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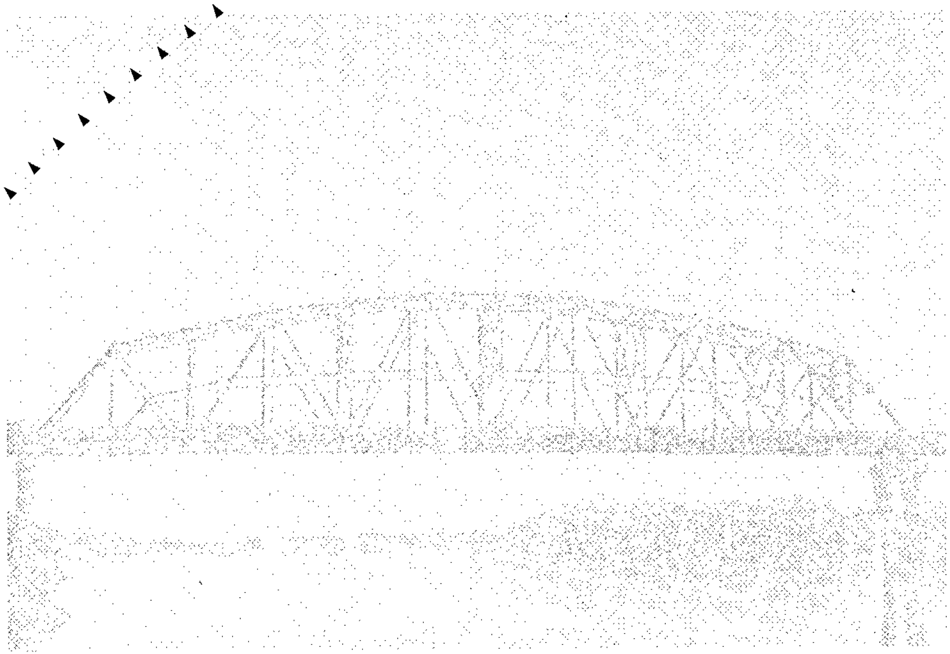

Monitoring and Assessment Program for Wabasha County Bridge

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A 143-m (470-foot) span steel truss bridge, the Wabasha County Bridge crosses the Mississippi River at Wabasha, Minn. In November 1996, the Minnesota Department of Transportation (Mn/DOT) implemented a retrofit strategy to mitigate perceptible vibrations in several truss members at moderate and strong wind gusts. In this strategy, Mn/DOT installed a "central cord" of tubular members, halfway between top and bottom cords, to reduce the effective length of the truss members, thereby increasing the natural frequencies of vibration and reducing the amplitude of vibration and the associated strains.

This report documents the monitoring and assessment program used to investigate the dynamic response and efficacy of the retrofit strategy for the Wabasha Country Bridge. Researchers determined amplitudes and frequencies of the vibration for the longest diagonal member. The measured frequencies are larger than those estimated before the retrofit and have resulted in reduced strains and displacements from vibration. Maximum strain levels at the quarter point of the member are estimated to be small after the retrofit, with peak values corresponding to 8.6 MPa (1.2 ksi).

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MONITORING AND ASSESSMENT PROGRAM FOR WABASHA COUNTY BRIDGE

Final Report

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EXECUTIVE SUMMARY

The Wabasha County Bridge is a 143-m (470-ft) span steel truss bridge crossing the Mississippi River in Wabasha, MN. In November 1996, the Minnesota Department of Transportation (Mn/DOT) implemented a retrofit strategy to mitigate perceptible vibrations in several truss members at moderate and strong wind gusts. In this strategy, a "central chord" of tubular members, halfway between top and bottom chords, was installed for the purpose of reducing the effective length of the truss members, thereby increasing the natural frequency of vibration and reducing the amplitude of vibration and the associated strains.

The vibrations observed in truss members before the Wabasha County Bridge was retrofitted may have resulted in larger than expected amplitudes of displacement, stress, and strain levels. For this reason, strain and stress levels needed to be quantified. To monitor the dynamic response of the longest diagonal truss member after the retrofit, a remote monitoring data acquisition (RMDA) system and appropriate instruments were purchased. Remote monitoring took place from August through November, 1997, and consisted of strain, acceleration, and wind speed data.

Frequencies of vibration for the longest diagonal truss member were measured during large accelerations and wind speeds. These frequencies, shown below, are consistent and compare well with calculated values. Also shown below are calculated frequencies of vibration that likely existed before the retrofit.

	Measured Frequencies after Retrofit (Hz)				Calculated Frequencies before Retrofit (Hz)	
	Large Accelerations		Large Wind Speeds			
Vibration Response	1st Mode	2nd Mode	1st Mode	2nd Mode	1st Mode	2nd Mode
Torsional	9.2	20.0	9.2	19.7	4.6	9.3
Strong-Axis	-	19.7	6.7	19.7	8.1	21.9
Weak-Axis	14.5	-	14.2	-	3.8	9.5

The effect of the retrofit in regards to frequencies of vibration, is evident. By bracing the diagonal member near the midpoint, first mode frequencies of vibration after the retrofit are approximately equal to and greater than second modes for torsional and weak-axis responses

before the retrofit, respectively. Strong-axis frequencies of vibration before and after the retrofit are approximately equal due to the negligible effect of the retrofit member in this direction.

Maximum accelerations measured during the monitoring period are nearly three times the magnitude of the maximum accelerations measured during the largest wind speeds. Corresponding wind speeds suggest a minimal contribution to the magnitude of these maximum accelerations. It is reasonably concluded that wind speeds do not result in the largest accelerations, and thus their contributions to displacement and stresses are minimal when compared the displacements calculated during large accelerations. The maximum strain increment measured at the quarter point of the member during the largest accelerations was 40-$\mu\varepsilon$, corresponding to a stress level of 8.6-MPa (1.2-ksi). Because the strain gages were located at the edge of the flange, approximate contributions of stresses resulting from vibration response are included.

A comparison of maximum single-amplitude displacements for each vibration response before and after the retrofit indicates a significant reduction. These displacements are shown below.

Response	Displacement	
	Before	After
Torsional	0.66-cm (0.26-in)	0.19-cm (0.075-in)
Strong-Axis	0.16-cm (0.062-in)	0.069-cm (0.027-in)
Weak-Axis	0.86-cm (0.34-in)	0.094-cm (0.037-in)

Amplitudes of vibration before the retrofit have been quantified by considering the combined effects of torsional and weak-axis displacement. An approximation of perceptible vibrations before the retrofit indicates double amplitude displacements were 2.0-cm (0.80-in). The equivalent displacement after the retrofit is 0.38-cm (0.15-in).

The retrofit strategy implemented by Mn/DOT has benefited the dynamic characteristics of the longest diagonal member of the Wabasha County Bridge. Increased frequencies of vibration have reduced the displacement amplitudes, resulting in very low stress and strain levels.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The Wabasha County Bridge, Minnesota Department of Transportation (Mn/DOT) Bridge No. 79000, is a 143-m (470-ft) span steel-truss highway bridge crossing the Mississippi River in Wabasha, MN (Figure 1.1). The bridge is a 12-panel, through-truss camelback design consisting of built up box and I-sections, with a road width of 12-m (40-ft). In November 1996, Mn/DOT retrofitted the bridge to mitigate perceptible vibrations in several truss members induced by moderate and strong wind gusts [1]. These vibrations raised questions regarding the possibility of fatigue distress.

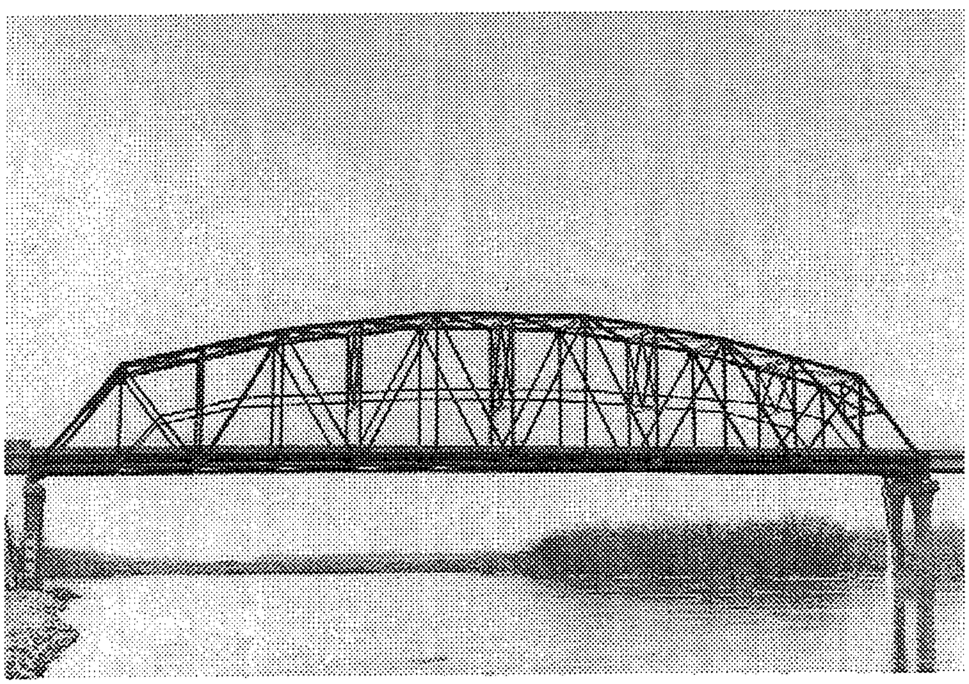


Figure 1.1 Wabasha County Bridge

Before implementing the retrofit strategy, a structural and materials testing company, Maxim Technologies Inc., was contracted by Mn/DOT to instrument and monitor the bridge [2], [3]. Instrumentation included accelerometers located on the longest diagonal to monitor movement, and strain gages mounted near the lower gusset. Also included in the instrumentation was an anemometer located on top of a nearby mill building, approximately 900-m (1000 yards), to measure wind speeds. Monitoring of the truss member occurred for a period of 2 months. As a result of the monitoring, amplitudes of vibration are available for certain wind speeds, but eyewitnesses have observed vibrations with amplitudes that are perceptibly larger than those calculated from the measured accelerations.

Independent of the measurements by Maxim, Mn/DOT opted for retrofitting the bridge. The retrofit strategy selected by Mn/DOT included a "central chord" of tubular members spanning the midpoints of truss members. By cutting the effective length of the truss members in approximately one-half, the retrofit scheme increased the natural frequencies of vibration of the truss members. These increased frequencies resulted in decreased amplitudes of vibration and corresponding strains.

1.2 OBJECTIVES

The vibrations observed in truss members before the Wabasha County Bridge was retrofitted may have resulted in larger than expected amplitudes of displacement, strain, and stress levels. This behavior could produce a substantial risk of fatigue failure from the number of cycles the individual truss members were exposed to. For this reason, strain and stress levels needed to be quantified. The primary objective of this research is to assess the dynamic response of one of the longest diagonal truss members after the retrofit and to evaluate the efficacy of the retrofit strategy. Specific tasks of this research include:

1. Select, purchase, and assemble the components of a remote monitoring data acquisition system (RMDA) and appropriate instruments. Included in this task is a description of the instrumentation plan for the Wabasha County Bridge.

2. Monitoring of the dynamic response of one member of the Wabasha County Bridge. This consists of collecting and processing acceleration, strain, and wind speed data. This includes a description of the data processing scheme, the format for data storage, and the method for accessing the data.

3. Analysis of the data collected in order to assess the dynamic response of the bridge and evaluate the retrofit. This analysis includes the computation of response displacements from the acceleration histories and identification of frequencies and modes of vibration.

4. Convey to Mn/DOT the techniques used for monitoring the Wabasha County Bridge with the assembled RMDA by means of a seminar. This technology transfer task includes the basic operation of the data acquisition system, as well as the processing, storage, and interpretation of the data.

1.3 OUTLINE

Chapter 2 describes the requirements of the remote monitoring data acquisition system needed for the proposed work. Discussed in detail is the equipment used to monitor vibrations of the Wabasha County Bridge, followed by a description of the instrumentation strategy. Chapter 3 explains the software used to collect the data in addition to an overview of the data collected. Chapter 4 describes the software and procedures used for data processing and analysis. Chapter 5 summarizes the vibration analysis of the longest diagonal of the Wabasha County Bridge. Chapter 6 contains the dynamic response assessment. In addition, a summary of the measured accelerations and strains and an evaluation of the retrofit strategy implemented by Mn/DOT are included. Conclusions are drawn in Chapter 7. Appendix A contains a glossary of terms used in the present study, many which originate with the SOMAT software and hardware. Appendix B includes the procedure files used for data processing and analysis.

CHAPTER 2
INSTRUMENTATION

2.1 REMOTE MONITORING

A remote monitoring data acquisition (RMDA) system to monitor the dynamic response to wind excitation of a diagonal member of the upstream truss in the Wabasha County Bridge must meet several requirements. Because the measurements were to be taken over a period of several months, the RMDA system was selected to withstand exposure to temperature and humidity fluctuations, dust, vibration, and impact. These conditions required a rugged RMDA enclosed in a waterproof and dustproof chassis, remaining operational for a temperature range of –30 to +50 °C (–25 to +120 °F). The RMDA would require remote-monitoring capabilities, that is, it must be able to start up when the bridge member begins to vibrate, and shutoff as soon as the vibrations cease, and it must afford the user the ability to access the data remotely. As a minimum, these remote capabilities would enable the occasional downloading of data by hardwire connection to the RMDA using a portable computer.

The vibration measurements to be taken, by virtue of their dynamic nature, require a high-speed data acquisition system. It is estimated that the largest frequencies of interest are approximately 20 to 25 Hz. To insure this range of interest will not contain components of higher frequencies, a conformable sample rate must be used. According to the Nyquist frequency formula [4], this would require a system capable of sampling at a rate of at least 40 to 50 samples per second over all channels. These high-speed measurement capabilities must be accessible through software with self-triggering capabilities. This feature would enable the RMDA to begin recording data only when the instruments indicate that the truss member is vibrating or when wind speeds are significant, and to stop once the magnitude of vibrations is negligible. Coupled with this self-triggering capability, the RMDA must also offer a variety of modes for recording data once it has triggered, including entire time histories or partial "bursts" only.

The RMDA should offer the option for electrical power to be delivered by AC lines or by DC cells, the most appropriate which are "gel cells", i.e. deep-cycle marine batteries. In order to extend the life of the batteries for applications in which gel cells are used, the RMDA system should offer low power consumption modes, particularly when data is not being recorded. The system must be able to accept signals from a variety of instruments including accelerometers, strain gages, anemometers, wind vanes, and temperature probes. The manufacturer of the RMDA should also offer a variety of software packages for data analysis, as well as timely technical support.

2.2 EQUIPMENT

Of the various RMDA systems on the market, only one was found to meet all of the necessary requirements. The SOMAT Series 2000 Field Computer System was purchased to monitor the vibrations in the Wabasha County Bridge. Included in this system are four analog transducer modules, six strain gage modules, and one pulse counter module. In addition to these signal-conditioning modules, two extended memory modules were also purchased. The components for this system are listed in Table 2.1.

Table 2.1 List of Components for SOMAT RMDA

Module	SOMAT Model No.	Quantity
high-speed processor	2071	1
power/communications	2025	1
4 MB extended memory	2034-4	2
8-bit strain gage module	2040	6
8-bit analog transducer	2085-8	4
pulse counter module	2060	1

Information about the system and its operation are documented by three references provided by SOMAT. These include an operating manual [5], reference manual [6], and users guide [7]. The initial intent was to purchase the SOMAT Series 2000 Field Computer System with a cellular telephone communications module. However, the sale of the latter unit was discontinued at the time that equipment was being purchased for the present project.

The eleven signal-conditioning modules of the SOMAT Series 2000 Field Computer System interact directly with different sensors to perform the actual data collection. The three types of sensors used include piezoresistive accelerometers, electrical resistance strain gages (350-Ohm), and a wind monitor. These sensors are listed in Table 2.2.

Table 2.2 List of Instruments and Transducers

Instrument	Manufacturer	Model No.	Quantity
5g piezoresistive accelerometer	EG&G IC Sensors	3028-005 P	4
350-Ohm resistance strain gage	JP Technologies	HSG 06-350-B3CS-50	6
Weather station	RM Young	05305-L80	1

2.2.1 SOMAT SERIES 2000 FIELD COMPUTER SYSTEM

The SOMAT Series 2000 Field Computer System is a versatile data acquisition system that includes data reduction and analysis capabilities. It can be used to measure and store data from all commonly used sensor types, including strain gages, accelerometers, displacement transducers, and thermocouples.

The minimum base system for the SOMAT 2000 includes the processor module (model No. 2011), power/communications module (model No. 2025), and a top cover. Stacked between the processor and power/communications modules are the signal-conditioning modules. The setup used for monitoring the Wabasha County Bridge consists of three different types of modules, each with a specific function. They include one pulse counter module (model No. 2060) to measure the wind speed, four analog transducer modules (model No. 2085-8) to measure and provide signal conditioning for the three accelerometers and wind direction, and six strain gage modules (model No. 2040). Also included in the stack are two extended memory modules (model No. 2034-4), which are used to store the collected data. Each module layer is identified by a channel number, corresponding to its location on the stack. The channel numbers are specified through hardware by jumper locations on the module circuit board. Hardware configuration of the modules for a specific application is also done by physically changing the jumper settings.

Each module comprises a precision-machined aluminum alloy case, providing protection from moisture, dust, and physical impact. The modules are separated by specially manufactured rubber gaskets, and locked together with captive screws. This results in a durable, compact system for data collection under various conditions. In addition, all circuit boards are specially fabricated to resist exposure to cycles of extreme temperatures and impact.

The processor module, (model No. 2011), located at the bottom of the stack, comprises the core of the system. It contains the circuitry that supports the microprocessor and memory. It allows each channel to be simultaneously sampled at a rate of up to 1200 times per second. The processor module contains 32 kilobytes (KB) of memory, four of which are allocated to program storage and the remaining 28-KB for data storage.

The power/communications module (model No. 2025) provides regulated power to the other components of the field computer. It also contains a serial communication port allowing communication to take place between the RMDA and a microcomputer. The power/communications module includes a lithium backup battery to preserve memory during a power loss. Located on the side of the module are transmit and receive lights, which indicate the status of communication connections. A run light is also located on the module and confirms the operation of a test. The power/communications module contains a real-time clock enabling the user to identify the day and time an event occurs and a wake-up feature, making it possible to begin a test at a specified time.

The pulse counter module (model No. 2060) is used to measure frequency and pulse width. Several types of transducers may be used for input. They include magnetic pickup transducers, hall effect transducers, logic level signals, and analog voltages. Signals may be recorded as low as 2-V peak to peak. The pulse counter module is configured for the specific type of transducer by changing jumper settings.

The analog transducer module (model No. 2085-8) is used to condition "DC-type" transducers if necessary and measure and amplify the voltage signals. Hardware configuration of the module includes the selection of excitation mode, input impedance, and input voltage range. These parameters are specified by jumper settings.

The strain gage module (model No. 2040) is designed to condition and measure voltages generated by resistive type strain gages in a Wheatstone bridge circuit. It can also be used with strain gage-based transducers, including strain gage accelerometers and strain gage-based pressure transducers. No additional signal conditioning is required. The strain gage modules allow direct connection to quarter-, half-, and full-bridge electrical resistance strain gage configurations. Hardware configuration of the module includes the selection of bridge completion and calibration resistor. These configurations are also set by jumper positions located on the circuit board. A photo of the SOMAT Series 2000 Field Computer System is shown in Figure 2.1.

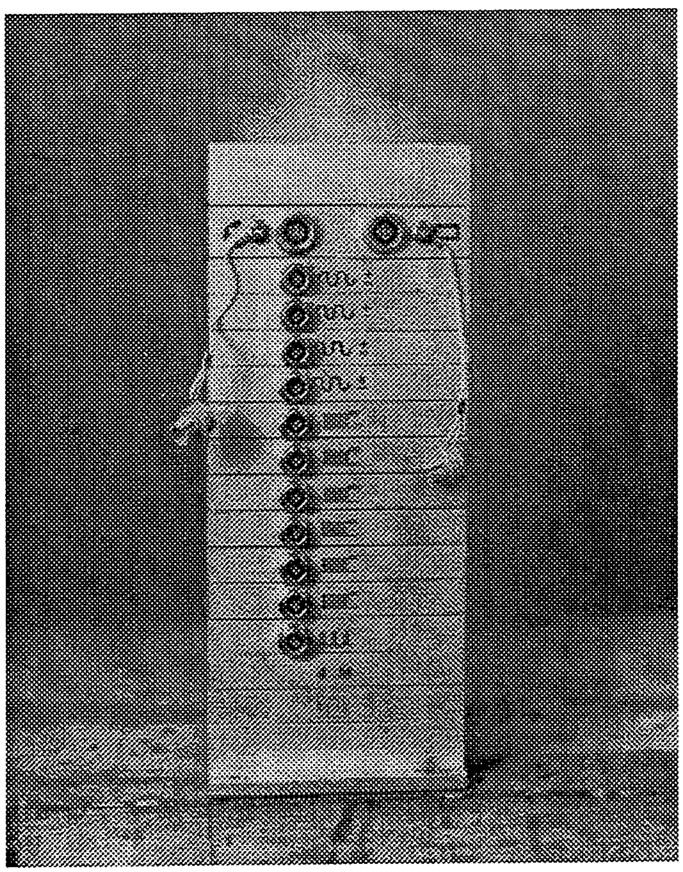


Figure 2.1 SOMAT Series 2000 Field Computer

2.2.2 ACCELEROMETERS

The accelerometers (EG&G model No. 3028-005 P) are solid state piezoresistive accelerometers with a range of ± 5-g. Their small size, low mass, and relatively low cost create a suitable choice for a variety of applications. Within the ceramic cover of the accelerometer is a micromachined silicon mass suspended from a silicon frame by multiple beams. Piezoresistors in the beams change resistance as the motion of the mass changes the strain in the beams. Silicon caps on the top and bottom of the device provide over-range stops and shock resistance. This three-layer silicon structure reduces the profile and mass of the accelerometer. The ceramic cover of the accelerometer is attached to a metal bracket for mechanical mounting.

The piezoresistive accelerometers are used with three analog transducer modules of the SOMAT Field Computer to measure accelerations. The modules are configured to provide a ±2.5 volt excitation used to power the full bridge of the accelerometers. The sensitivity of the accelerometers enable the use of a high input impedance with a first stage gain of 100. These configurations result in a maximum and minimum full-scale range of ± 25-mV and ± 2.5-mV respectively, corresponding with the output range of the accelerometer.

2.2.3 STRAIN GAGES

The strain gages (JP Technologies model No. HSG 06-350-B3CS-50) are of the 350-Ohm electrical resistance type. They are commonly used when environmental conditions are extreme. The gages are etched Karma/Evanohm grid on a glass-reinforced polymike backing. The strain gages require spot welding for installation.

The electrical resistance strain gages (350-Ohm) are used with the six strain gage modules of the SOMAT field computer to measure mechanical strain. A 3-wire quarter bridge configuration was used to measure strains. This configuration eliminates temperature problems associated with long lead wires. Calibration resistors (i.e. shunt values) that create the internal reference span used in calibration were configured for 350-Ohm type strain gages.

2.2.4 WIND MONITOR

The wind monitor (R.M. Young Company model No. 05305-L80) measures horizontal wind speed and direction. Designed for rugged and corrosive environments while remaining accurate and lightweight make its use well suited. The main housing, nose cone, propeller, and other internal parts are injection molded UV stabilized plastic. Bearings contain teflon seals and are filled with a low torque, wide temperature range grease to prevent contamination. The wind monitor mounts on a standard 2.5-cm (1.0-inch) pipe.

Wind speed signals from the wind monitor are used with the pulse counter module to measure wind velocity and azimuth signals with an analog transducer module to monitor wind direction. The pulse counter module was configured for the alternating current signal (AC sine wave) generated by the wind speed signal, which is proportional to wind speed. The analog transducer module used with the azimuth signal of the wind monitor was configured to provide a ±2.5 volt excitation and a high impedance input with a first stage gain of one. These settings result in a maximum and minimum full-scale range of ±2.5-V and ±125-mV respectively; corresponding to the output range of the azimuth signal which is also proportional to azimuth angle.

2.2.5 STORAGE BOX

The RMDA, terminals, and all connections are housed in a fiberglass storage box satisfying the NEMA-4 standard and measuring 45.7-cm (18-in) long by 38.1-cm (15-in) wide by 30.5-cm (12-in) high. The fiberglass construction offers lightweight, high strength security as well as protection from weather elements. Instrument cables enter the box through a small hole with a PVC extension on the side. Because the box is positioned along the diagonal member, this PVC extension points downward, preventing water from entering the box. Inside the box, the eleven instrument cables are connected to terminal strips, which are connected to the cables that plug into the corresponding field computer module. Also located in the box is the 80 amp-hour gel cell that is used as the external power supply to the field computer. Figure 2.2 is a photo of the storage box installed along the diagonal member.

2.3 INSTRUMENTATION

Strain gages and accelerometers were used to instrument the longest diagonal of the upstream truss of the bridge (Fig. 2.3) to measure the strain and accelerations. This truss member has been observed to be most vulnerable to vibrations. The wind monitor is attached to the retrofit member between the instrumented diagonal and the central vertical member of the truss. The fiberglass enclosure is positioned along the diagonal resting on the grating of the navigation light platform. This location minimizes length of wire leads, and permits convenient access to the data acquisition system.

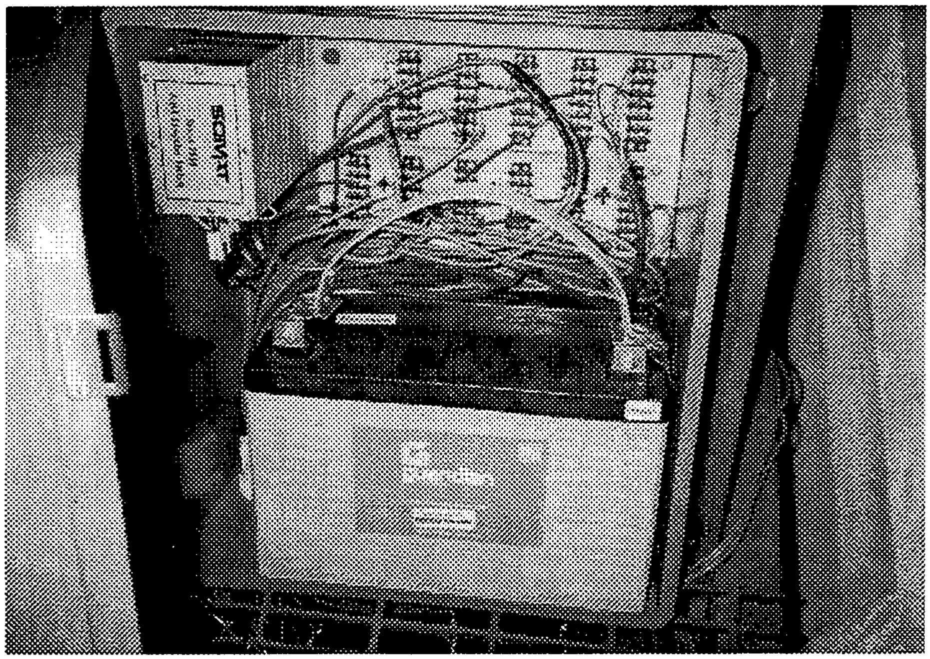


Figure 2.2 Storage Box with Field Computer, Connections, and Battery

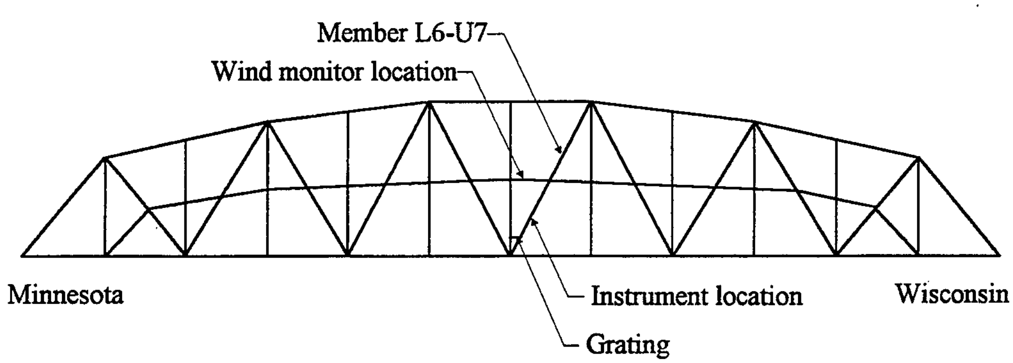
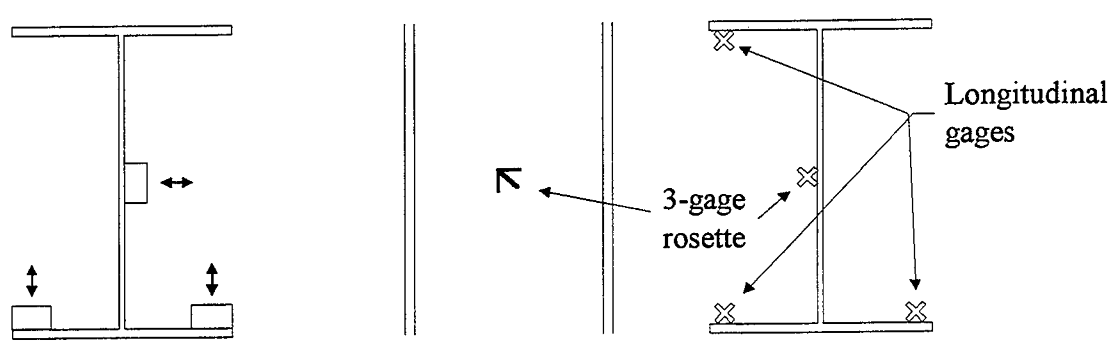


Figure 2.3 Upstream Truss, Wabasha County Bridge

Three accelerometers and six strain gages are located at the quarter length of the diagonal, approximately 4-m (13-ft) above the bridge deck (Fig. 2.4). This location is approximately mid-length of the distance from the bottom of the diagonal member to the intersection with the retrofit brace; thus, it has the potential for experiencing large translational and torsional vibration movements. Two accelerometers were attached to the edge of the flange on both sides of the web. The other accelerometer was attached to the middle of the web. A rosette assembly of strain gages, located opposite this accelerometer, was used to measure longitudinal and shear strains at this location. Two other strain gages are located next to the accelerometers on the flange. The final strain gage was attached to the other flange edge. The direction of the bridge truss is parallel to the strong-axis of the diagonal member. For a symmetric I-section, the strong axis is located at the midpoint of the web, parallel to the flanges. It is the location about which bending occurs in the strong-axis direction. Thus, strong-axis vibration occurs in the direction perpendicular to the plane of the truss (i.e. motion is in the direction of the river). Weak-axis vibrations of the member therefore occur in the direction parallel to the plane of the truss (i.e. motion is in the direction of traffic).



(a) Accelerometer location (b) Strain gage location

Figure 2.4 Instrument Location

Instrument location was based on frequency of vibration calculations of the instrumented member after the retrofit. The retrofit brace was assumed to act as a pinned restraint in the weak-axis and provide full restraint for torsional rotation. The effect of the brace in the direction of strong-axis translation was assumed to be negligible. The bolted gusset plate connections were assumed to act as fixed supports with respect to weak-axis bending due to the bolted length of the diagonal member and the orientation of the gusset plate normal to the weak-axis of the cross section. The connections were also assumed to restrain torsional rotation. For strong-axis vibration, the bolted gusset plate connections were assumed to act as pinned supports due to plate orientation and the relative stiffness of the member about its strong-axis and the plate about its weak-axis. These preliminary calculations showed that torsional and strong-axis vibration modes occurred at lower frequencies than weak-axis. Thus, vibrations due to wind effects would be prevalent in torsional and strong-axis directions. Identifying these vibration modes could effectively be accomplished by placing two accelerometers on the flange. Combining the measurements of these accelerometers results in the torsional and strong-axis accelerations of the member. Weak-axis accelerations are measured by the accelerometer at the center of the web.

To minimize the effects of radio and electromagnetic interference, the accelerometers were attached to the member inside an aluminum enclosure lined with copper foil shown in Figure 2.5. This was done after drift was encountered in the initial installation effort (see Section 2.4).

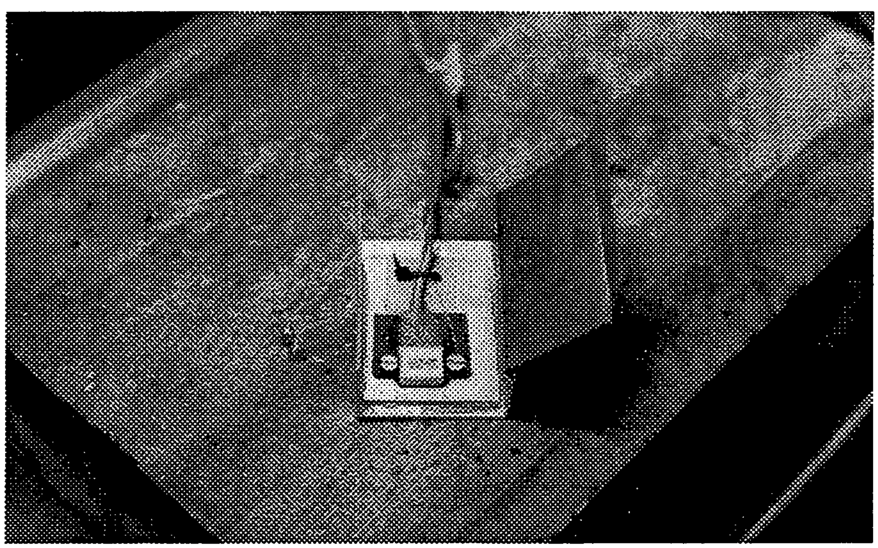


Figure 2.5 Accelerometer Enclosure

The metal bracket of the accelerometer was mechanically fastened to the base plate of the enclosure. The wire connections were covered with silicone caulking, and the shield wire was connected to the metal bracket of the accelerometer. The outside of the base plate was attached to the bridge with a quickset epoxy. The seams of the enclosure were then covered with silicon caulking. Figure 2.6 is a photo of two installed accelerometers.

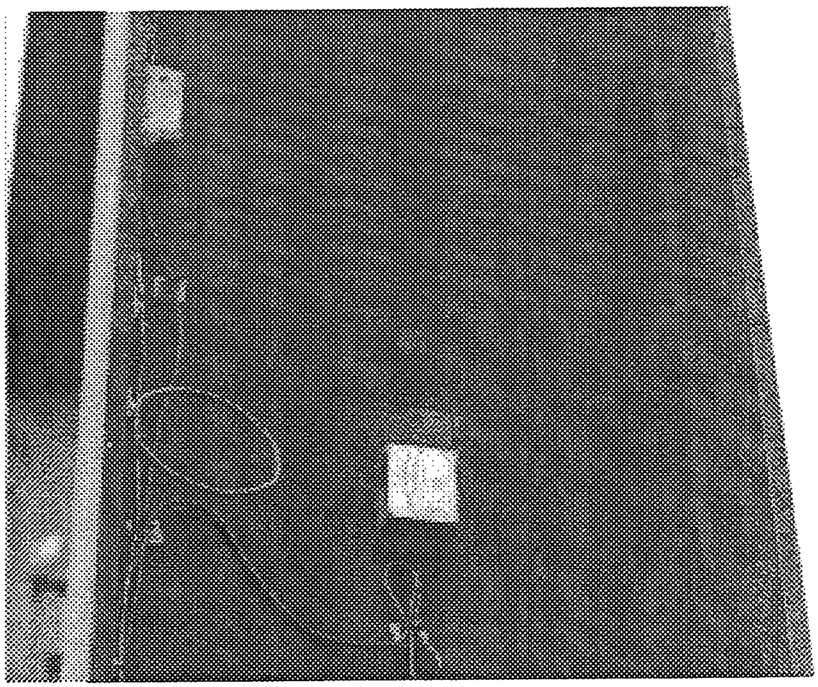


Figure 2.6 Installed Accelerometers

The strain gages were attached to the member by spot-welding. Surface preparation included use of a grinder to expose a clean, paint-free surface. The gage was first fixed in place by two tack welds placed near the outer edge of the strain gage flange midway in the longitudinal direction. Beginning at this longitudinal center and as close to the protective coating as possible, a spot-welded seam was placed around the strain gage. Attention was given to the manner in which each side of the strain gage was welded to reduce the residual strains introduced by the welding process. To further reduce the effect of residual strains, the gages were placed without traffic on the bridge. After the strain gage was welded into place, the connection and instrument were covered with silicone caulking. Figure 2.7 is a photo of the installed strain gage rosette.

The wind monitor was attached to the retrofit member by welding a sleeve assembly to a 3.8-cm x 0.64-cm x 28-cm (1½-in x ¼-in x 11-in) steel plate. The 2.5-cm (1.0-in) pipe that fastens to the wind monitor is securely attached to the sleeve by passing a bolt through both the sleeve and pipe. The top plate containing the sleeve is held to the top of the retrofit member by 9.5-mm (3/8-in) steel rods connected to a similar plate on the bottom of the retrofit member. Figure 2.8 is a photo of the installed wind monitor.

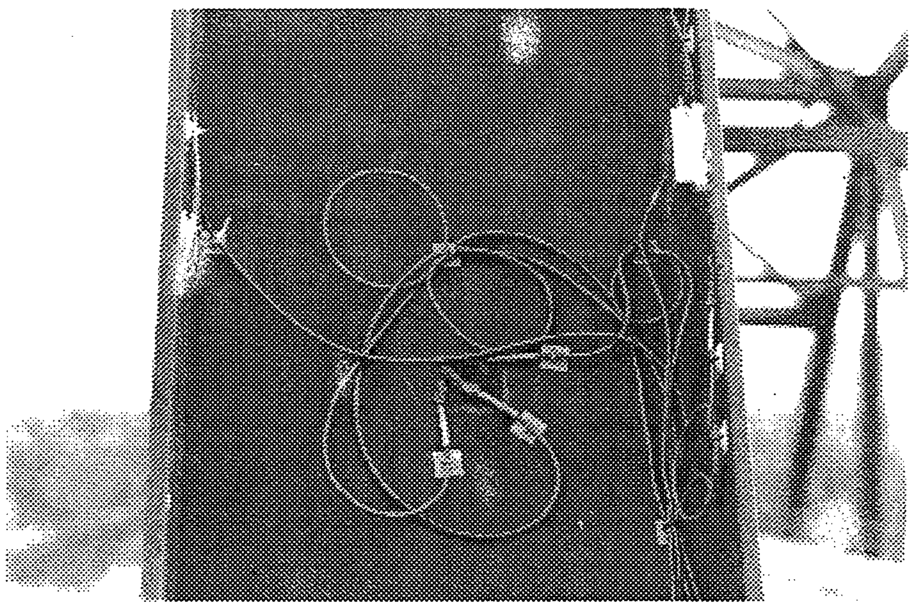


Figure 2.7 Strain Gage Rosette

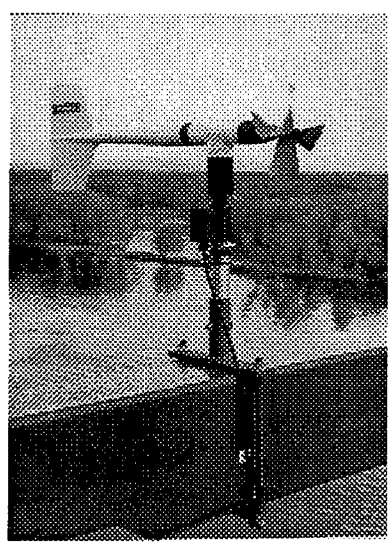


Figure 2.8 Wind Monitor

2.4 MODIFICATIONS

The metal bracket, which served to support the accelerometers, was initially attached directly to the instrumented truss member and covered with a silicone sealant to protect it from moisture. The first downloading of data revealed that signals generated by the accelerometer were not stable and exhibited an unacceptable amount of drift. The manufacturer of the accelerometers indicated that this drifting signal was the result of a defect in the dye used in the manufacturing process. Since the drift was undetectable in the short-term laboratory tests, it is believed that a variety of conditions present at the location of the bridge could have also contributed to the unstable signal. These conditions include interference from radio and electromagnetic waves. Another condition may be "stray electrical discharges" as power lines often cross at or near highway bridges (David Prine, Northwestern University, telephone conversation). In addition, the accelerometers were not shielded (insulated) from solar radiation and changes in ambient temperature. The combination of new accelerometers and the protection provided by the enclosure and copper foil (Figure 2.5) reduced the drifting to a manageable amount; i.e. signals did not drift out of measurable range of voltages that can be recorded by the SOMAT field computer.

Initial readings and verification of the strain measurements revealed unsatisfactory resolution of the strain modules. To validate these small strains, a longitudinal strain gage signal was externally conditioned using a strain indicator box (Micro Measurements, Raleigh, NC) and the signal run into the analog channel used for sampling and recording wind direction. After verifying the magnitude of strains, the field computer was removed and returned to SOMAT Corporation for modification of the strain gage modules in order to improve strain gage measurement resolution. These modifications consisted of increasing two resistors located on the module circuit board and were intended to enhance the sensitivity of the strain gage modules by a factor of four. However, due to large strain gage offsets, the modified strain gage modules were unable to calibrate the gages. The combination of long lead wires, residual strains during installation, and initial offsets of the gages caused these large offsets. To calibrate the strain gages, 50 KΩ potentiometers (pots) were installed onto a circuit board and were used to adjust manually the offset of the strain gages to zero.

Signals generated by the wind speed component of the wind monitor contained an excessive number of what appeared to be random "spikes." These spikes occurred randomly and "saturated" the wind speed voltage signal in the pulse counter module. Figure 3.1 shows a typical "spike" that commonly occurs within the measured wind speed data. The spike is "clipped" at 53 m/sec (118 mph) because the corresponding voltage is the maximum value that the SOMAT field computer will record.

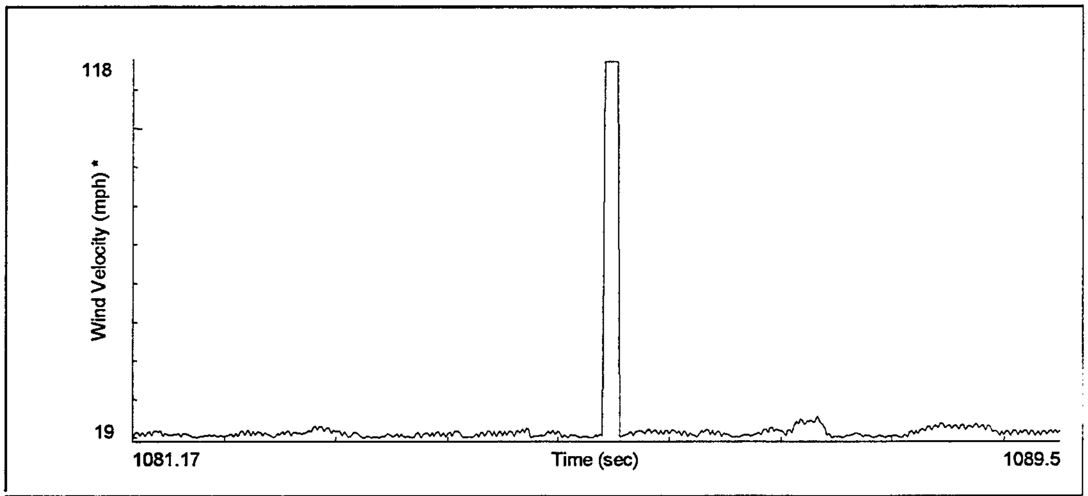


Figure 2.9 Typical Wind Speed Spike

* 1.0 mph = 0.45 m/sec

It was later discovered that noise (voltage) spikes are common in bridge monitoring applications and may be a result of stray electrical discharges from power line crossings (David Prine, Northwestern University, telephone conversation). To eliminate problems associated with spikes, hardware filters can be used. As an alternative, a software selectable "smoothing" function of the pulse counter module was modified to minimize the length of time for which the signal is affected by the noise spike. The smoothing function of the pulse counter module is an "averaging" of the wind speed signal over a user selected time window. The length of the time window controls the amount (percentage) of averaging that occurs, and by setting this value to zero, no averaging occurs, and only the current (instantaneous) value of wind speed is recorded. In this manner, the duration of the noise spikes was reduced to a minimum number of samples. In addition, by eliminating the smoothing of the wind speed signal, the amount of memory required to record member response to a slowly decaying wind speed signal, caused by the voltage spike, is minimized.

CHAPTER 3
DATA COLLECTION

3.1 SOMAT TEST CONTROL SOFTWARE

Preliminary data processing is accomplished through application of SOMAT's Test Control Software (TCS). TCS provides a menu-driven link between the user, the SOMAT 2000 Field Computer, and the PC support computer. It allows the user to set up a test, collect data in a variety of ways using different data modes, and display test results. Several features of TCS contribute to an efficient data collection process. The variety of triggering capabilities ensures that the data collected is meaningful. Different Data Modes enable data to be analyzed as it is being recorded; resulting in data that is of specific interest to the user. After a test has run for a desired length of time, using the TCS software, the user is able to stop the test and upload the data to the hard drive of the PC support computer. TCS allows viewing by plotting or browsing through the data values. Specific ranges and channels may be selected to facilitate the viewing of a particular event or entire histories. TCS is also able to convert the uploaded SOMAT format, a more efficient storage method, to an ASCII format, which can then be processed or viewed in external applications other than TCS.

3.2 DATA COLLECTION

Data collection begins with the creation of a setup file through TCS. The setup file contains hardware, calibration, and data mode information that define the parameters for a specific test. Creating a setup file involves (1) specifying the hardware, (2) calibrating the modules, and (3) setting the data mode(s).

Hardware Setup includes specifying the types of modules to be used in a test and their location on the hardware stack. An important purpose of the Hardware Setup is to match software specifications with hardware specifications. Specifications for the Strain Gage Modules include bridge configuration and calibration resistors. The Analog Transducer Modules require selection of excitation mode if necessary, input voltage range, and first stage gain. The Pulse Counter Module requires the selection of input signal type.

Calibration for the SOMAT 2000 Field Computer system is the process of determining relationships between the engineering data measured by a specific transducer and the corresponding internal units to be stored in the SOMAT Field Computer. Calibration begins with the selection of units (e.g. volts, kilograms, g's, etc.) in which the data should be displayed, a description of the data, and minimum and maximum values that are expected to occur for each channel. Additional parameters to be specified include a reference zero corresponding to the at-rest signal of the transducer, and the calibration mode. The calibration mode depends on the particular application for which the transducers are used.

For monitoring the Wabasha County Bridge, the Strain Gage Modules were calibrated using internal calibration resistors of the module. To verify each module, a decade resistor was used to simulate the voltage output produced by certain levels of strain. The measured strains are recorded in microstrain ($\mu\varepsilon$), which are 10^{-6} m/m (in/in). The Analog Transducer and Pulse Counter Modules were calibrated using a scale factor. For the analog modules measuring accelerations, this factor was determined manually by turning the accelerometer on its side (0-g reading) to a flat position (1-g reading). The factor used for the pulse counter module was obtained from the transducer manufacturer. These scale factors convert the input signal voltage to engineering units. The engineering units are g's for acceleration and miles per hour for wind speed.

Data modes for the setup file specify the way in which digital data attained from the individual modules is processed and saved during a test. Six different data modes are available through TCS. Selection depends on the purpose of the test and the intent of collecting and processing the data. Information needed for the setup file includes the specific data mode, channels over which each data mode should collect, and triggering conditions. For monitoring the Wabasha County Bridge, two data modes and triggering expressions were used. The Time History data mode, which collects data at a constant rate, and Burst History data mode, which collects data as a series of fixed-length time histories.

The Time History data mode was triggered on wind speed. Thus, when the wind reached a certain speed, data was collected until the wind speed fell below the specified trigger speed. The

Burst History data mode was triggered by accelerations. When the accelerations of the instrumented member reach a threshold or trigger value, data was collected one second before and four seconds after the trigger condition was attained. If, at the end of the time interval, the accelerations were still above the trigger threshold, a new burst was started and the time interval was repeated. Five seconds was chosen as the Burst History duration to effectively capture the response of the member during brief and sudden excitation forces. The threshold wind speed and acceleration values initially used were 6.7-m/sec (15-mph) and 0.15-g respectively. These values were increased to 8.9-m/sec (20-mph) and 0.175-g after the range vibration magnitudes of the truss member response was realized.

Due to the unstable characteristics of the accelerometer signals, additional software was required to accurately trigger data collection using the Burst History data mode. The External Computed Channel (EXCC) software obtained from SOMAT contains functions that are able to perform additional calculations in order to obtain the desired data. The EXCC software is installed separately and is fully compatible with TCS.

Since the baseline of the accelerometer signal was seldom equal to zero due to drift, triggering Burst History data collection on a threshold value could result in the collection of data at an actual acceleration less than the trigger value, or no collection at all, depending on the current value of the baseline. To eliminate any uncertainty associated with drifting of the baseline values of the accelerometer signals, a second software channel was computed using a function available in EXCC by averaging the signal of each accelerometer over the previous 32 samples. This computed average channel represents the current baseline of the accelerometer signal. A second software channel was then computed by subtracting this baseline from the corresponding accelerometer signal. This second software channel represents the corrected acceleration and was used to accurately trigger the Burst History data collection of the accelerometer signal.

Once a setup file has been created, TCS is able to initialize the Field Computer. This process clears all available memory, writes the test setup file to memory, and programs the Field Computer to perform the specified test. Once initialized, the Field Computer is ready to begin a test.

3.3 DATA OVERVIEW

Data was uploaded from the remote data acquisition system 25 times during the period of August 26 to November 30, 1997. Each of these tests contain two components; data collected using the Burst History and Time History data modes. In both cases, data was recorded from all instruments when corresponding trigger values were achieved. Table 3.1 summarizes the details of each test. The test name designates the day the test was started. The duration is the time elapsed from test initiation to the time data was uploaded (i.e. test termination). The test time represents actual time before the field computer memory was filled. Thus, a test time less than the duration time indicates the field computer memory became full before data was uploaded. The symbols BH and TH are abbreviations for Burst History and Time History data modes, respectively. The collection time corresponds to the time the field computer was recording data.

Table 3.1 Data Collection Summary

Test Name	Wind Speed Trigger, mph	Acceleration Trigger, g	Size KB	Duration hrs	Test Time, hrs		Collection Time, hrs	
					BH	TH	BH	TH
aug26_2	15.0	0.150	7968	66.1	6.73	66.14	1.32	3.55
aug29	15.0	0.150	8190	94.4	80.47	80.63	0.65	1.87
sept2	15.0	0.150	4604	52.1	52.04	51.61	0.95	0.04
sept4	15.0	0.150	7069	113.5	113.47	113.40	1.39	0.29
sept9	15.0	0.150	7777	70.7	70.73	70.43	3.55	0.07
sept12	15.0	0.150	8190	101.9	97.08	97.06	3.48	0.25
sept16	15.0	0.150	8192	69.7	48.05	47.80	2.46	0.94
sept19	15.0	0.150	8192	148.7	11.98	12.66	0.37	2.34
sept25	17.5	0.175	8190	96.5	65.36	65.49	1.27	1.73
sept29	20.0	0.175	8190	67.8	16.82	16.83	0.69	2.12
oct2	20.0	0.175	8083	93.3	93.20	93.23	2.59	0.82
oct6	20.0	0.175	8189	73.7	59.05	59.20	2.01	1.24
oct9	20.0	0.175	8190	96.8	70.09	70.97	1.54	1.55
oct13	20.0	0.175	8192	69.1	63.19	62.46	3.24	0.85
oct16	20.0	0.175	8191	94.5	84.34	84.33	2.01	1.24
oct20	20.0	0.175	8191	90.5	21.96	20.91	0.78	2.06
oct24	20.0	0.175	1191	18.8	18.74	18.68	0.54	0.01
oct27	20.0	0.175	6958	70.0	69.95	69.84	3.24	0.02
oct30	20.0	0.175	8191	92.0	5.10	51.75	1.47	1.60
nov3	20.0	0.175	4281	51.0	50.99	51.01	2.00	0.01
nov5	20.0	0.175	7512	120.3	120.29	120.30	3.49	0.03
nov10	20.0	0.175	6947	70.5	70.44	68.93	2.65	0.41
nov13	20.0	0.175	5179	95.9	95.82	95.65	2.24	0.13
nov17	20.0	0.175	5023	68.9	68.91	68.90	2.33	0.02
nov20	20.0	0.175	8191	387.7	128.15	128.32	2.67	0.79
Totals			**179071**	**2374.3**	**1583.0**	**1686.6**	**48.9**	**24.0**

The dashed line separating tests indicate when the gel cell was changed. Although capable of powering the field computer longer, the battery was changed on a conservative schedule to avoid the possibility of memory loss when the power supply to the RMDA system is lost while a test is in progress.

The data tests uploaded to the PC support computer have been compressed and stored on two high capacity Iomega Zip Disks. Figure 3.1 represents the schematics of the storage format. The directory for the stored data is *zip,* which is located in the main directory *Wabasha*. Subdirectories are organized according to the month in which data was collected. Additional subdirectories include data files collected prior to July 16, 1997, stored in *old_data*, tests that have been run in the Civil Engineering building at the University of Minnesota, stored in *office_tests*, and miscellaneous tests, located in *other*. Each of these subdirectories is further subdivided into setup and data folders, which contain setup and data files, respectively. The data files are named according to the date they were initiated. If more than one test was started on the same day, the date is followed by an underscore and a number (i.e. jul25_2). The setup files have the same names as the data files they represent.

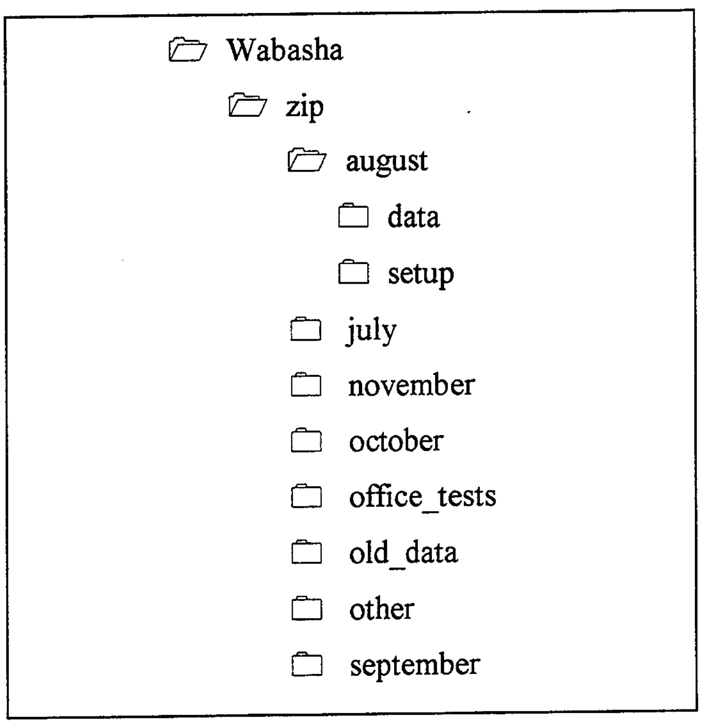


Figure 3.1 Data Storage Format

To access the files, an Iomega Zip Drive and Tools software must be used. The Iomega Tools software will automatically uncompress selected data files and store it in a specified location. After the data has been uncompressed, it can be accessed through TCS or SOMAT's Engineering Applications Software Environment (EASE) which is described in the following chapter.

CHAPTER 4

DATA PROCESSING AND ANALYSIS

4.1 SOFTWARE

Data processing and analysis was accomplished using SOMAT's Engineering Analysis Software Environment (EASE) [5]. EASE is a Windows-based software package for management, control, and graphical analysis of engineering test data. EASE provides valuable display and editing functions in addition to analysis capabilities such as spectral analysis, software filtering, and statistical and arithmetic functions. To automate these functions, the EASE Procedure Language (EPL) was used, which allows programming the entire data processing scheme as a list of EPL commands. The list of commands that comprise the data processing scheme includes numerous repetitive calls to EASE functions. Most of the functions available within EASE contain equivalent EPL commands, which are written in a text file to generate the data processing procedure. Several text files, referred to as "procedures", were written and systematically used to complete the various components of data processing and analysis. These procedures are included in Appendix B.

4.2 DATA PROCESSING

The objective of the data processing scheme was to organize the data in a format that would enable accurate and efficient analysis. Since data was collected using two different data modes, different data processing procedures had to be used for the Burst History and Time History data.

4.2.1 BURST HISTORY DATA

Data collected using the Burst History data mode consists of segments of data, referred to as bursts that were collected when accelerations exceeded threshold values. These bursts range in length from five seconds to several seconds, depending on the magnitude of accelerations that triggered collection. This data mode was needed because the acceleration signals are bi-directional (i.e. oscillate about a neutral position). In addition to the bursts, the Burst History records also include quiescent periods when the instruments were sampled, but data was not recorded (i.e. the trigger conditions were not satisfied). During these periods, the TCS software inserts real-time segments containing no data. Since many of the functions available in EASE require the data to be continuous records, it is necessary to eliminate the quiescent periods in the original Burst History record. The result of this conversion is a data file containing eleven channels of continuous data, corresponding to the data recorded from the eleven transducers using the Burst History data mode. This format is referred to as the data file of the original Burst History record.

Once the Burst History record has been converted to a data file containing 11 channels of continuous data, the long-term drift that exists in the measured accelerations can be compensated. Since the drift occurred over long time intervals, the random rising and falling of the acceleration baseline can be identified as a very low frequency trend. To remove these low frequencies, a high-pass filter was used with a cutoff frequency of 0.1 Hz. This filter attenuates frequencies less than 0.1 Hz while allowing signals that have frequencies larger than 0.1 Hz to pass without alteration.

After the acceleration data was filtered, the torsional and strong-axis response was calculated. Three accelerometers, located near the lower quarter point of the member, i.e. the midpoint between the bottom chord and the retrofit connection (Figure 2.3), were used to measure the dynamic response of the truss member. One of the accelerometers was attached to the center of the web and measured accelerations normal to the web (Figure 2.4a). The other two accelerometers were attached to opposite edges of the same flange (Figure 2.4a) and measured accelerations in the plane of the web (i.e. normal to the flanges). The accelerations measured at the flange edges are used to compute the strong-axis and torsional accelerations. To obtain the strong-axis response, the two flange accelerations were averaged. The torsional response was calculated as the difference of the flange accelerations divided by the distance between them. Therefore, torsional accelerations have units of g/m (g/ft). The weak-axis response is simply the acceleration measured by the accelerometer at the center of the web. After the strong-axis and torsional accelerations were computed, a new continuous data file was created. This new file contains eleven channels; strong, weak, and torsional accelerations, six channels of strain data, and two channels for wind speed and direction.

Due to the large number of bursts (i.e. several hundred) recorded by the RMDA for each Burst History record, it was deemed practical to consider only the larger accelerations in the data files. This was accomplished by using the Burst History data mode function available in EASE. EASE data modes are used to process, manipulate, and convert data that has already been collected. Repeating the Burst History selection process produces a reasonable number of bursts to analyze subsequently and enables data to be extracted based on significant torsional, strong-axis, and weak-axis accelerations.

The Burst History data mode within EASE was used to extract individual bursts from the continuous data records. The bursts were created by scanning each acceleration history for user defined threshold values. When the acceleration values exceeded the corresponding trigger value, data from all eleven channels was extracted one-second prior and four seconds after the trigger was attained. These time periods were chosen to remain consistent with the bursts that were originally collected. The Burst History data mode was used three times, once for each type of acceleration response (torsional, strong-axis, weak-axis). The extracted bursts were saved into seven separate files for each type of data that was analyzed. These include three files that contained the torsional, strong-axis, and weak-axis acceleration data extracted, two files for the corresponding rosette and longitudinal strains, and two files for the wind speed and direction. These files enabled the individual bursts of each type of data to be analyzed separately.

4.2.2 TIME HISTORY DATA

Data collected using the Time History data mode consisted of continuous segments of data (i.e. time histories) that were collected when wind speeds exceeded a threshold value. When wind speeds fell below the trigger, data collection ceased and real-time segments containing no data were inserted by TCS. This data mode, which is different from the Burst History mode, was needed because the wind speed signal is uni-directional (i.e. deviations in a single direction or sense from the neutral position). These quiescent periods do not coincide with those for the Burst History data mode because different trigger conditions were used. To facilitate processing within EASE, the quiescent segments were removed, resulting in a data file containing eleven channels of "continuous" data corresponding to the data recorded from the eleven transducers using the Time History data mode. This format is referred to as the data file of the original Time History record.

Once the data was converted to a continuous record, voltage spikes (Figure 2.9) that were present in the wind speed signal were removed. EASE contains an automatic despiking feature that scans a specified channel and identifies possible spikes. Possible spikes are distinguished by user defined parameters that include; amplitude change across two scans, ratio of the slope on the plateau of the spike to the rise slope, ratio of the slope before and after the spike, or the down step range at the end of the spike. When a possible spike is identified, the user is prompted to remove or ignore the spike. After all spikes were investigated, a new data file was created by substituting the new wind speed channel for the original channel that was contaminated with noise spikes.

Although the amount of data collected with the Time History data mode was generally less than with the Burst History data mode, the duration of wind speeds larger than the threshold values is potentially long (fewer events but of longer duration). To analyze Time History segments that have a practical length and are consistent with the Burst History data, five-second bursts were extracted. Data extracted from the Time History data was triggered off wind speed and included 5 seconds of data after the threshold values were achieved.

After the bursts were extracted, torsional and strong-axis accelerations were computed. To compensate for a nonzero baseline, an average of the five-second acceleration bursts was computed and the acceleration was shifted by this amount. Calculation of the torsional and strong-axis accelerations is similar to the Burst History calculation; the only difference was the size of acceleration histories on which the operations were performed. A new file was created containing the calculated modes of vibration, which comprise the segments of data from the original record that were analyzed.

4.3 DATA ANALYSIS

Analyzing the data created by the processing scheme described above consists of performing different analysis functions and exporting the results to a text file. The most valuable results from the analyzed data were produced from a spectrum, strain gage rosette, and statistical analyses.

4.3.1 SPECTRUM ANALYSIS

The spectrum analysis function performs a Fast Fourier Transform (FFT) on the processed strains and accelerations. The FFT is a mathematical method for transforming data from the time domain to the frequency domain [8]. A product of the FFT is the Fourier amplitude spectrum, which can be viewed as a correlation between energy and frequency of vibration and it can be used to identify the frequency content of importance of the data that was transformed. An example of a Fourier amplitude spectrum is shown in Figure 4.1. The different frequencies that make up the signal, referred to as spectral lines, each contain some amount of energy. The spectral line that contains the largest amount of energy corresponds to the frequency at which the member is most likely to vibrate under those conditions in which the vibrations were recorded. This frequency is identified as the fundamental frequency of the system assuming that the system is undamped or lightly damped and that it is in a free-vibration mode of response. Spectral lines that contain the second and third largest amounts of energy are interpreted as the frequencies of other modes of vibration.

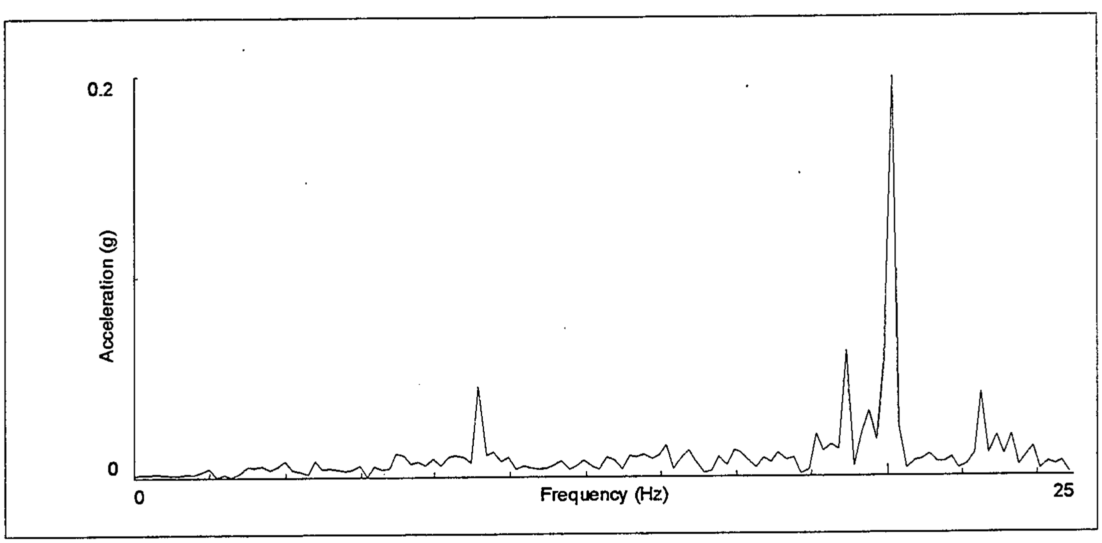


Figure 4.1 Fourier Amplitude Spectrum

The relevant parameter of the spectrum analysis is the amplitude of the resulting spectrum. The spectra calculated from the acceleration bursts use linear amplitude units, such that amplitudes are given in units of acceleration, g, which are most significant in the present type of vibration problem.

To obtain an accurate spectrum from the acceleration and longitudinal strain bursts that were generated through the processing scheme, the baseline was corrected a second time by shifting the data by its average value. Spectra were calculated using the baseline corrected bursts for the three modes of acceleration and three longitudinal strain gages.

For comparison to the spectra of the three modes of acceleration, lower amplitude spectral lines that occur at higher frequencies must be identified in the longitudinal strain gage spectra. This is accomplished by replacing the region containing the maximum amplitude with zero values, enabling the statistics function to identify higher frequencies that contain smaller amounts of energy. This process is repeated twice, resulting in the second and third largest spectral lines contained in the longitudinal strain spectra.

4.3.2 ROSETTE ANALYSIS

The rosette analysis function analyzes data collected from a rosette configuration. It calculates strains measured by each gage in the rosette assembly, principal strains and their angles, and the resulting shear strains. The values are obtained using standard transformation equations for plane strain [9].

Parameters of the rosette analysis include the type of rosette, the angles between gages, the elastic modulus, and Poisson's ratio of the base metal. The three strain gages located at mid depth of the web are arranged in a rectangular assembly separated by an angle of 45 degrees. The modulus of elasticity and Poisson's ratio for the steel truss member were taken to be 200 GPa (29000 ksi) and 0.29 respectively.

The rosette analysis was performed on the three strain gages located at mid depth of the web. The analysis is repeated for each set of gage readings that were extracted from the original Time History and Burst History data files.

4.3.3 STATISTICAL ANALYSIS

The statistical analysis function provides maximum, minimum, mean, and root mean square values from the data. The last component of data analysis includes the creation of several text files that tabulate the basic statistics of the processed and analyzed data. These text files include results from accelerations, strains, wind speed and direction, and acceleration and longitudinal strain spectrums.

Figure 4.2 is an example of a portion of the statistical information obtained when a text file is created for the acceleration data and corresponding amplitude spectrum. Acceleration results include maximum and minimum acceleration values for each burst that is extracted from the original Burst History data file. These are shown in the first two columns of Figure 4.2. Although only torsional vibration characteristics are shown in Figure 4.2, the entire text file contains the three acceleration modes used as a trigger in the data processing scheme. Separate text files were created for the acceleration modes that correspond to the trigger accelerations. Acceleration spectrum results were generated in a similar manner. They include maximum and mean amplitude values, the frequency of the maximum amplitude spectral line (denoted by fn), and the ratio of mean to maximum amplitude values.

Accelerations from torsional trigger		Torsional acceleration spectrum due to torsional trigger			
max	min	max	mean	fn	ratio
0.509	-0.402	0.098	0.014	20.120	0.138
0.615	-0.520	0.113	0.017	19.920	0.148
0.520	-0.405	0.136	0.010	20.120	0.075

Figure 4.2 Statistical Information for Accelerometer Data

Figure 4.3 is an example of a portion of the statistical information obtained when a text file is created for the longitudinal strain data. This includes maximum, minimum, and mean strain values, root mean squares (denoted by RMS), and the change in strain that occurs over each five second burst. Three text files were created for the longitudinal strain spectrums, which include the same statistics as the acceleration spectrums (Figure 4.2). The first file contains results for the original strain spectrums. The second and third text files correspond to the spectrums that result after the maximum spectral lines have been replaced with zero values. The results of the rosette analysis contain the same statistics as the longitudinal strains shown in Figure 4.3.

Strains due to torsional trigger				
max	min	mean	RMS	change
14.28	-15.84	0.00	6.80	30.10
20.68	-19.52	0.00	9.43	40.20
17.99	-21.88	0.00	8.97	39.90

Figure 4.3 Statistical Information for Longitudinal Strain Data

Figure 4.4 is an example of a portion of the statistical information obtained when a text file is created for the wind monitor data measured during torsional accelerations that exceeded trigger values. Wind speed and direction results include maximum, minimum, and mean values for the wind speed and direction recorded for each burst. The complete text file would also include measured wind speeds and directions measured during other modes of trigger accelerations. The orientation of the wind direction is schematically represented in Figure 5.23 of the following chapter.

Wind speed for torsional trigger			Wind direction for torsional trigger		
max	min	mean	max	min	mean
0.0	0.0	0.0	264.6	259.4	261.8
17.9	10.8	14.0	115.7	78.9	92.6
9.8	6.4	7.6	248.9	219.1	237.8

Figure 4.4 Statistical Information for Wind Monitor Data

Figures 4.2, 4.3, and 4.4 have been used to illustrate the method used to obtain statistical information from the data that was collected in the present study. The portions of text files shown in these figures represent data that was collected using the Burst History data mode. Similar text files were also created for the Time History data mode.

4.4 TRIGGER EVALUATION

After the analysis procedures were completed and initial results were available, an attempt was made to determine appropriate trigger values to use for both Time History and Burst History data processing.

To investigate the acceleration trigger values, amplitudes and frequencies of the Fourier Transforms were compared to the corresponding magnitudes of accelerations. It was discovered that a relationship does not exist between different values of acceleration (i.e. potential trigger values) and the quality of the resulting transform. Thus, trigger values were chosen to obtain a reasonable number of bursts that could be analyzed efficiently. To extract approximately 15-20 bursts from each Burst History record, trigger values approximately equal to 1.5-g/m (0.47-g/ft), 0.27-g, and 0.46-g were used for torsional, strong-axis, and weak-axis accelerations, respectively. The relative magnitudes of these trigger values indicate that torsional and weak-axis vibrations have a dominant effect on most events.

The threshold wind speed values were determined by plotting the wind speed channel and visually selecting an appropriate trigger value. Figure 4.5 is a continuous record of wind speed data collected during the test that was initiated on October 9. This figure shows that a reasonable trigger value may be approximately 16-m/sec (35-mph). By changing the minimum y-axis value of Figure 4.5 to 35, it is evident (Figure 4.6) that 12 segments of data corresponding to wind speeds larger than 16-m/sec (35-mph) will be extracted. Trigger values range from 8.5 to 17-m/sec (19 to 39-mph) for different Time History records, depending on the wind speed characteristics for the test considered. Values were chosen to extract approximately 10-15 bursts from each Time History record, which represented the data collected during the largest wind speeds of each test.

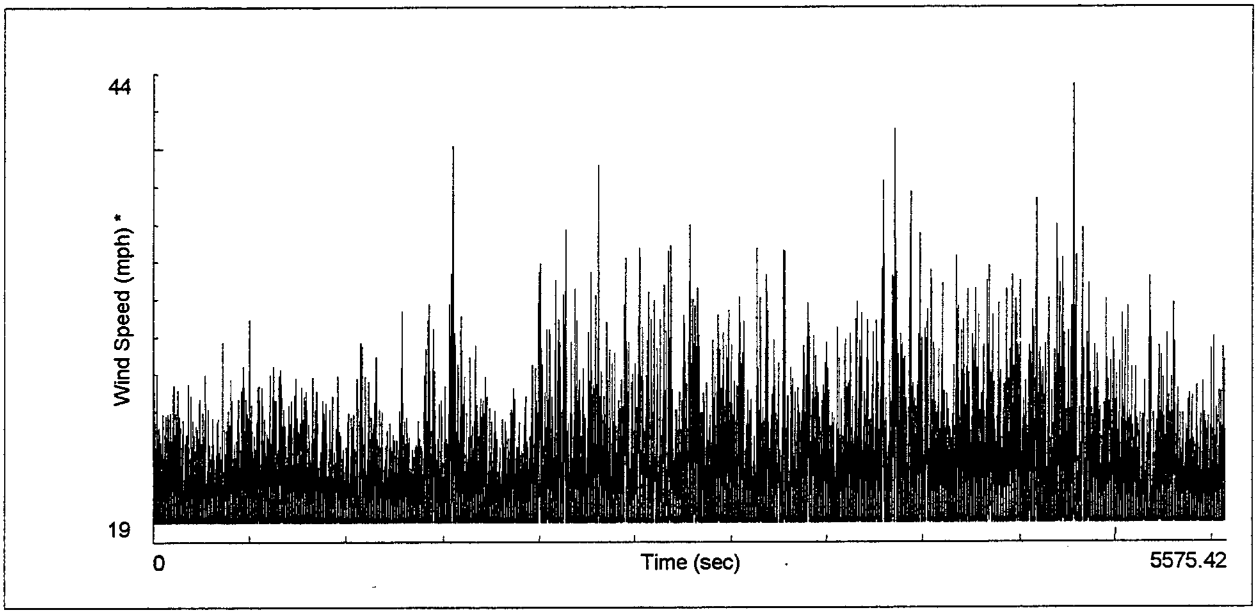


Figure 4.5 Continuous Record of Wind Speed Data

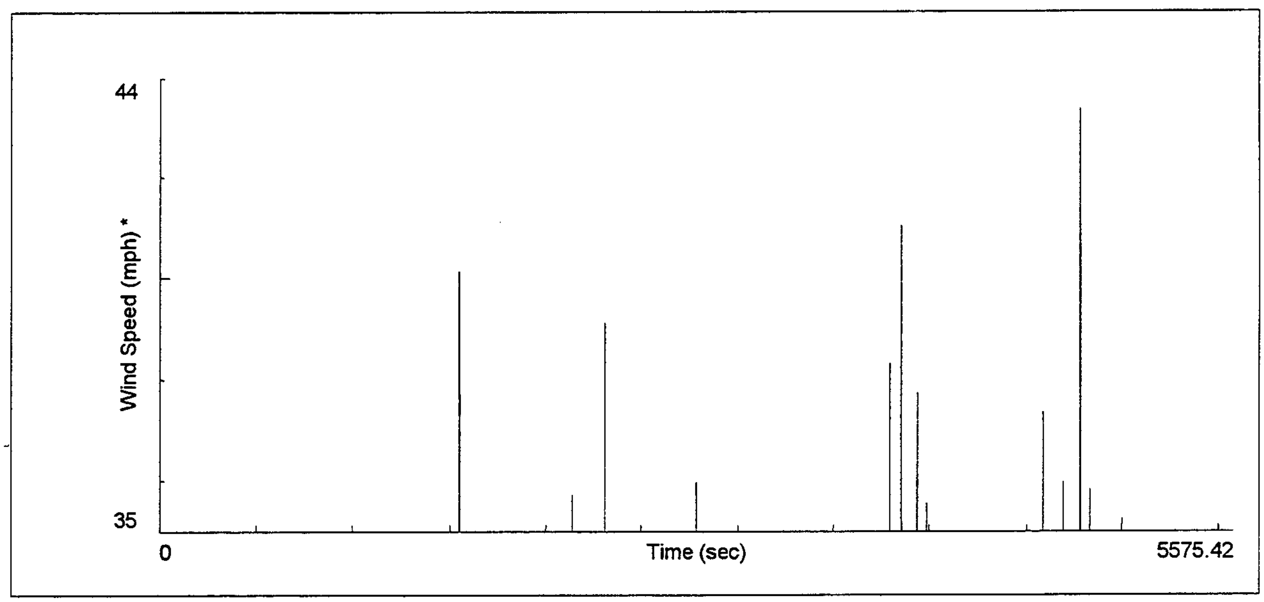


Figure 4.6 Modified Record of Wind Speed Data

* 1.0 mph = 0.45 m/sec

CHAPTER 5

VIBRATION ANALYSIS

5.1 INTRODUCTION

Vibration analysis included investigation of measured frequencies of vibration. Three types of acceleration response were considered: 1) torsional, 2) strong-axis, and 3) weak-axis vibration. For each response, two categories of data were examined. These include frequencies of vibration for the largest recorded accelerations (Burst History data) and largest wind speeds (Time History data). Thus, data contained within each response are divided into two components: *frequencies measured during large accelerations* and *frequencies measured during large wind speeds*. Because of the wide band of vibration frequencies measured, several characteristics of the response were examined in order to determine the vibration modes of the instrumented member.

5.2 DATA COMPONENTS

Data collected during the largest accelerations exhibit a significant characteristic in the corresponding longitudinal strains. Figure 5.1 shows a typical longitudinal strain measured during an acceleration of the instrumented truss member that triggered data collection.

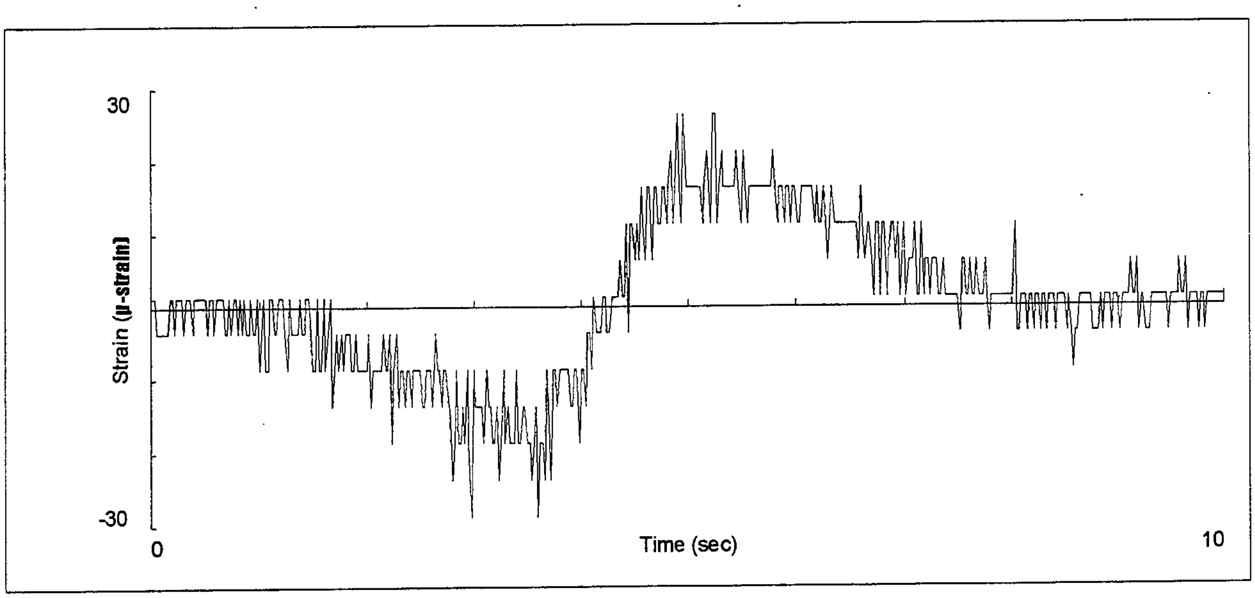


Figure 5.1 Typical Longitudinal Strain

The dominant low frequency trend evident in Figure 5.1 is attributed to the elongation of the truss member due to traffic loading. The period of this trend is approximately 7 seconds, which is equal to the time it would take a vehicle to pass the length of the bridge traveling at 20-m/sec (45-mph). Data collected during the largest wind speeds also on occasion exhibited longitudinal strains indicative of traffic loading. To permit a distinction between frequencies measured during large accelerations and frequencies measured during large wind speeds, only data measured during wind loading were analyzed for the latter component. Therefore, the two components of data from which frequencies of vibration are determined can be further classified as vibrations due to traffic loading and vibrations due to wind loading.

5.3 MEASURED FREQUENCIES OF VIBRATION

Measured frequencies of vibration were obtained from the amplitude spectra (Fourier Transforms) calculated for each segment of data analyzed. These spectra are a representation of the measured acceleration in the frequency domain. Figure 5.2 is a typical plot of an amplitude spectrum. This domain contains the different frequencies measured and the amount of energy they exhibit. The frequency values considered are those that contain the largest amount of energy (i.e. largest amplitude). Vibration of the instrumented member is most likely to occur at these frequencies and thus, are interpreted as the fundamental frequencies of the system.

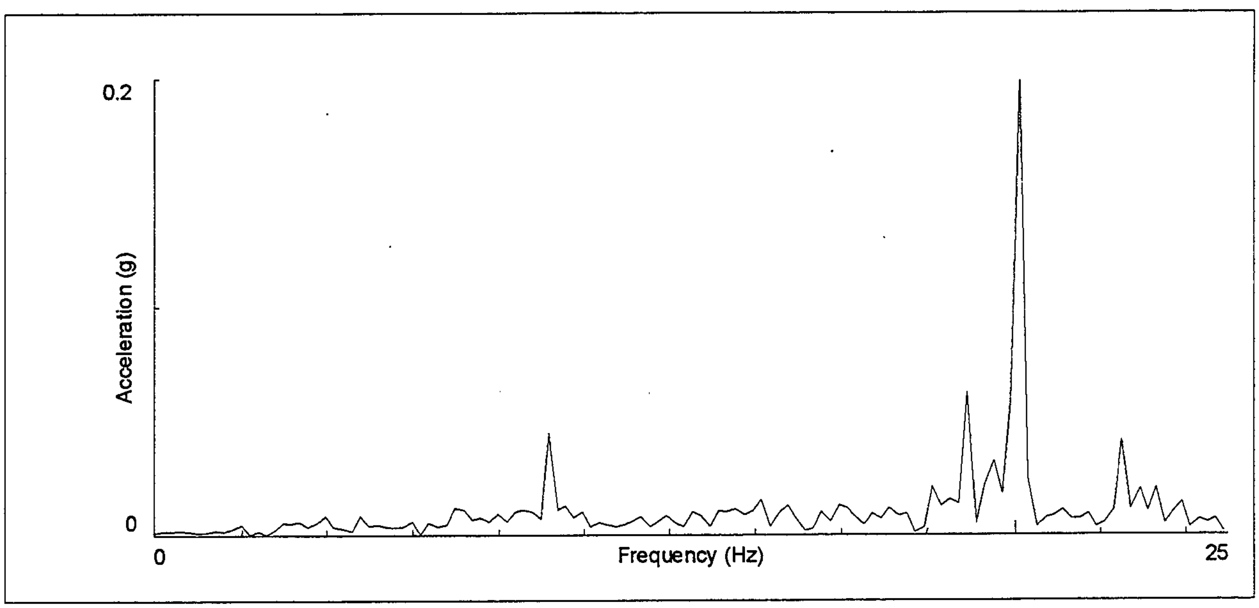


Figure 5.2 Typical Amplitude Spectrum

This plot shows that the largest amount of energy occurs at a frequency of 19.9 Hz. The next largest amount of energy occurs at 18.9 Hz, but is considered less significant because of the smaller amplitude. For the 5-second acceleration burst that Figure 5.2 represents, vibration of the member was most dominant at a frequency of 19.9 Hz. Frequencies of vibration for each vibration response are determined in a similar fashion.

The measured accelerations contain a very wide band of frequencies. In other words, large amounts of energy are contained within several different frequencies. It is believed that the complex dynamic characteristics present in the Wabasha truss bridge is a primary factor in the wide band of frequencies measured. More importantly, and related to these characteristics, is the nature of excitation from which accelerations are measured. Both traffic and wind loading of the entire bridge and the instrumented member may cause complex combinations of free- and forced-vibration response, which will result in measured frequencies other than natural modes for free vibration. Another consideration is instrumentation error. Inaccuracy of the instruments either due to design, installation, or implementation, could cause leakage of frequencies from other vibration responses. Contributing to this inaccuracy could be a variation in the instrumented member along its length. Frequencies included in this wide band could also be higher modes of vibration misrepresented by the sampling rate used for the collection of data in this study.

To identify fundamental modes of vibration for different acceleration responses, several characteristics of these responses are represented graphically. These characteristics are compared to an average frequency of vibration, which is obtained by averaging measured frequencies that fall in a specific range. For the frequencies measured during large accelerations and wind speeds, three graphs are created for each response.

The first graph referred to in each vibration response (Fig. 5.4) is a representation of the number of occurrences that each frequency was measured. Frequencies that occur more often are considered a better indication of a vibration mode in a particular response. Frequencies with few occurrences are less consistent and thus, less likely to be the mode at which the member will vibrate.

The second graph referred to in each vibration response shows the average magnitude of acceleration that resulted in the measured frequencies (Fig. 5.5). Larger accelerations contain a stronger signal and are less likely to contain frequencies from other responses. More specifically, smaller accelerations may contain a significant response of the entire bridge due to traffic or wind loading.

The third graph is a measure of the quality of the amplitude spectrum used to identify the frequency (Fig. 5.6). Ideally, a spectrum should contain one or two dominant peaks occurring at frequencies representing the fundamental mode or modes of vibration. Figure 5.2 is an example of a relatively reliable spectrum that can be used to identify the frequency of vibration for the particular 5-second acceleration burst it represents. Figure 5.3, however, is an example of an amplitude spectrum that contains a very wide band of frequencies with smaller magnitudes. From this particular spectrum it would be difficult to ascertain the frequency at which the member was vibrating for the 5-second acceleration burst. An approximate indication of the characteristics of an amplitude spectrum can be determined by evaluating the ratio of the average spectrum value to the maximum value. For example, the spectrum ratios for Figures 5.2 and 5.3 are 0.052 and 0.11. Evident in these two figures, amplitude spectrums with larger ratios (i.e. several peaks with smaller magnitudes) can be considered less reliable for determining modes of vibration in the instrumented member.

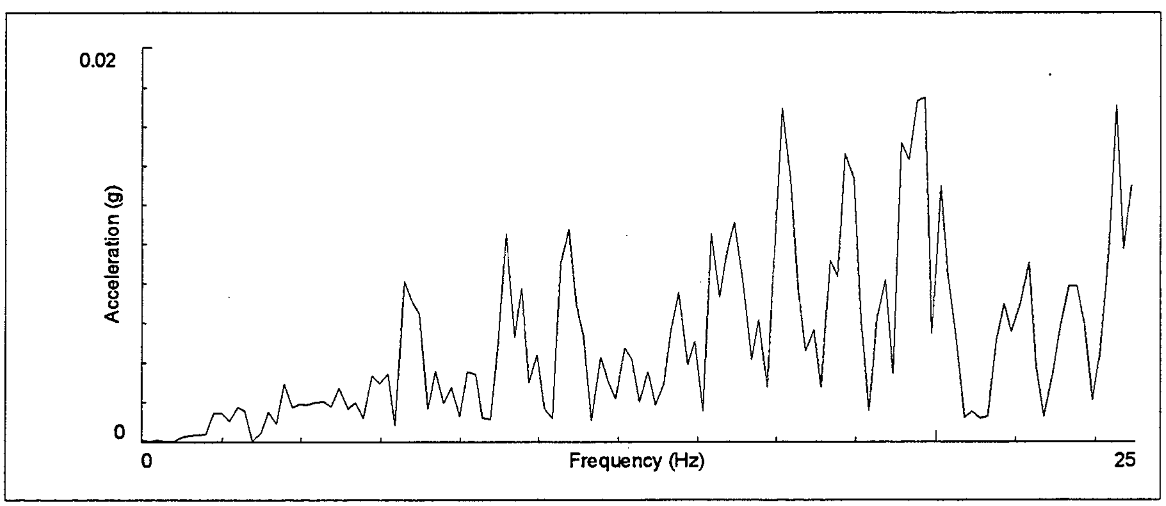


Figure 5.3 Wide Band Amplitude Spectrum

To quantify the average frequencies of vibration that are represented in the three graphs, standard deviations were considered. The largest standard deviation calculated for an average frequency identified as a mode of vibration is 0.55 Hz and is considered acceptable for this study.

5.3.1 TORSIONAL FREQUENCIES

The largest torsional accelerations that were measured produced consistent frequency values. Figure 5.4 indicates that 87% of these frequencies had a value of 20.0 Hz. Approximately 12% of the frequencies were 9.2 Hz and 1% (1 occurrence) was 16.1 Hz. Figure 5.5 shows the magnitude of acceleration that resulted in the frequency of 16.1 Hz is less than the average and maximum accelerations of the other two frequencies. The largest torsional acceleration recorded was 2.8-g/m (0.84-g/ft) at 20.0 Hz. Figure 5.6 suggests that the amplitude spectrums used to obtain the frequencies 9.2 and 20.0 Hz may be a stronger indication of vibration modes. These figures strongly suggest 1st and 2nd mode frequencies of torsional vibration are 9.2 and 20.0 Hz.

The largest wind speeds did not produce such consistent frequencies. Similarities to frequencies measured during large accelerations are evident, however. Figure 5.7 indicates that 55% of all torsional frequencies measured had a value of 19.7 Hz and 27% measured were 9.2 Hz. The remaining 18% were divided over four different frequencies (3.2, 13.9, 16.9, 23.4). Figures 5.8 and 5.9 indicate smaller accelerations and larger spectrum ratios for these other frequencies (3.2, 13.9, 16.9, 23.4), suggesting that these frequencies may be less reliable measures of the modes of vibration.

Comparing measured frequencies for both large accelerations and high wind speeds, 1st and 2nd mode frequencies of torsional vibration are approximately 9.2 and 20 Hz. Table 5.1 summarizes the characteristics of torsional vibration.

Table 5.1 Torsional Vibration Characteristics

Data Component	Frequency (Hz) 1st Mode	Frequency (Hz) 2nd Mode	Maximum Acceleration	Frequency of Max. Acc. (Hz)
Large Accelerations	9.2	20.0	2.8-g/m (0.84-g/ft)	20.0
Large Wind Speeds	9.2	19.7	1.0-g/m (0.31-g/ft)	19.1

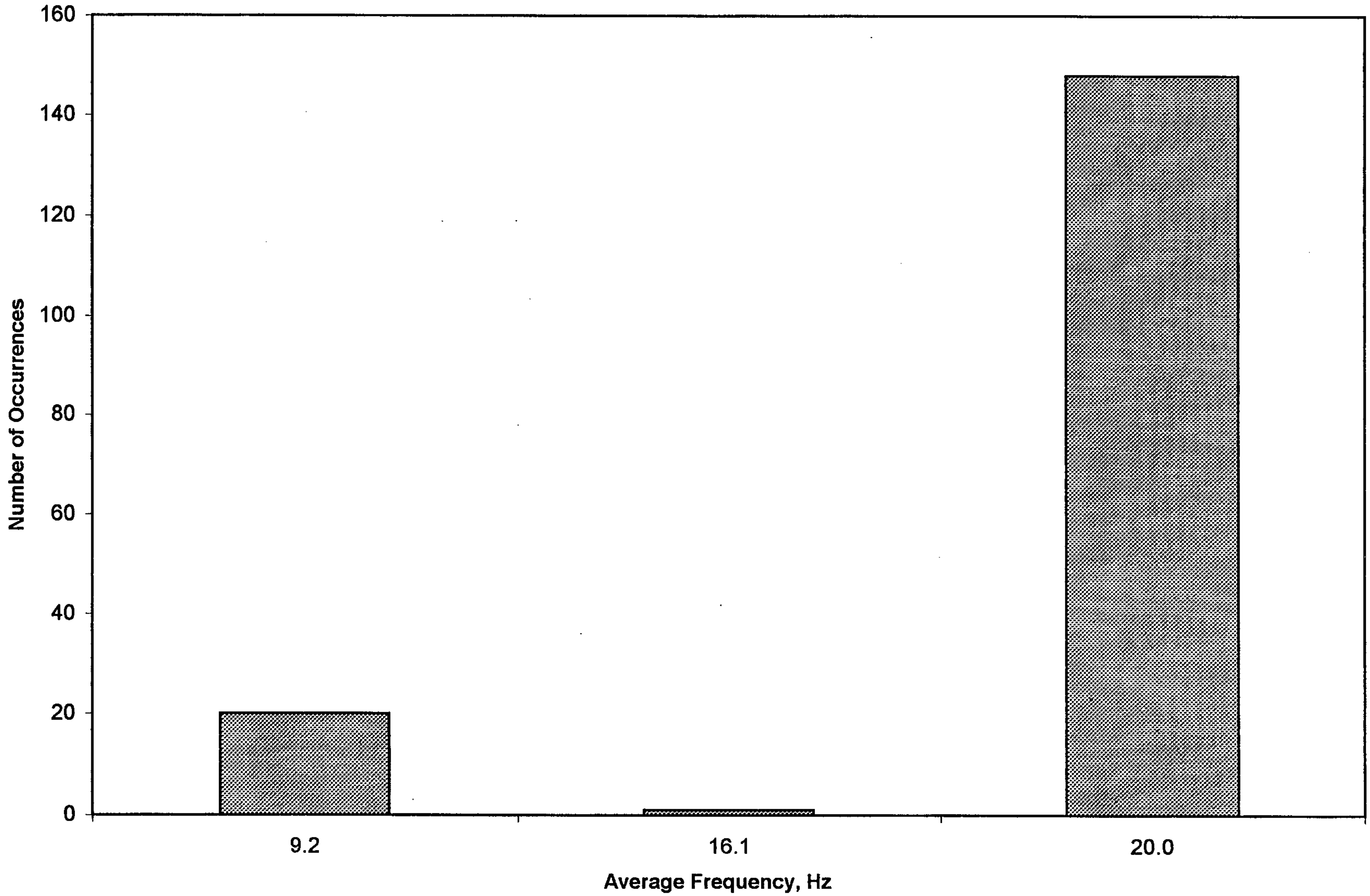


Figure 5.4 Average Frequency vs. Number of Occurrences (Burst History - Torsional)

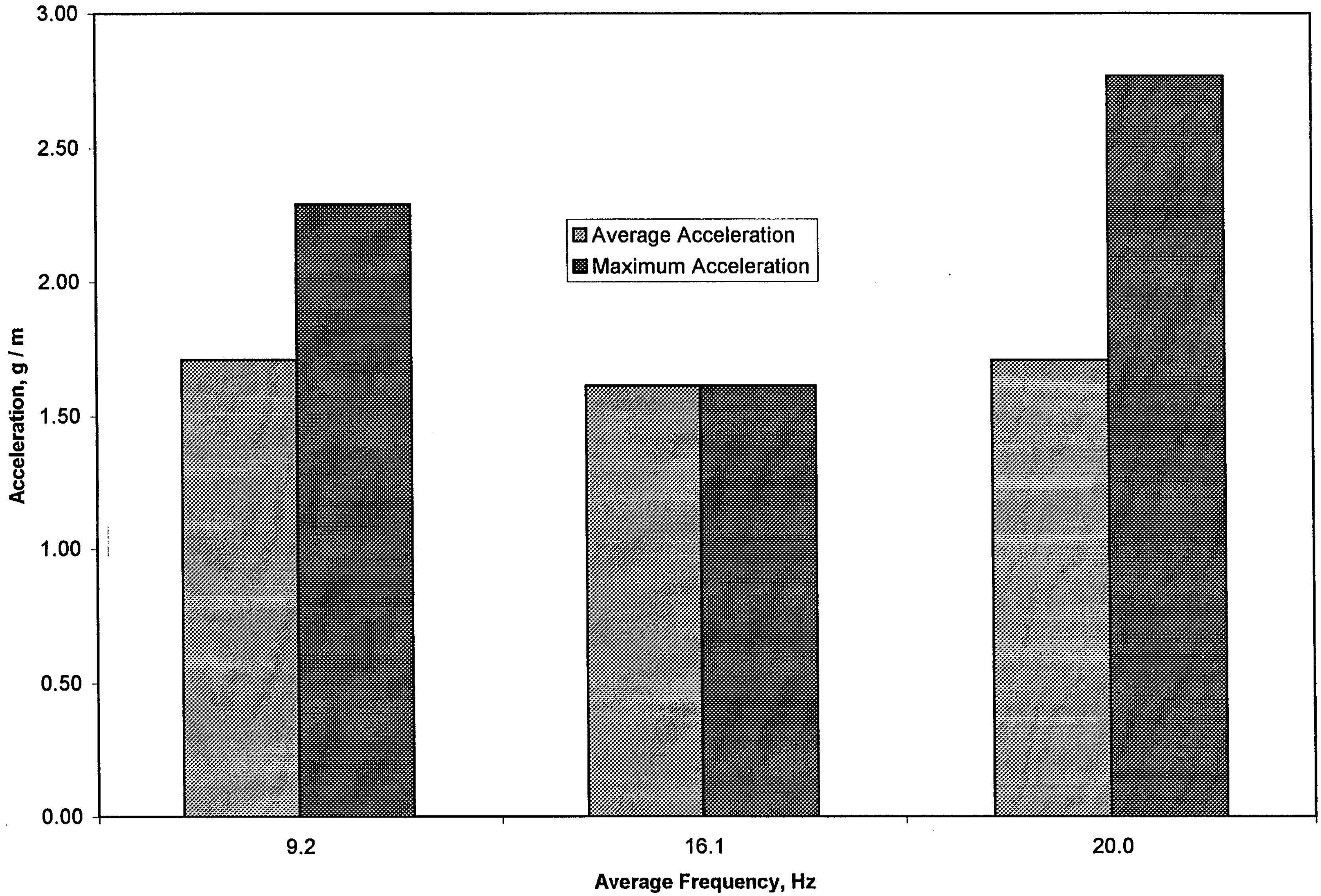


Figure 5.5 Average Frequency vs. Acceleration (Burst History - Torsional)

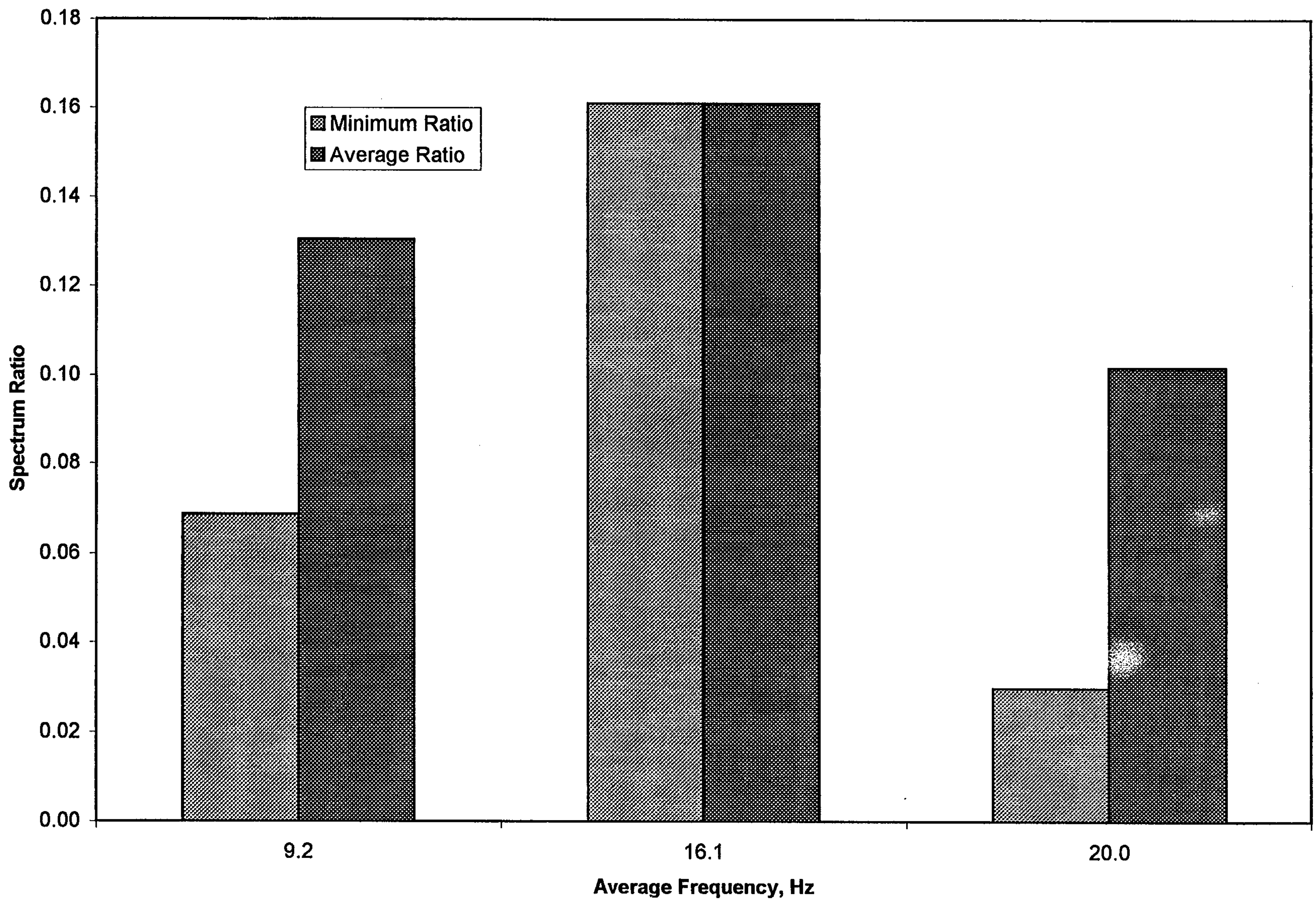


Figure 5.6 Average Frequency vs. Spectrum Ratio (Burst History - Torsional)

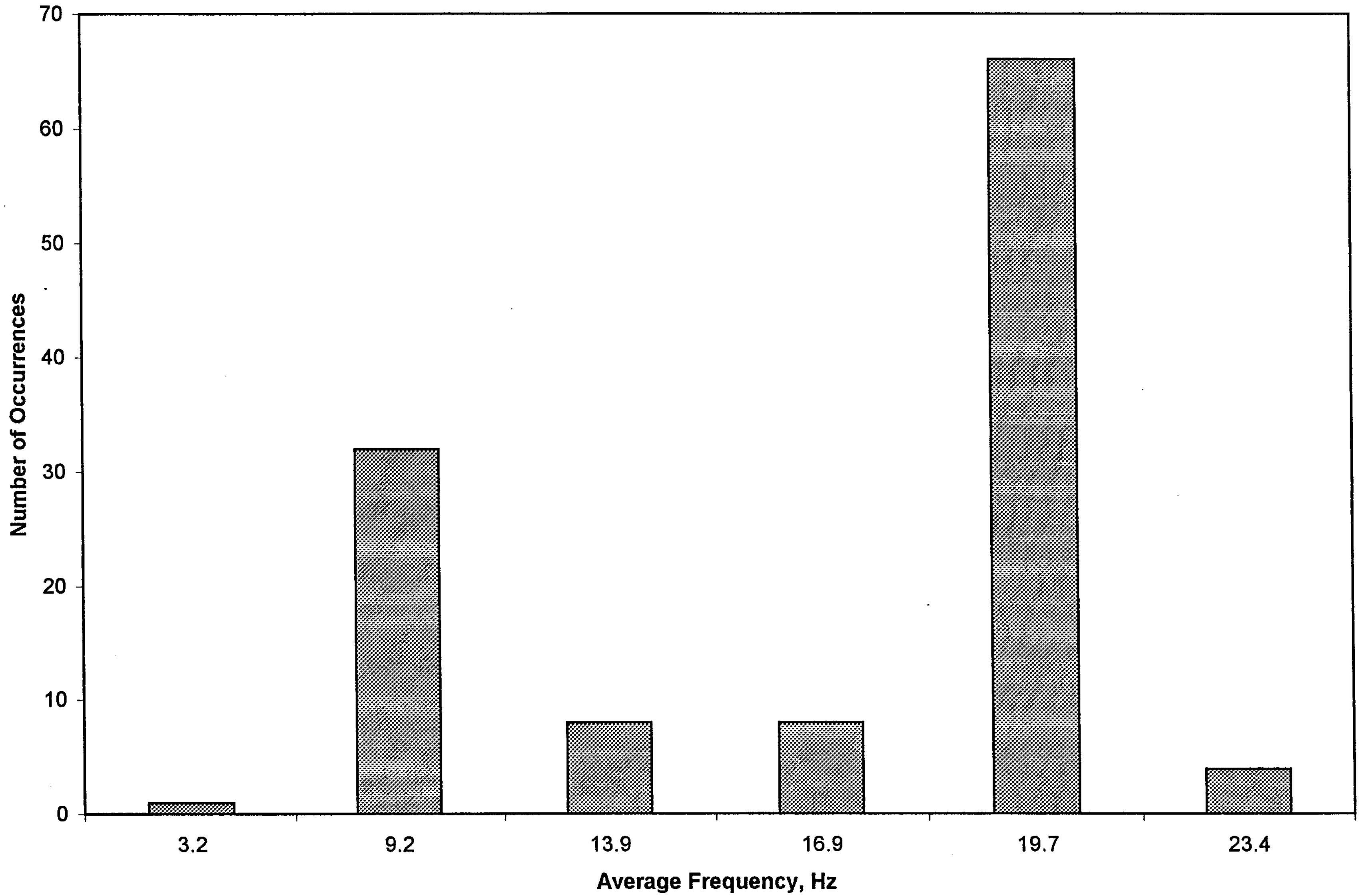


Figure 5.7 Average Frequency vs. Number of Occurrences (Time History - Torsional)

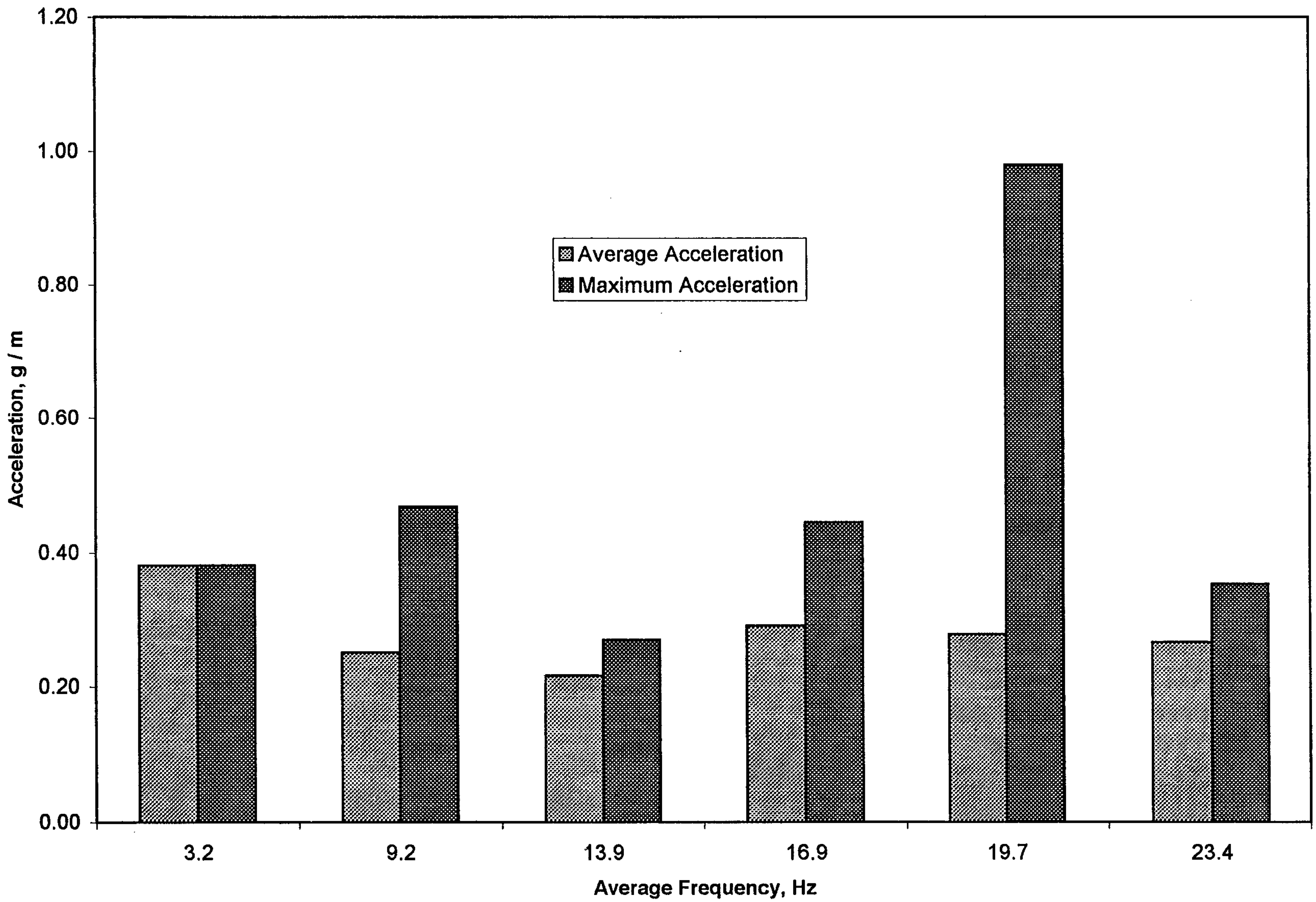


Figure 5.8 Average Frequency vs. Acceleration (Time History - Torsional)

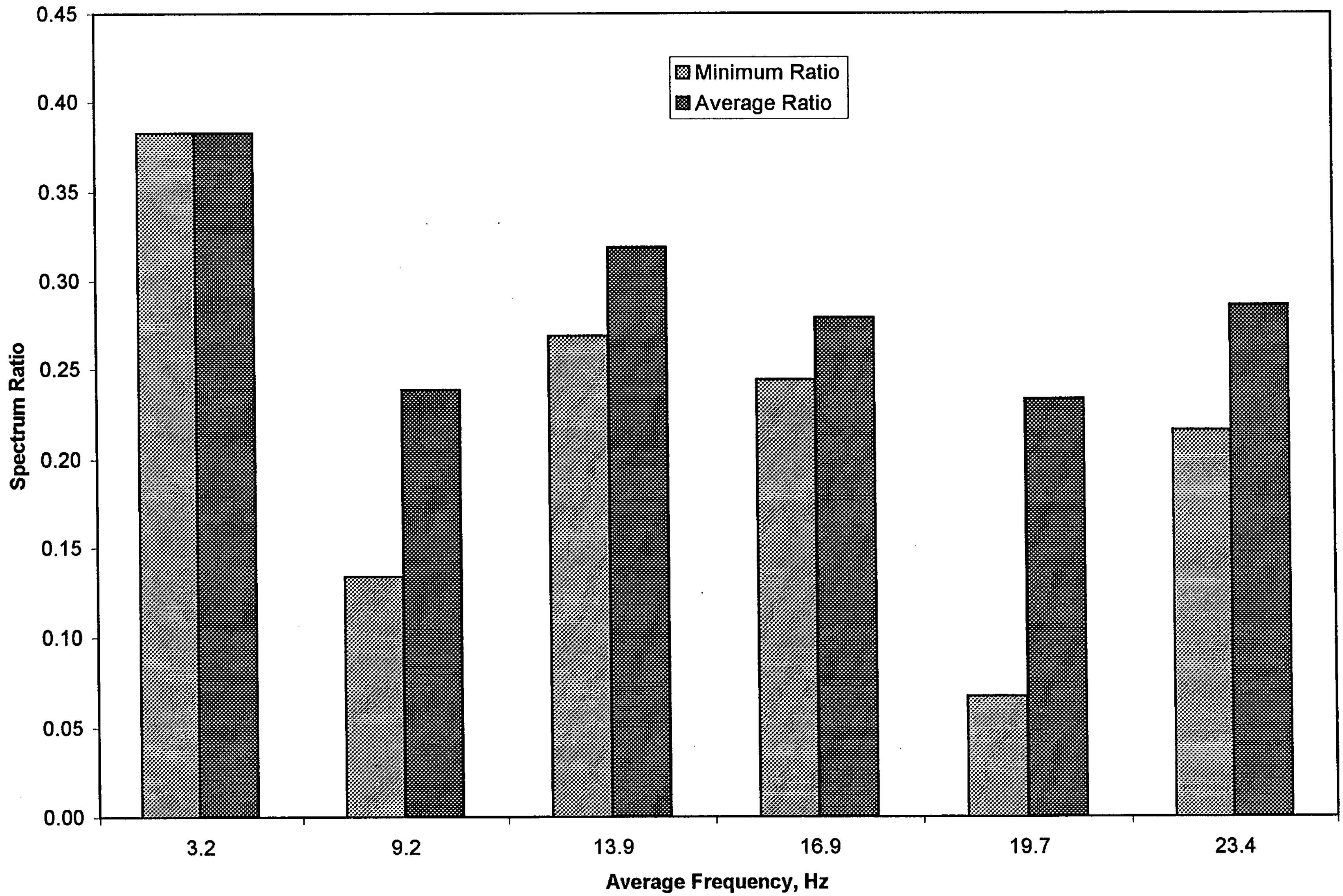


Figure 5.9 Average Frequency vs. Spectrum Ratio (Time History - Torsional)

5.3.2 STRONG-AXIS FREQUENCIES

Several frequencies are observed from the largest strong-axis accelerations measured. Figure 5.10 shows that 62% of the strong-axis frequencies had an average value of 19.7 Hz. The next largest percentage, 17.8 Hz comprising 20%, is not likely a fundamental frequency due to its proximity to 19.7 Hz. The largest strong-axis acceleration recorded was 0.41-g at 19.7 Hz shown in Figure 5.11. According to Figure 5.12, the lowest ratios also occur at 19.7 Hz. Although several frequencies were measured in strong-axis vibration, characteristics of these responses suggest that a 2nd mode of vibration occurs at 19.7 Hz. A 1st mode of vibration is clearly not identified from the frequencies measured during the largest accelerations.

Frequencies measured during the largest wind speeds also contain a wide band of frequencies. An interesting feature of this data is the strong presence of an average frequency of 6.7 Hz. This frequency was not identified for the largest accelerations that occurred in the member. Figure 5.13 reveals that 49% of the measured frequencies had an average value of 6.7 Hz. The next largest number of occurrences was 31% for an average frequency of 19.7 Hz. The remaining 20% of measured frequencies were divided between two different frequencies. The largest accelerations measured, represented by Figure 5.14, occurred at frequencies of 6.7 and 19.7 Hz and indicate these frequencies contain a stronger acceleration signal. Figure 5.15 shows that amplitude spectra identifying fundamental frequencies of 6.7 and 19.7 Hz may be a better indication of strong-axis vibration modes.

Comparing measured frequencies for both large accelerations and high wind speeds, 1st and 2nd mode frequencies of strong-axis vibration are 6.7 and 19.7 Hz. Table 5.2 summarizes the characteristics of strong-axis vibration.

Table 5.2 Strong-Axis Vibration Characteristics

Data Component	Frequency (Hz)		Maximum Acceleration	Frequency of Max. Acc. (Hz)
	1st Mode	2nd Mode		
Large Accelerations	-	19.7	0.41-g	19.7
Large Wind Speeds	6.7	19.7	0.14-g	19.9

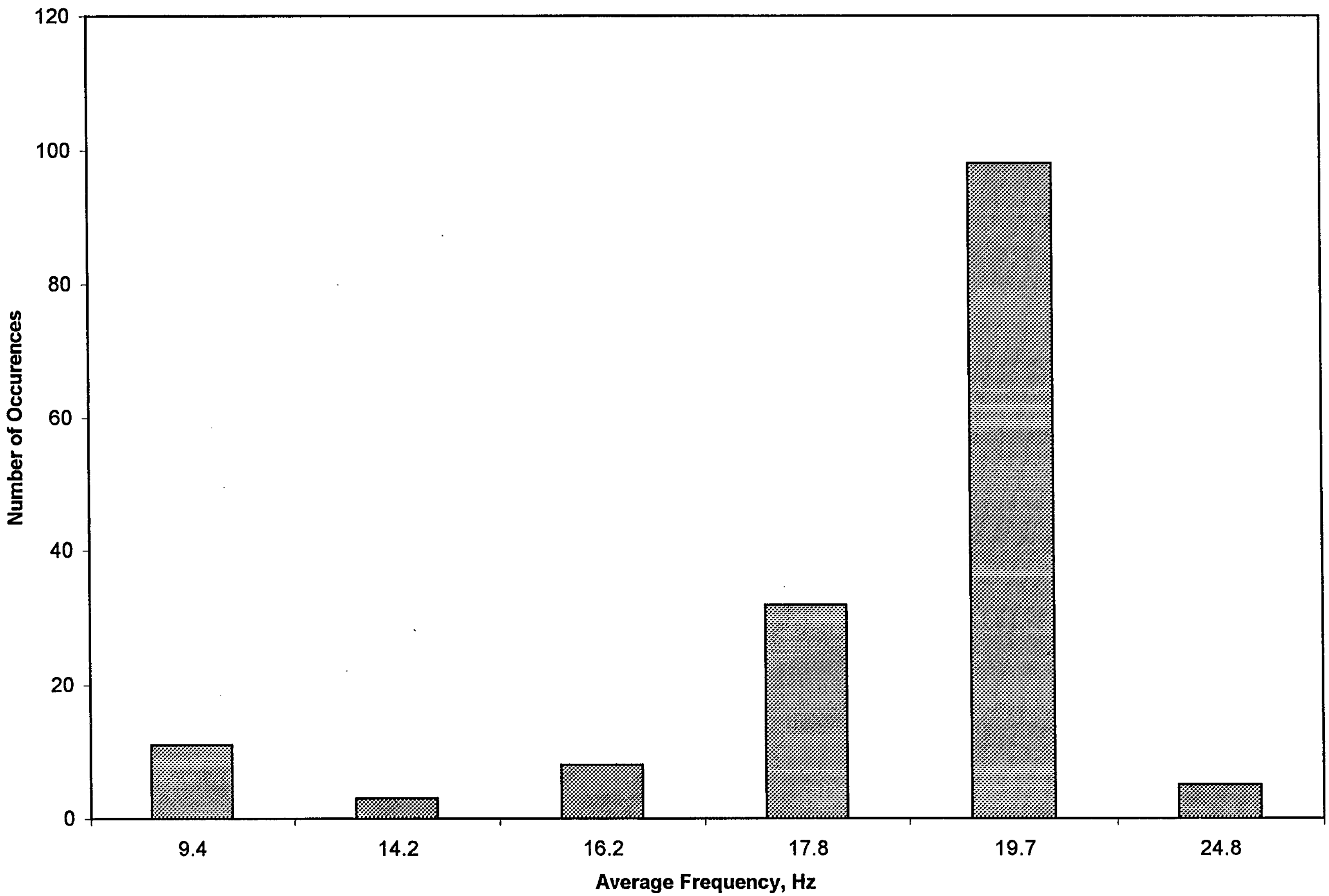


Figure 5.10 Average Frequency vs. Number of Occurrences (Burst History - Strong-Axis)

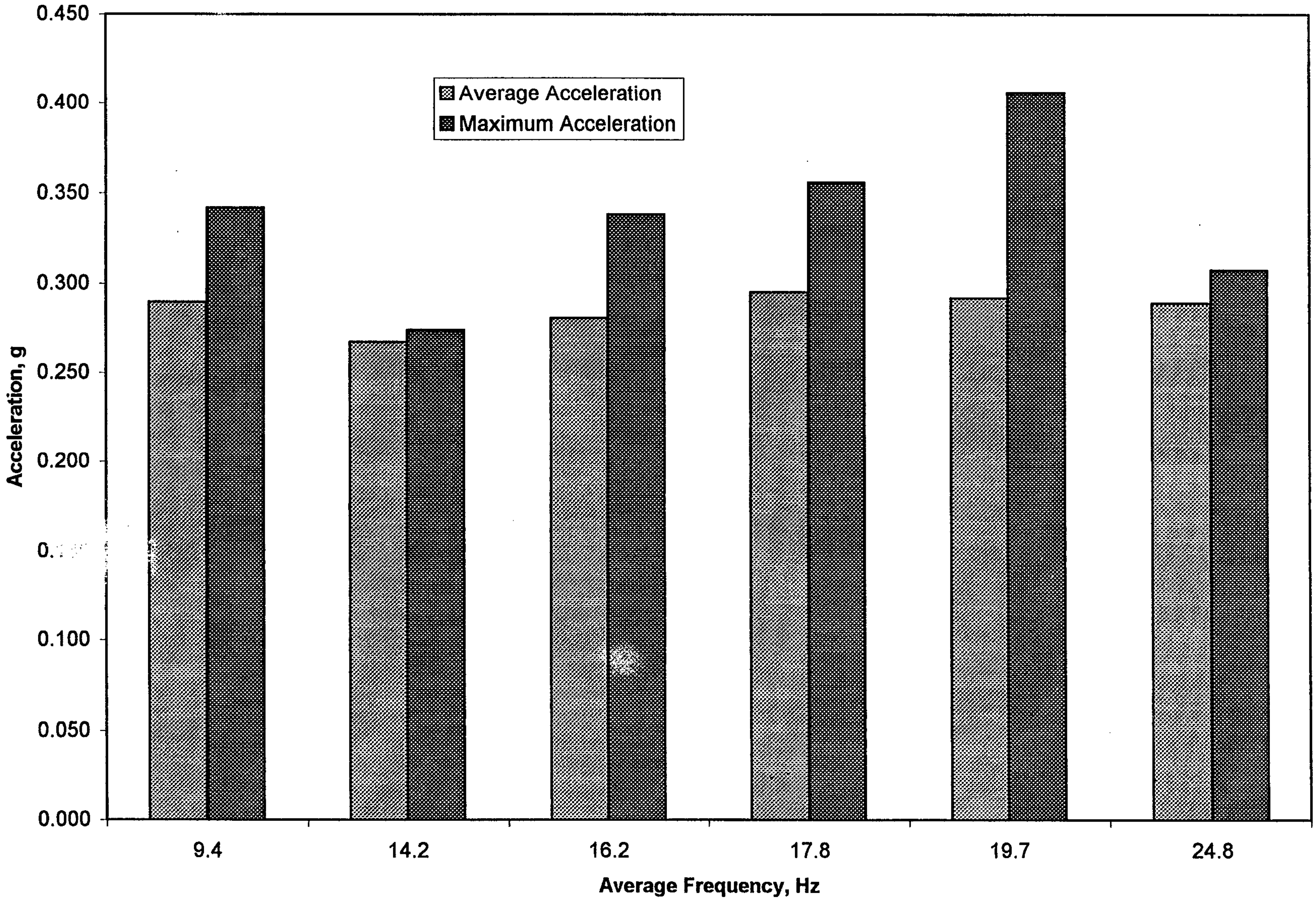


Figure 5.11 Average Frequency vs. Acceleration (Burst History - Strong-Axis)

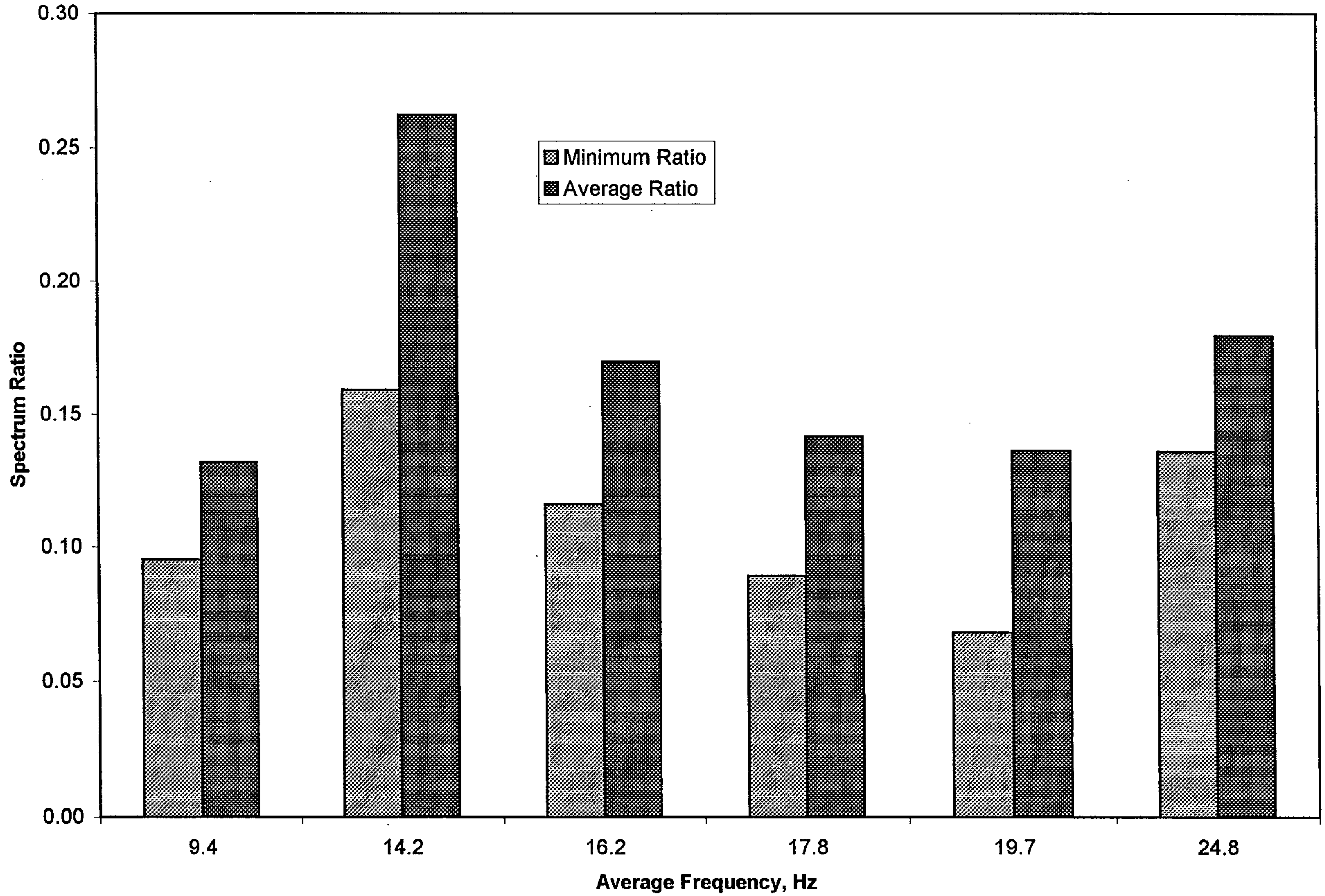


Figure 5.12 Average Frequency vs. Spectrum Ratio (Burst History - Strong-Axis)

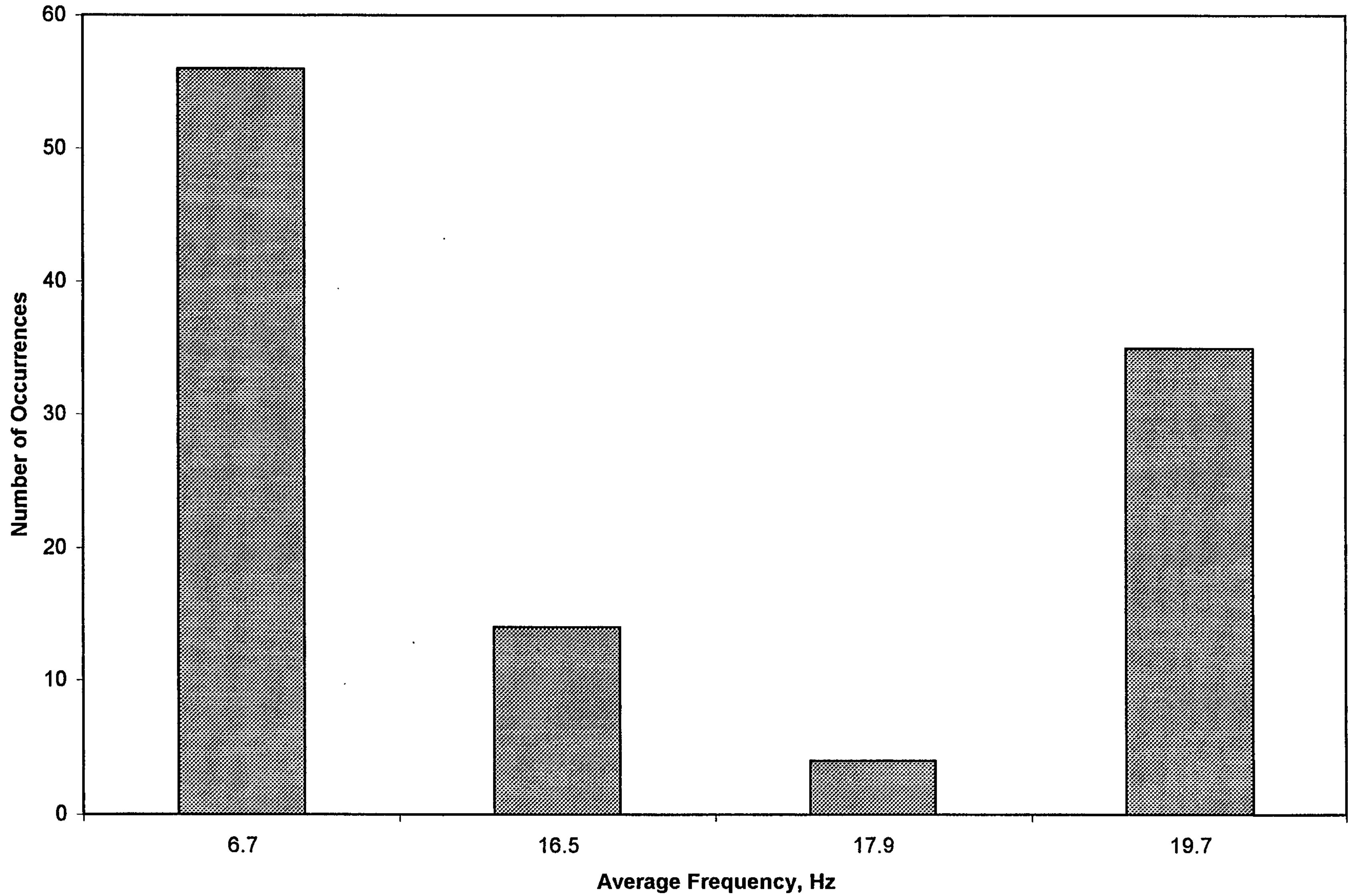


Figure 5.13 Average Frequency vs. Number of Occurrences (Time History - Strong-Axis)

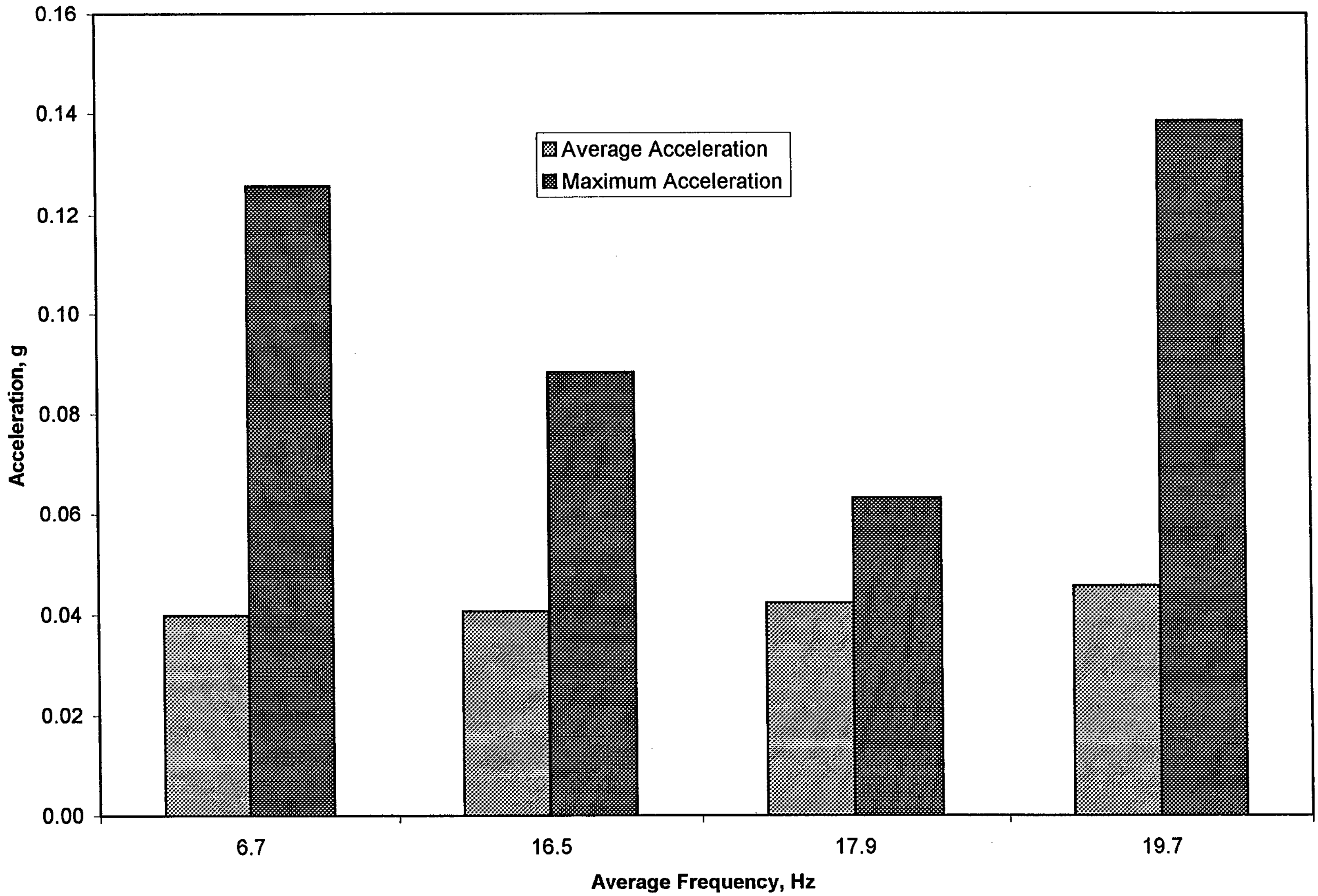


Figure 5.14 Average Frequency vs. Acceleration (Time History - Strong-Axis)

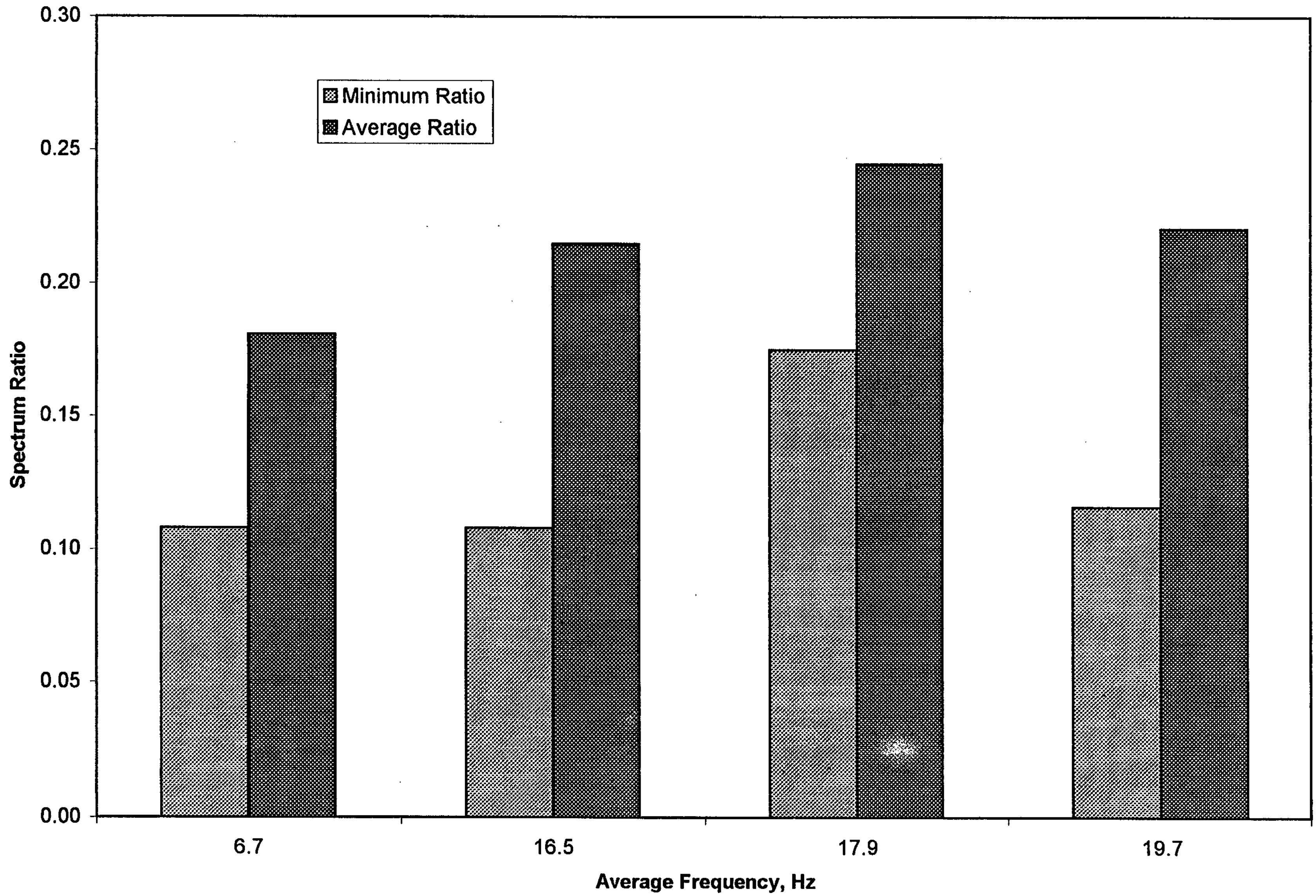


Figure 5.15 Average Frequency vs. Spectrum Ratio (Time History - Strong-Axis)

5.3.3 WEAK-AXIS FREQUENCIES

The largest weak-axis accelerations measured produced consistent frequency values. Figure 5.16 shows 71% of the accelerations measured had an average frequency of 14.5 Hz. The second largest percentage was 24% measured at approximately 11.0 Hz. As with the strong-axis, this frequency is unlikely a fundamental mode of vibration due to its nearness to 14.5 Hz. The largest acceleration measured was 0.79-g at 14.5 Hz, shown in Figure 5.17. Figure 5.18 indicates comparable spectrum ratios between measured average frequencies of 11.0 and 14.5 Hz. These figures suggest the 1st mode of weak-axis vibration is 14.5 Hz. A 2nd mode of vibration is not identified from the frequencies measured during the largest accelerations.

Weak-axis accelerations measured during the largest wind speeds resulted in the widest band of frequencies measured for any response. Although a larger number of different frequencies were measured, similarities to the results for large accelerations are easily identified. Figure 5.19 indicates 33% of the average frequencies are 14.2 Hz. The second largest, 24% occurs at 17.9%. Due to the frequencies measured during the largest accelerations and the proximity of 17.9% to 14.2%, it is unlikely 17.9 Hz is a fundamental mode of vibration. The largest weak-axis acceleration occurred at a frequency of 14.2 Hz (Figure 5.20) and suggests a stronger acceleration signal is represented. Figure 5.21 suggests the quality of spectra used to obtain vibration frequencies of approximately 14.2 Hz is better than at other frequencies.

Comparing the measured frequencies of vibration for both large accelerations and high wind speeds, it appears the 1st mode frequency for weak-axis vibration is 14.5 Hz. Table 5.3 summarizes the characteristics of weak-axis. A 2nd mode of vibration was not identified for weak axis response.

Table 5.3 Weak-Axis Vibration Characteristics

Data Component	Frequency (Hz) 1st Mode	Frequency (Hz) 2nd Mode	Maximum Acceleration	Frequency of Max. Acc. (Hz)
Large Accelerations	14.5	-	0.79-g	14.5
Large Wind Speeds	14.2	-	0.27-g	14.5

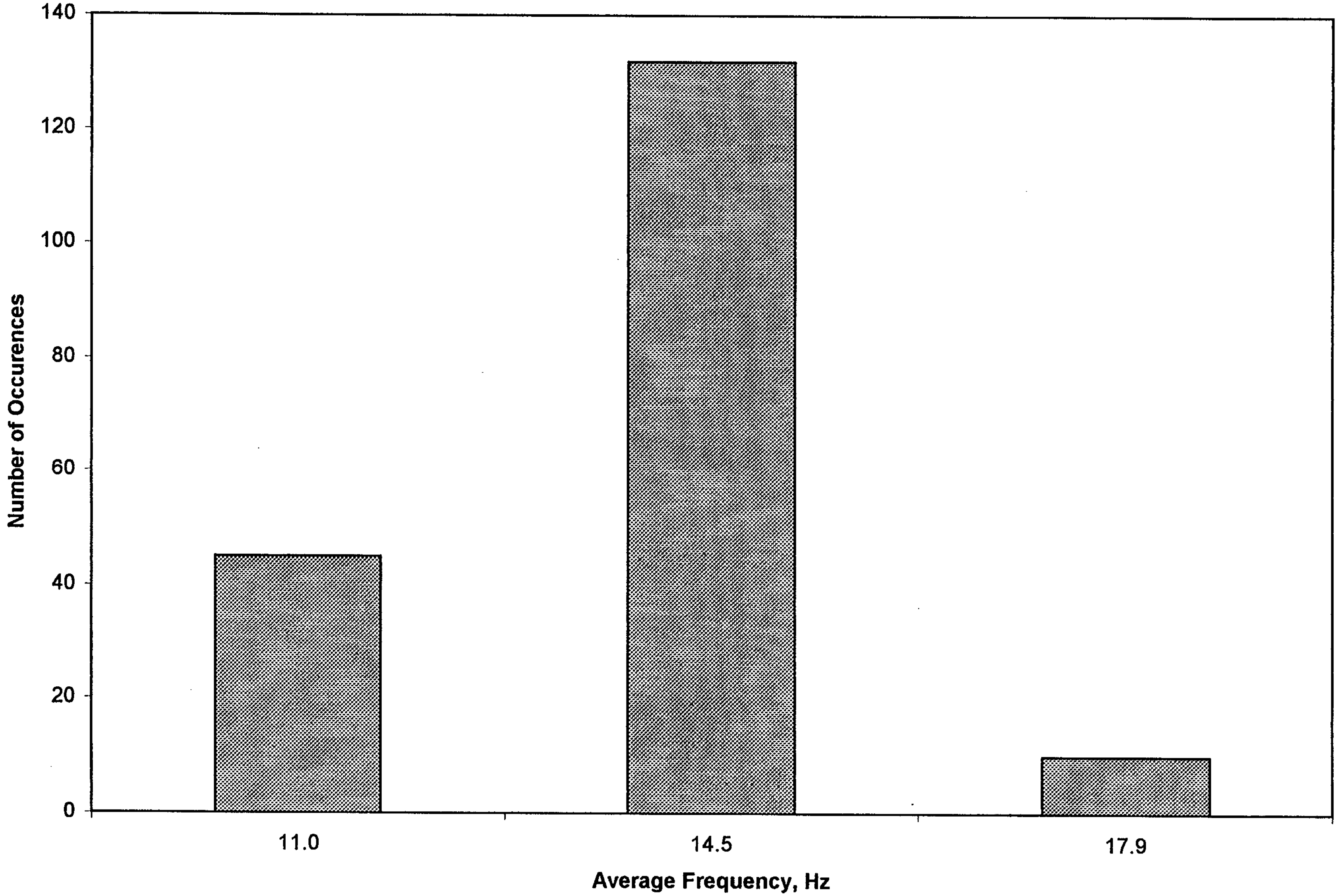


Figure 5.16 Average Frequency vs. Number of Occurences (Burst History - Weak-Axis)

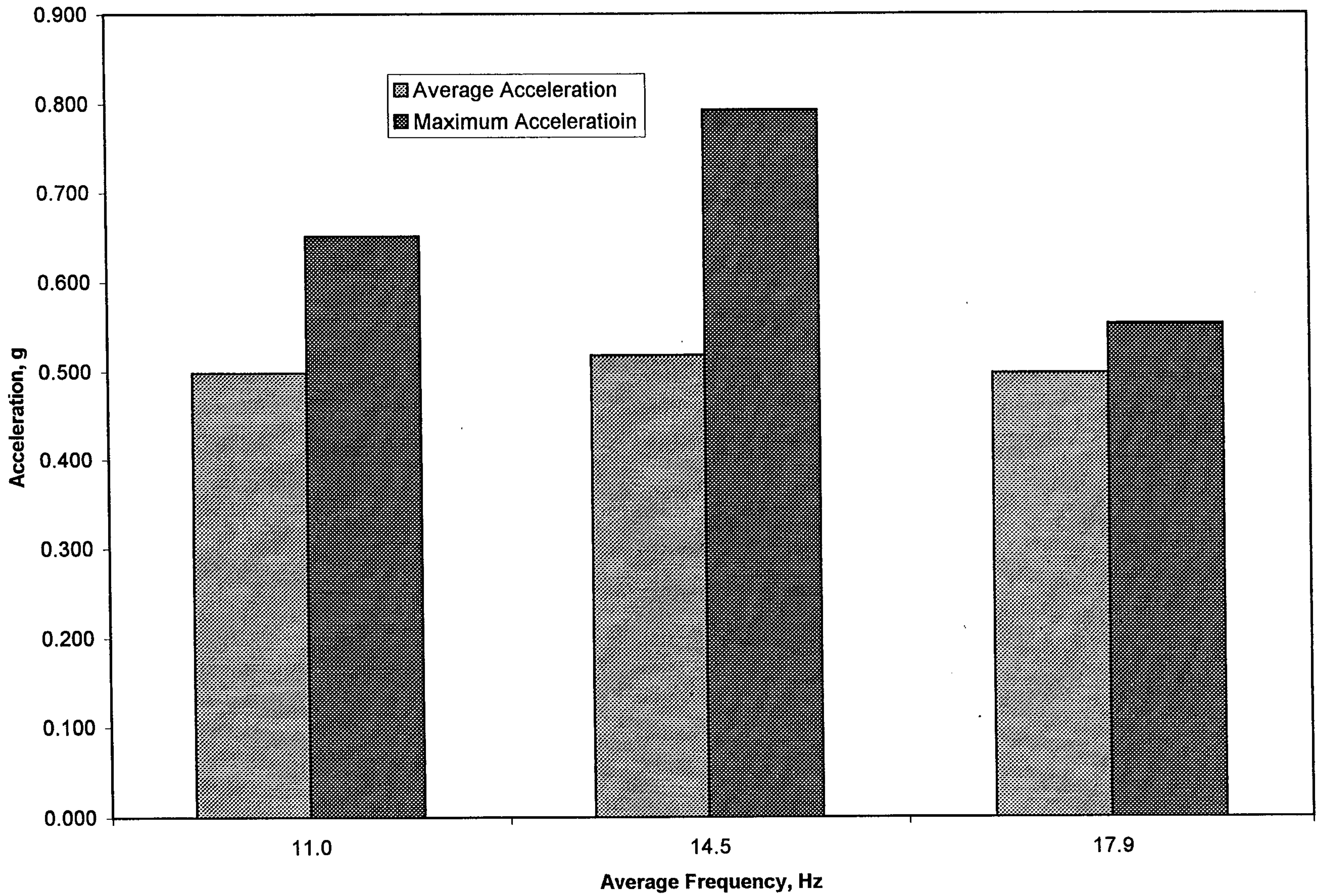


Figure 5.17 Average Frequency vs. Acceleration (Burst History - Weak-Axis)

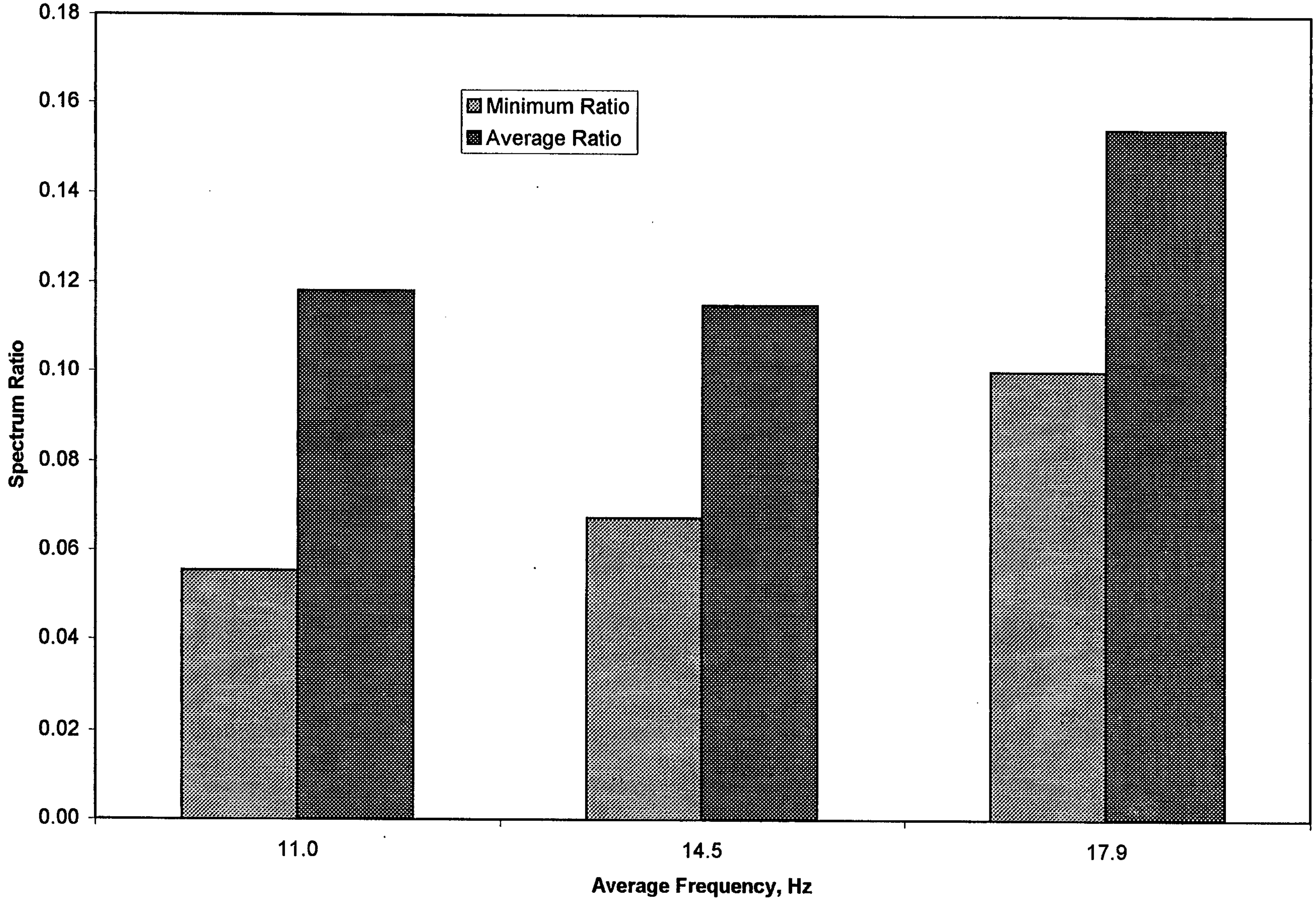


Figure 5.18 Average Frequency vs. Spectrum Ratio (Burst History - Weak-Axis)

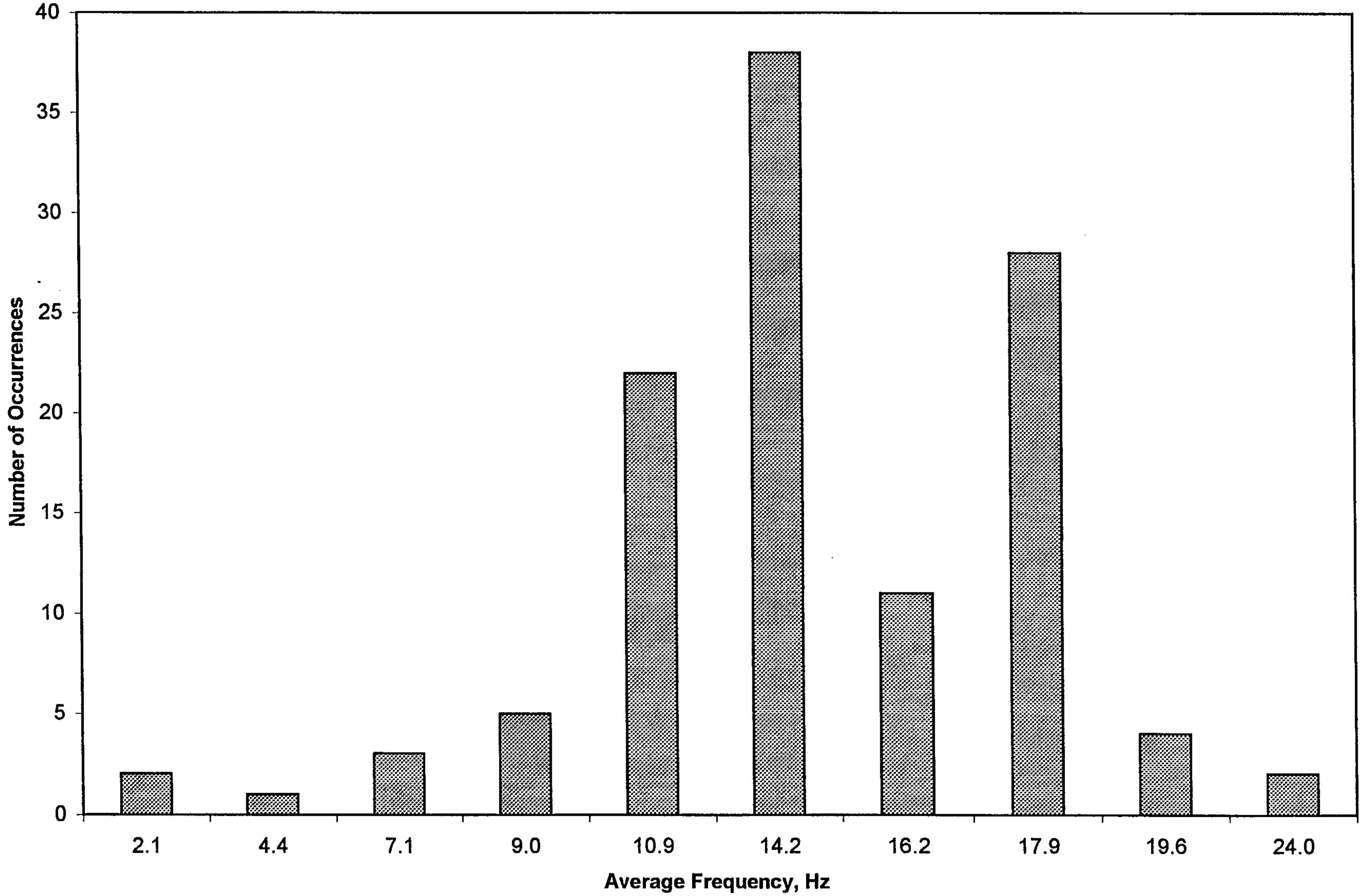


Figure 5.19 Average Frequency vs. Number of Occurrences (Time History - Weak-Axis)

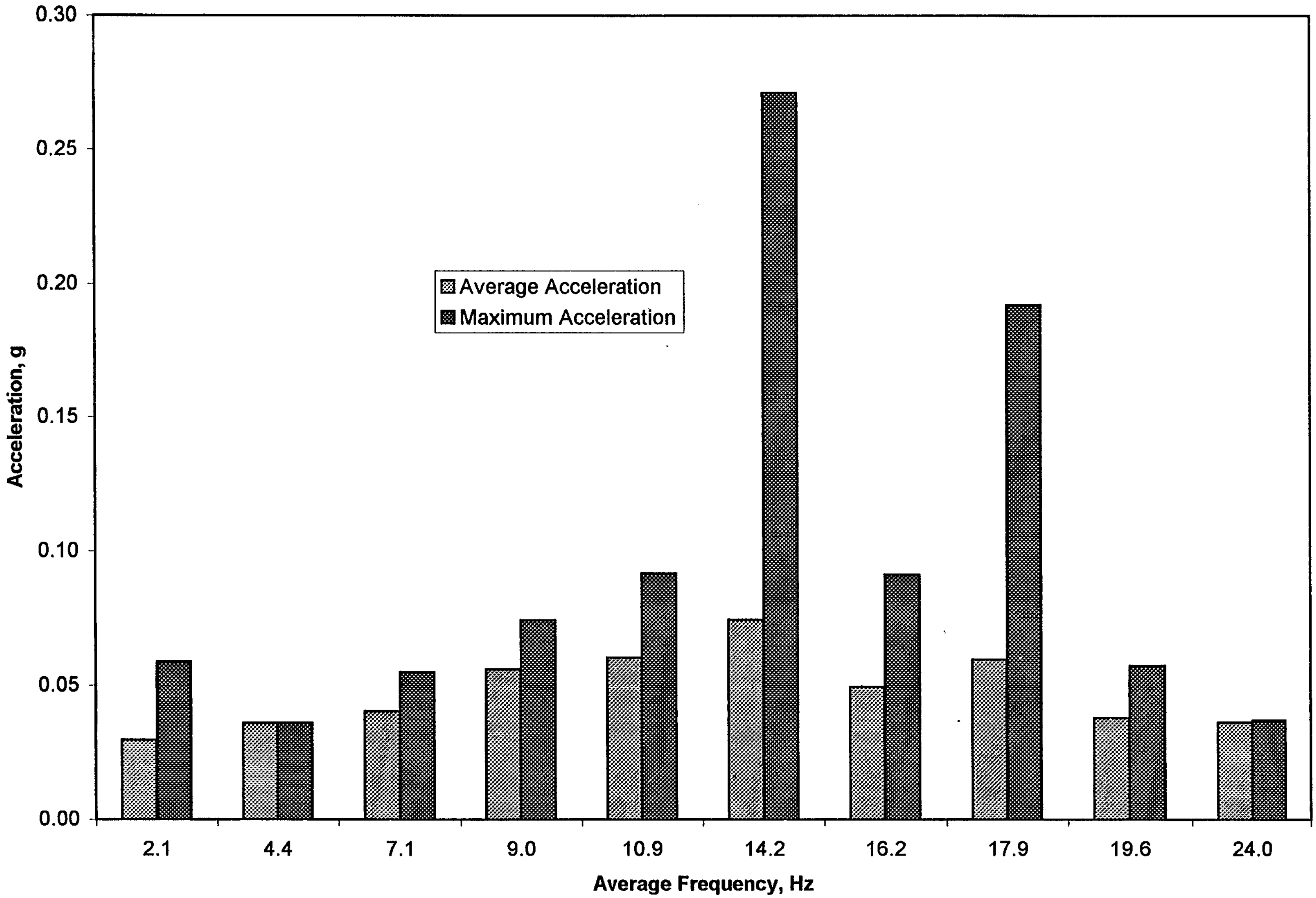


Figure 5.20 Average Frequency vs. Acceleration (Time History - Weak-Axis)

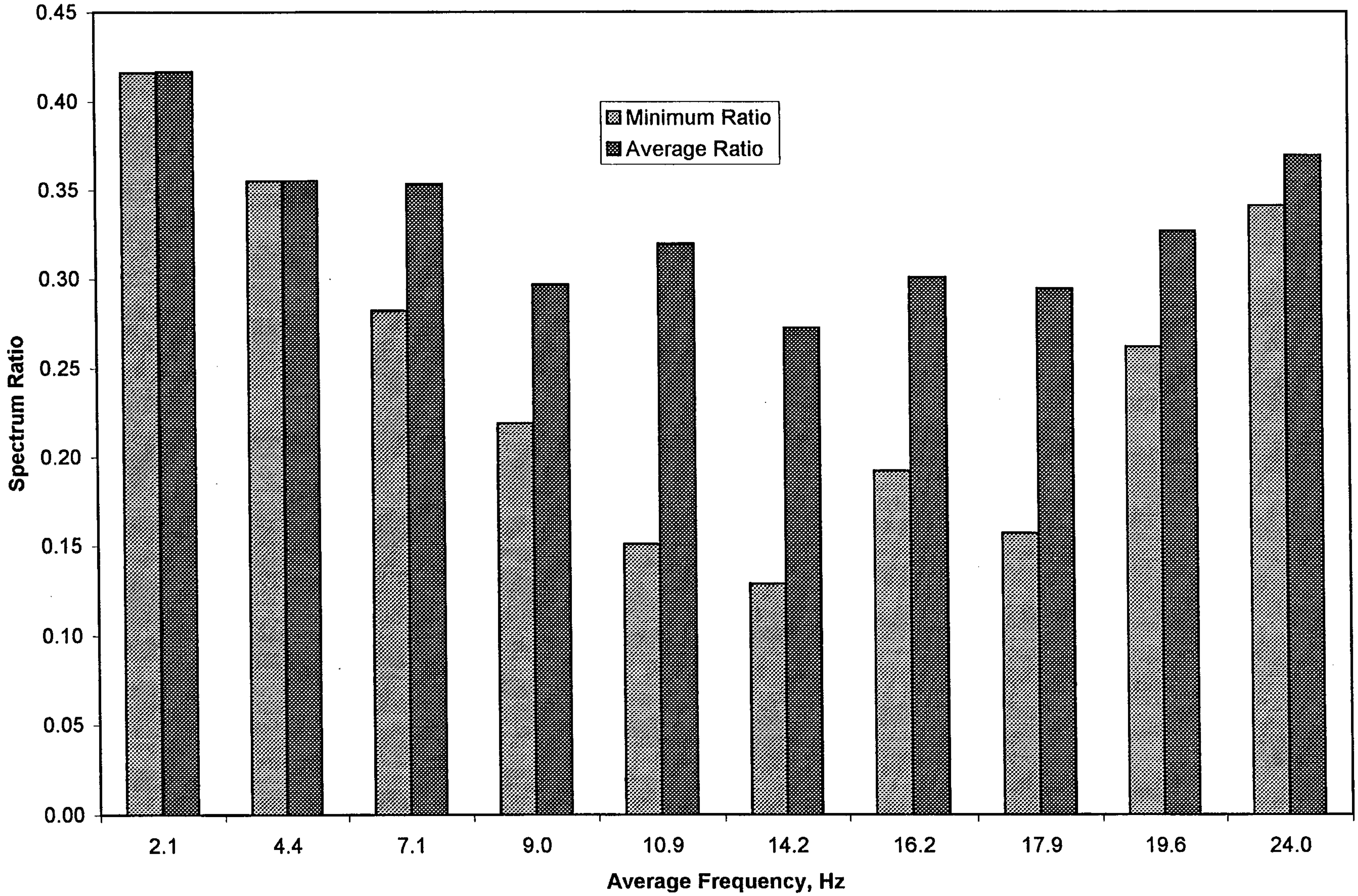


Figure 5.21 Average Frequency vs. Spectrum Ratio (Time History - Weak-Axis)

5.4 CALCULATED FREQUENCIES OF VIBRATION

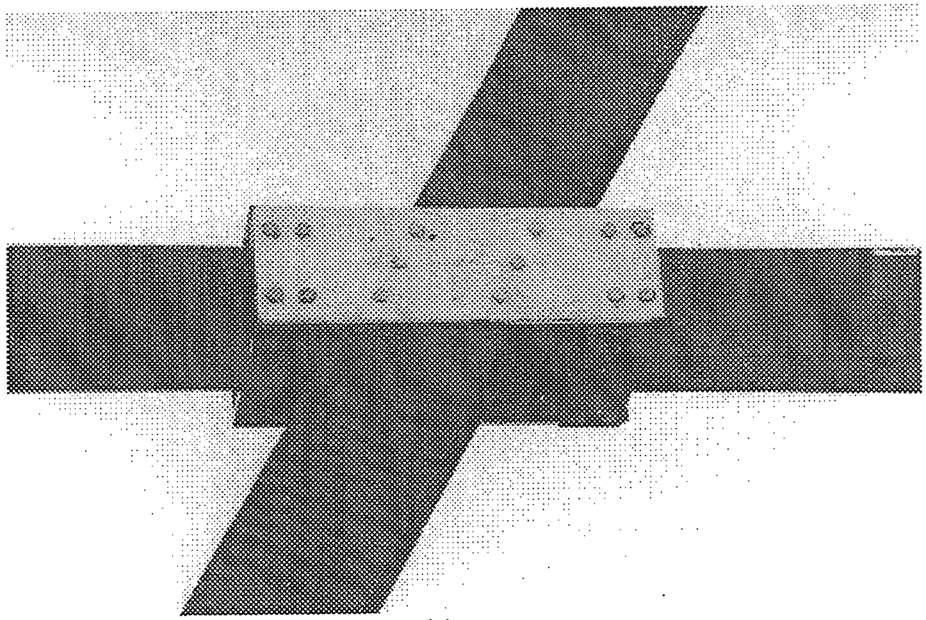
Frequencies of vibration are calculated by solution of the fourth order differential equation for free vibrations of a beam [10]. Solutions are obtained by conservatively assuming a tension force equal to 102-Mg (224-kips) for transverse vibrations and fully restrained connections for both transverse and torsional vibrations. The assumed tension force is the total service load used to design the member. Preliminary comparisons of measured and calculated frequencies of vibration reveal a better correspondence is made by assuming fixed supports at the retrofit connection in the weak-axis direction and at the gusset plate connection in the strong-axis direction. Two photographs of the retrofit connection are shown in Figure 5.22. It is likely that this type of connection provides a notable amount of rotational restraint in the weak-axis direction, enabling the assumption of a restrained connection to be made. Because the retrofit is assumed to restrain both torsional and weak-axis rotations at approximately midspan of the member, half of the full member length is used. For the strong-axis response, it is assumed that the retrofit does not provide a significant restraint and therefore the full member length is used. Table 5.4 lists the calculated frequencies of vibration.

Table 5.4 Calculated Frequencies of Vibration

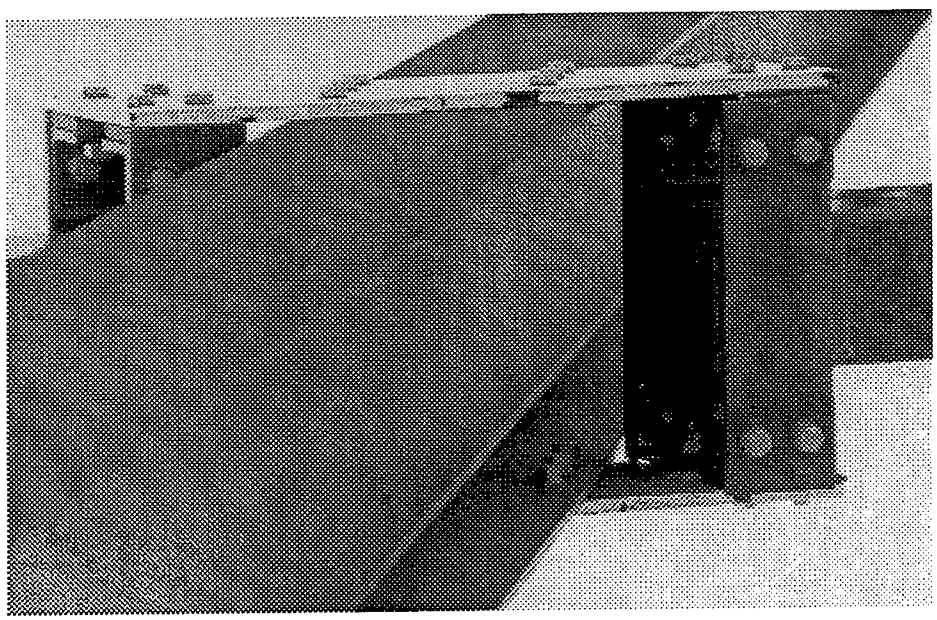
	Calculated Frequencies (Hz)	
Vibration Response	1st Mode	2nd Mode
Torsional	9.29	18.58
Strong-Axis	8.10	21.91
Weak-Axis	13.03	33.79

5.5 FREQUENCY EVALUATION

Summaries of the measured and calculated frequencies are shown in Table 5.5. Measured strong-axis frequencies are slightly lower than calculated. This can be attributed to the assumption of fully restrained connections. The gusset plate restrains rotations by weak-axis bending with respect to strong-axis vibration of the member. Therefore, a fully restrained connection is less likely realized. The second mode of torsional vibration and the first mode of weak-axis vibration are slightly higher than calculated values. One rationale for this discrepancy may be the location of the retrofit. If the retrofit were located less than mid-height of the instrumented member, the



(a)



(b)

Figure 5.22 Retrofit Connection

length used for calculated values would be too large, resulting in higher frequencies. Overall, vibration frequencies of the member during large accelerations and wind speeds are very similar and compare well with calculated values.

Table 5.5 Measured and Calculated Frequencies of Vibration

	Measured Frequencies (Hz)				Calculated Frequencies (Hz)	
	Large Accelerations		Large Wind Speeds			
Vibration Response	1st Mode	2nd Mode	1st Mode	2nd Mode	1st Mode	2nd Mode
Torsional	9.2	20.0	9.2	19.7	9.29	18.58
Strong-Axis	-	19.7	6.7	19.7	8.10	21.91
Weak-Axis	14.5	-	14.2	-	13.03	33.79

5.6 WIND AND VIBRATION CORRELATION

The effects of the largest wind speeds and their directions on acceleration magnitudes are examined in the following section. The wind direction is measured in degrees clockwise from the plane of the truss. Zero degrees would indicate wind parallel to the bridge, blowing directly from the Wisconsin side of the bridge. Ninety-degrees would be wind perpendicular to the bridge, blowing in the upstream direction and 270 degrees would be wind perpendicular to the bridge blowing in the downstream direction. Figure 5.23 is a schematic of the orientation of measured wind directions.

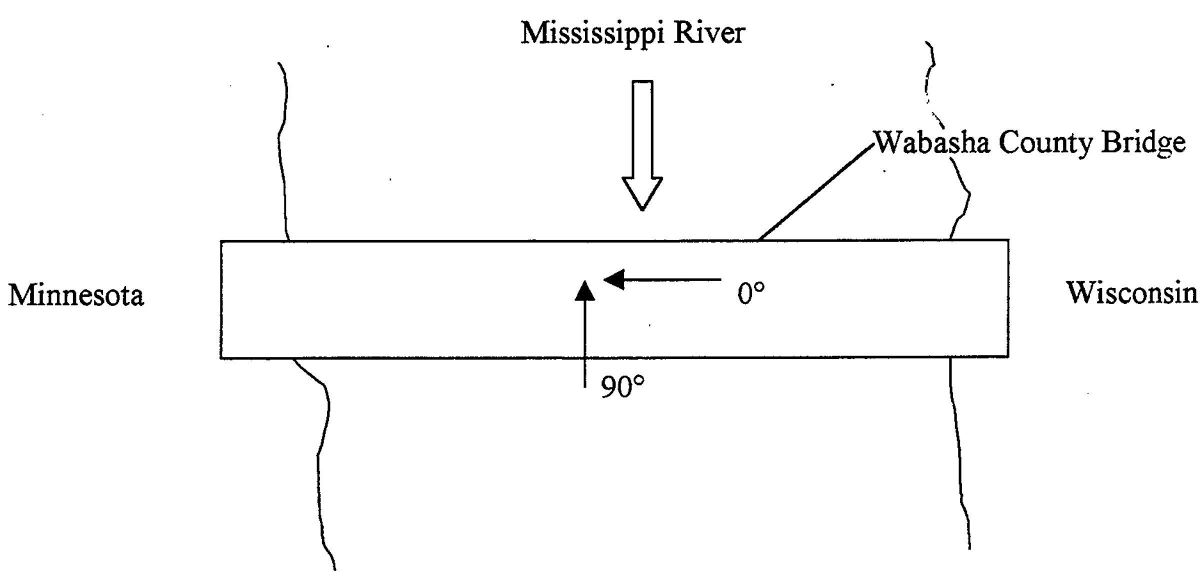


Figure 5.23 Wind Direction Orientation

5.6.1 LARGE WIND SPEEDS

Maximum accelerations measured during large wind speeds were small. Figure 5.24 is a plot comparing the magnitude of these accelerations and corresponding wind speeds. Vibration responses have been combined in this figure to simplify the contributions large wind speeds have on magnitudes of acceleration. The large distribution shown in Figure 5.24 suggests that little correlation exists between magnitudes of acceleration and corresponding wind speeds. Table 5.6 summarizes the accelerations and corresponding frequencies of vibration measured during the largest measured wind speed of 20.8 m/sec (46.5 mph) occurring at 211°.

Table 5.6 Vibration Characteristics During Maximum Wind Speed

Vibration Response	Acceleration at 20.8 m/sec (211°)	Frequency (Hz)
Torsional	0.56-g/m (0.17-g/ft)	19.1
Strong-Axis	0.04 g	6.7
Weak-Axis	0.07 g	14.1

Figure 5.24 reveals that the maximum wind speed measured, 20.8-m/sec (46.5-mph), did not result in the largest accelerations, however. These larger accelerations and the wind speeds and directions at which they occurred are shown in Table 5.7.

Table 5.7 Maximum Accelerations During Large Wind Speeds

Vibration Response	Maximum Acceleration	Frequency (Hz)	Wind Speed	Wind Direction
Torsional	0.98-g/m (0.30-g/ft)	19.1	14.4-m/sec (32.2-mph)	235°
Strong-Axis	0.14-g	19.9	11.3-m/sec (25.3-mph)	141°
Weak-Axis	0.27-g	14.5	14.4-m/sec (32.2-mph)	235°

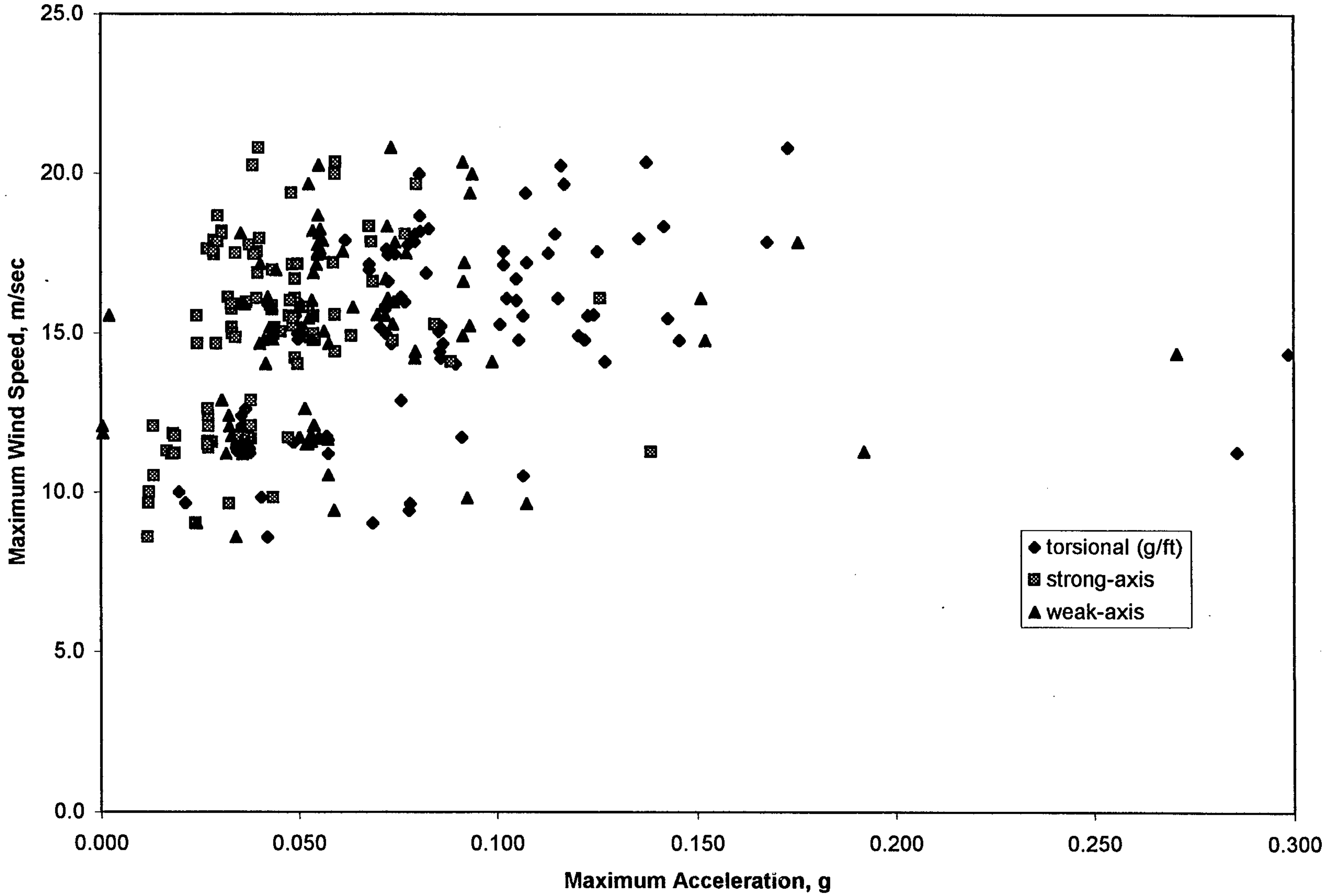


Figure 5.24 Maximum Acceleration vs. Maximum Wind Speed (Time History)

The largest torsional and weak-axis accelerations measured during large wind speeds occurred when the wind acted at approximately a 45° angle to the bridge. The wind direction of the maximum wind speed, 20.8-m/sec at 211° (46.5-mph), was approximately 15° closer to parallel with the bridge and may be a reason for the smaller accelerations measured during larger wind speeds. Smaller accelerations for strong-axis vibration can be attributed to the different frequencies at which they occurred.

Figure 5.25 is a plot comparing the magnitude of accelerations and corresponding wind directions. Vibration responses have also been combined in this figure to simplify the contributions wind direction may have on the magnitude of acceleration. Two trends in wind direction exist between 200 and 300 degrees and 100 and 150 degrees. These trends do not, however, appear to significantly affect the magnitudes of acceleration.

An attempt was also made to identify frequencies that may occur for certain wind directions. Although subtle differences were evident, variations in wind direction regarding the wide band of frequencies measured were inconclusive.

5.6.2 CORRELATION

Correlation of wind speed to the dynamic response of the bridge can be made through a comparison of maximum accelerations and wind speeds. Table 5.8 summarizes these characteristics.

Table 5.8 Maximum Accelerations and Wind Speeds

Vibration Response	Large Accelerations		Large Wind Speeds	
	Maximum Acceleration	Wind Speed	Maximum Acceleration	Wind Speed
Torsional	2.8-g/m (0.84 g/ft)	1.6-m/sec (3.6-mph)	0.98-g/m (0.30 g/ft)	14.4-m/sec (32.2-mph)
Strong-Axis	0.41 g	6.17-m/sec (13.8-mph)	0.14 g	11.3-m/sec (25.3-mph)
Weak-Axis	0.79 g	1.3-m/sec (2.9-mph)	0.27 g	14.4-m/sec (32.2-mph)

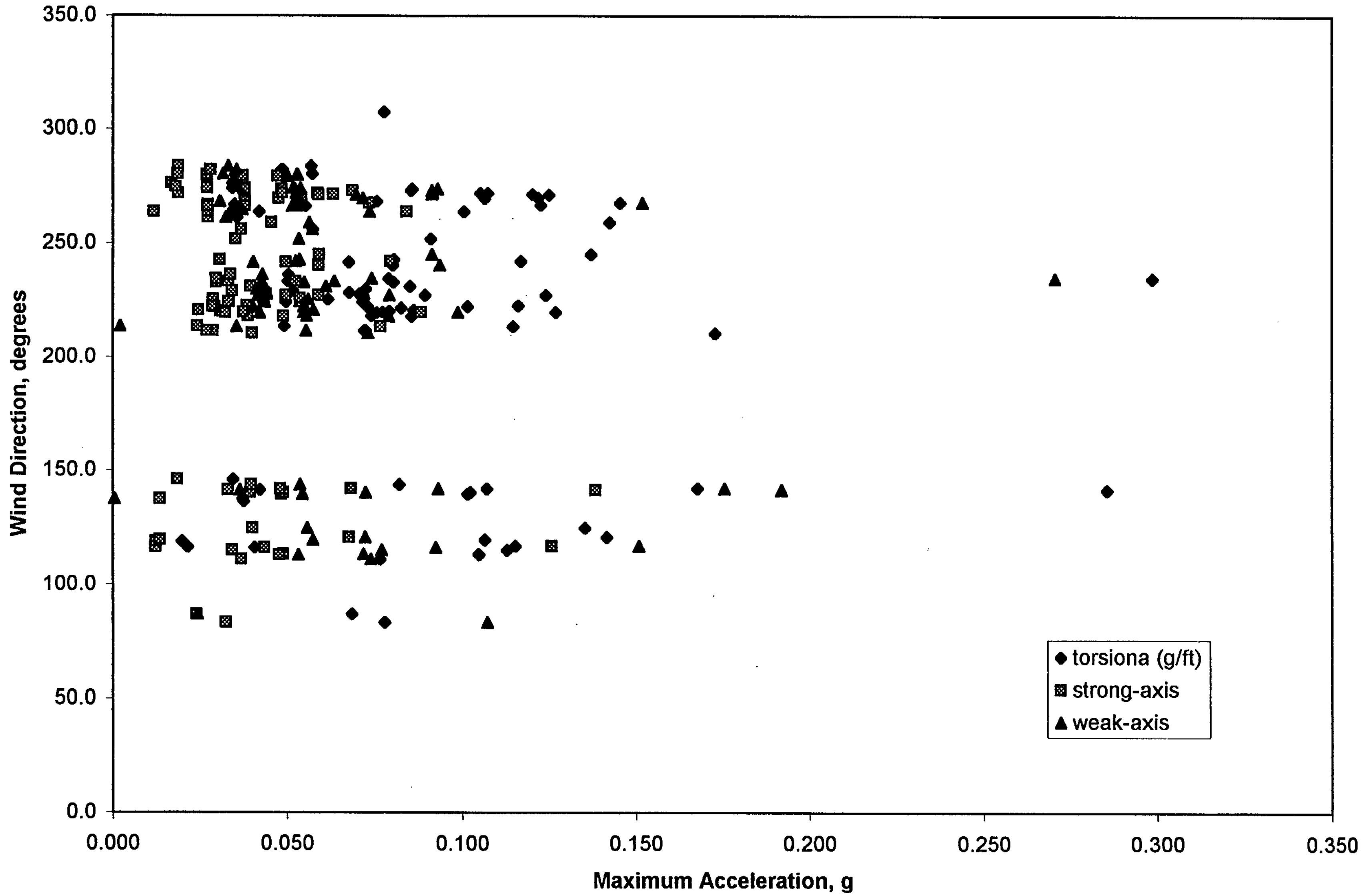


Figure 5.25 Maximum Acceleration vs. Wind Direction (Time History)

Maximum accelerations measured during large accelerations (i.e. Burst History data) are nearly three times the magnitude of the maximum accelerations measured during large wind speeds (i.e. Time History data). Corresponding wind speeds suggest a minimal contribution to the magnitude of these maximum accelerations. It is reasonably concluded that large wind speeds do not result in the largest accelerations, and thus their contributions to displacements and stresses are minimal when compared to accelerations recorded during traffic loading. Thus, one of the effects of the retrofit has been to uncouple (or weaken the coupling between) wind-induced vibration and maximum dynamic response of the instrumented member.

CHAPTER 6

DYNAMIC RESPONSE AND ASSESSMENT

6.1 INTRODUCTION

Having determined modes of vibration for the instrumented truss member, its dynamic response of can be further investigated. This includes the calculation of maximum displacements and stresses. Results of the study done before the retrofit by Maxim Technologies, Inc. are summarized and a comparison is made. In addition, an approximation of frequencies of vibration and displacements that may have existed before the retrofit is done and also compared to the results of the present study.

6.2 DISPLACEMENTS

The expression for maximum displacement as a function of the vibration frequency and peak acceleration is obtained by solving the linear differential equation describing free vibration of an idealized single degree of freedom system [11]. If damping of the member is neglected, this expression becomes:

$$u^t = \frac{\ddot{u}^t}{(2\,\pi\, f_n)^2}$$

where: u^t = maximum displacement, cm (in)

$\ddot{u}^t$ = maximum acceleration, cm/sec^2 (in/sec^2)

f_n = natural frequency of vibration (1/sec)

To obtain units of centimeters for maximum displacement, accelerations measured in g's must be multiplied by the acceleration of gravity (i.e. 980-cm/sec^2). Frequencies of vibration are measured in Hz (cycles/sec). Since torsional accelerations are measured in units of g/m (g/ft), they are multiplied by the distance h shown in Figure 6.1 to obtain units of g. Corresponding torsional displacements are therefore in the direction of torsional accelerations, also shown in Figure 6.1. The value of h with respect to the location of the accelerometers and the midpoint of the web is

0.28-m (0.93-ft).

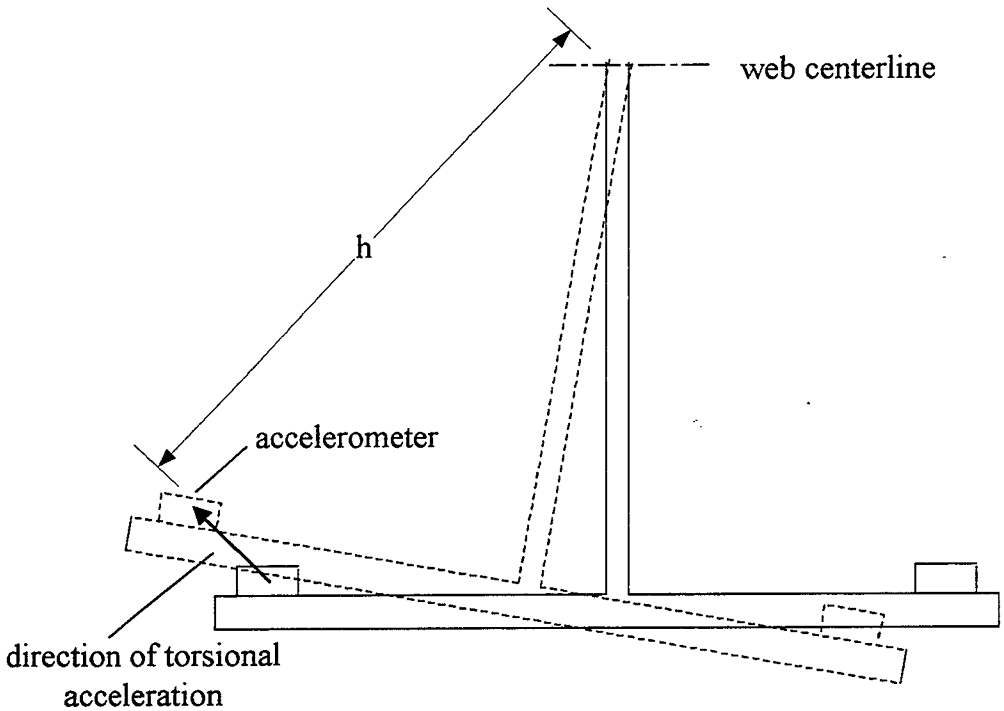


Figure 6.1 Torsional Acceleration Schematic

Because the calculated displacements are a function of both acceleration and frequency of vibration, peak values do not necessarily occur at the largest measured accelerations. Thus, the largest measured accelerations of each response and the different frequencies at which they occurred were considered in order to determine peak displacements. Accelerations, frequencies of vibration, and resulting peak displacements at the instrument location are shown in Table 6.1. The magnitudes of these displacements are very small and indicate a significant effect of the retrofit member on displacements due to vibration of the instrumented member.

6.3 STRESSES

Stress levels in the instrumented member are the combination of two types of phenomenon: elongation of the member due to traffic loading and bending from displacement of the member caused by vibration. The combination of these stresses is meaningful when considering the response of the member from a fatigue standpoint.

Table 6.1 Maximum Calculated Displacements

Vibration Response	Acceleration	Frequency (Hz)	Peak Displacement
Torsional	2.3-g/m (0.70-g/ft)	9.2	0.19-cm (0.075-in)
Strong-Axis	0.13-g	6.8	0.069-cm (0.027-in)
Weak-Axis	0.79-g	14.5	0.094-cm (0.037-in)

The largest measured strain change at the midpoint between the retrofit connection and the lower joint was 40 $\mu\varepsilon$, corresponding to a stress level of 8.6-MPa (1.2-ksi). Since the strain gages were located at the edge of the flange, the measured strains include approximate contributions of stresses resulting from vibration response.

6.4 PREVIOUS RESULTS

Strains, accelerations, and wind speeds were measured by Maxim Technologies, Inc. from September to mid November of 1996, prior to the retrofit. Maxim presented results of this study in two reports. The first of these reports was prepared for Sverdrup Civil, Inc. on October 22, 1996 and contains the preliminary results for the monitoring that took place during September and the first half of October [2]. The second report was prepared for Mn/DOT on February 24, 1997 and contains results for the second half of October and November [3]. The following sections summarize the results of the study done by Maxim Technologies as contained in both reports. Two members were instrumented: the longest diagonal (member L6-U7) and an adjacent vertical member (L7-U7). Only strains and accelerations measured on member L6-U7 will be examined to remain consistent with the present study.

6.4.1 STRAINS

In the Maxim study, strain gage measurements were recorded near the lower gusset plate of member L6-U7 for the monitoring period of mid October through November. The gauge was mounted at the edge of the flange and oriented along the longitudinal axis of the member. Maximum recorded strain levels were in the range of 200 to 300-$\mu\varepsilon$. Maxim reported little correlation between the response of the truss member and the recorded strain. In addition, when strain levels were high, Maxim Technologies, Inc. reported that truss member movement was generally small.

6.4.2 FREQUENCIES AND ACCELERATIONS

Accelerations were measured by Maxim Technologies, Inc. 6.1-m (20-ft) above the lower gusset plate of member L6-U7. The accelerometers were mounted 5-cm (2-in) from the edge of the flange and were orientated in different directions for the two monitoring periods. For the period of September to mid October, the accelerometer was orientated perpendicular to the flange (i.e. in the direction of strong-axis motion). The only low frequency vibration recorded during this period was 5.5 Hz and was observed as torsional. The maximum acceleration recorded at this frequency was 0.5-g. A second vibration frequency of 11.5 Hz was also recorded. No indication is given to the type of response exhibited by the member at this frequency. The maximum acceleration recorded at a frequency of 11.5 Hz was 0.45-g.

For the monitoring period of mid October through November, the accelerometer was oriented perpendicular to the web (i.e. in the direction of weak-axis motion). The fundamental frequency reported by Maxim during this period was 11.5 Hz. The frequency of recorded events during this monitoring period was never less than 11 Hz and consequently, dynamic movement was reported as very low.

6.4.3 DISPLACEMENTS

Using the same method described in Section 6.2, torsional vibration displacements can be calculated with the torsional accelerations and frequencies of vibration measured before the retrofit by Maxim Technologies, Inc. The maximum torsional displacement that results from this calculation is 0.41-cm (0.16-in).

6.4.4 WIND SPEED

Wind speed was measured from a nearby location, approximately 900-m (1000-yds) away, along the riverbank. Wind speeds exceeded 16-m/sec (35 mph) on five occasions. The maximum measured wind speed was approximately 21-m/sec (48-mph). Due to the low acceleration recorded during these wind speeds, no correlation with response acceleration was made by Maxim Technologies Inc.

6.4.5 SUMMARY

Table 6.2 is a summary of some of the vibration characteristics reported by Maxim Technologies, Inc.

Table 6.2 Vibration Characteristics by Maxim Technologies, Inc.

Response	Frequency	Maximum Acceleration	Displacement
Torsional	5.5 Hz	0.5 g	0.41-cm (0.16-in)
Maximum measured strain, $\mu\varepsilon$		200-300	
Maximum measured wind speed		21-m/sec (48-mph)	

6.5 COMPARISON

Differences in the location and direction of strain and acceleration measurements before and after the retrofit limit the ability to make direct comparisons with data collected before the retrofit. These distinctions are discussed in the following sections. An effort is made to compare the data measured by Maxim Technologies, Inc., with the present study in order to provide insight towards the effect of the retrofit strategy implemented by Mn/DOT.

6.5.1 STRAINS

Longitudinal strains for the present study were measured directly below the accelerometers. The location of these strain gages on the flange was approximately the same as the location used before the retrofit, however the magnitude of strains measured in each study are completely independent. Because the strain gages were located near the gusset plate prior to the retrofit, they may include strains induced by small bending moments present in the truss connection. This is also evident when comparing the period of oscillation in the strain histories. For the present study, typical strains contain a single oscillation with a period of approximately 7 seconds, roughly the time it takes a vehicle to travel the length of the bridge. Strains previously measured by Maxim Technologies, Inc. before the retrofit contain multiple oscillations with periods on the order of 0.5 seconds. These oscillations may be from the strain change that occurs as vehicle axles cross the joint near which the strain gage was attached or more probably due to member vibration.

To quantify the largest strain measurements made by Maxim Technologies (200 to 300-$\mu\varepsilon$), stresses resulting from the maximum displacements calculated in the present study were determined. These normal tensile stresses were calculated by considering a uniformly distributed load along the member length that would result in the maximum displacements shown in Table 6.1. Knowing this equivalent loading, forces and corresponding stresses could be determined near the bolted gusset plate connection where strains were measured in the previous study.

To calculate the uniformly distributed point loading causing transverse displacement in the strong and weak-axis directions, fully restrained end conditions at both the retrofit and gusset plate connection were assumed. This assumption is consistent with the approximated frequency of vibration calculations described previously. The equivalent loading was determined using the expression relating displacements and these loading and support conditions [9]. Knowing this loading, forces and corresponding stresses were subsequently computed near the gusset plate connection.

To calculate the uniformly distributed torque causing rotational displacement, an additional assumption regarding the torsional restraint at both the retrofit and gusset plate connection is necessary. Torsional restraint includes both a twisting and warping component. A connection provides twisting restraint if the member is prevented from twisting about its longitudinal axis. In an I-section, warping restraint prevents lateral displacement of the flanges at the connection. Because the length of the bolted gusset plate connection is relatively large, it is reasonable to assume both of these torsional components are restrained. It is evident that the retrofit connection (Figure 5.22) does in fact restrain the member from twisting. However, due to the bolted connection to the member and the number of bolts that exist in the connection to the retrofit brace, it is likely more reasonable to assume the retrofit does not provide a significant amount of warping restraint. The equivalent loading was determined using an expression relating rotation and these loading and support conditions [12]. Knowing this loading, forces and corresponding stresses were computed near the gusset plate connection.

To justify the comparison between measured strains before the retrofit and the approximate strains calculated in the procedure described above, these calculations were repeated for conditions that existed before implementation of the retrofit. The same assumptions regarding the bolted gusset plate connection were used. Table 6.3 summarizes the peak tensile stresses that result from the maximum calculated displacements before and after the retrofit. Corresponding strains are also shown, which were approximated by dividing the stress values by an assumed value for the modulus of elasticity equal to 200 GPa (29000 ksi) of the instrumented member.

Table 6.3 Calculated Stresses and Strains Before and After Retrofit

Response	Before Retrofit		After Retrofit	
	Stress	Strain (με)	Stress	Strain (με)
Torsional	12-MPa (1.8-ksi)	63	3.1-MPa (0.45-ksi)	16
Strong-Axis	5.0-MPa (0.73-ksi)	25	2.2-MPa (0.32-ksi)	11
Weak-Axis	19-MPa (2.8-ksi)	97	8.4-MPa (1.2-ksi)	42

The stresses and strains shown in Table 6.3 are approximate values for levels that would exist if the displacement in each direction of response acted independently. Since each response attains their peak displacement and corresponding strains at a different time instant, and the combined response occurs at another instant, an approximation must be made to estimate the peak value of the total response. An upper bound to this approximation can be found by assuming the maximum displacement of each vibration response occurs at the same time. A better approximation to the peak strain of the total response can be obtained by considering the square root of the sum of the squared quantities of each strain [11]. This latter method is a more reasonable approximation, due to the unlikely assumption that is made by summing the absolute values of each strain component. The upper bound and approximate stresses and strains of the total response of the member are shown in Table 6.4.

Table 6.4 Upper Bound and Approximate Stresses and Strains of Total Response

	Before Retrofit		After Retrofit	
	Stress	Strain (με)	Stress	Strain (με)
Absolute Sum	36-Mpa (5.3-ksi)	190	14-Mpa (2.0-ksi)	69
Including 40-με axial strain		230		109
Square-Root-of-Sum-of-Squares	23-MPa (3.4-ksi)	120	9.2-MPa (1.3-ksi)	46
Including 40-με axial strain		160		86

A comparison can be made with the strain levels measured before the retrofit by Maxim by adding the largest strain change measured at the quarter point of the member in the present study (40-με). An upper bound approximation of the strain levels that exist near the gusset plate after the retrofit is thus, 109-με. A more reasonable approximation is made by adding the largest strain change to the root mean square value (86-με), which is significantly less than the largest strains measured before the retrofit. A reasonable approximation of the strain levels before the retrofit including the largest strain measured at the quarter point is 160-με. This value is less than the strains measured by Maxim before the retrofit (200 to 300-με) likely because the small bending moments that may exist in the gusset plate connection are not included. The approximation after the retrofit (86-με) assumes that the retrofit connection does not restrain the truss member from warping. It is important to consider, however, that a significant amount of warping restraint at the location of the retrofit connection would increase stress levels near the gusset plate.

6.5.2 FREQUENCIES AND ACCELERATIONS

Two frequencies of vibration were reported before the retrofit. The measured frequency of 5.5 Hz was observed as torsional; however, the type of vibration response that occurs at a frequency of 11.5 Hz is not indicated in either report. Because only one accelerometer was used for both monitoring periods, different components of vibration response are present in these measurements. Figure 6.2 is a representation of these components and shows their contributions in the measured accelerations. Since this frequency was measured for both monitoring periods when the accelerometer was oriented in two different directions, it is difficult to ascertain the response it may represent. For the monitoring period of September to mid October, the accelerometer used by Maxim was oriented as in Figure 6.2a. It is evident that the accelerations measured will contain components of both torsional and strong-axis motion. For the monitoring period of mid-October through November, the accelerometer was orientated as in Figure 6.2b. These measured accelerations will contain components of torsional and weak-axis motion.

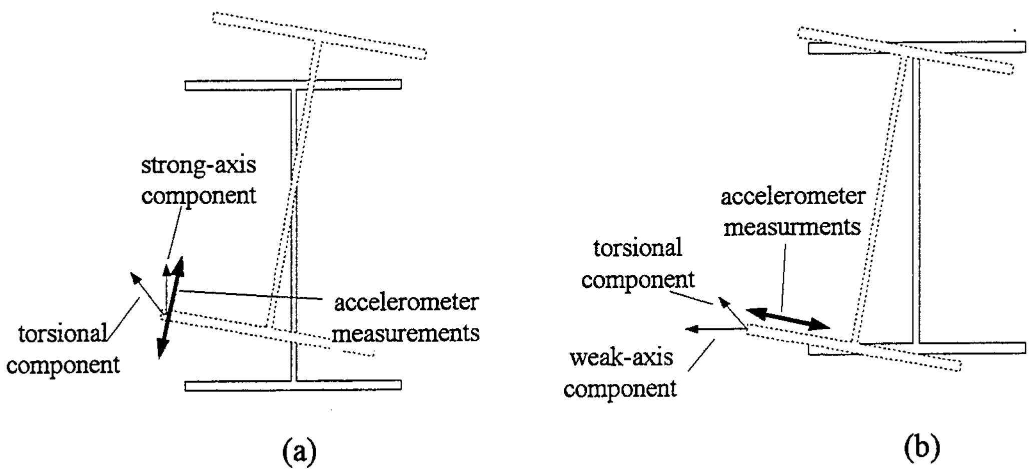


Figure 6.2 Acceleration Components

The vibration response at a frequency of 11.5 Hz could therefore represent either of the components shown in Figure 6.2 and consequently, cannot be compared to frequencies of vibration measured in the present study.

6.5.3 DISPLACEMENTS

Displacements of vibration have been computed using the expression (Section 7.2) representing the solution of the differential equation describing free vibration of an idealized single degree of freedom system. This expression is a function of acceleration and frequency of vibration. Therefore, calculated displacements are only as accurate as the accelerations and frequencies of vibration used in this expression. For this reason, a comparison of displacements using measured data before the retrofit is not emphasized in this study.

6.5.4 SUMMARY

For comparison purposes with the present study, it is intuitive to consider only the torsional vibration characteristics as reported by Maxim Technologies, Inc. Table 6.5 tabulates the results of the studies done before and after the retrofit. The peak displacements shown contain only a torsional component and therefore do not represent the largest displacements exhibited by the instrumented member.

Table 6.5 Vibration Comparison Before and After Retrofit

Study	Torsional Frequency (Hz)	Maximum Acceleration (g)	Peak Displacement	Strain (με)
Before Retrofit	5.5	0.50	0.41-cm (0.16-in)	200-300
After Retrofit	9.2	0.78	0.19-cm (0.075-in)	86

The maximum acceleration measured after the retrofit in the present study has been multiplied by the distance *h* in Figure 6.1 to obtain the same units of acceleration measured by Maxim Technologies Inc. In regards to torsional acceleration, the frequency of vibration after the retrofit has increased significantly and resulted in reduced displacements and corresponding strains.

6.6 RESPONSE ASSESSMENT

In addition to the comparison of data collected by Maxim Technologies and the present study, a more complete evaluation of truss member response can be accomplished by comparing approximate calculated frequencies of vibration before the retrofit to measured frequencies of vibration after the retrofit. Using these calculated frequencies of vibration along with approximated magnitudes of acceleration, perceptible vibrations before the retrofit can be quantified.

6.6.1 FREQUENCY COMPARISON

To determine the increase in vibration frequencies resulting from the retrofit, a comparison can be made to approximate calculated frequencies of vibration. Using the procedure described previously (section 5.4) and changing the member length for torsional and weak-axis vibration responses, vibration modes before implementation of the retrofit were calculated. Because calculated frequencies of vibration compare well with measured values after the retrofit, it is reasonable to assume an approximate comparison can be made with values before the retrofit. Estimated and measured frequencies of vibration before and after the retrofit are summarized in Table 6.6. The unidentified frequency of 11.5 Hz measured by Maxim is not grouped with any of the calculated frequencies of vibration before the retrofit. It is evident that this frequency could represent a vibration component of either torsional, strong-axis, or weak axis response.

Table 6.6 Frequencies Before and After Retrofit

<table>
<tr><th rowspan="3"></th><th colspan="6">Frequency (Hz)</th></tr>
<tr><th colspan="2">Torsional</th><th colspan="2">Strong-Axis</th><th colspan="2">Weak-Axis</th></tr>
<tr><th>1st Mode</th><th>2nd Mode</th><th>1st Mode</th><th>2nd Mode</th><th>1st Mode</th><th>2nd Mode</th></tr>
<tr><td>Calculated Before Retrofit</td><td>4.64</td><td>9.29</td><td>8.10</td><td>21.91</td><td>3.77</td><td>9.47</td></tr>
<tr><td>Measured Before Retrofit</td><td>5.5</td><td colspan="5">11.5</td></tr>
<tr><td>Measured After Retrofit</td><td>9.2</td><td>20.0</td><td>6.7</td><td>19.7</td><td>14.5</td><td>-</td></tr>
<tr><td>Calculated After Retrofit</td><td>9.29</td><td>18.58</td><td>8.10</td><td>21.91</td><td>13.03</td><td>33.79</td></tr>
</table>

The effect of the retrofit strategy is evident. In addition to the increased frequencies of torsional vibration as measured by Maxim and calculated in Table 6.6, similar trends are exhibited by weak-axis vibration. Strong axis frequencies of vibrations are approximately the same, due to the negligible bracing effect in the direction of strong-axis motion. By bracing the diagonal member near the midpoint, first mode frequencies of vibration after the retrofit are approximately equal to and greater than second modes for torsional and weak-axis responses before the retrofit, respectively.

6.6.2 PERCEPTIBLE VIBRATIONS BEFORE THE RETROFIT

Perceptible vibrations before the retrofit can be quantified by considering the combining effects of displacements from different modes of vibration. These combined effects consist of the *total* distance the member is displaced due to vibration. Because a single vibration response in the instrumented member is unlikely, perceptible vibrations are most meaningful when total displacements are taken into account. Figure 6.3 is a representation of the two types of combined vibration responses that would be most prevalent from the standpoint of an eyewitness standing or traveling on the bridge. In Figure 6.3a, *W* represents the total displacement resulting from torsional and weak-axis displacement. Figure 6.3b identifies the total displacement due to torsional and strong-axis displacement by *S*.

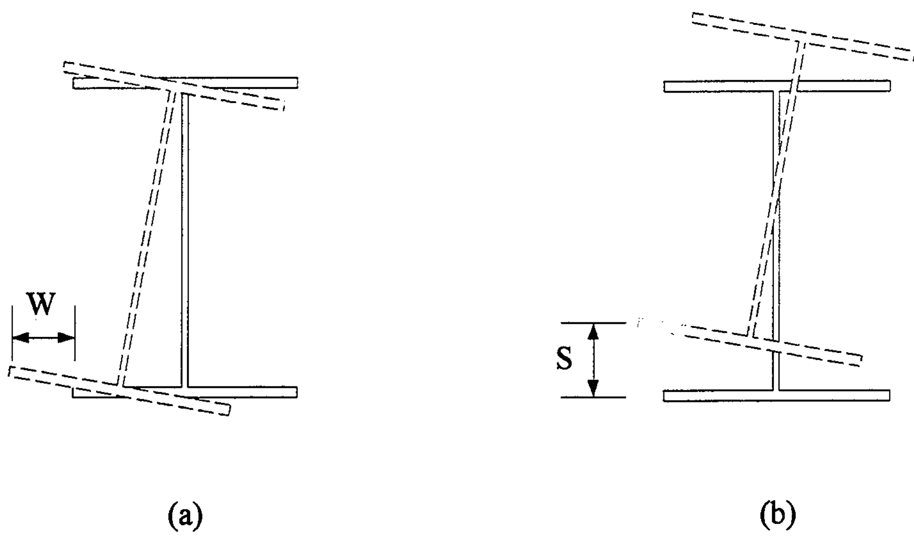


Figure 6.3 Combined Displacement Effects

In order to separate the displacement components of different vibration responses, it is necessary to know the frequencies of vibration and the magnitude of accelerations for each response. To remain consistent and to investigate all three components of vibration, approximate calculated frequencies of vibration before the retrofit are used. Maximum acceleration values measured by Maxim Technologies, Inc. are decomposed into the measured components shown in Figure 6.2 and used in these displacement calculations. Knowing the largest displacements that potentially existed before the retrofit in each vibration response, an approximation of the largest perceptible displacements can be made.

To decompose the accelerations measured before the retrofit into separate components, it is necessary to consider them as the sum of two responses. Thus, the measured acceleration shown in Figure 6.2a can be expressed as the sum of a torsional and strong-axis component in the direction of measured accelerations. Similarly, the measured acceleration shown in Figure 6.2b can be expressed as the sum of a torsional and weak-axis component in the direction of the measured accelerations. Resulting from this consideration are two equations and three unknowns, namely torsional, strong-axis, and weak-axis accelerations that existed before the retrofit. An assumption must be made to eliminate one of the unknowns and permit the solution of two equations with two unknowns. This assumption is that the magnitude of strong-axis acceleration before the retrofit is approximately equal to the magnitude of strong-axis acceleration that was measured in the present study. Because the effect of the retrofit is negligible in the strong-axis direction, it is reasonable to believe the magnitude of measured accelerations in this direction are approximately the same.

To obtain the largest displacements that potentially existed in each vibration response, the first modes of vibration shown in Table 6.6 are used. Table 6.7 shows these frequencies, the approximated magnitudes of acceleration, and the corresponding displacements. Also shown are equivalent values after the retrofit for the present study (from Table 6.1).

Table 6.7 Maximum Displacements Before and After Retrofit

Response	Frequency (Hz)		Acceleration (g)		Displacement	
	Before	After	Before	After	Before	After
Torsional	4.64	9.2	0.57	0.65 *	0.66-cm (0.26-in)	0.19-cm (0.075-in)
Strong-Axis	8.10	6.8	0.41	0.13	0.16-cm (0.062-in)	0.069-cm (0.027-in)
Weak-Axis	3.77	14.5	0.49	0.79	0.86-cm (0.34-in)	0.094-cm (0.037-in)

* multiplied by *h* in Figure 6.1 to obtain acceleration units of g

From the displacements before the retrofit shown in Table 6.7, it is evident that the largest combination will result from torsional and weak-axis components (Fig. 6.3a). An upper bound to the largest perceptible displacements before the retrofit can be obtained by summing the absolute value of the weak axis displacement, and the component of torsional acceleration in the weak axis direction, 0.56-cm (0.22-in). Thus, an upper bound single-amplitude displacement value can be approximated as 1.4-cm (0.56-in). Since each response attains their peak displacement at a different time instant, and the combined response occurs at another instant, a better approximation to the largest perceptible vibrations is obtained by taking the square root of the sum of the squares of these quantities. This calculation results in a single-amplitude displacement of 1.0-cm (0.40-in). For measured displacements after the retrofit, the upper bound displacement is 0.25-cm (0.10-in). Using the square root of the sum of the squares, the approximated displacement is 0.19-cm (0.075-in). Table 6.8 summarizes the perceptible displacements before and after the retrofit.

Table 6.8 Total Perceptible Displacements

Condition	Perceptible Displacement
Before retrofit	1.0-cm (0.40-in)
After retrofit	0.25-cm (0.075-in)

It is important to note that the displacements shown in Table 6.8 are single amplitude (i.e. from neutral or at-rest position to peak response). Whereas, an eyewitness would most likely focus on the double-amplitude displacement (i.e. from peak to peak responses). Thus, the double amplitude displacements that may have been perceived before the retrofit are equal to 2.0-cm (0.80-in). After the retrofit, double amplitude displacements are 0.38-cm (0.15-in).

6.7 RETROFIT EVALUATION

The beneficial effects of the retrofit implementation have been identified by making three comparisons before and after the retrofit: 1) measured torsional vibration characteristics (Table 6.5), 2) calculated and measured frequencies of vibration (Table 6.6), and 3) total perceptible vibrations (Table 6.8). These three approaches indicate that frequencies of vibration in torsional and weak-axis directions have increased from first to second mode responses. Also shown is a significant decrease in displacements, considering both individual mode and combined responses.

CHAPTER 7
SUMMARY AND CONCLUSIONS

This report has documented: 1) selection and purchase of a remote monitoring data acquisition system, 2) instrumentation, collection and analysis of acceleration, strain, and wind speed data of the longest diagonal member of the Wabasha County Bridge, and 3) a dynamic response assessment and evaluation of the retrofit. Conclusions drawn from this study include:

1. Remote monitoring of accelerations, strains, and wind speeds is a feasible and efficient method of evaluating bridge behavior. Several instrumentation and software considerations have been identified and will prove useful in future applications.

2. Fundamental frequencies of vibration for torsional, strong-axis, and weak-axis have been determined. Table 7.1 summarizes the dynamic characteristics of the instrumented member after implementation of the retrofit.

Table 7.1 Dynamic Characteristic Summary

Response	Frequency (Hz)		Maximum Acceleration	Maximum Displacement
	1st Mode	2nd Mode		
Torsional	9.2	20.0	0.78 g	0.19-cm (0.075-in)
Strong-Axis	6.7	19.7	0.41 g	0.069-cm (0.027-in)
Weak-Axis	14.5	-	0.79 g	0.094-cm (0.037-in)

3. Results of the study done before the retrofit by Maxim Technologies Inc. indicate that measured torsional frequencies of vibration are smaller than measured in the present study. Torsional displacements calculated in the previous study are larger as a result of the smaller frequencies. Table 7.2 summarizes the results of the two studies in regards to torsional accelerations.

Table 7.2 Torsional Vibration Comparison

Study	Torsional Frequency (Hz)	Maximum Acceleration (g)	Peak Displacement
Before Retrofit	5.5	0.50	0.41-cm (0.16-in)
After Retrofit	9.2	0.78	0.19-cm (0.075-in)

4. A comparison of calculated frequencies of vibration before the retrofit suggest that frequencies of vibration have increased from first to second mode responses due to the bracing effect of the retrofit. Table 7.3 summarizes these frequencies.

Table 7.3 Frequencies Before and After Retrofit

	Frequency (Hz)					
	Torsional		Strong-Axis		Weak-Axis	
	1st Mode	2nd Mode	1st Mode	2nd Mode	1st Mode	2nd Mode
Calculated Before Retrofit	4.64	9.29	8.10	21.91	3.77	9.47
Measured After Retrofit	9.2	20.0	6.7	19.7	14.5	-

5. Amplitudes of vibration before the retrofit have been quantified by considering the combined effects of torsional and weak-axis displacement. An approximation of perceptible vibrations before the retrofit indicates double amplitude displacements were 2.0-cm (0.80-in). The equivalent displacement after the retrofit is 0.38-cm (0.15-in).

6. The largest accelerations occurred during traffic loading. This is verified by the nature of corresponding strain readings and wind speeds. Accelerations resulting from exclusive wind loading are considerably smaller. Frequencies of vibration for these two types of loading compare well.

7. The largest strain increment measurement recorded midway between the retrofit connection and lower chord was 40-$\mu\varepsilon$. This strain level corresponds to a stress of 8.6-MPa (1.2-ksi).

8. The retrofit strategy implemented by Mn/DOT has benefited the dynamic characteristics of the longest diagonal member of the Wabasha County Bridge. Increased frequencies of vibration have reduced the displacement amplitudes, resulting in very low stress and strain levels.

Future work in this area should include the addition of cellular capabilities to the present remote monitoring data acquisition system. These capabilities will allow increased flexibility and efficiency in data collection for future field studies.

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APPENDIX A

GLOSSARY

TERMINOLOGY

Test: Period of time where RMDA was monitoring and recording data, including both Burst History and Time History data collection modes.

Burst History Data: Data collection mode triggered by accelerations, using the Burst History data mode in TCS

Time History Data: Data collection mode triggered by wind speed, using the Time History data mode in TCS.

Bursts: Segments of data corresponding to the Burst History data mode, either recorded by TCS or extracted by EASE.

Record: Refers to a specific Time History or Burst History database in TCS or EASE format, including quiescent segments where field computer does not collect data.

Data File: File that contains the continuous records of all instruments for the duration of the entire test.

Continuous Record: Refers to the continuous format of original data in EASE format, excluding periods where field computer is not collecting.

Channel: Constituents of the data file. Each channel corresponds to the continuous record of a particular instrument or a record computed from one or more instrument signals..

Procedures: EPL commands written in a text file that execute EASE functions.

Frequency Spectrum: Another name for the Fast Fourier Transform (FFT) calculated with the frequency analysis tool available in EASE.

Mode: Refers to the response mode at which the member vibrates.

Response: External indication of vibration in the instrumented member. Three types of responses were measured, including weak-axis, strong-axis, and torsional.

ACCRONYMS

RMDA: Remote Data Acquisition system; includes field computer and accessories.

TCS: Test Control Software (SOMAT); used by the field computer to sample and record data.

EXCC: External Computed Channels (SOMAT); software used within TCS to compute software channels.

EASE: Engineering Analysis Software Environment (SOMAT); used to analyze the field data.

EPL: EASE Procedure Language (SOMAT), a subset of EASE.

FFT: Fast Fourier Transform

APPENDIX B

EASE PROCEDURE FILES

EASE PROCEDURE FILES

Following is an index and brief description of the EASE EPL procedure files used for all data processing and analysis.

BH_PROC.PRS B-3
Primary data processing procedure for Burst History data. Performs filter on acceleration channels, calculates torsional and strong-axis accelerations, extracts individual bursts from continuous Burst History record and performs rosette analysis.

OFFSPEC.PRS B-12
Performs offset and Fast Fourrier Transform on extracted acceleration burst segments.

OFFSPEC2.PRS B-18
Performs offset and Fast Fourrier Transform on extracted longitudinal strain bursts.

SPEC2.PRS B-20
Removes 1st peak frequency from longitudinal strain spectrums.

SPEC3.PRS B-22
Removes 2nd peak frequency from longitudinal strain spectrums.

TEXT.PRS B-24
Compiles all relevant data and statistics into a text file (Burst History data).

SAVE.PRS B-40
Deletes end portions of channel list to eliminate processing problems due to saturated signals at beginning and end of Time History wind speed channel.

GT_WIND.PRS B-41
Primary data processing procedure for Time History data. Extracts individual bursts from Time History continuous records, calculates torsional and strong-axis accelerations, and performs rosette analysis.

WIND_ANA.PRS B-45
Performs offset and Fast Fourrier Transform on extracted acceleration burst segments.

TEXT2.PRS B-47
Compiles all relevant data and statistics into a text file (Time History data).

BH_PROC.PRS

```
SETGLOBALKEY Key=aug, Text=c:\wabasha\data\august\compon\burst\aug26.def

SETGLOBALKEY Key=acc, Text=c:\wabasha\data\august\compon\burst\acc26.sif
□

□
SETGLOBALKEY Key=t_trchan, Text=c:\wabasha\data\august\trigger\tor26.def
SETGLOBALKEY Key=toracc, Text=c:\wabasha\data\august\burst\accel\tor26.def
SETGLOBALKEY Key=toracc2, Text=c:\wabasha\data\august\burst\accel\tor26_2.def
SETGLOBALKEY Key=toracc3, Text=c:\wabasha\data\august\burst\accel\tor26_3.def
SETGLOBALKEY Key=torlong,
Text=c:\wabasha\data\august\burst\strain\long\tor26.def
SETGLOBALKEY Key=torspe, Text=c:\wabasha\data\august\burst\speed\tor26.def
SETGLOBALKEY Key=tordir, Text=c:\wabasha\data\august\burst\direct\tor26.def
SETGLOBALKEY Key=tor_ros,
Text=c:\wabasha\data\august\burst\strain\rose\tor26.def

SETGLOBALKEY Key=s_trchan, Text=c:\wabasha\data\august\trigger\str26.def
SETGLOBALKEY Key=stracc, Text=c:\wabasha\data\august\burst\accel\str26.def
SETGLOBALKEY Key=stracc2, Text=c:\wabasha\data\august\burst\accel\str26_2.def
SETGLOBALKEY Key=stracc3, Text=c:\wabasha\data\august\burst\accel\str26_3.def
SETGLOBALKEY Key=strlong,
Text=c:\wabasha\data\august\burst\strain\long\str26.def
SETGLOBALKEY Key=strspe, Text=c:\wabasha\data\august\burst\speed\str26.def
SETGLOBALKEY Key=strdir, Text=c:\wabasha\data\august\burst\direct\str26.def
SETGLOBALKEY Key=str_ros,
Text=c:\wabasha\data\august\burst\strain\rose\str26.def

SETGLOBALKEY Key=w_trchan, Text=c:\wabasha\data\august\trigger\wea26.def
SETGLOBALKEY Key=weaacc, Text=c:\wabasha\data\august\burst\accel\wea26.def
SETGLOBALKEY Key=weaacc2, Text=c:\wabasha\data\august\burst\accel\wea26_2.def
SETGLOBALKEY Key=weaacc3, Text=c:\wabasha\data\august\burst\accel\wea26_3.def
SETGLOBALKEY Key=wealong,
Text=c:\wabasha\data\august\burst\strain\long\wea26.def
SETGLOBALKEY Key=weaspe, Text=c:\wabasha\data\august\burst\speed\wea26.def
SETGLOBALKEY Key=weadir, Text=c:\wabasha\data\august\burst\direct\wea26.def
SETGLOBALKEY Key=wea_ros,
Text=c:\wabasha\data\august\burst\strain\rose\wea26.def

SETGLOBALKEY Key=tortrig, Text=0.48
SETGLOBALKEY Key=strtrig, Text=0.265
SETGLOBALKEY Key=weatrig, Text=0.475

SETGLOBALKEY Key=calc, Text=c:\wabasha\data\august\calc\calc26.def
SETGLOBALKEY Key=prelim, Text=c:\wabasha\data\august\prelim\pre26.def
SETGLOBALKEY Key=roseoff,
Text=c:\wabasha\data\august\burst\offset\rose\rose26.def
SETGLOBALKEY Key=trigger, Text=c:\wabasha\data\august\trigger\trig26.def
SETGLOBALKEY Key=tempburst,
Text=c:\wabasha\data\august\burst\temp\tempbur.def
SETGLOBALKEY Key=tempdelete,
Text=c:\wabasha\data\august\burst\temp\tempdel.def
```

```
;     Perform filter on acceleration channels

{
FILTER Chan1=[aug]-L8,Chan2=[aug]-L9, Chan3=[aug]-L10, Output=[acc],
Append=No, FiltType=Butterworth, Order=2,PassType=HighPass,
WinType=Uniform, Cutoff1_Hz=0.1
}

      ;TORSIONAL TRIGGER

      ;Calculate strong-axis and torsional frequencies
{
DESKCALCULATOR Chan1=[acc]-L1, Chan2=[acc]-L2, Equation=Chan1-Chan2,
Chname=calc_tor,
Desc=calculated torsion, Output=[calc]
}
{
DESKCALCULATOR Chan1=[acc]-L1, Chan2=[acc]-L2, Equation=(Chan1+Chan2)/2,
Chname=calc_str,
Desc=calculated strong axis, Output=[calc], Append=On
}
      ;Create trigger channel
{
DESKCALCULATOR Chan1=[calc]-L1, Equation=Chan1 >= [tortrig], Chname=tor_trig,
Desc=torsion trigger, Output=[trigger]
}
      ;Save created channels into prelim channel list

SETOUTTYPE SIF - 16 bit integers
{
SAVEFILEAS Output=[prelim], Chan1=[aug]-L1,Chan2=[aug]-L2,Chan3=[aug]-
L3,Chan4=[aug]-L4,
Chan5=[aug]-L5,Chan6=[aug]-L6,Chan7=[aug]-L7, Chan8=[calc]-L1,Chan9=[calc]-
L2, Chan10=[acc]-L3,
Chan11=[aug]-L11,Chan12=[trigger]-L1
}
SAVEFILEAS Output=[t_trchan], Chan1=[prelim]-L12

SAVEFILEAS Output=[toracc], Chan1=[prelim]-L8

SAVEFILEAS Output=[toracc2], Chan1=[prelim]-L9

SAVEFILEAS Output=[toracc3], Chan1=[prelim]-L10

SAVEFILEAS Output=[torlong], Chan1=[prelim]-L2

SAVEFILEAS Output=[torspe], Chan1=[prelim]-L1

SAVEFILEAS Output=[tordir], Chan1=[prelim]-L11

      ;Extract individual bursts from prelim file

LABEL Name=start1
{
BURSTHISTORY Chan1=[prelim]-L1, Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4, Chan5=[prelim]-L5,
```

```
Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-L8,Chan9=[prelim]-
L9,Chan10=[prelim]-L10,Chan11=[prelim]-L11,
Chan12=[prelim]-L12,Output=[tempburst], Append=Off,Trigger=On False-True
Transition, TriggerChan=Chan12,
DataType=16 Bit Integer, AddTimeChannel=Yes,NumBursts=1, PreTrigger=1.0,
PostTrigger=4.0
}

SETGLOBALKEY Key=burstnum, Text=[[tempburst]-L1.DM_NumPoints]

GOTO Label=continue1, Test=[burstnum]

GOTO Label=end1

LABEL Name=continue1

STATISTICS Chan=[tempburst]-L3

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L3, Output=[roseoff],
Scale=1,Offset=[offsetval]

STATISTICS Chan=[tempburst]-L4

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L4, Output=[roseoff],
Append=On, Scale=1,Offset=[offsetval]
}
STATISTICS Chan=[tempburst]-L5

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L5, Output=[roseoff],
Append=On,Scale=1,Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes
{
ROSETTE Chan1=[roseoff]-L1, Chan2=[roseoff]-L2, Chan3=[roseoff]-
L3,Output=[tor_ros], Append=On,
RosetteType=Rectangular, ModulusUnits=ksi, Modulus=29000,PoissonRatio=0.29,
OutputAxialStrains=On,OutputPrincipalStrains=On,OutputShearStrains=On,
BeginAngle=0,EndAngle=90,AngleIncrement=45
}
SAVEFILEAS Output=[toracc], Append=On, Chan1=[tempburst]-L8

SAVEFILEAS Output=[toracc2], Append=On, Chan1=[tempburst]-L9

SAVEFILEAS Output=[toracc3], Append=On, Chan1=[tempburst]-L10
{
SAVEFILEAS Output=[torlong], Append=On, Chan1=[tempburst]-L2,
Chan2=[tempburst]-L6,
Chan3=[tempburst]-L7
}
SAVEFILEAS Output=[torspe], Append=On, Chan1=[tempburst]-L1
```

```
SAVEFILEAS Output=[tordir], Append=On, Chan1=[tempburst]-L11

SETGLOBALKEY Key=updel, Text=[[tempburst]-L12.DM_MaxValue]
{
DELETEDATA Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,Chan5=[prelim]-L5,
Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-L8,Chan9=[prelim]-
L9,Chan10=[prelim]-L10,Chan11=[prelim]-L11,
Chan12=[prelim]-L12, XLower=0.0, XUpper=[updel], Output=[tempdelete],
Append=Off
}
{
SAVEFILEAS Output=[prelim], Append=Off, Chan1=[tempdelete]-L1,
Chan2=[tempdelete]-L2,Chan3=[tempdelete]-L3,
Chan4=[tempdelete]-L4,Chan5=[tempdelete]-L5,Chan6=[tempdelete]-
L6,Chan7=[tempdelete]-L7,Chan8=[tempdelete]-L8,
Chan9=[tempdelete]-L9,Chan10=[tempdelete]-L10,Chan11=[tempdelete]-
L11,Chan12=[tempdelete]-L12
}
GOTO Label=start1

LABEL Name=end1

      ;STRONG TRIGGER

      ;Create trigger channel
{
DESKCALCULATOR Chan1=[calc]-L2, Equation=Chan1 >= [strtrig], Chname=str_trig,
Desc=strong trigger, Output=[trigger], Append=Off
}
      ;Recreate prelim file

SETOUTTYPE SIF - 16 bit integers
{
SAVEFILEAS Output=[prelim], Chan1=[aug]-L1,Chan2=[aug]-L2,Chan3=[aug]-
L3,Chan4=[aug]-L4,
Chan5=[aug]-L5,Chan6=[aug]-L6,Chan7=[aug]-L7,Chan8=[calc]-L1,Chan9=[calc]-
L2,Chan10=[acc]-L3,
Chan11=[aug]-L11,Chan12=[trigger]-L1, Append=Off
}
SAVEFILEAS Output=[s_trchan], Chan1=[prelim]-L12

SAVEFILEAS Output=[stracc], Chan1=[prelim]-L9

SAVEFILEAS Output=[stracc2],Chan1=[prelim]-L10

SAVEFILEAS Output=[stracc3],Chan1=[prelim]-L8

SAVEFILEAS Output=[strlong], Chan1=[prelim]-L2

SAVEFILEAS Output=[strspe], Chan1=[prelim]-L1

SAVEFILEAS Output=[strdir], Chan1=[prelim]-L11

      ;Extract individual bursts from prelim file

LABEL Name=start2
```

```
{
BURSTHISTORY Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,
Chan5=[prelim]-L5,Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-
L8,Chan9=[prelim]-L9,Chan10=[prelim]-L10,
Chan11=[prelim]-L11,Chan12=[prelim]-L12, Output=[tempburst],
Append=Off,Trigger=On False-True Transition,
TriggerChan=Chan12, DataType=16 Bit Integer, AddTimeChannel=Yes, NumBursts=1,
PreTrigger=1.0, PostTrigger=4.0
}
SETGLOBALKEY Key=burstnum, Text=[[tempburst]-L1.DM_NumPoints]

GOTO Label=continue2, Test=[burstnum]

GOTO Label=end2

LABEL Name=continue2

STATISTICS Chan=[tempburst]-L3

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L3, Output=[roseoff],
Scale=1,Offset=[offsetval]

STATISTICS Chan=[tempburst]-L4

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L4, Output=[roseoff],
Append=On, Scale=1,Offset=[offsetval]
}
STATISTICS Chan=[tempburst]-L5

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L5, Output=[roseoff],
Append=On,Scale=1,Offset=[offsetval]
}
STATISTICS ClearKeys=Yes
{
ROSETTE Chan1=[roseoff]-L1, Chan2=[roseoff]-L2, Chan3=[roseoff]-
L3,Output=[str_ros], Append=On,
RosetteType=Rectangular, ModulusUnits=ksi, Modulus=29000,PoissonRatio=0.29,
OutputAxialStrains=On,OutputPrincipalStrains=On,OutputShearStrains=On,
BeginAngle=0,EndAngle=90,AngleIncrement=45
}
SAVEFILEAS Output=[stracc], Append=On, Chan1=[tempburst]-L9

SAVEFILEAS Output=[stracc2], Append=On, Chan1=[tempburst]-L10

SAVEFILEAS Output=[stracc3], Append=On, Chan1=[tempburst]-L8
{
SAVEFILEAS Output=[strlong], Append=On, Chan1=[tempburst]-L2,
Chan2=[tempburst]-L6,
Chan3=[tempburst]-L7
}
```

```
SAVEFILEAS Output=[strspe], Append=On, Chan1=[tempburst]-L1

SAVEFILEAS Output=[strdir], Append=On, Chan1=[tempburst]-L11

SETGLOBALKEY Key=updel, Text=[[tempburst]-L12.DM_MaxValue]
{
DELETEDATA Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,Chan5=[prelim]-L5,
Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-L8,Chan9=[prelim]-
L9,Chan10=[prelim]-L10,Chan11=[prelim]-L11,
Chan12=[prelim]-L12, XLower=0.0, XUpper=[updel], Output=[tempdelete],
Append=Off
}
{
SAVEFILEAS Output=[prelim], Append=Off, Chan1=[tempdelete]-L1,
Chan2=[tempdelete]-L2,Chan3=[tempdelete]-L3,
Chan4=[tempdelete]-L4,Chan5=[tempdelete]-L5,Chan6=[tempdelete]-
L6,Chan7=[tempdelete]-L7,Chan8=[tempdelete]-L8,
Chan9=[tempdelete]-L9,Chan10=[tempdelete]-L10, Chan11=[tempdelete]-L11,
Chan12=[tempdelete]-L12
}

GOTO Label=start2

LABEL Name=end2

      ;WEAK TRIGGER

      ;Calculate trigger channel
{
DESKCALCULATOR Chan1=[acc]-L3, Equation=Chan1 >= [weatrig], Chname=wea_trig,
Desc=weak trigger, Output=[trigger]
}

      ;Recreate prelim file

SETOUTTYPE SIF - 16 bit integers
{
SAVEFILEAS Output=[prelim], Chan1=[aug]-L1,Chan2=[aug]-L2,Chan3=[aug]-
L3,Chan4=[aug]-L4,
Chan5=[aug]-L5,Chan6=[aug]-L6,Chan7=[aug]-L7,Chan8=[calc]-L1,Chan9=[calc]-
L2,Chan10=[acc]-L3,
Chan11=[aug]-L11,Chan12=[trigger]-L1, Append=Off
}
SAVEFILEAS Output=[w_trchan], Chan1=[prelim]-L12

SAVEFILEAS Output=[weaacc], Chan1=[prelim]-L10

SAVEFILEAS Output=[weaacc2], Chan1=[prelim]-L8

SAVEFILEAS Output=[weaacc3], Chan1=[prelim]-L9

SAVEFILEAS Output=[wealong], Chan1=[prelim]-L2

SAVEFILEAS Output=[weaspe], Chan1=[prelim]-L1

SAVEFILEAS Output=[weadir], Chan1=[prelim]-L11
```

```
      ;Extract individual bursts from prelim file

LABEL Name=start3
{
BURSTHISTORY Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,
Chan5=[prelim]-L5,Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-
L8,Chan9=[prelim]-L9,Chan10=[prelim]-L10,
Chan11=[prelim]-L11, Chan12=[prelim]-L12, Output=[tempburst],
Append=Off,Trigger=On False-True Transition,
TriggerChan=Chan12,DataType=16 Bit Integer, AddTimeChannel=Yes, NumBursts=1,
PreTrigger=1.0, PostTrigger=4.0
}
SETGLOBALKEY Key=burstnum, Text=[[tempburst]-L1.DM_NumPoints]

GOTO Label=continue3, Test=[burstnum]

GOTO Label=end3

LABEL Name=continue3

STATISTICS Chan=[tempburst]-L3

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L3, Output=[roseoff],
Scale=1,Offset=[offsetval]

STATISTICS Chan=[tempburst]-L4

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L4, Output=[roseoff],
Append=On, Scale=1,Offset=[offsetval]
}
STATISTICS Chan=[tempburst]-L5

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[tempburst]-L5, Output=[roseoff],
Append=On,Scale=1,Offset=[offsetval]
}
STATISTICS ClearKeys=Yes
{
ROSETTE Chan1=[roseoff]-L1, Chan2=[roseoff]-L2, Chan3=[roseoff]-
L3,Output=[wea_ros], Append=On,
RosetteType=Rectangular, ModulusUnits=ksi, Modulus=29000,PoissonRatio=0.29,
OutputAxialStrains=On,OutputPrincipalStrains=On,OutputShearStrains=On,
BeginAngle=0,EndAngle=90,AngleIncrement=45
}
SAVEFILEAS Output=[weaacc], Append=On, Chan1=[tempburst]-L10

SAVEFILEAS Output=[weaacc2], Append=On, Chan1=[tempburst]-L8

SAVEFILEAS Output=[weaacc3], Append=On, Chan1=[tempburst]-L9
```

```
{
SAVEFILEAS Output=[wealong], Append=On, Chan1=[tempburst]-
L2,Chan2=[tempburst]-L6,
Chan3=[tempburst]-L7
}
SAVEFILEAS Output=[weaspe], Append=On, Chan1=[tempburst]-L1

SAVEFILEAS Output=[weadir], Append=On, Chan1=[tempburst]-L11

SETGLOBALKEY Key=updel, Text=[[tempburst]-L12.DM_MaxValue]
{
DELETEDATA Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,Chan5=[prelim]-L5,
Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-L8,Chan9=[prelim]-
L9,Chan10=[prelim]-L10, Chan11=[prelim]-L11,
Chan12=[prelim]-L12,XLower=0.0, XUpper=[updel], Output=[tempdelete],
Append=Off
}
{
SAVEFILEAS Output=[prelim], Append=Off, Chan1=[tempdelete]-L1,
Chan2=[tempdelete]-L2,Chan3=[tempdelete]-L3,
Chan4=[tempdelete]-L4,Chan5=[tempdelete]-L5,Chan6=[tempdelete]-
L6,Chan7=[tempdelete]-L7,Chan8=[tempdelete]-L8,
Chan9=[tempdelete]-L9,Chan10=[tempdelete]-L10, Chan11=[tempdelete]-L11,
Chan12=[tempdelete]-L12
}
GOTO Label=start3

LABEL Name=end3

REMOVEGLOBALKEY Key=aug
REMOVEGLOBALKEY Key=acc
REMOVEGLOBALKEY Key=t_trchan
REMOVEGLOBALKEY Key=toracc
REMOVEGLOBALKEY Key=toracc2
REMOVEGLOBALKEY Key=toracc3
REMOVEGLOBALKEY Key=torlong
REMOVEGLOBALKEY Key=tor_ros
REMOVEGLOBALKEY Key=torspe
REMOVEGLOBALKEY Key=tordir
REMOVEGLOBALKEY Key=s_trchan
REMOVEGLOBALKEY Key=stracc
REMOVEGLOBALKEY Key=stracc2
REMOVEGLOBALKEY Key=stracc3
REMOVEGLOBALKEY Key=strlong
REMOVEGLOBALKEY Key=str_ros
REMOVEGLOBALKEY Key=strspe
REMOVEGLOBALKEY Key=strdir
REMOVEGLOBALKEY Key=w_trchan
REMOVEGLOBALKEY Key=weaacc
REMOVEGLOBALKEY Key=weaacc2
REMOVEGLOBALKEY Key=weaacc3
REMOVEGLOBALKEY Key=wealong
REMOVEGLOBALKEY Key=wea_ros
REMOVEGLOBALKEY Key=weaspe
REMOVEGLOBALKEY Key=weadir
REMOVEGLOBALKEY Key=tortrig
```

```
REMOVEGLOBALKEY Key=strtrig
REMOVEGLOBALKEY Key=weatrig
REMOVEGLOBALKEY Key=calc
REMOVEGLOBALKEY Key=prelim
REMOVEGLOBALKEY Key=offset
REMOVEGLOBALKEY Key=trigger
REMOVEGLOBALKEY Key=tempburst
REMOVEGLOBALKEY Key=tempdelete
REMOVEGLOBALKEY Key=offsetval
REMOVEGLOBALKEY Key=burstnum
REMOVEGLOBALKEY Key=updel
REMOVEGLOBALKEY Key=adjust
REMOVEGLOBALKEY Key=roseoff
```

OFFSPEC.PRS

```
SETGLOBALKEY Key=toroff,
Text=c:\wabasha\data\august\burst\offset\accel\tor26.def
□
SETGLOBALKEY Key=toroff2,
Text=c:\wabasha\data\august\burst\offset\accel\tor26_2.def
□
SETGLOBALKEY Key=toroff3,
Text=c:\wabasha\data\august\burst\offset\accel\tor26_3.def
SETGLOBALKEY Key=torspec,
Text=c:\wabasha\data\august\burst\spec\accel\tor26.def
SETGLOBALKEY Key=torspec2,
Text=c:\wabasha\data\august\burst\spec\accel\tor26_2.def
SETGLOBALKEY Key=torspec3,
Text=c:\wabasha\data\august\burst\spec\accel\tor26_3.def
SETGLOBALKEY Key=stroff,
Text=c:\wabasha\data\august\burst\offset\accel\str26.def
SETGLOBALKEY Key=stroff2,
Text=c:\wabasha\data\august\burst\offset\accel\str26_2.def
SETGLOBALKEY Key=stroff3,
Text=c:\wabasha\data\august\burst\offset\accel\str26_3.def
SETGLOBALKEY Key=strspec,
Text=c:\wabasha\data\august\burst\spec\accel\str26.def
SETGLOBALKEY Key=strspec2,
Text=c:\wabasha\data\august\burst\spec\accel\str26_2.def
SETGLOBALKEY Key=strspec3,
Text=c:\wabasha\data\august\burst\spec\accel\str26_3.def
SETGLOBALKEY Key=weaoff,
Text=c:\wabasha\data\august\burst\offset\accel\wea26.def
SETGLOBALKEY Key=weaoff2,
Text=c:\wabasha\data\august\burst\offset\accel\wea26_2.def
SETGLOBALKEY Key=weaoff3,
Text=c:\wabasha\data\august\burst\offset\accel\wea26_3.def
SETGLOBALKEY Key=weaspec,
Text=c:\wabasha\data\august\burst\spec\accel\wea26.def
SETGLOBALKEY Key=weaspec2,
Text=c:\wabasha\data\august\burst\spec\accel\wea26_2.def
SETGLOBALKEY Key=weaspec3,
Text=c:\wabasha\data\august\burst\spec\accel\wea26_3.def

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[toroff], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END
```

```
SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[torspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=toroff
REMOVEGLOBALKEY Key=torspec
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName tor26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurat
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[toroff2], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26_2.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[torspec2],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=toroff2
REMOVEGLOBALKEY Key=torspec2
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName tor26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[toroff3], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END
```

```
SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26_3.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[torspec3],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=toroff3
REMOVEGLOBALKEY Key=torspec3
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[stroff], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName str26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[strspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=stroff
REMOVEGLOBALKEY Key=strspec
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName str26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[stroff2], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
```

```
SELECT DM_FileName str26_2.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[strspec2],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=stroff2
REMOVEGLOBALKEY Key=strspec2
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName str26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[stroff3], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName str26_3.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[strspec3],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=stroff3
REMOVEGLOBALKEY Key=strspec3
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[weaoff], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26.def
```

```
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[weaspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=weaoff
REMOVEGLOBALKEY Key=weaspec
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName wea26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[weaoff2], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26_2.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[weaspec2],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=weaoff2
REMOVEGLOBALKEY Key=weaspec2
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\accel
SELECT DM_FileName wea26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[weaoff3], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26_3.def
SELECTALL
```

```
{
AUTOPOWER [WholeDM_Active], Output=[weaspec3],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=weaoff3
REMOVEGLOBALKEY Key=weaspec3
REMOVEGLOBALKEY Key=offsetval
```

OFFSPEC2.PRS

```
SETGLOBALKEY Key=toroff,
Text=c:\wabasha\data\august\burst\offset\long\tor26.def
□
SETGLOBALKEY Key=torspec,
Text=c:\wabasha\data\august\burst\spec\strain\tor26.def
□
SETGLOBALKEY Key=stroff,
Text=c:\wabasha\data\august\burst\offset\long\str26.def
SETGLOBALKEY Key=strspec,
Text=c:\wabasha\data\august\burst\spec\strain\str26.def
SETGLOBALKEY Key=weaoff,
Text=c:\wabasha\data\august\burst\offset\long\wea26.def
SETGLOBALKEY Key=weaspec,
Text=c:\wabasha\data\august\burst\spec\strain\wea26.def

SELECT DM_Directory c:\wabasha\data\august\burst\strain\long
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[toroff], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName tor26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[torspec], Append=No, Blocksize=8100,
Overlap=0, Window=Uniform, Weighting=None, Average Type=PeakHold, IntDiff=0,
Units=Linear, RMS=No, dbRef=1.0
}
REMOVEGLOBALKEY Key=toroff
REMOVEGLOBALKEY Key=torspec
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\strain\long
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[stroff], Scale=1,
Offset=[offsetval], Append=On
```

```
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName str26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[strspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=stroff
REMOVEGLOBALKEY Key=strspec
REMOVEGLOBALKEY Key=offsetval

SELECT DM_Directory c:\wabasha\data\august\burst\strain\long
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[weaoff], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName wea26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[weaspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
REMOVEGLOBALKEY Key=weaoff
REMOVEGLOBALKEY Key=weaspec
REMOVEGLOBALKEY Key=offsetval
```

SPEC2.PRS

```
SETGLOBALKEY Key=torspec2,
Text=c:\wabasha\data\august\burst\spec\strain\tor26_2.def
SETGLOBALKEY Key=strspec2,
Text=c:\wabasha\data\august\burst\spec\strain\str26_2.def
SETGLOBALKEY Key=weaspec2,
Text=c:\wabasha\data\august\burst\spec\strain\wea26_2.def

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=+, Value1=[Stats_MaxTime], Value2=2, Key=upper, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=0, XUpper=[upper], Output=[torspec2],
Append=On, Value=0.0

STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper

END

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=+, Value1=[Stats_MaxTime], Value2=2, Key=upper, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=0, XUpper=[upper], Output=[strspec2],
Append=On, Value=0.0

STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper

END

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=+, Value1=[Stats_MaxTime], Value2=2, Key=upper, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=0, XUpper=[upper], Output=[weaspec2],
Append=On, Value=0.0
```

```
STATISTICS ClearKeys=Yes
END
REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper
REMOVEGLOBALKEY Key=torspec2
REMOVEGLOBALKEY Key=strspec2
REMOVEGLOBALKEY Key=weaspec2
```

SPEC3.PRS

```
SETGLOBALKEY Key=torspec3,
Text=c:\wabasha\data\august\burst\spec\strain\tor26_3.def
□
SETGLOBALKEY Key=strspec3,
Text=c:\wabasha\data\august\burst\spec\strain\str26_3.def
□
SETGLOBALKEY Key=weaspec3,
Text=c:\wabasha\data\august\burst\spec\strain\wea26_3.def

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName tor26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=+, Value1=[Stats_MaxTime], Value2=1.1, Key=upper, Display=Accurate
MATH Type=-, Value1=[Stats_MaxTime], Value2=1.1, Key=lower, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=[lower], XUpper=[upper],
Output=[torspec3],  Append=On,Value=0.0

STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper

END

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName str26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=+, Value1=[Stats_MaxTime], Value2=1.1, Key=upper, Display=Accurate
MATH Type=-, Value1=[Stats_MaxTime], Value2=1.1, Key=lower, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=[lower], XUpper=[upper],
Output=[strspec3],  Append=On,Value=0.0

STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper

END

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName wea26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]
```

```
MATH Type=+, Value1=[Stats_MaxTime], Value2=1.1, Key=upper, Display=Accurate
MATH Type=-, Value1=[Stats_MaxTime], Value2=1.1, Key=lower, Display=Accurate

POKE Chan1=[DM_ChanList.chan], XLower=[lower], XUpper=[upper],
Output=[weaspec3],  Append=On,Value=0.0

STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=lower
REMOVEGLOBALKEY Key=upper
REMOVEGLOBALKEY Key=torspec3
REMOVEGLOBALKEY Key=strspec3
REMOVEGLOBALKEY Key=weaspec3
```

TEXT.PRS

```
SETGLOBALKEY Key=input, Text=c:\wabasha\zip\october\oct16.dat
□

□
SETGLOBALKEY Key=totstat,
Text=c:\wabasha\data\august\results\burst\text\totstat.txt
SETGLOBALKEY Key=trigacc,
Text=c:\wabasha\data\august\results\burst\text\trigacc.txt
SETGLOBALKEY Key=toracc,
Text=c:\wabasha\data\august\results\burst\text\toracc.txt
SETGLOBALKEY Key=stracc,
Text=c:\wabasha\data\august\results\burst\text\stracc.txt
SETGLOBALKEY Key=weaacc,
Text=c:\wabasha\data\august\results\burst\text\weaacc.txt
SETGLOBALKEY Key=trigspec,
Text=c:\wabasha\data\august\results\burst\text\trigspec.txt
SETGLOBALKEY Key=weaspec,
Text=c:\wabasha\data\august\results\burst\text\weaspec.txt
SETGLOBALKEY Key=strspec,
Text=c:\wabasha\data\august\results\burst\text\strspec.txt
SETGLOBALKEY Key=torspec,
Text=c:\wabasha\data\august\results\burst\text\torspec.txt
SETGLOBALKEY Key=long,
Text=c:\wabasha\data\august\results\burst\text\long.txt
SETGLOBALKEY Key=rose,Text=c:\wabasha\data\august\results\burst\text\rose.txt
SETGLOBALKEY Key=straspec,
Text=c:\wabasha\data\august\results\burst\text\straspec.txt
SETGLOBALKEY Key=spec2,
Text=c:\wabasha\data\august\results\burst\text\spec2.txt
SETGLOBALKEY Key=spec3,
Text=c:\wabasha\data\august\results\burst\text\spec3.txt
SETGLOBALKEY Key=speed,
Text=c:\wabasha\data\august\results\burst\text\speed.txt
SETGLOBALKEY Key=direct,
Text=c:\wabasha\data\august\results\burst\text\direct.txt

MATH Type=/, Value1=[[input]-L1.DM_NumPoints], Value2=180000, Key=rectime,
Format=Accurate
MATH Type=/, Value1=[[input]-L1.DM_ElapsedTime], Value2=3600, Key=samtime,
Format=Accurate

MAKEFILE File=[totstat]
Total burst history record information

Upload date         [[input]-L1.DM_FileDate]
Upload  time              [[input]-L1.DM_FileTime]
Start date          [[input]-L1.DM_RunDate]
Start time          [[input]-L1.DM_RunTime]
Test title          [[input]-L1.DM_TestTitle]
Recording           [rectime]
Sampling            [samtime]

END MAKE
```

```
REMOVEGLOBALKEY Key=totstat
REMOVEGLOBALKEY Key=rectime
REMOVEGLOBALKEY Key=samtime


MAKEFILE File=[trigacc]
Accelerations from torsional trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[trigacc], Append=On
[Stats_MaxVal]     [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[trigacc], Append=On

Accelerations from strong  trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[trigacc], Append=On
[Stats_MaxVal]     [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[trigacc], Append=On

Accelerations from weak trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[trigacc], Append=On
```

```
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=trigacc

MAKEFILE File=[toracc]
Torsional accelerations from strong trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName str26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[toracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[toracc], Append=On

Torsional accelerations from weak trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[toracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=toracc

MAKEFILE File=[stracc]
Strong-axis accelerations from weak trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName wea26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]
```

```
MAKEFILE File=[stracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[stracc], Append=On

Strong-axis accelerations from torsion trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[stracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=stracc

MAKEFILE File=[weaacc]
Weak-axis accelerations from torsion trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName tor26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[weaacc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[weaacc], Append=On

Weak-axis accelerations from strong trigger
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\accel
SELECT DM_FileName str26_2.def

FOR DM_ChanList
```

```
STATISTICS [DM_ChanList]

MAKEFILE File=[weaacc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=weaacc

MAKEFILE File=[trigspec]
Torsional acceleration spectrum due to torsional trigger
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[trigspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

MAKEFILE File=[trigspec], Append=On

Strong-Axis acceleration spectrum from strong trigger
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[trigspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END


MAKEFILE File=[trigspec], Append=On
```

```
Weak-axis acceleration spectrum from weak trigger
max    mean   fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[trigspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END
REMOVEGLOBALKEY Key=trigspec

MAKEFILE File=[torspec]
Torsional acceleration spectrum from strong trigger
max    mean   fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName str26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[torspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

MAKEFILE File=[torspec], Append=On

Torsional acceleration spectrum from weak trigger
max    mean   fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName wea26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]
```

```
MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[torspec], Append=On
[Stats_MaxVal]     [Stats_Mean]       [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

REMOVEGLOBALKEY Key=torspec

MAKEFILE File=[strspec]
Strong-axis acceleration spectrum from weak trigger
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName wea26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[strspec], Append=On
[Stats_MaxVal]     [Stats_Mean]       [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

MAKEFILE File=[strspec], Append=On

Strong-axis acceleration spectrum from torsion trigger
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName tor26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[strspec], Append=On
[Stats_MaxVal]     [Stats_Mean]       [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END
```

```
REMOVEGLOBALKEY Key=strspec

MAKEFILE File=[weaspec]
Weak-axis acceleration spectrum from torsion trigger
max    mean   fn     ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName tor26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[weaspec], Append=On
[Stats_MaxVal]     [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

MAKEFILE File=[weaspec], Append=On

Weak-axis acceleration spectrum from strong trigger
max    mean   fn     ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\accel
SELECT DM_FileName str26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[weaspec], Append=On
[Stats_MaxVal]     [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

REMOVEGLOBALKEY Key=weaspec

MAKEFILE File=[long]
Strains due to torsional trigger
max    min    mean   RMS    change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName tor26.def
```

```
FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=stradiff,
Display=Accurate

MAKEFILE File=[long], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [stradiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=stradiff
END

MAKEFILE File=[long], Append=On

Strains from strong trigger
max   min   mean  RMS   change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=stradiff,
Display=Accurate

MAKEFILE File=[long], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [stradiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=stradiff
END

MAKEFILE File=[long], Append=On

Strains from weak trigger
max   min   mean  RMS   change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\offset\long
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=stradiff,
Display=Accurate

MAKEFILE File=[long], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [stradiff]
END
```

```
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=stradiff
END
REMOVEGLOBALKEY Key=long


MAKEFILE File=[rose]
Strain rosette due to torsional trigger
max   min   mean  RMS   change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\strain\rose
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=rosdiff,
Display=Accurate

MAKEFILE File=[rose], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [rosdiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=rosdiff
END

MAKEFILE File=[rose], Append=On

Strain rosette due to strong trigger
max   min   mean  RMS   change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\strain\rose
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-,Value1=[Stats_MaxVal],Value2=[Stats_MinVal], Key=rosdiff,
Display=Accurate

MAKEFILE File=[rose], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [rosdiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=rosdiff
END

MAKEFILE File=[rose], Append=On

Strain rosette due to weak trigger
max   min   mean  RMS   change
END MAKE
```

```
SELECT DM_Directory c:\wabasha\data\august\burst\strain\rose
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal],Value2=[Stats_MinVal], Key=rosdiff,
Display=Accurate

MAKEFILE File=[rose], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]      [Stats_RMS] [rosdiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=rosdiff
END
REMOVEGLOBALKEY Key=rose

MAKEFILE File=[straspec]
Strain spectrum due to torsional trigger
max   mean   fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName tor26.def

FOR DM_ChanList
STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[straspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[straspec], Append=On

Strain spectrum due to strong trigger
max   mean   fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[straspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
```

```
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END

MAKEFILE File=[straspec], Append=On

Strain spectrum due to weak trigger
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[straspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END
REMOVEGLOBALKEY Key=straspec

MAKEFILE File=[spec2]
Second spectrum peak due to torsional trigger
max   mean  fn2   ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName tor26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec2], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END

MAKEFILE File=[spec2], Append=On

Second spectrum peak due to strong trigger
max   mean  fn2   ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
```

```
SELECT DM_FileName str26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec2], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END

MAKEFILE File=[spec2], Append=On

Second spectrum peak due to weak trigger
max   mean   fn2   ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName wea26_2.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec2], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END
REMOVEGLOBALKEY Key=spec2

MAKEFILE File=[spec3]
Third spectrum peak due to torsional trigger
max   mean   fn3   ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName tor26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec3], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [str_rat]
```

```
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END

MAKEFILE File=[spec3], Append=On

Third spectrum peak due to strong trigger
max    mean   fn3    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName str26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec3], Append=On
[Stats_MaxVal]     [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END

MAKEFILE File=[spec3], Append=On

Third spectrum peak due to weak trigger
max    mean   fn3    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\spec\strain
SELECT DM_FileName wea26_3.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=str_rat,
Display=Accurate

MAKEFILE File=[spec3], Append=On
[Stats_MaxVal]     [Stats_Mean]      [Stats_MaxTime]    [str_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=str_rat
END
REMOVEGLOBALKEY Key=spec3

MAKEFILE File=[speed]
Wind speed for torsional trigger
max    min    mean
END MAKE
```

```
SELECT DM_Directory c:\wabasha\data\august\burst\speed
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[speed], Append=On
[Stats_MaxVal]     [Stats_MinVal]     [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[speed], Append=On

Wind speed for strong trigger
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\speed
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[speed], Append=On
[Stats_MaxVal]     [Stats_MinVal]     [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[speed], Append=On

Wind speed for weak trigger
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\speed
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[speed], Append=On
[Stats_MaxVal]     [Stats_MinVal]     [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=speed

MAKEFILE File=[direct]
Wind direction for torsional trigger
max   min   mean
END MAKE
```

```
SELECT DM_Directory c:\wabasha\data\august\burst\direct
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[direct], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[direct], Append=On

Wind direction from strong trigger
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\direct
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[direct], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

MAKEFILE File=[direct], Append=On

Wind direction from weak trigger
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\burst\direct
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[direct], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=direct
REMOVEGLOBALKEY Key=input
```

SAVE.PRS

```
SETGLOBALKEY Key=save, Text=c:\wabasha\zip\october\oct9.dat
SETGLOBALKEY Key=temp1, Text=c:\wabasha\data\august\compon\time\temp.def
SETGLOBALKEY Key=temp2, Text=c:\wabasha\data\august\compon\time\temp2.def

{
DELETEDATA Chan1=[save]-L12,Chan2=[save]-L13,Chan3=[save]-L14,
Chan4=[save]-L15,Chan5=[save]-L16,Chan6=[save]-L17,Chan7=[save]-
L18,Chan8=[save]-L19,
Chan9=[save]-L20,Chan10=[save]-L21,Chan11=[save]-L22,Chan12=[save]-
L23,XLower=0,
XUpper=68.58, Output=[temp1], Append=Off
}
{
DELETEDATA Chan1=[temp1]-L1,Chan2=[temp1]-L2,Chan3=[temp1]-L3,Chan4=[temp1]-
L4,
Chan5=[temp1]-L5,Chan6=[temp1]-L6,Chan7=[temp1]-L7,Chan8=[temp1]-
L8,Chan9=[temp1]-L9,
Chan10=[temp1]-L10,Chan11=[temp1]-L11,Chan12=[temp1]-L12,XLower=4371.08,
XUpper=4405.66, Output=[temp2], Append=off
}
REMOVEGLOBALKEY Key=save
REMOVEGLOBALKEY Key=temp1
REMOVEGLOBALKEY Key=temp2
```

GT_WIND.PRS

```
SETGLOBALKEY Key=input, Text=c:\wabasha\data\august\compon\time\aug26.def

SETGLOBALKEY Key=trigger, Text=c:\wabasha\data\august\trigger\wind26.def
SETGLOBALKEY Key=prelim, Text=c:\wabasha\data\august\time\prelim\pre26.def

SETGLOBALKEY Key=acc_off,
Text=c:\wabasha\data\august\time\offset\accel\off26.def
SETGLOBALKEY Key=calc, Text=c:\wabasha\data\august\time\calc\calc26.def
SETGLOBALKEY Key=ros_off,
Text=c:\wabasha\data\august\time\offset\rose\off26.def
SETGLOBALKEY Key=toracc, Text=c:\wabasha\data\august\time\accel\tor26.def
SETGLOBALKEY Key=stracc, Text=c:\wabasha\data\august\time\accel\str26.def
SETGLOBALKEY Key=weaacc, Text=c:\wabasha\data\august\time\accel\wea26.def
SETGLOBALKEY Key=long, Text=c:\wabasha\data\august\time\long\long26.def
SETGLOBALKEY Key=rose, Text=c:\wabasha\data\august\time\rose\rose26.def
SETGLOBALKEY Key=speed, Text=c:\wabasha\data\august\time\speed\spe26.def
SETGLOBALKEY Key=direct, Text=c:\wabasha\data\august\time\direct\dir26.def
SETGLOBALKEY Key=time, Text=c:\wabasha\data\august\time\time\time26.def

SETGLOBALKEY Key=tempburst, Text=c:\wabasha\data\august\time\temp\tempbur.def
SETGLOBALKEY Key=tempdelete,
Text=c:\wabasha\data\august\time\temp\tempdel.def
{
DESKCALCULATOR Chan1=[input]-L2, Equation=Chan1>=35, Chname=wind_trig,
Desc=wind trigger, Output=[trigger]
}
{
SAVEFILEAS Output=[prelim], Chan1=[input]-L1,Chan2=[input]-L2,Chan3=[input]-
L3,Chan4=[input]-L4,
Chan5=[input]-L5,Chan6=[input]-L6,Chan7=[input]-L7, Chan8=[input]-
L8,Chan9=[input]-L9,Chan10=[input]-L10,
Chan11=[input]-L11, Chan12=[input]-L12,Chan13=[trigger]-L1
}
SAVEFILEAS Output=[toracc],Chan1=[prelim]-L9
SAVEFILEAS Output=[stracc], Chan1=[prelim]-L10
SAVEFILEAS Output=[weaacc],Chan1=[prelim]-L11
SAVEFILEAS Output=[long], Chan1=[prelim]-L3
SAVEFILEAS Output=[speed], Chan1=[prelim]-L2
SAVEFILEAS Output=[direct], Chan1=[prelim]-L12
SAVEFILEAS Output=[time], Chan1=[prelim]-L1

LABEL Name=start
{
BURSTHISTORY Chan1=[prelim]-L1, Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,
Chan5=[prelim]-L5,Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-
L8,Chan9=[prelim]-L9,Chan10=[prelim]-L10,
Chan11=[prelim]-L11,Chan12=[prelim]-L12,Chan13=[prelim]-L13,
Output=[tempburst],Append=Off,
Trigger=On False-True Transition,  TriggerChan=Chan13,DataType=16 Bit
Integer, AddTimeChannel=Yes,
NumBursts=1, PreTrigger=0.0, PostTrigger=5.0
}
```

```
SETGLOBALKEY Key=burstnum, Text=[[tempburst]-L1.DM_NumPoints]

GOTO Label=continue, Test=[burstnum]

GOTO Label=end

LABEL Name=continue

;     Calculate and apply offsets chan 8 and 9 accelerations

STATISTICS Chan=[tempburst]-L9

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L9, Output=[acc_off], Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

STATISTICS Chan=[tempburst]-L10

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L10, Output=[acc_off], Append=On, Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

;     Calculate strong-axis and torsional accelerations
{
DESKCALCULATOR Chan1=[acc_off]-L1, Chan2=[acc_off]-L2, Equation=Chan1-Chan2,
Chname=calc_tor,
Desc=calculated torsion, Output=[calc]
}
{
DESKCALCULATOR Chan1=[acc_off]-L1, Chan2=[acc_off]-L2,
Equation=(Chan1+Chan2)/2, Chname=calc_str,
Desc=calculated strong axis, Output=[calc], Append=On
}
;     Calculate and apply offset to weak-axis acceleration

STATISTICS Chan=[tempburst]-L11

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L11, Output=[calc], Append=On, Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

;     Calculate and apply offsets to rosette strains

STATISTICS Chan=[tempburst]-L4

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
```

```
SCALEANDOFFSET Chan1=[tempburst]-L4, Output=[ros_off], Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

STATISTICS Chan=[tempburst]-L5

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L5, Output=[ros_off], Append=On, Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

STATISTICS Chan=[tempburst]-L6

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate

SCALEANDOFFSET Chan1=[tempburst]-L6, Output=[ros_off], Append=On, Scale=1,
Offset=[offsetval]

STATISTICS ClearKeys=Yes

;     Perform rosette analysis
{
ROSETTE Chan1=[ros_off]-L1, Chan2=[ros_off]-L2, Chan3=[ros_off]-
L3,Output=[rose], Append=On,
RosetteType=Rectangular, ModulusUnits=ksi, Modulus=29000,PoissonRatio=0.29,
OutputAxialStrains=On,OutputPrincipalStrains=On,OutputShearStrains=On,
BeginAngle=0,EndAngle=90,AngleIncrement=45
}

SAVEFILEAS Output=[toracc], Append=On, Chan1=[calc]-L1
SAVEFILEAS Output=[stracc], Append=On, Chan1=[calc]-L2
SAVEFILEAS Output=[weaacc], Append=On, Chan1=[calc]-L3
SAVEFILEAS Output=[long], Append=On,Chan1=[tempburst]-L3,Chan2=[tempburst]-
L7,Chan3=[tempburst]-L8
SAVEFILEAS Output=[speed], Append=On,Chan1=[tempburst]-L2
SAVEFILEAS Output=[direct], Append=On,Chan1=[tempburst]-L12
SAVEFILEAS Output=[time], Append=On, Chan1=[tempburst]-L1

SETGLOBALKEY Key=updel, Text=[[tempburst]-L13.DM_MaxValue]
{
DELETEDATA Chan1=[prelim]-L1,Chan2=[prelim]-L2,Chan3=[prelim]-
L3,Chan4=[prelim]-L4,Chan5=[prelim]-L5,
Chan6=[prelim]-L6,Chan7=[prelim]-L7,Chan8=[prelim]-L8,Chan9=[prelim]-
L9,Chan10=[prelim]-L10,Chan11=[prelim]-L11,
Chan12=[prelim]-L12, Chan13=[prelim]-L13,XLower=0.0, XUpper=[updel],
Output=[tempdelete], Append=Off
}
{
SAVEFILEAS Output=[prelim], Append=Off, Chan1=[tempdelete]-L1,
Chan2=[tempdelete]-L2,Chan3=[tempdelete]-L3,
Chan4=[tempdelete]-L4,Chan5=[tempdelete]-L5,Chan6=[tempdelete]-
L6,Chan7=[tempdelete]-L7,Chan8=[tempdelete]-L8,
Chan9=[tempdelete]-L9,Chan10=[tempdelete]-L10,Chan11=[tempdelete]-
L11,Chan12=[tempdelete]-L12,
```

```
Chan13=[tempdelete]-L13
}
GOTO Label=start

LABEL Name=end

REMOVEGLOBALKEY Key=input
REMOVEGLOBALKEY Key=trigger
REMOVEGLOBALKEY Key=prelim
REMOVEGLOBALKEY Key=offset
REMOVEGLOBALKEY Key=ros_off
REMOVEGLOBALKEY Key=acc_off
REMOVEGLOBALKEY Key=toracc
REMOVEGLOBALKEY Key=stracc
REMOVEGLOBALKEY Key=weaacc
REMOVEGLOBALKEY Key=long
REMOVEGLOBALKEY Key=rose
REMOVEGLOBALKEY Key=speed
REMOVEGLOBALKEY Key=direct
REMOVEGLOBALKEY Key=time
REMOVEGLOBALKEY Key=offsetval
REMOVEGLOBALKEY Key=tempburst
REMOVEGLOBALKEY Key=tempdelete
REMOVEGLOBALKEY Key=burstnum
REMOVEGLOBALKEY Key=updel
REMOVEGLOBALKEY Key=calc
```

WIND_ANA.PRS

```
SETGLOBALKEY Key=torspec, Text=c:\wabasha\data\august\time\spec\tor26.def
SETGLOBALKEY Key=strspec, Text=c:\wabasha\data\august\time\spec\str26.def
SETGLOBALKEY Key=weaspec, Text=c:\wabasha\data\august\time\spec\wea26.def
SETGLOBALKEY Key=offset,
Text=c:\wabasha\data\august\time\offset\long\off26.def

;     Calculate and apply offsets to strain bursts

SELECT DM_Directory c:\wabasha\data\august\time\long
SELECT DM_FileName long26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Value1=0.0, Value2=[Stats_Mean], Type=-, Key=offsetval, Form=Accurate
{
SCALEANDOFFSET Chan1=[DM_ChanList.chan], Output=[offset], Scale=1,
Offset=[offsetval], Append=On
}
STATISTICS ClearKeys=Yes

END

;     Perform spectral analysis

SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName tor26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[torspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName str26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[strspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}
SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName wea26.def
SELECTALL
{
AUTOPOWER [WholeDM_Active], Output=[weaspec],
Append=No, Blocksize=8100, Overlap=0, Window=Uniform, Weighting=None,
AverageType=PeakHold, IntDiff=0, Units=Linear, RMS=No, dBRef=1.0
}

REMOVEGLOBALKEY Key=torspec
REMOVEGLOBALKEY Key=strspec
```

```
REMOVEGLOBALKEY Key=weaspec
REMOVEGLOBALKEY Key=offset
REMOVEGLOBALKEY Key=offsetval
```

TEXT2.PRS

```
SETGLOBALKEY Key=input, Text=c:\wabasha\zip\october\oct16.dat

SETGLOBALKEY Key=totstat,
Text=c:\wabasha\data\august\results\time\text\totstat.txt
SETGLOBALKEY Key=toracc,
Text=c:\wabasha\data\august\results\time\text\toracc.txt
SETGLOBALKEY Key=stracc,
Text=c:\wabasha\data\august\results\time\text\stracc.txt
SETGLOBALKEY Key=weaacc,
Text=c:\wabasha\data\august\results\time\text\weaacc.txt
SETGLOBALKEY Key=torspec,
Text=c:\wabasha\data\august\results\time\text\torspec.txt
SETGLOBALKEY Key=strspec,
Text=c:\wabasha\data\august\results\time\text\strspec.txt
SETGLOBALKEY Key=weaspec,
Text=c:\wabasha\data\august\results\time\text\weaspec.txt
SETGLOBALKEY Key=long, Text=c:\wabasha\data\august\results\time\text\long.txt
SETGLOBALKEY Key=rose,Text=c:\wabasha\data\august\results\time\text\rose.txt
SETGLOBALKEY Key=speed,
Text=c:\wabasha\data\august\results\time\text\speed.txt
SETGLOBALKEY Key=direct,
Text=c:\wabasha\data\august\results\time\text\direct.txt
SETGLOBALKEY Key=time, Text=c:\wabasha\data\august\results\time\text\time.txt
SETGLOBALKEY Key=tabular,
Text=c:\wabasha\data\august\results\time\text\tab.txt

MATH Type=/, Value1=[[input]-L13.DM_NumPoints], Value2=180000, Key=rectime,
Format=Accurate
MATH Type=/, Value1=[[input]-L13.DM_ElapsedTime], Value2=3600, Key=samtime,
Format=Accurate

MAKEFILE File=[totstat]
Entire time history record information

Upload date         [[input]-L13.DM_FileDate]
Upload  time              [[input]-L13.DM_FileTime]
Start date          [[input]-L13.DM_RunDate]
Start time          [[input]-L13.DM_RunTime]
Test title          [[input]-L13.DM_TestTitle]
Recording           [rectime]
Sampling            [samtime]


END MAKE

REMOVEGLOBALKEY Key=totstat
REMOVEGLOBALKEY Key=rectime
REMOVEGLOBALKEY Key=samtime


MAKEFILE File=[toracc]
Torsional accelerations from time history burst
max   min
```

```
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[toracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=toracc

MAKEFILE File=[stracc]
Strong-axis accelerations from time history burst
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[stracc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=stracc

MAKEFILE File=[weaacc]
Weak-axis accelerations from time history burst
max   min
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\accel
SELECT DM_FileName wea26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[weaacc], Append=On
[Stats_MaxVal]    [Stats_MinVal]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=weaacc
```

```
MAKEFILE File=[torspec]
Torsional acceleration spectrum from time history burst
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\spec
SELECT DM_FileName tor26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[torspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

REMOVEGLOBALKEY Key=torspec

MAKEFILE File=[strspec]
Strong-axis acceleration spectrum from time history burst
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\spec
SELECT DM_FileName str26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[strspec], Append=On
[Stats_MaxVal]    [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

REMOVEGLOBALKEY Key=strspec

MAKEFILE File=[weaspec]
Weak-axis acceleration spectrum from time history burst
max   mean  fn    ratio
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\spec
SELECT DM_FileName wea26.def

FOR DM_ChanList
```

```
STATISTICS [DM_ChanList]

MATH Type=/, Value1=[Stats_Mean], Value2=[Stats_MaxVal], Key=acc_rat,
Display=Accurate

MAKEFILE File=[weaspec], Append=On
[Stats_MaxVal]     [Stats_Mean]      [Stats_MaxTime]    [acc_rat]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=acc_rat
END

REMOVEGLOBALKEY Key=weaspec


MAKEFILE File=[long]
Strains due to time history burst
max    min    mean   RMS    change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\offset\long
SELECT DM_FileName off26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=stradiff,
Display=Accurate

MAKEFILE File=[long], Append=On
[Stats_MaxVal]     [Stats_MinVal]     [Stats_Mean]      [Stats_RMS] [stradiff]
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=stradiff
END

REMOVEGLOBALKEY Key=long

MAKEFILE File=[rose]
Strain rosette due to time history burst
max    min    mean   RMS    change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\rose
SELECT DM_FileName rose26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MATH Type=-, Value1=[Stats_MaxVal], Value2=[Stats_MinVal], Key=rosdiff,
Display=Accurate

MAKEFILE File=[rose], Append=On
[Stats_MaxVal]     [Stats_MinVal]     [Stats_Mean]      [Stats_RMS] [rosdiff]
```

```
END
STATISTICS ClearKeys=Yes
REMOVEGLOBALKEY Key=rosdiff
END

REMOVEGLOBALKEY Key=rose

MAKEFILE File=[speed]
Wind speed for time history burst
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\speed
SELECT DM_FileName spe26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[speed], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=speed

MAKEFILE File=[direct]
Wind direction for time history burst
max   min   mean
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\direct
SELECT DM_FileName dir26.def

FOR DM_ChanList

STATISTICS [DM_ChanList]

MAKEFILE File=[direct], Append=On
[Stats_MaxVal]    [Stats_MinVal]    [Stats_Mean]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=direct

MAKEFILE File=[time]
Elapsed time for time history burst
min   max   change
END MAKE

SELECT DM_Directory c:\wabasha\data\august\time\time
SELECT DM_FileName time26.def

FOR DM_ChanList
```

```
STATISTICS [DM_ChanList]

FORMATNUMBER Value=[DM_ChanList.DM_MinValue], Format=6.0f, Key=min
FORMATNUMBER Value=[DM_ChanList.DM_MaxValue], Format=6.0f, Key=max

MATH Type=-, Value1=[max], Value2=[min], Key=change, Display=Accurate

FORMATNUMBER Value=[change], Format=6.0f, Key=change

MAKEFILE File=[time], Append=On
[min] [max] [change]
END
STATISTICS ClearKeys=Yes
END

REMOVEGLOBALKEY Key=time
REMOVEGLOBALKEY Key=input
REMOVEGLOBALKEY Key=change
REMOVEGLOBALKEY Key=max
REMOVEGLOBALKEY Key=min
REMOVEGLOBALKEY Key=tabular
```