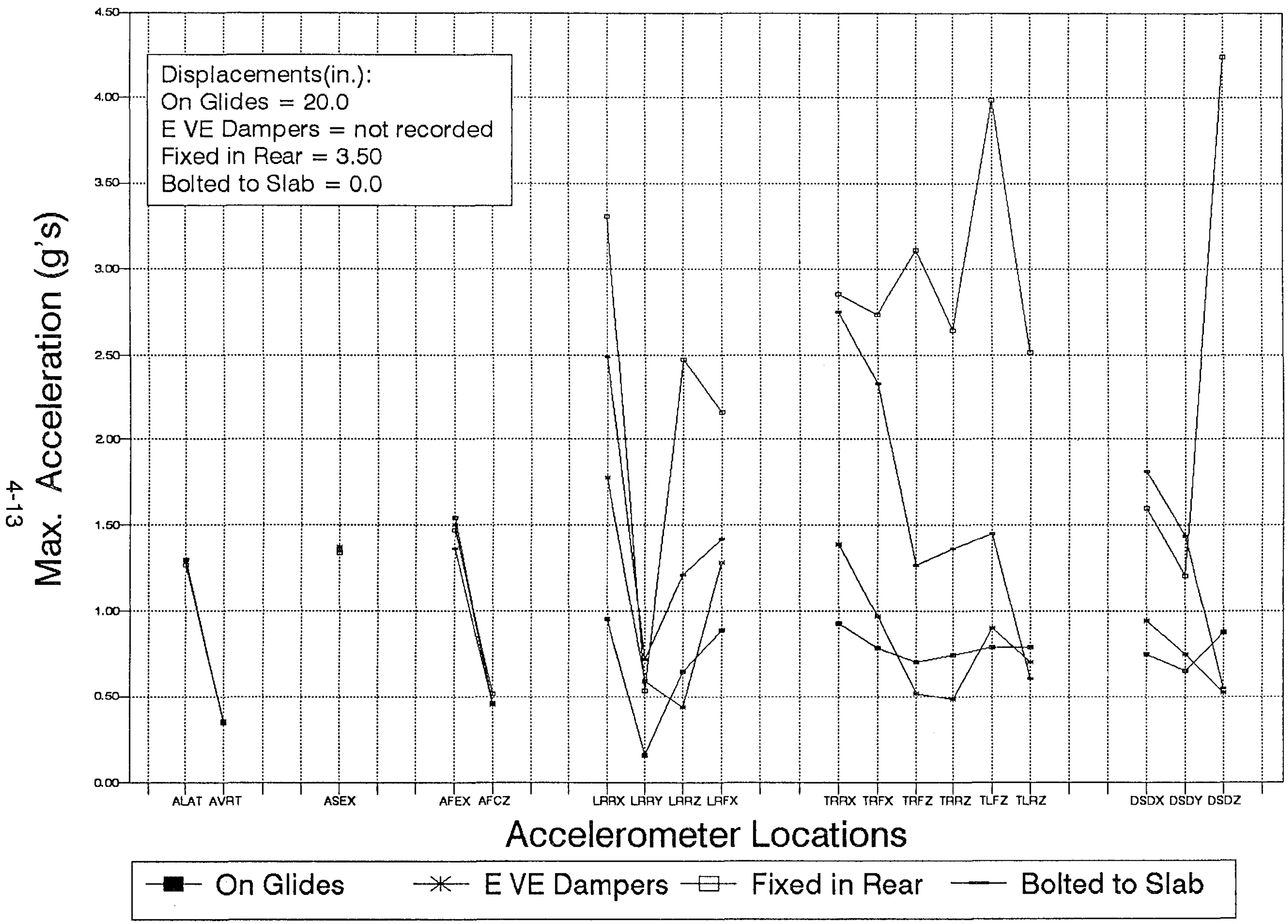


Fig. 4-5 IBM 9371, IBM2 Input

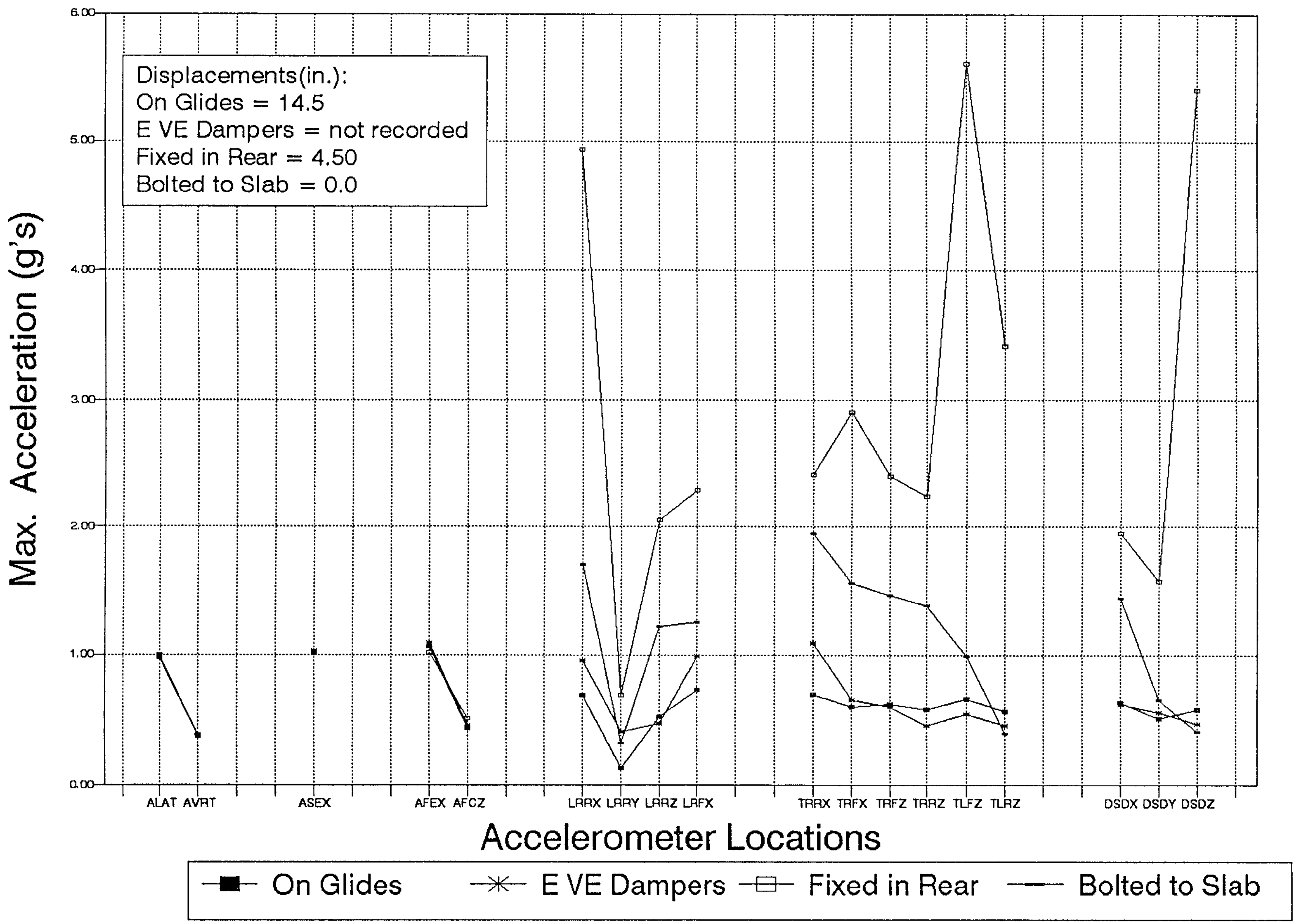


Fig. 4-6 IBM 9371, Bellcore Input

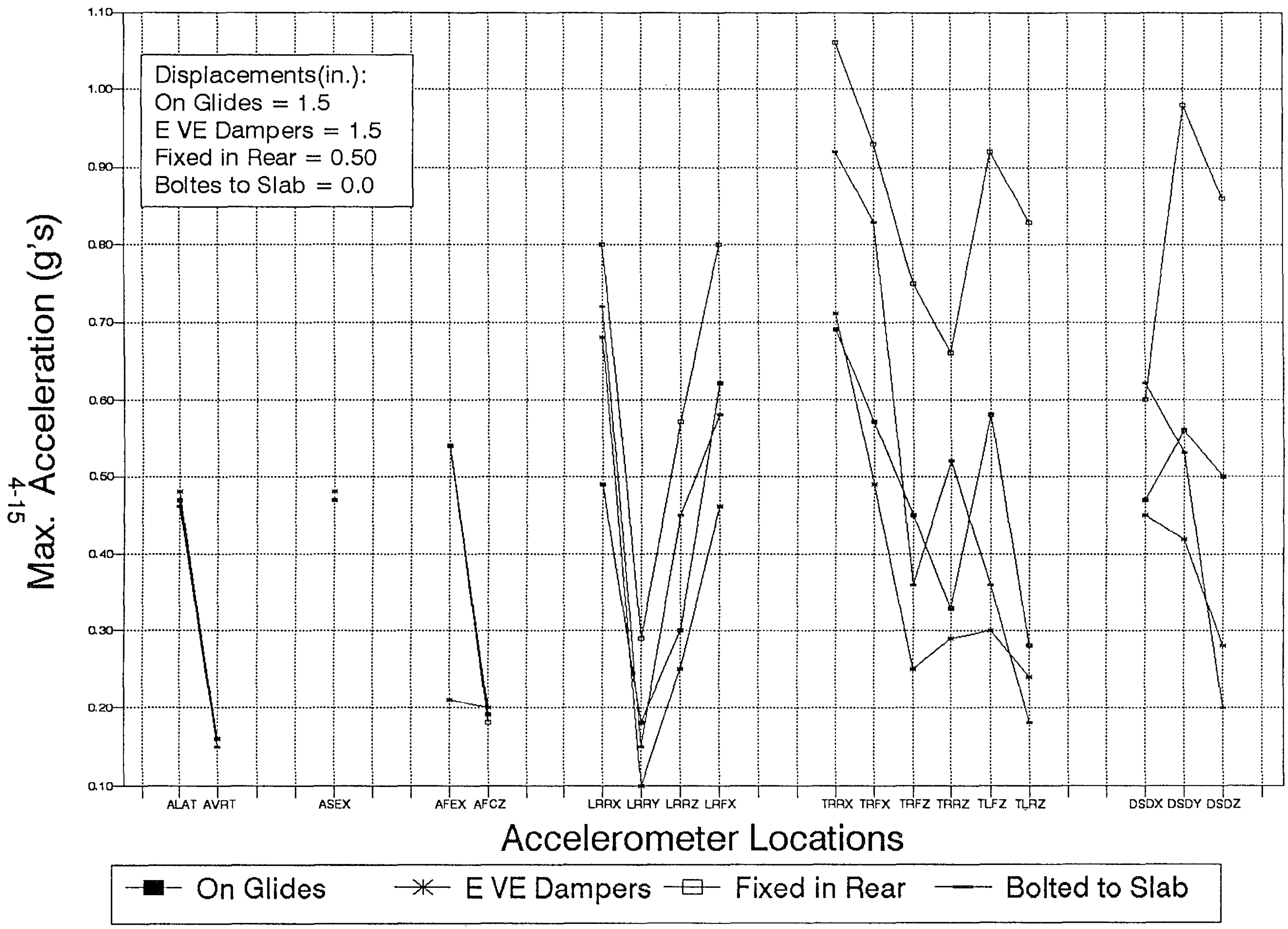


Fig. 4-7 IBM 9371, Taft RC-7 Input

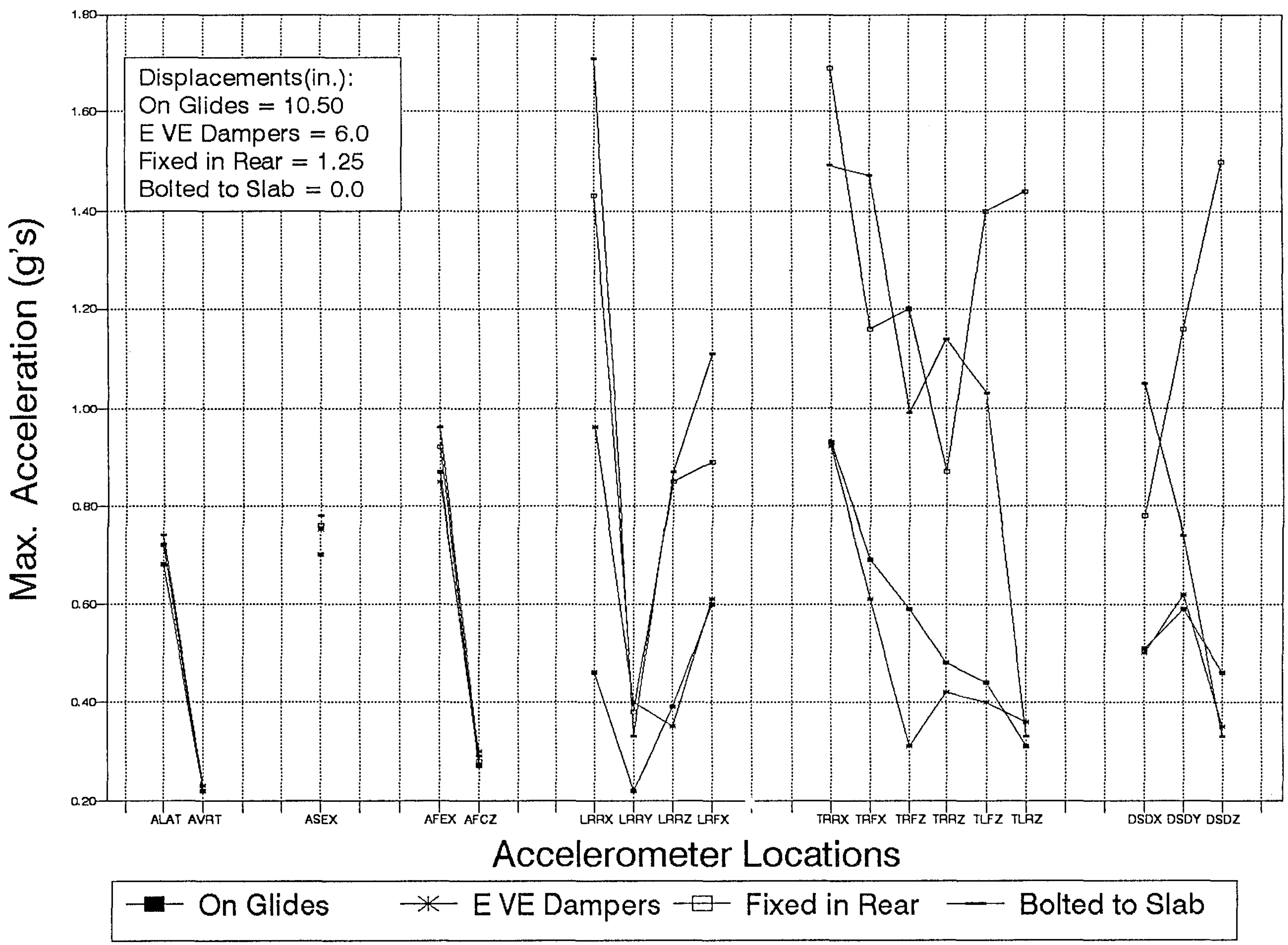


Fig. 4-8 IBM 9371, El Centro RC-7 Input

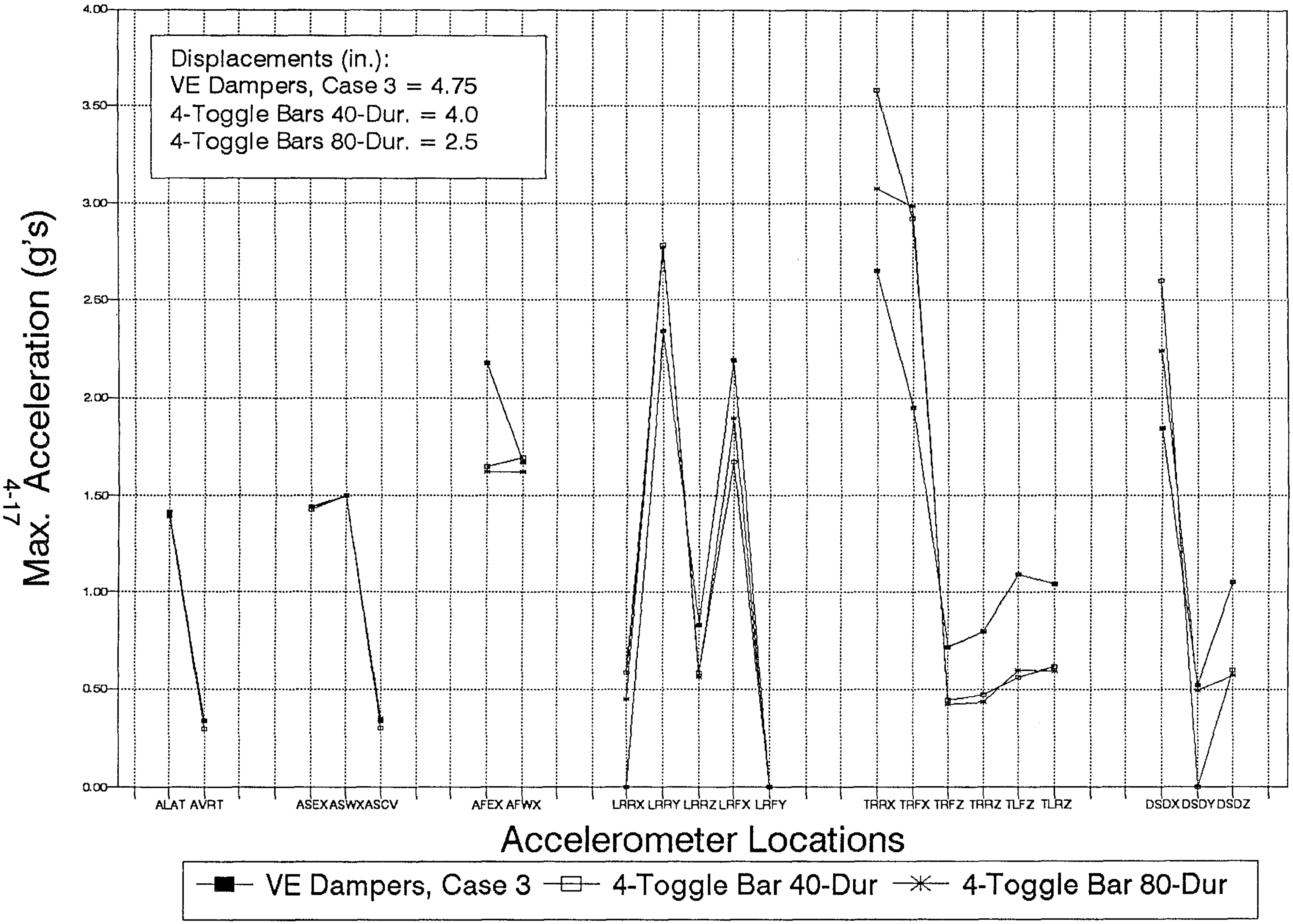


Fig. 4-9 IBM 9221, IBM2 Input

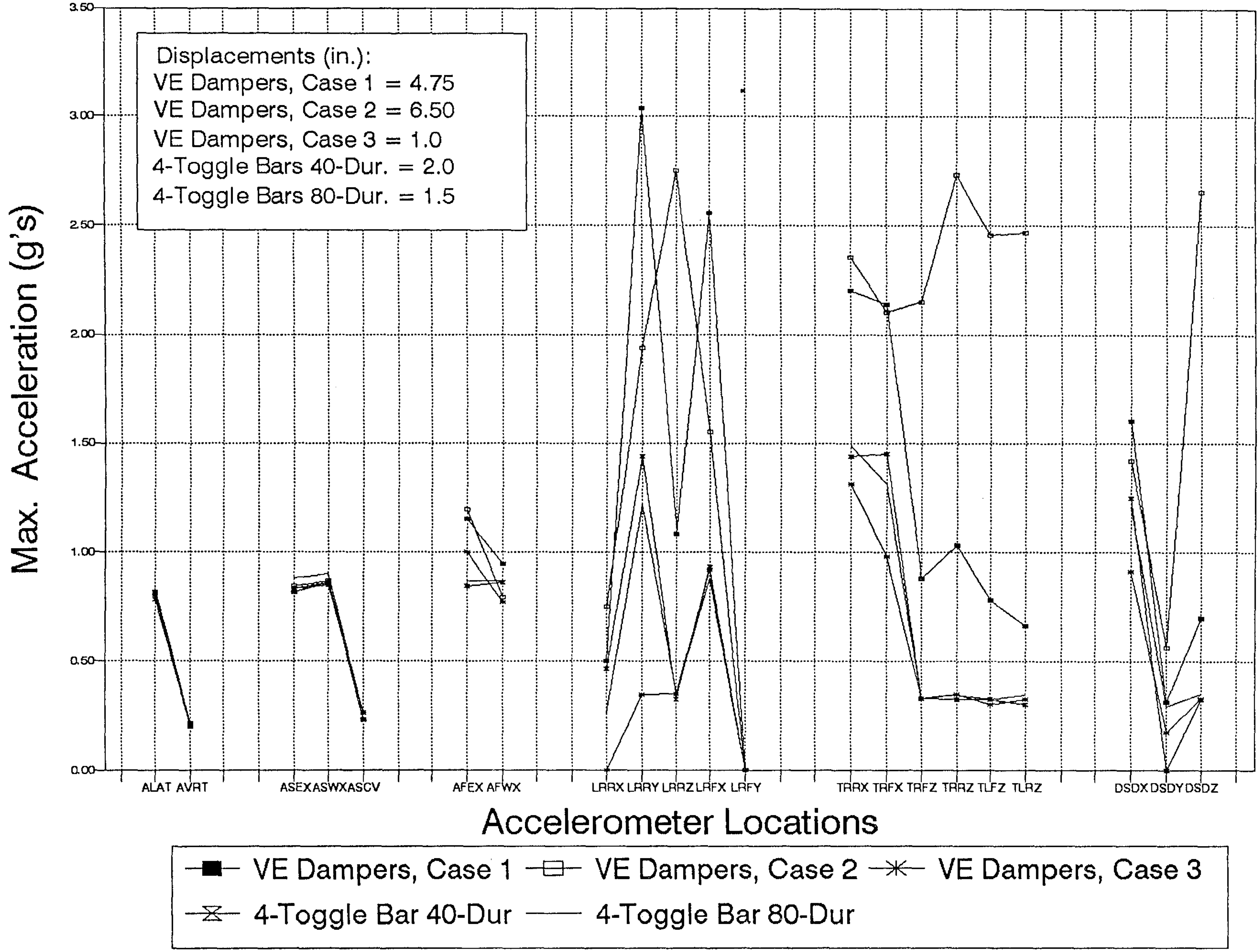


Fig. 4-10 IBM 9221, El Centro RC-7 Input

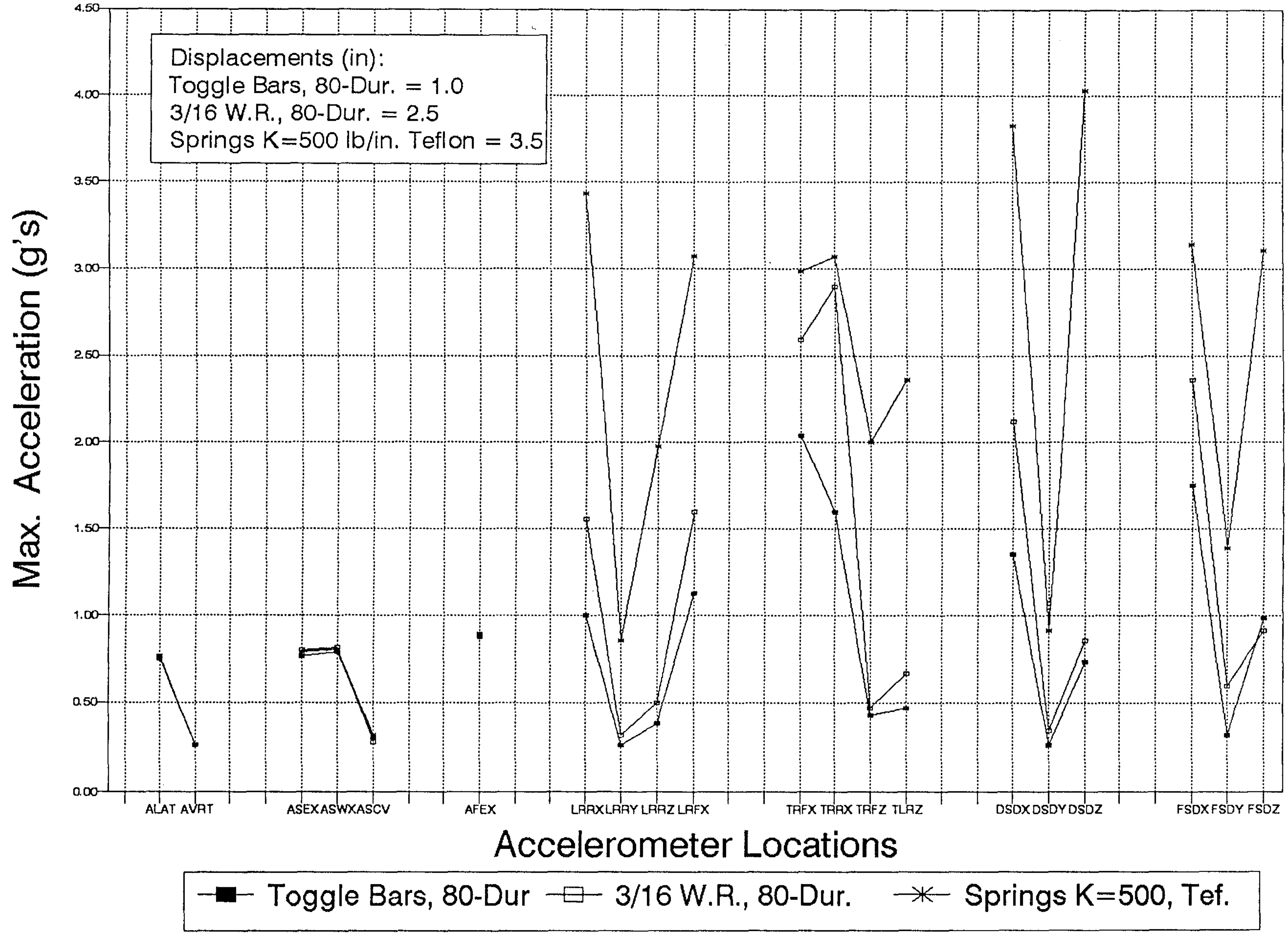


Fig. 4-11 Frame-8, IBM1 Input

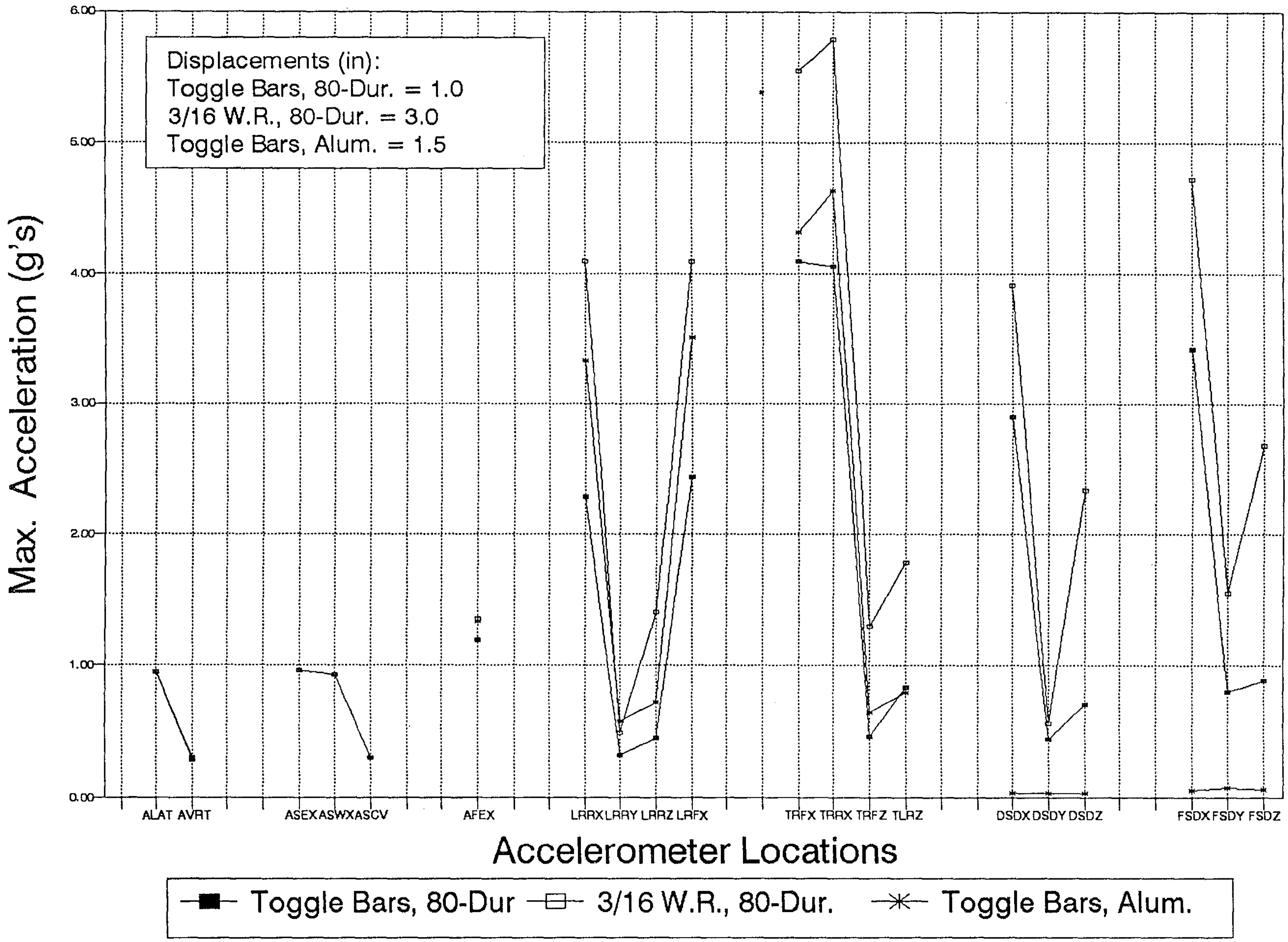


Fig. 4-12 Frame-8, IBM2 Input

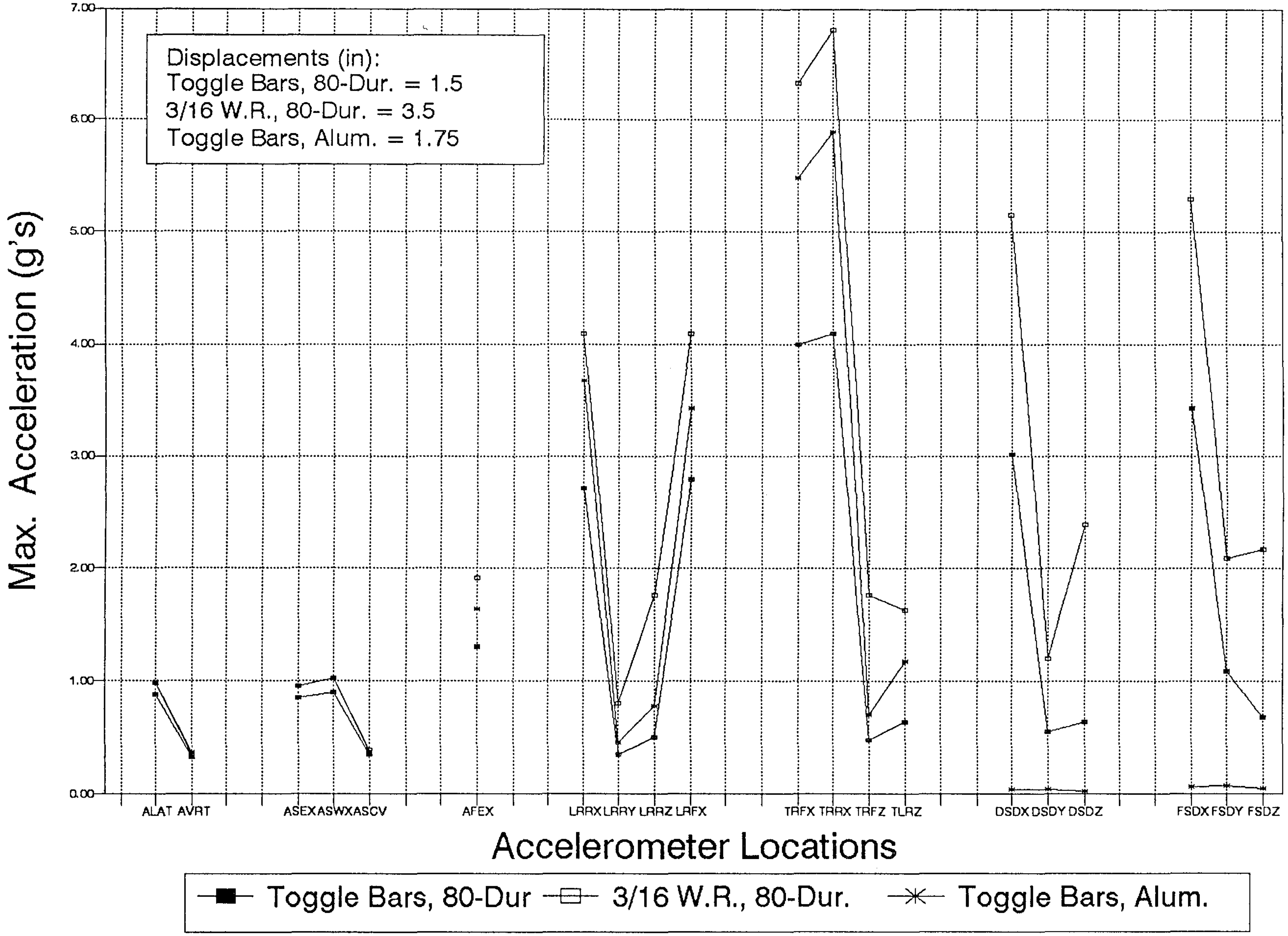


Fig. 4-13 Frame-8, Bellcore Input

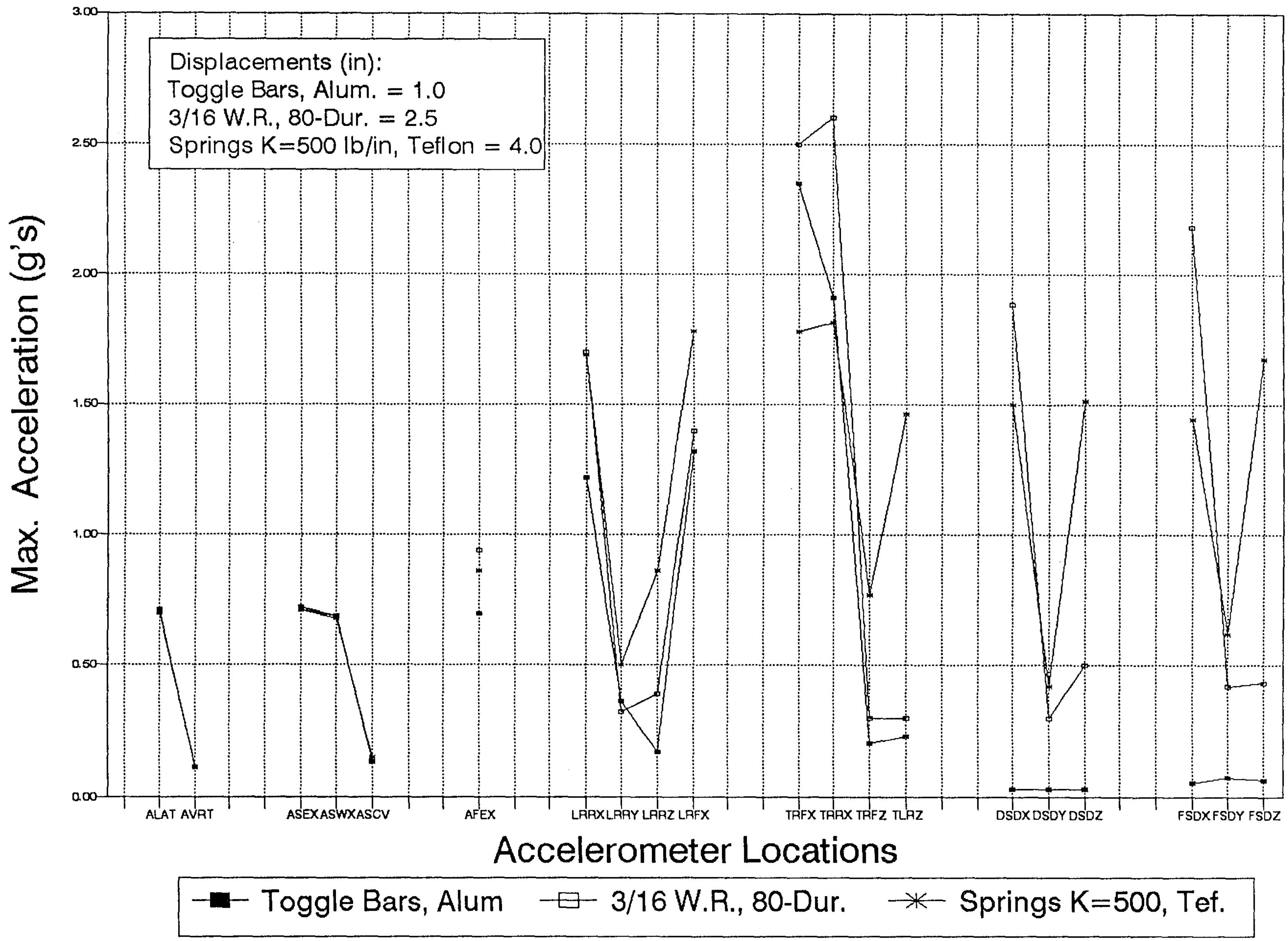


Fig. 4-14 Frame-8, El Centro RC-7 Input

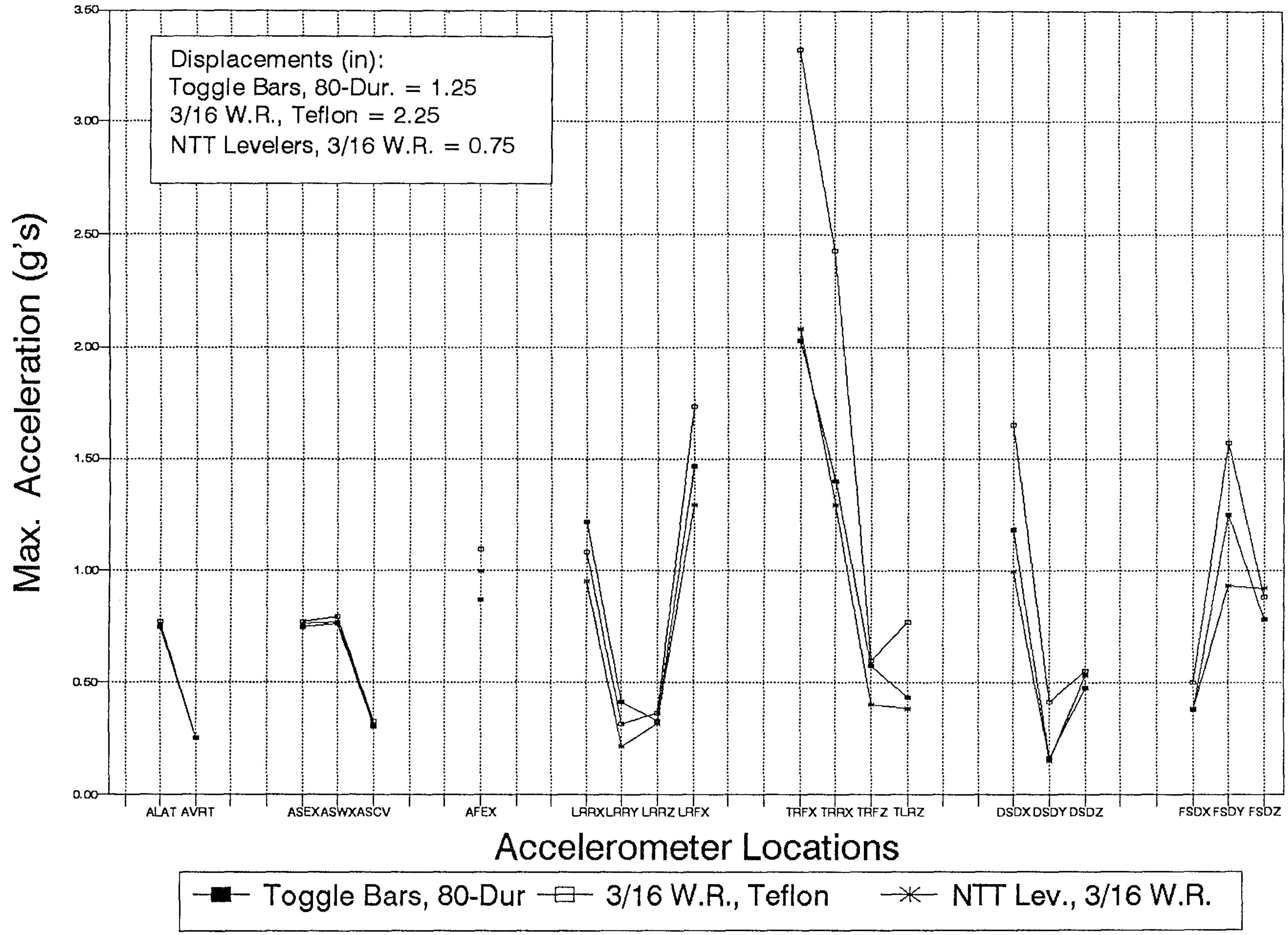


Fig. 4-15 Frame-1, IBM1 Input

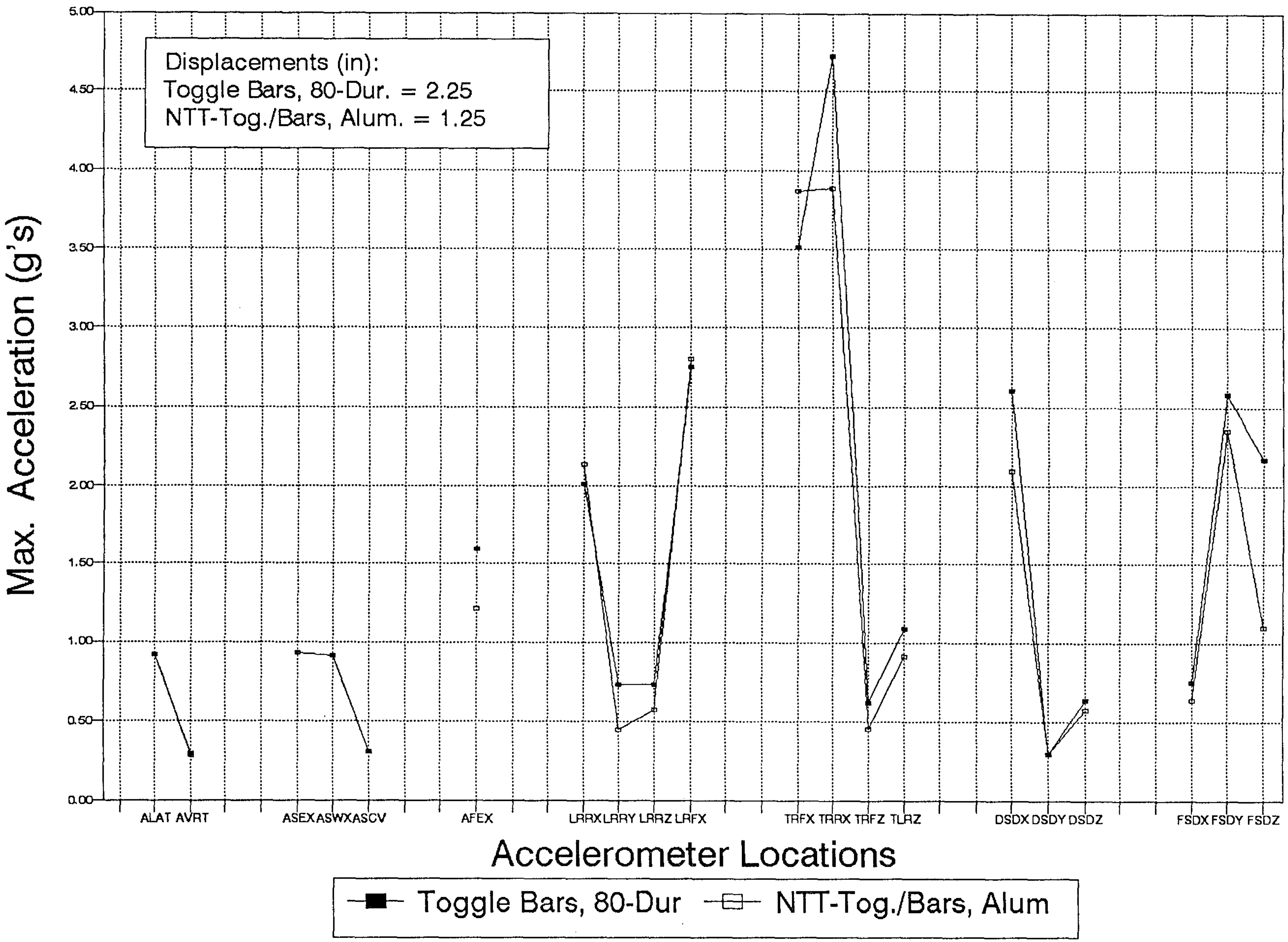


Fig. 4-16 Frame-1, IBM2 Input

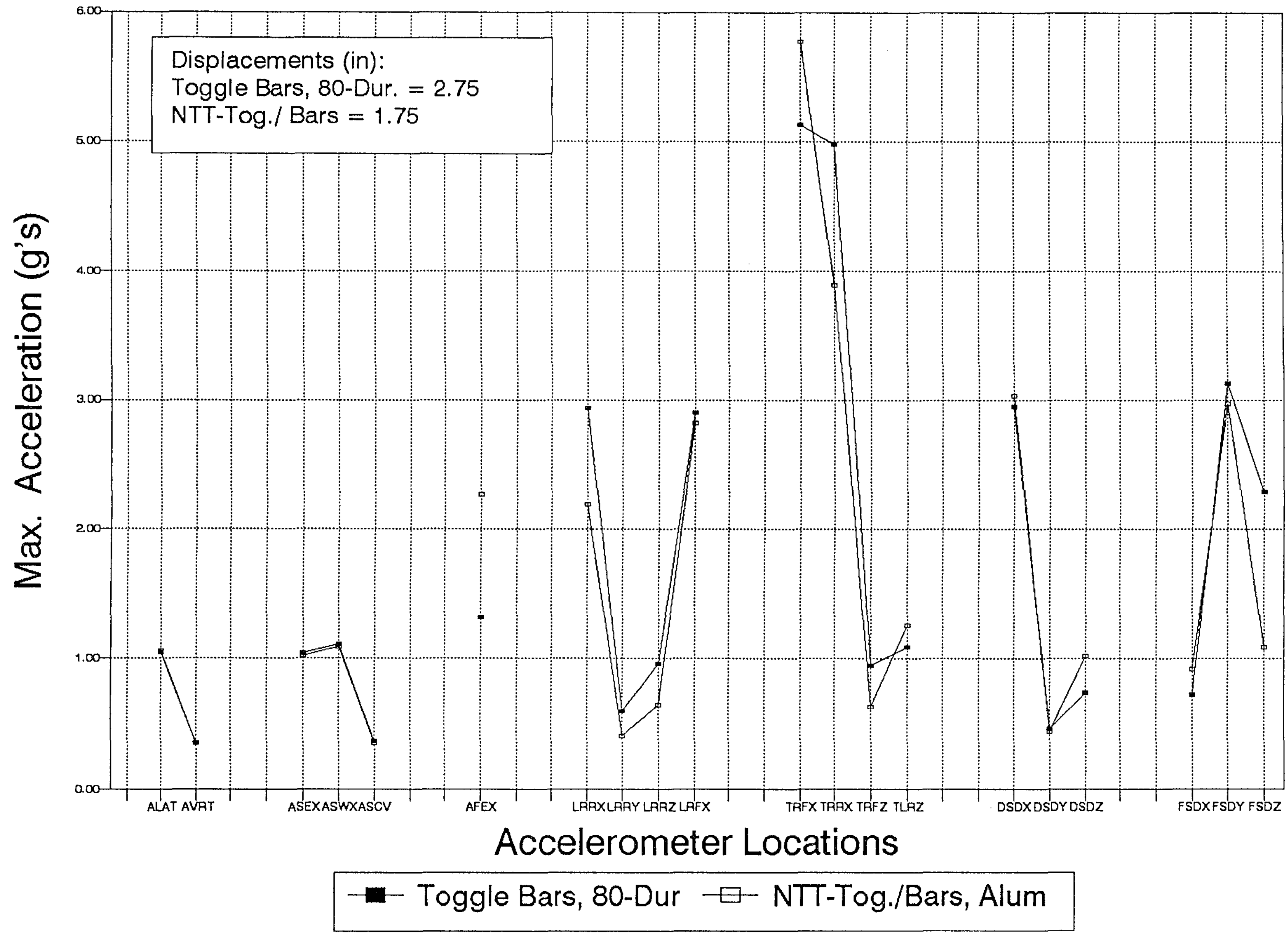


Fig. 4-17 Frame-1, Bellcore Input

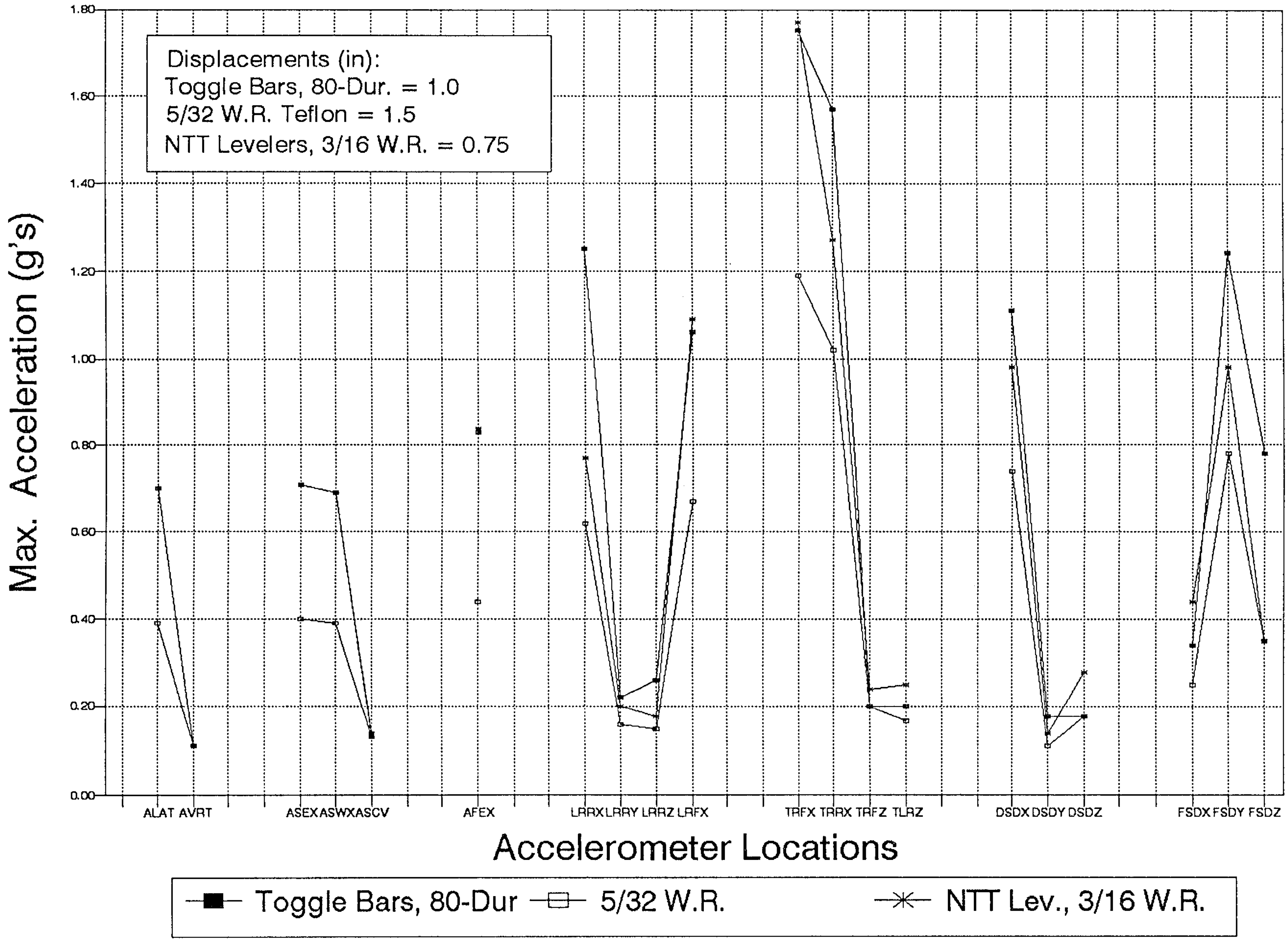


Fig. 4-18 Frame-1, El Centro RC-7 Input

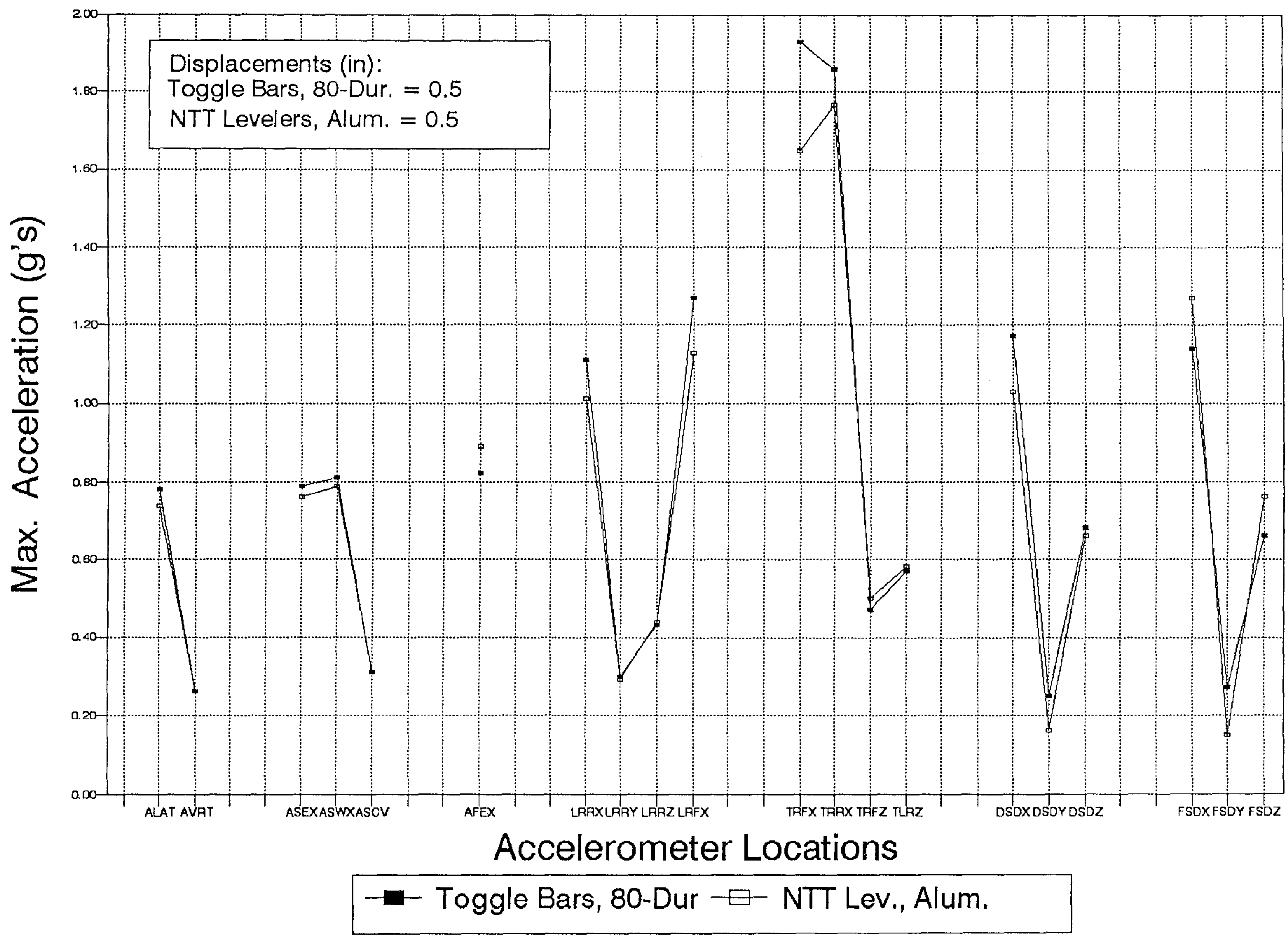


Fig. 4-19 Endicott Frame, IBM1 Input

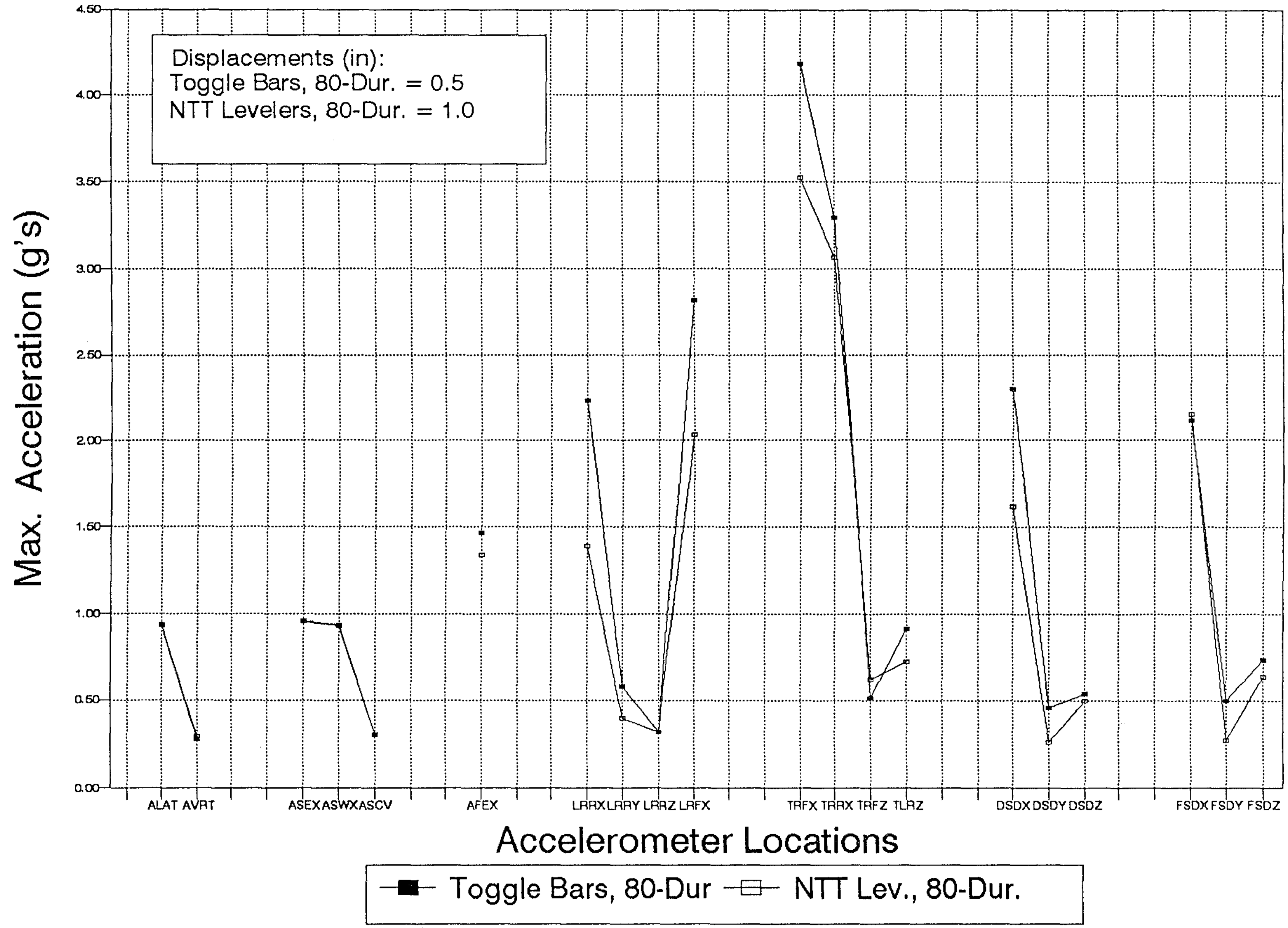


Fig. 4-20 Endicott Frame, IBM2 Input

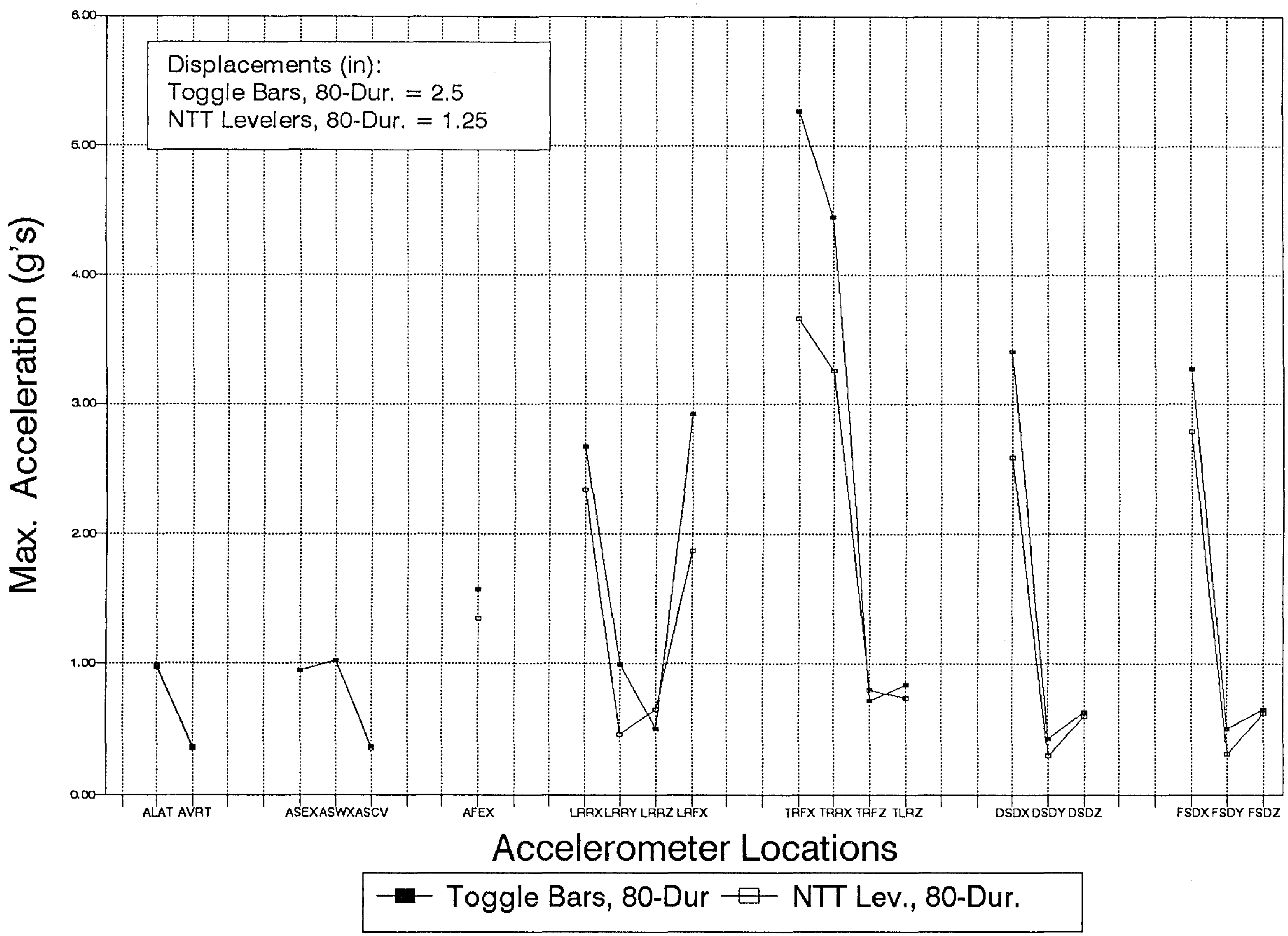


Fig. 4-21 Endicott Frame, Bellcore Input

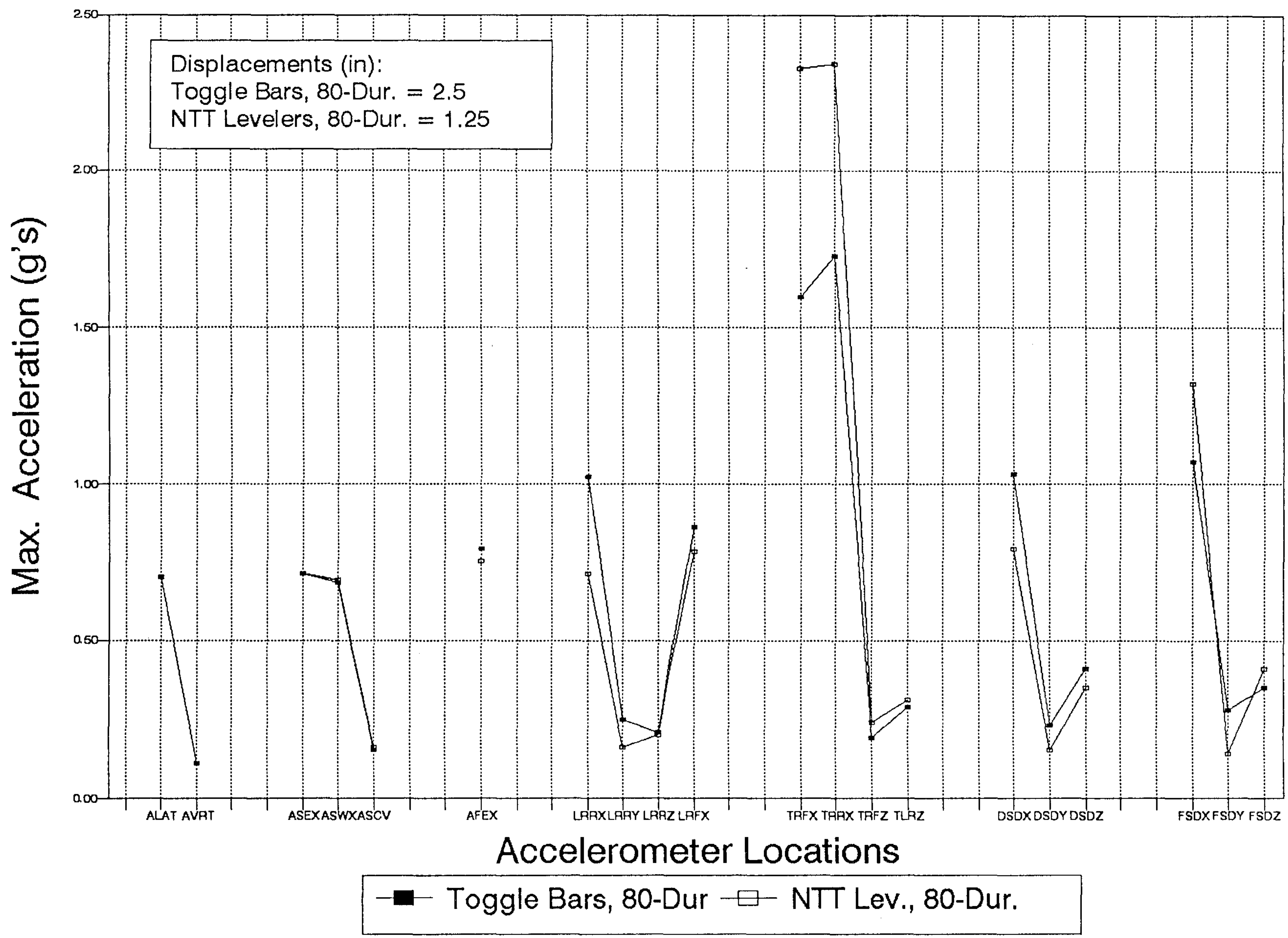


Fig. 4-22 Endicott Frame, El Centro RC-7 Input

SECTION 5

DISCUSSION OF TEST RESULTS AND RECOMMENDATIONS

Generally speaking, test results show that there is a trade off in the system response between the relative displacement and the maximum acceleration. Typically, a smaller relative displacement is accompanied by a larger maximum acceleration. The reverse of this also holds true.

5.1 June 1991 Test

For the IBM 9370 mainframe system, the test results show that, for the IBM2 input simulation runs, the fixed base case gives the overall best results. The maximum acceleration values in this case are all below 2.5 g's while the relative displacement is zero.

The results from the Bellcore input simulation runs for the IBM 9370 mainframe system show that the locked casters case gives the overall best results. Here the maximum acceleration values are all below 2.0 g's and the relative displacement is 2.75 in.

The results from Taft RC-7 input simulation runs for the IBM 9370 mainframe system show that the D VE dampers, 4-Hz wire ropes, and the fixed base cases all give similar acceptable results. The maximum acceleration values for all three cases are below 1.5 g's, and the relative displacements are all between zero and 0.75 in.

Similar observations can be made for the El Centro RC-7 input simulation runs. The maximum acceleration values for all three cases are below 1.5 g's, and the relative displacements are all between zero and 2.50 in.

For the IBM 9371 mainframe system, the results show that, for the IBM2 input simulation runs, the bolted-to-slab case gives the overall best results. The maximum acceleration values in this case are all below 3.0 g's with no relative displacements.

The results from the Bellcore input simulation runs for the IBM 9371 mainframe system show that the bolted-to-slab case also gives the overall best results with all maximum acceleration values below 2.0 g's.

The results from Taft RC-7 input simulation runs for the IBM 9371 mainframe system show that E VE dampers give the best results. The maximum acceleration values are all below 0.8 g's, and the relative displacement is 1.5 n. However, from El Centro RC-7 input simulation runs, the bolted-to-slab case provides the best result with all maximum acceleration values below 1.8 g's with no relative displacements.

The conclusion that can be drawn from these results is that the fixed-base and locked-caster installation methods appear to be a good low cost solution for anchoring mainframe computer systems to raised floors.

5.2 August 1991 Test

For the IBM 9221 mainframe system, the results show that, for the IBM2 input simulation runs, the VE dampers, case 3, gives the overall best results. The maximum acceleration values are all below 3.0 g's and the relative displacement is 4.75 inches. The same conclusion can be drawn from the El Centro RC-7 input simulation results where the maximum acceleration values for this input are all below 1.5 g's and the relative displacement is 1.0 inch.

The conclusion that can be drawn from these results is that, overall, the viscoelastic damper device provides sufficient stiffness and damping characteristics to offer a good solution for anchoring the IBM 9221 mainframe computer system to the raised floor.

5.3 June 1992 Test

For the Frame 8 system, the results show that toggle bars appear to satisfy the dual requirements, i.e., a small relative displacement and a small maximum acceleration. The bushings which seem to work best are the 80-durometer ones.

For the Endicott Frame, the results show that toggle bars are promising, but the response is much improved if they are used with the NTT levelers. The trade off here between the displacement and the acceleration seems to hold true for all the runs except Bellcore. For this simulation run, the response shows a small relative displacement and a small maximum acceleration for the NTT levelers with the toggle bars. Again, the 80-durometer bushings seems to work best here.

For the Frame 1 system, the results are not as clear cut. Here the 5/32-in wire cables performed well for the El Centro RC-7 simulation runs. For the IBM1 and Bellcore simulation runs, the toggle bars with the 80-durometer bushings worked well. Finally, for the IBM2 simulation runs, the NTT levelers with toggle bars and aluminum bushings appear to perform the best. Therefore, it appears levelers could help the response of the system.

The conclusion that can be drawn from these results is that a restraint system consisting of toggle bars with 80-durometer bushings appear to be a good low cost solution for anchoring mainframe computer systems to a raised floor. To possibly improve this response in terms of relative displacement and maximum acceleration, NTT levelers with toggle bars and 80-durometer bushings could be used. This method of anchoring will also provide good results, but at a much higher cost.

An assessment of the overall test results indicates that there is a need to formulate installation procedures for computers and data processing equipment according to their dynamic behavior in a seismic environment. It is clear that an optimum restraint system is one which provides, on the one hand, sufficient stiffness to limit lateral displacement of the computer system within acceptable range and, on the other hand, sufficient damping or energy dissipation capacity to minimize its absolute acceleration. The amount of stiffness and damping of the restraint system required is, in turn, a function of the system characteristics, its location in the structure, the structural characteristics, soil conditions, and seismic conditions at the site. Sufficient knowledge currently exists on the dynamics of these types of systems under conditioning specified above, and this knowledge base can be utilized in the formulation of realistic installation guidelines and in the development of efficient restraint systems.

SECTION 6

REFERENCES

1. Bellcore, *Network Equipment-Building Systems (NEBS), Generic Equipment Requirements*, Report TR-EOP-000063, Issue 3, Whippany, NJ, March, 1988.

2. Demetriades, G.F., Constantinou, M.C. and Reinhorn, A.M., *Study of wire Rope Systems for Seismic Protection of Equipment in Buildings*, Tech. Rep. No. NCEER-92-0012, National Center for Earthquake Engineering Research, Buffalo, NY, 1992.

3. FIMS, *Data Processing Facilities - Guidelines for Earthquake Hazard Mitigation*, FIMS Inc., 1987.

4. Foss, J.W. and Nikolakopoulou, G.A., "Electronic Data Processing Equipment Braced to Resist Seismic Loading," *Proc. 7th World Conference on Earthquake Engrg.*, Istanbul, Turkey, 1980.

5. Frey, R.A., "Earthquake Testing for Data Processing Equipment," *Proc. Inst. Environ. Sci.*, 1992.

6. Frey, R.A. and Nikolsky, G.N., *IBM Earthquake Simulation Tests in IBM Mainframe Products*, Tech. Rep. No. TR01.C604, Endicott, NY, 1992.

7. Gates, W.E. and Scawthorn, C., "Mitigation of Earthquake Effects on Data Processing Equipment," *Proc. ASCE National Spring Convention*, Las Vegas, NV, 1982.

8. Green, R.S. and Frey, R.A., *Loma Prieta Earthquake Effects on IBM Equipment*, Tech. Rep. No. TR02.1634, IBM San Jose, CA, 1990.

9. HoLung, J.A. and Lin, Y.K., *Seismic Testing on IBM Computers*, Tech. Rep. No. TR54.730, Boca Raton, FL, 1993.

10. IBM, *Earthquake resistance for IBM Hardware Products*, Corporate Bulletin C-B 1-9711-009, Purchase, NY, 1992.

APPENDIX

SUMMARY OF TEST RESULTS

Table A-1 Maximum Acceleration Values(g's), Locked Caster Case, IBM-9370, June 1991

June 1991 IBM-9370		LOCKED CASTERS			
		RUN-5 IBM-2	RUN-6A BELLCORE	RUN-9 TAFT RC-7	RUN-11A EC RC-7
SHAKER	ALAT	1.30	1.00	0.47	0.74
	AVRT	0.35	0.38	0.16	0.22
SLAB	ASEX	1.40	1.00	0.48	0.78
FLOOR	AFEX	1.40	1.00	0.51	0.85
	AFCZ	0.56	1.00	0.24	0.35
LOWER	LRRX	1.06	1.60	0.40	0.48
	LRRY	2.83	0.85	0.26	0.46
	LRRZ	2.03	1.43	0.26	0.39
	LRFX	0.98	0.79	0.39	0.46
TOP	TRRX	1.55	1.91	0.47	0.72
	TRFX	0.90	0.99	0.43	0.42
	TRFZ	0.62	1.10	0.26	0.41
	TRRZ	1.04	1.30	0.24	0.37
	TLFZ	0.93	1.00	0.21	0.36
	TLRZ	1.19	1.22	0.22	0.38
DSD	DSDX	0.81	0.88	0.26	0.22
	DSDY	0.40	0.67	0.16	0.67
	DSDZ	0.90	0.85	0.24	0.96
DISPL. [in.]		19.00	2.75	6.25	13.00

Table A-2 Maximum Acceleration Values(g's), Bungee Cords Case, IBM-9370, June 1991

June 1991 IBM-9370		BUNGEE CORDS				
		RUN-16 IBM-2	RUN-17 BELLCORE	RUN-18 TAFT RC-7	RUN-19 EC RC-7 FREE CASTERS	RUN-19A EC RC-7 LOCKED CASTER
SHAKER	ALAT	1.30	1.00	0.47	0.71	0.74
	AVRT	0.34	0.38	0.16	0.23	0.23
SLAB	ASEX	1.37	1.03	0.48	0.76	0.78
FLOOR	AFEX	1.50	1.19	0.50	0.85	0.85
	AFCZ	0.74	0.83	0.24	0.72	0.31
LOWER	LRRX	1.47	1.22	0.54	1.12	0.98
	LRRY	0.83	1.03	0.43	0.64	0.50
	LRRZ	2.02	2.24	0.24	0.37	0.55
	LRFX	1.69	1.11	0.48	0.40	0.64
TOP	TRRX	1.88	1.96	0.70	1.09	1.20
	TRFX	1.62	1.33	0.37	0.54	0.64
	TRFZ	1.80	1.82	0.30	0.35	0.49
	TRRZ	1.87	2.10	0.23	0.34	0.54
	TLFZ	1.70	1.19	0.19	0.37	0.61
	TLRZ	1.67	1.48	0.24	0.37	0.54
DSD	DSDX	1.08	1.00	0.34	0.70	0.83
	DSDY	0.52	0.40	0.16	0.34	0.38
	DSDZ	1.60	1.27	0.21	0.34	0.54
DISPL. [in.]		18.00	15.00	6.00	16.75	15.00

Table A-3 Maximum Acceleration Values(g's), 4-Toggle Bar Case, IBM-9370, June 1991

June 1991 IBM-9370		4 - TOGGLE BARS			
		RUN-20A IBM-1	RUN-21 BELLCORE	RUN-22 TAFT RC-7	RUN-23 EC RC-7
SHAKER	ALAT	0.68	1.00	0.47	0.74
	AVRT	0.21	0.38	0.16	0.22
SLAB	ASEX	0.70	1.04	0.48	0.76
FLOOR	AFEX	0.75	1.12	0.50	1.00
	AFCZ	0.33	0.65	0.24	0.94
LOWER	LRRX	3.33	4.50	2.24	3.34
	LRRY	1.39	4.69	1.09	1.00
	LRRZ	0.50	0.95	0.35	1.60
	LRFX	1.37	3.03	1.05	1.78
TOP	TRRX	3.50	4.58	2.47	2.95
	TRFX	2.33	3.22	1.94	2.30
	TRFZ	0.58	0.89	0.41	1.66
	TRRZ	0.51	0.94	0.36	1.64
	TLFZ	0.64	0.58	0.45	1.10
	TLRZ	0.79	0.91	0.48	1.10
DSD	DSDX	2.24	3.05	1.53	1.76
	DSDY	0.83	0.72	0.39	0.50
	DSDZ	0.56	0.54	0.41	1.13
DISPL. [in.]		0.00	0.00	0.00	0.00

Table A-4 Maximum Acceleration Values(g's), 2-Spring Case, IBM-9370, June 1991

June 1991 IBM-9370		2 - SPRINGS			
		RUN-24 IBM-1	RUN-25 BELLCORE	RUN-26 TAFT RC-	RUN-27 EC RC-7
SHAKER	ALAT	0.67	1.00	0.48	0.72
	AVRT	0.21	0.38	0.16	0.22
SLAB	ASEX	0.69	1.03	0.48	0.77
FLOOR	AFEX	0.77	1.12	0.54	0.92
	AFCZ	0.89	1.79	0.25	2.64
LOWER	LRRX	0.78	2.16	0.54	3.20
	LRRY	0.55	1.11	0.36	1.18
	LRRZ	0.60	3.30	0.31	4.15
	LRFX	0.63	2.09	0.38	1.60
TOP	TRRX	1.04	3.17	0.79	3.07
	TRFX	0.85	1.99	0.49	2.17
	TRFZ	0.60	3.16	0.31	3.34
	TRRZ	0.63	2.86	0.30	3.74
	TLFZ	0.52	2.87	0.19	3.48
	TLRZ	0.58	2.73	0.37	3.16
DSD	DSDX	0.57	1.57	0.45	1.76
	DSDY	0.36	0.59	0.19	0.41
	DSDZ	0.54	2.65	0.31	3.14
DISPL. [in.]		9.50	10.00	7.50	17.00

Table A-5 Maximum Acceleration Values(g's), F-Damper Case, IBM-9370, June 1991

June 1991 IBM-9370		F VE DAMPERS	
		RUN-30F2 TAFT RC-7	RUN-31F2 EC RC-7
SHAKER	ALAT	0.47	0.35
	AVRT	0.16	0.11
SLAB	ASEX	0.48	0.35
FLOOR	AFEX	0.55	0.37
	AFCZ	0.33	0.19
LOWER	LRRX	1.11	0.60
	LRRY	0.50	0.13
	LRRZ	0.86	0.26
	LRFX	1.66	0.44
TOP	TRRX	1.30	0.54
	TRFX	0.79	0.51
	TRFZ	0.83	0.25
	TRRZ	0.84	0.27
	TLFZ	0.88	0.18
	TLRZ	0.68	0.19
DSD	DSDX	0.72	0.45
	DSDY	0.33	0.09
	DSDZ	0.83	0.20
DISPL. [in.]		4.00	7.50

Table A-6 Maximum Acceleration Values(g's), D-Damper Case, IBM-9370, June 1991

June 1991 IBM-9370		D VE DAMPERS	
		RUN-30D3 TAFT RC-7	RUN-31D EC RC-7
SHAKER	ALAT	0.47	0.73
	AVRT	0.16	0.23
SLAB	ASEX	0.47	0.78
FLOOR	AFEX	0.51	0.97
	AFCZ	0.36	0.34
LOWER	LRRX	0.71	0.81
	LRRY	0.28	0.18
	LRRZ	1.02	0.43
	LRFX	0.56	0.87
TOP	TRRX	0.98	0.96
	TRFX	1.00	0.92
	TRFZ	0.73	0.50
	TRRZ	1.04	0.42
	TLFZ	0.56	0.38
	TLRZ	0.77	0.40
DSD	DSDX	0.68	0.77
	DSDY	0.19	0.16
	DSDZ	0.70	0.40
DISPL. [in.]		0.00	2.50

Table A-7 Maximum Acceleration Values(g's), 4-Hz. Wire Rope Case, IBM-9370, June 1991

June 1991 IBM-9370		4 - Hz. WIRE ROPES			
		RUN - W737A BELLCORE	RUN - W438A TAFT RC-7	RUN - W639A EC RC-7	RUN - 36 IBM-2
SHAKER	ALAT	1.00	0.47	0.77	1.28
	AVRT	0.38	0.17	0.22	0.34
SLAB	ASEX	1.03	0.48	0.81	1.34
FLOOR	AFEX	1.15	0.57	1.00	1.55
	AFCZ	1.01	0.22	0.32	0.59
LOWER	LRRX	2.07	0.79	1.06	1.92
	LRRY	0.67	0.14	0.27	0.53
	LRRZ	2.44	0.25	0.87	1.68
	LRFX	1.90	0.78	1.01	1.82
TOP	TRRX	3.73	0.98	1.11	2.42
	TRFX	3.11	0.83	0.99	2.15
	TRFZ	2.09	0.31	0.88	1.54
	TRRZ	2.46	0.26	0.88	1.76
	TLFZ	2.89	0.30	0.43	2.34
	TLRZ	3.46	0.22	0.52	2.80
DSD	DSDX	2.35	0.64	0.81	1.67
	DSDY	0.28	0.10	0.17	0.35
	DSDZ	3.19	0.25	0.52	2.56
DISPL. [in.]		2.75	0.75	1.25	2.50

Table A-8 Maximum Acceleration Values(g's), 4-Wire Rope Case, IBM-9370, June, 1991

June 1991 IBM-9370		2-Hz WIRE ROPES	
		RUN - W1338B TAFT RC-7	RUN - W1739B EC RC-7
SHAKER	ALAT	0.47	0.77
	AVRT	0.16	0.24
SLAB	ASEX	0.48	0.81
FLOOR	AFEX	0.59	1.30
	AFCZ	0.51	1.06
LOWER	LRRX	1.33	1.09
	LRRY	0.47	0.85
	LRRZ	0.91	2.99
	LRFX	1.23	3.77
TOP	TRRX	1.29	2.76
	TRFX	1.05	2.71
	TRFZ	0.90	2.71
	TRRZ	0.90	2.86
	TLFZ	1.22	4.39
	TLRZ	1.25	3.38
DSD	DSDX	0.71	2.42
	DSDY	0.36	0.74
	DSDZ	1.23	3.69
DISPL. [in.]		3.75	2.75

Table A-9 Maximum Acceleration Values(g's), Fixed Base Case, IBM-9370, June 1991

June 1991 IBM-9370		FIXED BASE			
		RUN-60 IBM-2	RUN-61 BELLCORE	RUN-62C TAFT RC-7	RUN-63 EC RC-7
SHAKER	ALAT	1.30	0.99	0.47	0.72
	AVRT	0.35	0.38	0.16	0.23
SLAB	ASEX	1.35	1.04	0.47	0.77
FLOOR	AFEX	1.52	1.08	0.58	0.71
	AFCZ	0.54	1.60	0.24	0.32
LOWER	LRRX	2.15	1.41	0.72	0.98
	LRRY	0.40	0.31	0.09	0.12
	LRRZ	1.77	1.77	0.24	0.32
	LRFX	1.87	1.27	0.68	0.91
TOP	TRRX	2.07	3.17	1.06	1.07
	TRFX	2.21	2.77	1.09	1.14
	TRFZ	1.51	1.24	0.22	0.43
	TRRZ	1.76	1.70	0.24	0.34
	TLFZ	1.03	2.09	0.23	0.36
	TLRZ	1.06	2.70	0.24	0.31
DSD	DSDX	1.37	2.12	0.74	0.91
	DSDY	0.48	0.66	0.11	0.21
	DSDZ	1.10	2.64	0.27	0.33
DISPL. [in.]		0.00	0.00	0.00	0.00

Table A-10 Maximum Acceleration Values(g's), On Glides Case, IBM-9371, June 1991

June 1991 IBM-9371		GLIDES			
		RUN-40 IBM-2	RUN-41 BELLCORE	RUN-42B TAFT RC-7	RUN-43 EC RC-7
SHAKER	ALAT	1.30	1.00	0.47	0.68
	AVRT	0.34	0.38	0.16	0.22
SLAB	ASEX	1.36	1.02	0.47	0.70
FLOOR	AFEX	1.54	1.06	0.54	0.87
	AFCZ	0.46	0.44	0.19	0.27
LOWER	LRRX	0.95	0.68	0.49	0.46
	LRRY	0.16	0.12	0.18	0.22
	LRRZ	0.64	0.52	0.30	0.39
	LRFX	0.89	0.73	0.62	0.60
TOP	TRRX	0.93	0.70	0.69	0.93
	TRFX	0.78	0.60	0.57	0.69
	TRFZ	0.70	0.62	0.45	0.59
	TRRZ	0.74	0.58	0.33	0.48
	TLFZ	0.79	0.66	0.58	0.44
	TLRZ	0.79	0.57	0.28	0.31
DSD	DSDX	0.75	0.63	0.47	0.51
	DSDY	0.65	0.51	0.56	0.59
	DSDZ	0.88	0.58	0.50	0.46
DISPL. [in.]		20.00	14.50	1.50	10.50

Table A-11 Maximum Acceleration Values(g's), E-Damper Case, IBM-9371, June 1991

June 1991 IBM-9371		E VE DAMPERS IN REAR ATTACHED TO WALL			
		RUN-44 IBM-2	RUN-45 BELLCORE	RUN-46B TAFT RC-7	RUN-47 EC RC-7
SHAKER	ALAT	1.30	1.00	0.48	0.72
	AVRT	0.34	0.37	0.16	0.23
SLAB	ASEX	1.37	1.03	0.48	0.75
FLOOR	AFEX	1.50	1.10	0.21	0.85
	AFCZ	0.45	0.46	0.20	0.30
LOWER	LRRX	1.78	0.95	0.68	0.96
	LRRY	0.59	0.41	0.10	0.40
	LRRZ	0.43	0.47	0.25	0.35
	LRFX	1.28	0.99	0.46	0.61
TOP	TRRX	1.39	1.10	0.71	0.92
	TRFX	0.97	0.65	0.49	0.61
	TRFZ	0.51	0.60	0.25	0.31
	TRRZ	0.48	0.46	0.29	0.42
	TLFZ	0.90	0.54	0.30	0.40
	TLRZ	0.70	0.46	0.24	0.36
DSD	DSDX	0.94	0.62	0.45	0.50
	DSDY	0.75	0.56	0.42	0.62
	DSDZ	0.52	0.47	0.28	0.35
DISPL. [in.]				1.50	6.00

Table A-12 Maximum Acceleration Values(g's), Fixed in Rear Case, IBM-9371, June 1991

June 1991 IBM-9371		FIXED IN REAR ONLY			
		RUN-64 IBM-2	RUN-65 BELLCORE	RUN-66A TAFT RC-7	RUN-67 EC RC-7
SHAKER	ALAT	1.27	0.99	0.47	0.72
	AVRT	0.35	0.37	0.16	0.22
SLAB	ASEX	1.34	1.01	0.47	0.76
FLOOR	AFEX	1.47	1.02	0.54	0.92
	AFCZ	0.51	0.51	0.18	0.28
LOWER	LRRX	3.31	4.94	0.80	1.43
	LRRY	0.53	0.68	0.29	0.38
	LRRZ	2.47	2.06	0.57	0.85
	LRFX	2.16	2.29	0.80	0.89
TOP	TRRX	2.85	2.41	1.06	1.69
	TRFX	2.73	2.90	0.93	1.16
	TRFZ	3.11	2.40	0.75	1.20
	TRRZ	2.64	2.24	0.66	0.87
	TLFZ	3.99	5.61	0.92	1.40
	TLRZ	2.51	3.42	0.83	1.44
DSD	DSDX	1.60	1.95	0.60	0.78
	DSDY	1.20	1.57	0.98	1.16
	DSDZ	4.24	5.40	0.86	1.50
DISPL. [in.]		3.50	4.50	0.50	1.25

Table A-13 Maximum Acceleration Values(g's), Bolted To Slab Case, IBM-9371, June 1991

June 1991 IBM-9371		BOLTED TO SLAB			
		RUN-68 IBM-2	RUN-69 BELLCORE	RUN-70 TAFT RC-7	RUN-71 EC RC-7
SHAKER	ALAT	1.29	0.97	0.46	0.74
	AVRT	0.34	0.38	0.15	0.23
SLAB	ASEX	1.35	1.03	0.47	0.78
FLOOR	AFEX	1.36	1.06	0.54	0.96
	AFCZ	0.45	0.44	0.20	0.29
LOWER	LRRX	2.49	1.70	0.72	1.71
	LRRY	0.72	0.32	0.15	0.33
	LRRZ	1.21	1.22	0.45	0.87
	LRFX	1.42	1.26	0.58	1.11
TOP	TRRX	2.75	1.95	0.92	1.49
	TRFX	2.33	1.56	0.83	1.47
	TRFZ	1.27	1.46	0.36	0.99
	TRRZ	1.36	1.39	0.52	1.14
	TLFZ	1.45	0.99	0.36	1.03
	TLRZ	0.60	0.39	0.18	0.33
DSD	DSDX	1.82	1.44	0.62	1.05
	DSDY	1.44	0.65	0.53	0.74
	DSDZ	0.55	0.41	0.20	0.33
DISPL. [in.]					

Table A-14 Maximum Acceleration Values(g's), Locked Caster Case, IBM-9221, August 1991

August 1991 IBM-9221		LOCKED CASTERS			
		RUN-4 EC RC-1	RUN-5 EC RC-3	RUN-6 EC RC-7	RUN-8 IBM-2
SHAKER	ALAT	0.13	0.47	0.82	1.70
	AVRT	0.02	0.20	0.21	0.33
SLAB	ASEX	0.14	0.49	0.86	1.80
	ASWX	0.14	0.49	0.89	1.90
	ASCV	0.03	0.24	0.24	0.34
FLOOR	AFEX	0.17	0.56	0.96	2.04
	AFWX	0.20	0.52	0.85	2.20
LOWER	LRRX	0.06	0.30	0.37	0.44
	LRRY	0.25	0.57	0.72	1.36
	LRRZ	0.08	0.39	0.43	0.85
	LRFX	0.23	0.45	0.62	0.84
	LRFY	0.00	0.00	0.00	0.00
TOP	TRRX	0.39	0.63	0.81	1.27
	TRFX	0.25	0.52	0.77	1.06
	TRFZ	0.07	0.49	0.50	0.72
	TRRZ	0.07	0.38	0.41	0.77
	TLFZ	0.07	0.46	0.49	0.93
	TLRZ	0.88	0.42	0.43	0.67
DSD	DSDX	0.18	0.30	0.41	0.72
	DSDY	0.06	0.19	0.37	0.44
	DSDZ	0.08	0.43	0.45	0.72
DISPL. [in.]		4.75	8.00	12.25	29.00

Table A-15 Maximum Acceleration Values(g's), VE Dampers, Case -1, IBM-9221, August 1991

August 1991 IBM-9221		VE DAMPERS, CASE 1		
		RUN-57 EC RC-1	RUN-58 EC RC-3	RUN-59 EC RC-7
SHAKER	ALAT	0.42	0.49	0.81
	AVRT	0.21	0.21	0.20
SLAB	ASEX	0.45	0.50	0.82
	ASWX	0.45	0.51	0.86
	ASCV	0.24	0.24	0.23
FLOOR	AFEX	0.53	0.57	1.15
	AFWX	0.48	0.54	0.94
LOWER	LRRX	0.18	0.15	0.50
	LRRY	0.82	0.96	3.04
	LRRZ	0.32	0.31	1.08
	LRFX	0.55	0.56	2.56
	LRFY	0.00	0.00	0.00
TOP	TRRX	0.71	0.97	2.20
	TRFX	0.59	0.71	2.14
	TRFZ	0.27	0.30	0.88
	TRRZ	0.31	0.31	1.03
	TLFZ	0.30	0.29	0.78
	TLRZ	0.29	0.31	0.66
DSD	DSDX	0.42	0.62	1.60
	DSDY	0.18	0.16	0.31
	DSDZ	0.29	0.31	0.70
DISPL. [in.]		1.50	2.75	4.75

Table A-16 Maximum Acceleration Values(g's), VE Dampers, Case -2, IBM-9221, August 1991

August 1991 IBM-9221		VE DAMPERS, CASE 2		
		RUN-60 EC RC-1	RUN-61 EC RC-3	RUN-62 EC RC-7
SHAKER	ALAT	0.45	0.48	0.82
	AVRT	0.21	0.21	0.21
SLAB	ASEX	0.46	0.50	0.84
	ASWX	0.47	0.51	0.87
	ASCV	0.26	0.25	0.23
FLOOR	AFEX	0.51	0.56	1.19
	AFWX	0.50	0.51	0.79
LOWER	LRRX	0.20	0.46	0.75
	LRRY	0.78	1.05	1.94
	LRRZ	0.53	0.53	2.75
	LRFX	0.54	0.54	1.55
	LRFY	0.00	0.00	0.00
TOP	TRRX	0.79	0.95	2.36
	TRFX	0.60	0.82	2.10
	TRFZ	0.46	0.48	2.15
	TRRZ	0.52	0.52	2.73
	TLFZ	0.41	0.84	2.46
	TLRZ	0.38	0.78	2.47
DSD	DSDX	0.50	0.64	1.42
	DSDY	0.18	0.40	0.56
	DSDZ	0.39	0.82	2.66
DISPL. [in.]		2.00	2.50	6.50

Table A-17 Maximum Acceleration Values(g's), VE Dampers, Case -3, IBM-9221, August 1991

August 1991 IBM-9221		VE DAMPERS, CASE 3			
		RUN-63 EC RC-1	RUN-64 EC RC-3	RUN-65 EC RC-7	RUN-66 IBM-2
SHAKER	ALAT	0.43	0.47	0.80	1.41
	AVRT	0.20	0.20	0.21	0.33
SLAB	ASEX	0.44	0.49	0.83	1.44
	ASWX	0.45	0.49	0.86	1.50
	ASCV	0.25	0.24	0.26	0.33
FLOOR	AFEX	0.50	0.51	1.00	2.18
	AFWX	0.46	0.50	0.77	1.67
LOWER	LRRX	0.00	0.00	0.00	0.00
	LRRY	0.35	0.34	0.34	2.34
	LRRZ	0.36	0.35	0.35	0.83
	LRFX	0.60	0.54	0.92	2.19
	LRFY	0.00	0.00	0.00	0.00
TOP	TRRX	1.24	1.20	1.31	2.65
	TRFX	1.08	0.95	0.98	1.95
	TRFZ	0.29	0.32	0.33	0.71
	TRRZ	0.35	0.35	0.35	0.80
	TLFZ	0.29	0.31	0.30	1.09
	TLRZ	0.34	0.34	0.32	1.04
DSD	DSDX	0.79	0.78	0.91	1.84
	DSDY	0.15	0.13	0.17	0.52
	DSDZ	0.33	0.35	0.33	1.05
DISPL. [in.]		1.00		1.00	4.75

Table A-18 Maximum Acceleration Values(g's), 4-Toggle Bar Free Casters, 40-Durometer, IBM-9221, August 1991

August 1991 IBM-9221		4-TOGGLE BARS FREE CASTERS 40-DUROMETER		
		RUN-12 EC RC-1	RUN-13 EC RC-7	RUN-14 IBM-2
SHAKER	ALAT	0.45	0.78	1.39
	AVRT	0.20	0.20	0.29
SLAB	ASEX	0.46	0.83	1.43
	ASWX	0.48	0.85	1.50
	ASCV	0.25	0.26	0.30
FLOOR	AFEX	0.47	0.84	1.65
	AFWX	0.49	0.86	1.69
LOWER	LRRX	0.31	0.46	0.58
	LRRY	0.96	1.44	2.79
	LRRZ	0.31	0.32	0.58
	LRFX	0.49	0.93	1.67
	LRFY	0.00	0.00	0.00
TOP	TRRX	1.10	1.44	3.59
	TRFX	0.78	1.45	2.92
	TRFZ	0.33	0.33	0.44
	TRRZ	0.31	0.32	0.47
	TLFZ	0.34	0.32	0.56
	TLRZ	0.30	0.30	0.61
DSD	DSDX	0.81	1.25	2.60
	DSDY	0.27	0.00	0.00
	DSDZ	0.32	0.32	0.60
DISPL. [in.]		1.75	2.00	4.00

Table A-19 Maximum Acceleration Values(g's), 4-Toggle Bar
Free Casters, 80-Durometer, IBM-9221, August 1991

August 1991 IBM-9221		4-TOGGLE BARS FREE CASTERS 80-DUROMETER	
		RUN-15 EC RC-7	RUN-16 IBM-2
SHAKER	ALAT	0.83	1.39
	AVRT	0.21	0.33
SLAB	ASEX	0.88	1.44
	ASWX	0.90	1.50
	ASCV	0.26	0.35
FLOOR	AFEX	0.87	1.62
	AFWX	0.87	1.62
LOWER	LRRX	0.26	0.45
	LRRY	1.22	2.77
	LRRZ	0.34	0.56
	LRFX	0.88	1.89
	LRFY	0.00	0.00
TOP	TRRX	1.49	3.08
	TRFX	1.31	2.99
	TRFZ	0.33	0.42
	TRRZ	0.34	0.43
	TLFZ	0.32	0.60
	TLRZ	0.34	0.59
DSD	DSDX	1.20	2.24
	DSDY	0.29	0.49
	DSDZ	0.35	0.57
DISPL. [in.]		1.50	2.50

Table A-20 Maximum Acceleration Values(g's), Toggle Bars, 80-Durometer Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		Toggle Bars 80 - Durometer Bushings					
		RUN-2 EC-3	RUN-3 EC-7	RUN-4 EC-1.5	RUN-5 IBM-1	RUN-6 IBM-2	RUN-7 BELLCORE
SHAKER	ALAT	0.45	0.70	0.59	0.75	0.95	0.87
	AVRT	0.11	0.11	0.17	0.26	0.29	0.32
SLAB	ASEX	0.47	0.71	0.57	0.77	0.96	0.84
	ASWX	0.47	0.68	0.61	0.79	0.93	0.90
	ASCV	0.16	0.15	0.23	0.30	0.30	0.35
FLOOR	AFEX	0.54	0.73	0.59	0.90	1.20	1.30
LOWER	LRRX	0.82	1.08	0.85	1.00	2.29	2.71
	LRRY	0.63	0.36	0.21	0.26	0.32	0.35
	LRRZ	0.19	0.18	0.26	0.38	0.45	0.50
	LRFX	1.04	1.41	1.05	1.13	2.44	2.78
TOP	TRFX	2.53	2.90	2.23	2.04	4.09	4.00
	TRRX	1.70	2.15	1.75	1.60	4.05	4.09
	TRFZ	0.19	0.22	0.27	0.43	0.46	0.47
	TLRZ	0.25	0.22	0.28	0.47	0.83	0.63
DSD	DSDX	1.46	1.93	1.50	1.36	2.89	3.01
	DSDY	0.35	0.33	0.21	0.26	0.43	0.55
	DSDZ	0.46	0.39	0.55	0.74	0.70	0.63
FSD	FSDX	2.34	2.53	2.01	1.75	3.42	3.42
	FSDY	0.78	0.51	0.25	0.32	0.80	1.08
	FSDZ	0.53	0.28	0.41	0.99	0.89	0.67
Displacement [in.]		1.00	1.00	1.00	1.00	1.00	1.50

Table A-21 Maximum Acceleration Values(g's), 3/16 Wire Ropes, 80-Durometer Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		3/16 Wire Ropes 80 - Durometer Bushings					
		RUN-8 EC-3	RUN-9 EC-7	RUN-10 EC-1.5	RUN-11 IBM-1	RUN-12 IBM-2	RUN-13 BELLCORE
SHAKER	ALAT	0.45	0.70	0.57	0.77	0.95	0.97
	AVRT	0.11	0.11	0.17	0.26	0.28	0.35
SLAB	ASEX	0.46	0.71	0.56	0.80	0.96	0.94
	ASWX	0.46	0.69	0.59	0.82	0.93	1.02
	ASCV	0.13	0.13	0.20	0.28	0.30	0.38
FLOOR	AFEX	0.50	0.94	0.63	0.88	1.36	1.91
LOWER	LRRX	0.49	1.70	1.15	1.56	4.09	4.09
	LRRY	0.12	0.32	0.24	0.32	0.49	0.80
	LRRZ	0.21	0.39	0.35	0.50	1.41	1.76
	LRFX	0.45	1.40	1.09	1.60	4.09	4.09
TOP	TRFX	0.61	2.50	1.92	2.59	5.54	6.33
	TRRX	0.68	2.60	2.19	2.89	5.78	6.81
	TRFZ	0.23	0.30	0.38	0.47	1.30	1.76
	TLRZ	0.21	0.30	0.34	0.67	1.79	1.62
DSD	DSDX	0.55	1.88	1.49	2.12	3.91	5.15
	DSDY	0.16	0.30	0.31	0.34	0.56	1.20
	DSDZ	0.46	0.50	0.61	0.86	2.33	2.39
FSD	FSDX	0.53	2.18	1.72	2.36	4.73	5.30
	FSDY	0.28	0.42	0.56	0.60	1.55	2.09
	FSDZ	0.43	0.43	0.62	0.91	2.68	2.16
Displacement [in.]		1.00	2.50	2.00	2.50	3.00	3.50

Table A-22 Maximum Acceleration Values(g's), 3/16 Wire Ropes Teflon Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		3/16 Wire Ropes Teflon Bushings		
		RUN-14 EC-3	RUN-15 EC-7 (failed)	RUN-16 EC-7
SHAKER	ALAT	0.45	0.70	0.70
	AVRT	0.11	0.11	0.12
SLAB	ASEX	0.46	0.72	0.71
	ASWX	0.45	0.68	0.68
	ASCV	0.13	0.16	0.16
FLOOR	AFEX	0.47	0.86	0.73
LOWER	LRRX	0.42	1.05	1.59
	LRRY	0.22	0.69	1.20
	LRRZ	0.20	0.78	0.35
	LRFX	0.45	1.06	1.45
TOP	TRFX	0.62	1.55	2.23
	TRRX	0.73	1.56	3.53
	TRFZ	0.23	0.95	0.24
	TLRZ	0.21	1.13	0.32
DSD	DSDX	0.56	1.04	2.02
	DSDY	0.20	0.48	0.32
	DSDZ	0.45	1.63	0.47
FSD	FSDX	0.53	1.35	1.98
	FSDY	0.31	0.84	0.85
	FSDZ	0.39	1.14	0.42
Displacemet [in.]		1.00	36.00	3.00

Table A-23 Maximum Acceleration Values(g's), 5/32 Wire Ropes and Springs with Teflon Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		5/32 Wire Ropes With Springs, K=570 lb/in. Teflon Bushings				
		RUN-18 EC-3	RUN-19 EC-7	RUN-20 EC-1.5	RUN-21 IBM-1	RUN-22 IBM-2
SHAKER	ALAT	0.45	0.70	0.57	0.77	0.95
	AVRT	0.11	0.11	0.17	0.26	0.28
SLAB	ASEX	0.46	0.71	0.55	0.79	0.97
	ASWX	0.46	0.68	0.58	0.81	0.93
	ASCV	0.13	0.15	0.22	0.32	0.31
FLOOR	AFEX	0.51	0.86	0.63	0.88	0.98
LOWER	LRRX	0.65	1.69	2.32	3.43	2.97
	LRRY	0.23	0.50	0.63	0.86	1.06
	LRRZ	0.27	0.86	1.97	1.98	1.82
	LRFX	0.49	1.78	2.15	3.07	3.19
TOP	TRFX	0.71	1.78	3.18	2.98	3.31
	TRRX	0.81	1.81	3.30	3.07	3.27
	TRFZ	0.27	0.77	1.89	2.00	1.98
	TLRZ	0.27	1.46	2.00	2.36	2.45
DSD	DSDX	0.61	1.50	3.76	3.83	3.83
	DSDY	0.12	0.42	0.59	0.91	0.94
	DSDZ	0.59	1.51	3.44	4.03	3.48
FSD	FSDX	0.64	1.44	2.84	3.14	2.99
	FSDY	0.24	0.62	0.91	1.39	1.32
	FSDZ	0.39	1.67	2.55	3.10	3.08
Displacement [in.]		2.00	4.00	3.50	3.50	5.50

Table A-24 Maximum Acceleration Values(g's), 5/32 Wire Ropes and Brackets with Teflon Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		5/32 Wire Ropes & Brackets Teflon Bushings			
		RUN-23 EC-3	RUN-24 EC-7	RUN-25 EC-1.5	RUN-26 IBM-1
SHAKER	ALAT	0.58	0.76	0.94	0.95
	AVRT	0.17	0.25	0.29	0.35
SLAB	ASEX	0.56	0.77	0.97	0.93
	ASWX	0.60	0.79	0.94	1.01
	ASCV	0.22	0.30	0.30	0.40
FLOOR	AFEX	0.61	0.94	1.79	2.20
LOWER	LRRX	1.06	1.69	4.09	4.09
	LRRY	0.35	0.54	1.12	1.02
	LRRZ	0.38	0.50	1.21	1.66
	LRFX	1.31	1.93	3.96	4.09
TOP	TRFX	2.25	3.10	6.65	6.95
	TRRX	1.82	2.51	5.96	7.99
	TRFZ	0.31	0.52	1.18	1.75
	TLRZ	0.31	0.45	1.61	2.05
DSD	DSDX	1.49	2.19	3.60	5.86
	DSDY	0.23	0.43	0.71	0.75
	DSDZ	0.71	0.97	1.98	2.18
FSD	FSDX	1.95	2.67	5.84	6.14
	FSDY	0.43	0.82	1.47	1.71
	FSDZ	0.48	1.17	2.21	3.60
Displacement [in.]		1.50	2.00	2.50	2.75

Table A-25 Maximum Acceleration Values(g's), Toggle Bars, Aluminum Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		Toggle Bars Aluminum Bushings					
		RUN-27 EC-3	RUN-28 EC-7	RUN-29 EC-1.5	RUN-30 IBM-1	RUN-31 IBM-2	RUN-32 BELLCORE
SHAKER	ALAT	0.44	0.71	0.57	0.76	0.95	0.97
	AVRT	0.11	0.11	0.16	0.25	0.28	0.36
SLAB	ASEX	0.46	0.72	0.56	0.75	0.96	0.94
	ASWX	0.45	0.69	0.59	0.76	0.93	1.02
	ASCV	0.13	0.13	0.23	0.31	0.29	0.37
FLOOR	AFEX	0.57	0.70	0.55	0.86	1.34	1.64
LOWER	LRRX	0.84	1.22	1.34	1.40	3.33	3.67
	LRRY	0.25	0.36	0.37	0.36	0.57	0.45
	LRRZ	0.20	0.17	0.28	0.41	0.71	0.77
	LRFX	0.95	1.32	1.36	1.25	3.50	3.42
TOP	TRFX	1.48	2.35	2.49	2.72	4.32	5.48
	TRRX	1.36	1.91	2.22	2.24	4.63	5.89
	TRFZ	0.17	0.20	0.29	0.43	0.64	0.69
	TLRZ	0.20	0.23	0.28	0.41	0.79	1.17
DSD	DSDX	0.03	0.03	0.02	0.03	0.03	0.03
	DSDY	0.03	0.03	0.03	0.03	0.03	0.03
	DSDZ	0.03	0.03	0.03	0.03	0.03	0.02
FSD	FSDX	0.05	0.05	0.05	0.04	0.05	0.06
	FSDY	0.07	0.07	0.07	0.06	0.07	0.07
	FSDZ	0.06	0.06	0.05	0.04	0.06	0.04
Displacement [in.]		0.75	1.00	0.75	1.00	1.50	1.75

Table A-26 Maximum Acceleration Values(g's), Toggle Bars Loose, Aluminum Bushings, Frame-8, June 1992

IBM0692 FRAME - 8		Toggle Bars Loose Aluminum Bushings	
		RUN-33 IBM-1	RUN-34 IBM-2
SHAKER	ALAT	0.75	0.95
	AVRT	0.26	0.29
SLAB	ASEX	0.79	0.96
	ASWX	0.81	0.93
	ASCV	0.30	0.29
FLOOR	AFEX	1.06	1.64
LOWER	LRRX	1.79	3.33
	LRRY	0.55	0.87
	LRRZ	0.86	1.23
	LRFX	2.16	3.85
TOP	TRFX	2.52	5.57
	TRRX	2.92	6.95
	TRFZ	1.03	1.55
	TLRZ	1.17	1.73
DSD	DSDX	0.04	0.03
	DSDY	0.02	0.03
	DSDZ	0.03	0.03
FSD	FSDX	0.05	0.03
	FSDY	0.07	0.07
	FSDZ	0.05	0.06
Displacement [in.]		1.75	2.50

Table A-27 Maximum Acceleration Values(g's), Normal Levelers-Plastic Coating, X-Axis, Frame-8, June 1992

IBM0692 FRAME - 8		Normal Levelers - Plastic Coating X-Axis, Raised Casters				
		RUN-37 EC-1	RUN-38 EC-3	RUN-39 EC-5	RUN-40 EC-7	RUN-41 IBM-1
SHAKER	ALAT	0.36	0.44	0.39	0.71	0.74
	AVRT	0.11	0.11	0.11	0.11	0.25
SLAB	ASEX	0.35	0.46	0.40	0.72	0.77
	ASWX	0.35	0.46	0.38	0.69	0.79
	ASCV	0.12	0.14	0.13	0.13	0.31
FLOOR	AFEX	0.46	0.49	0.45	0.79	0.96
LOWER	LRRX	0.60	0.67	0.70	0.68	0.75
	LRRY	0.15	0.15	0.19	0.20	0.28
	LRRZ	0.34	0.45	0.51	0.46	0.75
	LRFX	0.60	0.74	0.76	0.81	0.92
TOP	TRFX	0.60	0.68	0.61	0.84	0.88
	TRRX	0.63	0.73	0.67	0.73	0.97
	TRFZ	0.29	0.49	0.58	0.52	0.69
	TLRZ	0.52	0.38	0.50	0.44	0.63
DSD	DSDX	0.03	0.76	0.70	0.70	1.03
	DSDY	0.03	0.18	0.19	0.18	0.26
	DSDZ	0.03	0.64	0.63	0.62	1.13
FSD	FSDX	0.07	0.21	0.24	0.35	0.39
	FSDY	0.06	0.66	0.55	0.75	1.03
	FSDZ	0.06	0.46	0.52	0.44	0.79
Displacement [in.]		4.00	4.00	4.00	8.00	15.00

Table A-28 Maximum Acceleration Values(g's), Normal Levelers-Plastic Coating, Y-Axis, Frame-8, June 1992

IBM0692 FRAME - 8		Normal Levelers - Plastic Coating Y-Axis, Raised Casters			
		RUN-42 EC-3	RUN-43 EC-7	RUN-44 IBM-1	RUN-45 IBM-2
SHAKER	ALAT	0.45	0.72	0.76	0.95
	AVRT	0.11	0.11	0.26	0.28
SLAB	ASEX	0.46	0.72	0.78	0.98
	ASWX	0.46	0.70	0.80	0.95
	ASCV	0.14	0.13	0.30	0.30
FLOOR	AFEX	0.50	0.85	0.95	1.31
LOWER	LRRX	0.21	0.36	0.46	0.81
	LRRY	0.58	0.56	0.74	0.70
	LRRZ	0.41	0.32	0.52	0.64
	LRFX	0.64	0.62	0.81	0.77
TOP	TRFX	0.70	0.70	0.84	0.97
	TRRX	0.34	0.47	0.59	0.82
	TRFZ	0.44	0.36	0.60	0.74
	TLRZ	0.41	0.36	0.61	0.74
DSD	DSDX	0.47	0.48	0.79	0.76
	DSDY	0.60	0.55	0.61	0.75
	DSDZ	0.60	0.48	0.92	0.98
FSD	FSDX	0.62	0.68	0.67	0.88
	FSDY	0.28	0.40	0.48	0.70
	FSDZ	0.50	0.48	0.87	0.99
Displacement [in.]		5.00	10.00	9.50	16.00

Table A-29 Maximum Acceleration Values(g's), Normal Levelers-Plastic Coating, X-Axis, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Normal Levelers - Plastic Coating X-Axis, Raised Casters				
		RUN-46 EC-3	RUN-47 EC-7	RUN-48 IBM-1	RUN-49 IBM-2	RUN-50 BELLCORE
SHAKER	ALAT	0.45	0.71	0.75	0.96	0.96
	AVRT	0.12	0.11	0.26	0.29	0.37
SLAB	ASEX	0.46	0.72	0.77	0.97	0.94
	ASWX	0.46	0.69	0.80	0.95	1.01
	ASCV	0.14	0.14	0.30	0.30	0.35
FLOOR	AFEX	0.48	0.87	0.89	1.02	1.28
LOWER	LRRX	0.81	0.65	0.73	1.15	0.81
	LRRY	0.29	0.25	0.26	0.50	0.44
	LRRZ	0.00	0.48	0.84	1.44	1.50
	LRFX	0.65	0.60	0.65	1.13	1.05
TOP	TRFX	0.77	0.84	0.86	0.93	1.01
	TRRX	0.92	0.89	1.03	1.42	1.39
	TRFZ	0.36	0.45	0.78	1.23	1.55
	TLRZ	0.56	0.52	0.99	1.17	1.16
DSD	DSDX	0.70	0.59	0.65	1.10	0.81
	DSDY	0.27	0.17	0.17	0.32	0.33
	DSDZ	0.59	0.60	0.99	1.28	1.16
FSD	FSDX	0.50	0.46	0.64	0.81	0.69
	FSDY	0.17	0.14	0.12	0.19	0.26
	FSDZ	0.59	0.60	0.92	1.11	1.01
Displcament [in.]		2.25	8.50	8.00	16.00	24.00

Table A-30 Maximum Acceleration Values(g's), Toggle Bars, 80-Durometer, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Toggle Bars 80 - Durometer Bushings				
		RUN-51 EC-3	RUN-52 EC-7	RUN-53 IBM-1	RUN-54 IBM-2	RUN-55 BELLCORE
SHAKER	ALAT	0.45	0.70	0.78	0.94	0.97
	AVRT	0.11	0.11	0.26	0.28	0.36
SLAB	ASEX	0.47	0.71	0.79	0.95	0.95
	ASWX	0.47	0.68	0.81	0.93	1.03
	ASCV	0.15	0.15	0.31	0.30	0.36
FLOOR	AFEX	0.49	0.79	0.82	1.47	1.57
LOWER	LRRX	0.66	1.02	1.11	2.23	2.67
	LRRY	0.23	0.25	0.30	0.58	0.99
	LRRZ	0.19	0.21	0.43	0.32	0.50
	LRFX	0.64	0.86	1.27	2.81	2.92
TOP	TRFX	1.49	1.60	1.93	4.18	5.26
	TRRX	1.39	1.73	1.86	3.30	4.45
	TRFZ	0.22	0.19	0.47	0.52	0.71
	TLRZ	0.31	0.29	0.57	0.91	0.84
DSD	DSDX	0.56	1.03	1.17	2.30	3.41
	DSDY	0.30	0.23	0.25	0.46	0.42
	DSDZ	0.41	0.41	0.68	0.54	0.63
FSD	FSDX	0.96	1.07	1.14	2.11	3.27
	FSDY	0.26	0.28	0.27	0.50	0.50
	FSDZ	0.35	0.35	0.66	0.74	0.65
Displacement [in.]		0.25	0.50	0.50	0.50	2.50

Table A-31 Maximum Acceleration Values(g's), Toggle Bars and NTT Levelers, 80-Durometer, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Toggle Bars & NTT Levelers 80 - Durometer Bushings				
		RUN-56 EC-3	RUN-57 EC-7	RUN-58 IBM-1	RUN-59 IBM-2	RUN-60 BELLCORE
SHAKER	ALAT	0.45	0.70	0.76	0.94	0.98
	AVRT	0.11	0.11	0.27	0.29	0.35
SLAB	ASEX	0.47	0.71	0.78	0.96	0.95
	ASWX	0.47	0.69	0.81	0.94	1.03
	ASCV	0.16	0.16	0.34	0.30	0.35
FLOOR	AFEX	0.48	0.75	0.93	1.34	1.35
LOWER	LRRX	0.47	0.71	0.93	1.39	2.34
	LRRY	0.11	0.16	0.30	0.40	0.46
	LRRZ	0.20	0.20	0.46	0.32	0.65
	LRFX	0.63	0.78	1.19	2.03	1.87
TOP	TRFX	2.05	2.33	1.90	3.52	3.66
	TRRX	1.92	2.34	1.91	3.06	3.26
	TRFZ	0.30	0.24	0.49	0.62	0.80
	TLRZ	0.33	0.31	0.65	0.73	0.74
DSD	DSDX	0.63	0.79	0.96	1.62	2.59
	DSDY	0.08	0.15	0.18	0.26	0.30
	DSDZ	0.46	0.35	0.71	0.50	0.60
FSD	FSDX	1.03	1.32	1.34	2.15	2.78
	FSDY	0.11	0.14	0.18	0.27	0.31
	FSDZ	0.36	0.41	0.79	0.64	0.62
Displacement [in.]		0.00	0.50	0.50	1.00	1.25

Table A-32 Maximum Acceleration Values(g's), Toggle Bars and Casters, Aluminum Bushings, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Toggle Bars & Casters Aluminum Bushings				
		RUN-61 EC-3	RUN-62 EC-7	RUN-63 IBM-1	RUN-64 IBM-2	RUN-65 BELLCORE
SHAKER	ALAT	0.44	0.69	0.75	0.93	0.95
	AVRT	0.10	0.11	0.26	0.29	0.35
SLAB	ASEX	0.47	0.70	0.78	0.96	0.94
	ASWX	0.47	0.67	0.80	0.93	1.01
	ASCV	0.14	0.15	0.31	0.30	0.35
FLOOR	AFEX	0.49	0.85	0.80	1.62	1.81
LOWER	LRRX	0.50	1.06	1.13	2.28	2.58
	LRRY	0.30	0.40	0.54	0.62	0.66
	LRRZ	0.21	0.19	0.46	0.40	0.56
	LRFX	0.84	1.21	1.51	3.04	2.87
TOP	TRFX	1.67	1.49	1.94	4.48	5.33
	TRRX	1.30	1.73	2.36	4.26	4.37
	TRFZ	0.21	0.21	0.48	0.62	0.74
	TLRZ	0.34	0.36	0.62	0.69	1.16
DSD	DSDX	0.53	1.06	1.09	3.13	3.38
	DSDY	0.26	0.29	0.33	0.55	0.92
	DSDZ	0.51	0.47	0.75	0.67	0.68
FSD	FSDX	0.68	1.05	1.17	2.78	2.92
	FSDY	0.27	0.26	0.39	0.66	0.58
	FSDZ	0.46	0.49	0.76	0.50	0.84
Displacement [in.]		0.50	0.75	1.00	1.25	1.75

Table A-33 Maximum Acceleration Values(g's), Toggle Bars and NTT Levelers, Aluminum Bushings, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Toggle Bars With NTT Levelers Aluminum Bushings				
		RUN-66 EC-3	RUN-67 EC-7	RUN-68 IBM-1	RUN-69 IBM-2	RUN-70 BELLCORE
SHAKER	ALAT	0.45	0.71	0.74	0.95	0.96
	AVRT	0.11	0.11	0.26	0.28	0.35
SLAB	ASEX	0.46	0.71	0.76	0.96	0.95
	ASWX	0.46	0.69	0.79	0.93	1.03
	ASCV	0.15	0.13	0.31	0.30	0.35
FLOOR	AFEX	0.48	0.72	0.89	1.37	1.66
LOWER	LRRX	0.41	0.70	1.01	1.41	2.42
	LRRY	0.23	0.17	0.29	0.36	0.56
	LRRZ	0.20	0.18	0.44	0.31	0.72
	LRFX	0.63	0.80	1.13	2.02	1.99
TOP	TRFX	1.62	2.09	1.65	3.92	3.57
	TRRX	1.88	2.21	1.77	3.11	3.41
	TRFZ	0.30	0.30	0.50	0.72	0.86
	TLRZ	0.34	0.30	0.58	0.85	0.84
DSD	DSDX	58.00	0.80	1.03	1.75	3.48
	DSDY	0.16	0.16	0.16	0.26	0.35
	DSDZ	0.48	0.43	0.66	0.56	0.62
FSD	FSDX	1.10	1.17	1.27	2.10	2.86
	FSDY	0.16	0.14	0.15	0.29	0.39
	FSDZ	0.42	0.45	0.76	0.63	0.75
Displacement [in.]		0.00	0.50	0.50	0.75	1.25

Table A-34 Maximum Acceleration Values(g's), Toggle Bars Loose, Aluminum Bushings, Endicott Frame, June 1992

IBM0692 ENDICOTT FRAME		Toggle Bars Loose Aluminum Bushings RUN-71 IBM-1	RUN-72 IBM-2
SHAKER	ALAT	0.76	0.93
	AVRT	0.26	0.29
SLAB	ASEX	0.77	0.96
	ASWX	0.78	0.93
	ASCV	0.34	0.32
FLOOR	AFEX	1.09	1.44
LOWER	LRRX	2.09	3.08
	LRRY	0.62	1.17
	LRRZ	1.71	2.48
	LRFX	1.99	3.16
TOP	TRFX	3.54	5.12
	TRRX	3.42	4.26
	TRFZ	1.79	2.27
	TLRZ	2.23	2.20
DSD	DSDX	2.46	3.98
	DSDY	0.50	1.31
	DSDZ	1.88	2.38
FSD	FSDX	1.79	3.68
	FSDY	0.28	0.46
	FSDZ	2.14	2.32
Displacement [in.]		1.75	2.00

Table A-35 Maximum Acceleration Values(g's), Casters, Non Operational, Frame-1, June 1992

IBM0692 FRAME - 1		Casters Non-Operational	
		RUN-73 EC-1	RUN-74 EC-3
SHAKER	ALAT	0.37	0.45
	AVRT	0.11	0.11
SLAB	ASEX	0.35	0.46
	ASWX	0.35	0.46
	ASCV	0.14	0.12
FLOOR	AFEX	0.44	0.47
LOWER	LRRX	0.44	0.42
	LRRY	0.24	0.26
	LRRZ	0.21	0.28
	LRFX	0.40	0.41
TOP	TRFX	0.40	0.42
	TRRX	0.53	0.49
	TRFZ	0.18	0.18
	TLRZ	0.20	0.20
DSD	DSDX	0.20	0.20
	DSDY	0.13	0.13
	DSDZ	0.15	0.18
FSD	FSDX	0.32	0.23
	FSDY	0.35	0.41
	FSDZ	0.67	0.70
Displacement [in.]		5.00	12.00

Table A-36 Maximum Acceleration Values(g's), NTT Levelers, Frame-1, June 1992

IBM0692 FRAME - 1		NTT Levelers			
		RUN-75 EC-1	RUN-76 EC-3	RUN-77 EC-5	RUN-78 EC-7
SHAKER	ALAT	0.36	0.45	0.38	0.71
	AVRT	0.11	0.11	0.11	0.11
SLAB	ASEX	0.35	0.46	0.39	0.71
	ASWX	0.36	0.46	0.38	0.69
	ASCV	0.13	0.13	0.13	0.12
FLOOR	AFEX	0.40	0.44	0.46	0.90
LOWER	LRRX	0.42	0.49	0.60	0.77
	LRRY	0.24	0.33	0.23	0.38
	LRRZ	0.28	0.30	0.36	0.49
	LRFX	0.51	0.69	0.51	0.76
TOP	TRFX	0.83	0.84	0.53	0.85
	TRRX	0.73	0.68	0.75	0.91
	TRFZ	0.19	0.26	0.19	0.25
	TLRZ	0.17	0.30	0.17	0.24
DSD	DSDX	0.38	0.47	0.41	0.49
	DSDY	0.16	0.25	0.10	0.23
	DSDZ	0.23	0.33	0.16	0.33
FSD	FSDX	0.51	0.49	0.34	0.50
	FSDY	0.43	0.50	0.40	0.65
	FSDZ	0.59	0.50	0.71	0.93
Displacement [in.]		2.50	1.50	4.50	9.00

Table A-37 Maximum Acceleration Values(g's), Normal Levelers, Plastic Coating, Frame-1, June 1992

IBM0692 FRAME - 1		Normal Levelers Plastic Coating			
		RUN-79 EC-1	RUN-80 EC-3	RUN-81 EC-5	RUN-82 EC-7
SHAKER	ALAT	0.37	0.44	0.38	0.71
	AVRT	0.11	0.11	0.11	0.11
SLAB	ASEX	0.36	0.46	0.39	0.71
	ASWX	0.37	0.46	0.38	0.69
	ASCV	0.13	0.14	0.12	0.14
FLOOR	AFEX	0.44	0.49	0.43	0.79
LOWER	LRRX	0.73	0.43	0.52	0.77
	LRRY	0.26	0.27	0.17	0.24
	LRRZ	0.35	0.33	0.32	0.36
	LRFX	0.59	0.57	0.59	0.95
TOP	TRFX	0.82	0.83	0.60	1.22
	TRRX	0.65	0.72	0.59	0.86
	TRFZ	0.23	0.39	0.20	0.22
	TLRZ	0.30	0.34	0.13	0.33
DSD	DSDX	0.41	0.39	0.41	0.45
	DSDY	0.13	0.12	0.17	0.28
	DSDZ	0.33	0.50	0.17	0.36
FSD	FSDX	0.42	0.44	0.36	0.41
	FSDY	0.34	0.33	0.47	0.46
	FSDZ	0.62	0.71	0.60	0.57
Displacement [in.]		3.00	1.00	3.00	14.00

Table A-38 Maximum Acceleration Values(g's), Toggle Bars, 80-Durometer Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		Toggle Bars 80 - Durometer Bushings						
		RUN-83 EC-3	RUN-84 EC-7	RUN-85 EC-1.5	RUN-86 IBM-1	RUN-87 IBM-2	RUN-88 BELLCORE (failed)	RUN-89 BELLCORE
SHAKER	ALAT	0.44	0.70	0.58	0.74	0.92	1.01	1.05
	AVRT	0.11	0.11	0.17	0.25	0.29	0.35	0.35
SLAB	ASEX	0.46	0.71	0.56	0.74	0.93	1.00	1.05
	ASWX	0.46	0.69	0.60	0.76	0.91	1.06	1.11
	ASCV	0.13	0.14	0.21	0.30	0.30	0.37	0.36
FLOOR	AFEX	0.50	0.83	0.59	0.87	1.59	1.50	1.33
LOWER	LRRX	0.44	1.25	1.03	1.22	2.01	2.56	2.94
	LRRY	0.16	0.22	0.40	0.41	0.73	0.99	0.60
	LRRZ	0.14	0.26	0.23	0.32	0.73	1.58	0.96
	LRFX	0.66	1.06	1.32	1.47	2.75	2.92	2.90
TOP	TRFX	0.79	1.75	2.00	2.03	3.51	4.63	5.13
	TRRX	0.65	1.57	1.31	1.40	4.73	5.20	4.97
	TRFZ	0.22	0.20	0.29	0.57	0.61	0.85	0.95
	TLRZ	0.16	0.20	0.40	0.43	1.09	0.97	1.09
DSD	DSDX	0.56	1.11	1.10	1.18	2.61	2.96	2.95
	DSDY	0.11	0.18	0.11	0.16	0.29	0.60	0.46
	DSDZ	0.17	0.18	0.25	0.47	0.63	0.76	0.73
FSD	FSDX	0.23	0.34	0.33	0.37	0.75	1.07	0.72
	FSDY	0.66	1.24	1.16	1.25	2.58	3.84	3.13
	FSDZ	0.39	0.78	0.67	0.78	2.17	4.55	2.29
Displacement [in.]		0.00	1.00	1.00	1.25	2.25		2.75

Table A-39 Maximum Acceleration Values(g's), Toggle Bars, Aluminum Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		Toggle Bars Aluminum Bushings					
		RUN-90 EC-3	RUN-91 EC-7	RUN-92 EC-1.5	RUN-93 IBM-1	RUN-94 IBM-2	RUN-95 BELLCORE
SHAKER	ALAT	0.44	0.70	0.57	0.75	0.93	0.94
	AVRT	0.11	0.11	0.17	0.26	0.29	0.35
SLAB	ASEX	0.46	0.70	0.56	0.74	0.94	0.95
	ASWX	0.46	0.68	0.60	0.76	0.92	1.01
	ASCV	0.12	0.14	0.18	0.31	0.30	0.35
FLOOR	AFEX	0.50	1.00	0.66	1.17	1.48	2.24
LOWER	LRRX	0.70	1.23	1.48	1.39	2.66	2.81
	LRRY	0.24	0.30	0.46	0.24	0.76	0.80
	LRRZ	0.20	0.33	0.38	0.36	0.83	0.76
	LRFX	0.88	1.32	1.50	1.68	2.93	3.42
TOP	TRFX	1.34	2.19	2.47	2.76	3.95	5.00
	TRRX	1.07	1.77	1.80	1.96	4.70	4.61
	TRFZ	0.20	0.26	0.31	0.48	0.61	0.72
	TLRZ	0.21	0.23	0.40	0.42	1.05	1.42
DSD	DSDX	0.71	1.47	1.34	1.36	2.45	2.94
	DSDY	0.16	0.24	0.22	0.31	0.35	0.42
	DSDZ	0.20	0.20	0.27	0.50	0.78	0.99
FSD	FSDX	0.26	0.38	0.47	0.56	0.98	1.12
	FSDY	0.82	1.39	1.51	1.66	2.93	3.01
	FSDZ	0.55	0.78	0.81	0.86	2.38	2.17
Displacement [in.]		1.00	1.25	1.00	1.25	1.75	2.25

Table A-40 Maximum Acceleration Values(g's), 5/32 Wire Ropes, Teflon Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		5/32 Wire Ropes With Brackets Teflon Bushings					
		RUN-96 EC-3	RUN-97 EC-7	RUN-98 EC-1.5	RUN-99 IBM-1	RUN-100 IBM-2	RUN-101 BELLCORE (failure)
SHAKER	ALAT	0.45	0.39	0.58	0.72	0.91	1.07
	AVRT	0.11	0.11	0.17	0.26	0.29	0.34
SLAB	ASEX	0.46	0.40	0.57	0.74	0.92	1.05
	ASWX	0.46	0.39	0.60	0.75	0.90	1.09
	ASCV	0.14	0.13	0.19	0.31	0.30	0.33
FLOOR	AFEX	0.52	0.44	0.64	0.86	1.49	1.93
LOWER	LRRX	0.49	0.62	1.11	1.69	2.53	3.96
	LRRY	0.25	0.16	0.24	0.47	0.98	3.01
	LRRZ	0.16	0.15	0.32	0.48	1.02	2.16
	LRFX	0.48	0.67	1.23	1.84	4.09	4.09
TOP	TRFX	0.65	1.19	2.08	3.26	4.95	6.30
	TRRX	0.68	1.02	1.83	2.71	5.65	7.96
	TRFZ	0.19	0.20	0.34	0.50	1.56	2.96
	TLRZ	0.15	0.17	0.24	0.65	1.54	2.08
DSD	DSDX	0.46	0.74	1.26	1.85	2.83	3.27
	DSDY	0.15	0.11	0.28	0.37	0.66	1.26
	DSDZ	0.16	0.18	0.28	0.56	1.14	3.15
FSD	FSDX	0.32	0.25	0.59	0.74	1.08	2.00
	FSDY	0.59	0.78	1.29	1.91	3.50	5.71
	FSDZ	0.32	0.35	0.78	1.23	4.05	5.85
Displacement [in.]		1.00	1.50	1.75	2.25	3.00	

Table A-41 Maximum Acceleration Values(g's), NTT Levelers with Toggle Bars, Aluminum Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		NTT Levelers With Toggle Bars Aluminum Bushings						
		RUN-102 EC-3	RUN-103 EC-5	RUN-104 EC-1.5	RUN-105 EC-7	RUN-106 IBM-1	RUN-107 IBM-2	RUN-108 BELLCORE
SHAKER	ALAT	0.45	0.38	0.58	0.00	0.74	0.92	1.06
	AVRT	0.11	0.11	0.17	0.00	0.25	0.28	0.35
SLAB	ASEX	0.46	0.39	0.57	0.00	0.74	0.93	1.03
	ASWX	0.46	0.39	0.60	0.00	0.74	0.91	1.09
	ASCV	0.14	0.14	0.20	0.00	0.31	0.30	0.35
FLOOR	AFEX	0.42	0.43	0.67	0.00	0.81	1.21	2.27
LOWER	LRRX	0.45	0.52	0.86	0.01	0.98	2.13	2.19
	LRRY	0.15	0.09	0.27	0.00	0.27	0.44	0.40
	LRRZ	0.20	0.16	0.28	0.00	0.41	0.57	0.64
	LRFX	0.66	0.55	0.86	0.01	1.26	2.80	2.82
TOP	TRFX	1.60	0.84	2.45	0.01	1.86	3.87	5.77
	TRRX	0.83	0.70	1.56	0.01	1.59	3.89	3.89
	TRFZ	0.24	0.23	0.31	0.00	0.48	0.45	0.63
	TLRZ	0.17	0.17	0.28	0.00	0.39	0.91	1.26
DSD	DSDX	0.79	0.60	1.20	0.04	1.03	2.10	3.03
	DSDY	0.14	0.07	0.18	0.03	0.17	0.29	0.44
	DSDZ	0.20	0.18	0.25	0.03	0.43	0.57	1.03
FSD	FSDX	0.31	0.17	0.42	0.07	0.42	0.63	0.92
	FSDY	0.78	0.64	1.20	0.07	1.07	2.35	2.97
	FSDZ	0.42	0.42	0.54	0.06	1.08	1.10	1.09
Displacement [in.]		0.00	0.00	0.00	0.75	0.75	1.25	1.75

Table A-42 Maximum Acceleration Values(g's), NTT Levelers with 3/16 Wire Ropes, Aluminum Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		NTT Levelers With 3/16 Wire Ropes Aluminum Bushings					
		RUN-109 EC-3	RUN-110 EC-7	RUN-111 EC-1.5	RUN-112 IBM-1	RUN-113 IBM-2	RUN-114 BELLCORE
SHAKER	ALAT	0.46	0.70	0.57	0.76	0.94	0.97
	AVRT	0.11	0.11	0.17	0.25	0.28	0.35
SLAB	ASEX	0.47	0.71	0.56	0.76	0.96	0.96
	ASWX	0.46	0.69	0.59	0.77	0.93	1.02
	ASCV	0.14	0.13	0.20	0.31	0.31	0.35
FLOOR	AFEX	0.50	0.84	0.70	0.99	1.35	1.42
LOWER	LRRX	0.40	0.77	0.80	0.95	2.23	2.44
	LRRY	0.13	0.20	0.14	0.21	0.50	0.64
	LRRZ	0.14	0.18	0.22	0.31	0.54	0.76
	LRFX	0.56	1.09	0.92	1.29	2.82	2.59
TOP	TRFX	1.27	1.77	2.79	2.08	4.13	5.93
	TRRX	0.82	1.27	1.22	1.29	3.39	4.15
	TRFZ	0.18	0.24	0.32	0.40	0.63	0.74
	TLRZ	0.14	0.25	0.25	0.38	0.77	1.00
DSD	DSDX	0.66	0.98	1.26	0.99	2.15	3.35
	DSDY	0.12	0.14	0.22	0.15	0.30	0.41
	DSDZ	0.21	0.28	0.31	0.53	0.81	1.11
FSD	FSDX	0.35	0.44	0.52	0.38	0.95	1.10
	FSDY	0.64	0.98	1.17	0.93	2.42	3.10
	FSDZ	0.42	0.35	0.61	0.92	1.39	1.89
Displacement [in.]		0.25	0.75	0.75	0.75	1.25	2.00

Table A-43 Maximum Acceleration Values(g's), 3/16 Wire Ropes, Teflon Bushings, Frame-1, June 1992

IBM0692 FRAME - 1		3/16 Wire Rope Teflon Bushings					
		RUN-115 EC-3	RUN-116 EC-7	RUN-117 EC-1.5	RUN-118 IBM-1	RUN-119 IBM-2	RUN-120 BELLCORE
SHAKER	ALAT	0.45	0.71	0.58	0.77	0.93	0.96
	AVRT	0.11	0.12	0.17	0.25	0.29	0.36
SLAB	ASEX	0.47	0.71	0.57	0.77	0.95	0.95
	ASWX	0.46	0.69	0.60	0.79	0.93	1.01
	ASCV	0.15	0.14	0.21	0.32	0.31	0.35
FLOOR	AFEX	0.48	0.87	0.62	1.09	1.53	1.71
LOWER	LRRX	0.57	1.20	0.74	1.08	2.32	3.96
	LRRY	0.24	0.32	0.31	0.31	0.73	1.03
	LRRZ	0.17	0.33	0.22	0.36	0.82	1.31
	LRFX	0.80	1.55	1.54	1.73	3.69	4.09
TOP	TRFX	0.97	2.30	2.40	3.32	6.35	7.60
	TRRX	0.67	1.91	1.55	2.43	4.16	5.96
	TRFZ	0.24	0.34	0.35	0.60	1.84	2.29
	TLRZ	0.16	0.36	0.37	0.77	1.33	1.87
DSD	DSDX	0.34	1.39	0.94	1.65	2.91	3.51
	DSDY	0.13	0.24	0.36	0.41	0.56	0.70
	DSDZ	0.20	0.25	0.29	0.55	1.01	1.83
FSD	FSDX	0.35	0.47	0.56	0.50	1.22	1.78
	FSDY	0.53	1.51	1.10	1.57	2.67	3.78
	FSDZ	0.35	0.66	0.52	0.88	3.35	4.57
Displacement [in.]		0.75	2.25	1.25	2.25	2.75	4.00

Table A-44 Maximum Acceleration Values(g's), Springs with 3/16 Wire Ropes, Frame-1, June 1992

IBM0692 FRAME - 1		Springs With 3/16 Wire Ropes K=570 lbs/in			
		RUN-121 EC-3	RUN-122 EC-7	RUN-123 EC-1.5	RUN-124 IBM-1
SHAKER	ALAT	0.45	0.71	0.60	0.75
	AVRT	0.12	0.11	0.17	0.26
SLAB	ASEX	0.46	0.72	0.57	0.78
	ASWX	0.46	0.68	0.61	0.80
	ASCV	0.15	0.13	0.22	0.36
FLOOR	AFEX	0.52	0.94	0.83	1.20
LOWER	LRRX	0.46	2.14	2.56	2.14
	LRRY	0.20	0.64	0.96	1.19
	LRRZ	0.14	1.27	2.13	1.92
	LRFX	0.63	2.37	2.92	2.96
TOP	TRFX	0.84	2.23	4.05	3.53
	TRRX	0.82	2.27	3.13	3.26
	TRFZ	0.23	1.31	2.21	2.05
	TLRZ	0.18	1.23	1.45	1.97
DSD	DSDX	0.41	1.28	1.33	1.42
	DSDY	0.12	0.46	0.23	0.55
	DSDZ	0.17	1.25	1.39	2.50
FSD	FSDX	0.16	0.90	0.60	0.98
	FSDY	0.48	2.07	1.45	2.28
	FSDZ	0.41	2.26	3.41	5.09
Displacement [in.]		0.75	4.00	4.00	4.75

Table A-45 Maximum Acceleration Values(g's), Springs with 3/16 Wire Ropes, Frame-1, June 1992

IBM0692 FRAME - 1		Springs, K=230 lbs/in. 3/16 Wire Ropes RUN-125 EC-3
SHAKER	ALAT	0.45
	AVRT	0.11
SLAB	ASEX	0.46
	ASWX	0.46
	ASCV	0.13
FLOOR	AFEX	0.59
LOWER	LRRX	1.88
	LRRY	0.65
	LRRZ	1.48
	LRFX	2.43
TOP	TRFX	3.22
	TRRX	2.13
	TRFZ	1.81
	TLRZ	1.67
DSD	DSDX	1.05
	DSDY	0.26
	DSDZ	1.31
FSD	FSDX	0.68
	FSDY	1.70
	FSDZ	2.58
Displacement [in.]		5.25

Table A-46 Maximum Acceleration Values(g's), Fixed to Ground, X-Axis, Frame-1, June 1992

IBM0692 FRAME - 1		Fixed To Ground (Slab) X-Axis, No Raised Floor Surface					
		RUN-126 EC-3	RUN-127 EC-7	RUN-128 EC-1.5	RUN-129 IBM-1	RUN-130 IBM-2	RUN-131 BELLCORE
SHAKER	ALAT	0.45	0.70	0.60	0.71	0.93	0.99
	AVRT	0.10	0.11	0.16	0.26	0.29	0.35
SLAB	ASEX	0.97	0.71	0.58	0.72	0.96	0.98
	ASWX	0.47	0.68	0.62	0.74	0.94	1.04
	ASCV	0.14	0.14	0.20	0.30	0.30	0.36
FLOOR	AFEX	0.00	0.00	0.00	0.00	0.00	0.00
LOWER	LRRX	0.47	0.70	0.63	0.73	0.98	1.08
	LRRY	0.10	0.12	0.08	0.11	0.14	0.14
	LRRZ	0.14	0.18	0.20	0.30	0.31	0.51
	LRFX	0.49	0.73	0.62	0.76	0.96	1.02
TOP	TRFX	3.03	4.02	2.11	2.02	4.74	5.50
	TRRX	1.01	1.47	1.06	1.46	2.21	3.09
	TRFZ	0.23	0.32	0.28	0.44	0.44	0.57
	TLRZ	0.18	0.26	0.22	0.32	0.40	0.45
DSD	DSDX	1.25	1.64	1.21	1.16	1.98	2.28
	DSDY	0.33	0.41	0.28	0.27	0.50	0.53
	DSDZ	0.21	0.31	0.25	0.33	0.36	0.55
FSD	FSDX	0.76	0.98	0.47	0.66	1.32	0.96
	FSDY	0.81	1.25	1.03	1.14	1.83	2.36
	FSDZ	0.46	0.57	0.43	0.71	0.80	1.10
Displacement [in.]		0.00	0.00	0.00	0.00	0.00	0.00

Table A-47 Maximum Acceleration Values(g's), Fixed to Ground, Y-Axis, Frame-1, June 1992

IBM0692 FRAME - 1		Fixed To Ground (Slab) Y-Axis, No raised Floor Surface					
		RUN-132 EC-3	RUN-133 EC-7	RUN-134 EC-1.5	RUN-135 IBM-1	RUN-136 IBM-2	RUN-137 BELLCORE
SHAKER	ALAT	0.45	0.70	0.59	0.76	0.93	0.98
	AVRT	0.11	0.10	0.16	0.26	0.29	0.35
SLAB	ASEX	0.46	0.71	0.58	0.77	0.95	0.97
	ASWX	0.46	0.69	0.62	0.79	0.92	1.03
	ASCV	0.14	0.14	0.19	0.30	0.29	0.35
FLOOR	AFEX	0.00	0.00	0.00	0.00	0.00	0.00
LOWER	LRRX	0.01	0.01	0.01	0.02	0.01	0.03
	LRRY	0.49	0.72	0.64	0.78	0.95	1.06
	LRRZ	0.14	0.14	0.18	0.32	0.28	0.37
	LRFX	0.49	0.73	0.63	0.78	0.95	1.03
TOP	TRFX	0.62	1.03	1.03	1.25	1.56	1.96
	TRRX	0.63	1.04	1.05	1.22	1.49	1.93
	TRFZ	0.19	0.17	0.28	0.41	0.31	0.44
	TLRZ	0.15	0.16	0.20	0.34	0.29	0.37
DSD	DSDX	0.06	0.09	0.08	0.18	0.11	0.14
	DSDY	0.47	0.83	0.81	0.87	1.18	1.61
	DSDZ	0.18	0.19	0.30	0.46	0.37	0.62
FSD	FSDX	1.45	2.44	1.81	3.09	3.43	5.34
	FSDY	0.14	0.23	0.19	0.39	0.55	0.92
	FSDZ	0.35	0.57	0.43	0.81	1.05	1.03
Displacement [in.]		0.00	0.00	0.00	0.00	0.00	0.00

Table A-48 Maximum Acceleration Values(g's), Fixed to Ground, One-Bolt, X-Axis, Frame-1, June 1992

IBM0692 FRAME - 1		Fixed To Ground (Slab) X-Axis, One-Bolt, Casters Are Off The Ground					
		RUN-138 EC-3	RUN-139 EC-7	RUN-140 EC-1.5	RUN-141 IBM-1	RUN-142 IBM-2	RUN-143 BELLCORE
SHAKER	ALAT	0.45	0.71	0.59	0.73	0.93	1.01
	AVRT	0.11	0.11	0.17	0.26	0.29	0.35
SLAB	ASEX	0.46	0.72	0.58	0.74	0.96	0.99
	ASWX	0.46	0.69	0.61	0.76	0.93	1.06
	ASCV	0.13	0.13	0.18	0.30	0.29	0.37
FLOOR	AFEX	0.00	0.00	0.00	0.00	0.00	0.00
LOWER	LRRX	0.47	0.70	0.71	0.79	1.04	1.32
	LRRY	0.17	0.20	0.11	0.09	0.63	0.57
	LRRZ	0.23	0.28	0.23	0.33	0.69	0.78
	LRFX	0.38	0.79	0.60	0.90	1.15	1.60
TOP	TRFX	2.25	2.90	2.62	2.02	3.63	5.31
	TRRX	1.02	1.36	1.12	1.36	2.53	3.09
	TRFZ	0.20	0.20	0.29	0.39	0.46	0.55
	TLRZ	0.15	0.27	0.20	0.33	0.52	0.66
DSD	DSDX	1.11	1.40	1.31	0.97	1.85	2.30
	DSDY	0.16	0.25	0.19	0.22	0.41	0.42
	DSDZ	0.21	0.23	0.28	0.38	0.71	0.75
FSD	FSDX	0.71	0.85	0.70	0.81	1.60	1.72
	FSDY	0.88	1.24	1.14	0.94	1.95	2.66
	FSDZ	0.48	0.67	0.56	0.83	1.84	1.60
Displacement [in.]		0.00	0.00	0.00	0.00	0.00	0.00

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