CHARA TECHNICAL REPORT

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Vibration Tests on the Western OPLE Inertial Slab

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1. INTRODUCTION

The beams from the five telescopes of the CHARA Array all converge at a central building which houses the optical delay lines as well as the beam combination optics. The building is L-shaped with the long part of the "L" running east-west and the short part pointing south. The foundation of this building is segmented to reduce vibration transmission. There are a number of "inertial" slabs which are 24 inches thick set in key locations throughout the building. Around these slabs is a continuously poured floor, four inches thick, which is not coupled to the inertial slabs, and which supports both the inner and outer buildings. To investigate the vibration transmission characteristics of the building floor, vibration power spectra were taken at five locations on the inertial slab just to the west of the optical delay lines. This slab is to support optical tables with beam compressors, longitudinal dispersion correctors, and beam switching mechanisms.

2. DESCRIPTION OF TEST AND EQUIPMENT USED

Measurements at the five locations were made in both the vertical direction (up-and-down motion of the slab) and the horizontal direction (side-to-side motion of the slab). The data were taken while a construction crew was still working at the east end of the building. One set of data was taken while the 100 inch telescope dome was continuously rotating at maximum speed.

The measurements consisted of continuously recording acceleration data from a seismic accelerometer in physical contact with the inertial slab. The integration time was about 1.6 seconds. A Fourier transform was then calculated to generate the power spectral density of the vibration. Finally, ten trials were averaged to smooth the data a bit.

The measurements were made with a Wilcoxon Research[2] Model 731A Seismic Accelerometer attached to a Model P31 Power Unit and Amplifier (also made by Wilcoxon Research) which in turn output the signal to an Intel based 486 which was running a spectrum analysis application written by Data Physics (408-371-7100). The application discarded the raw

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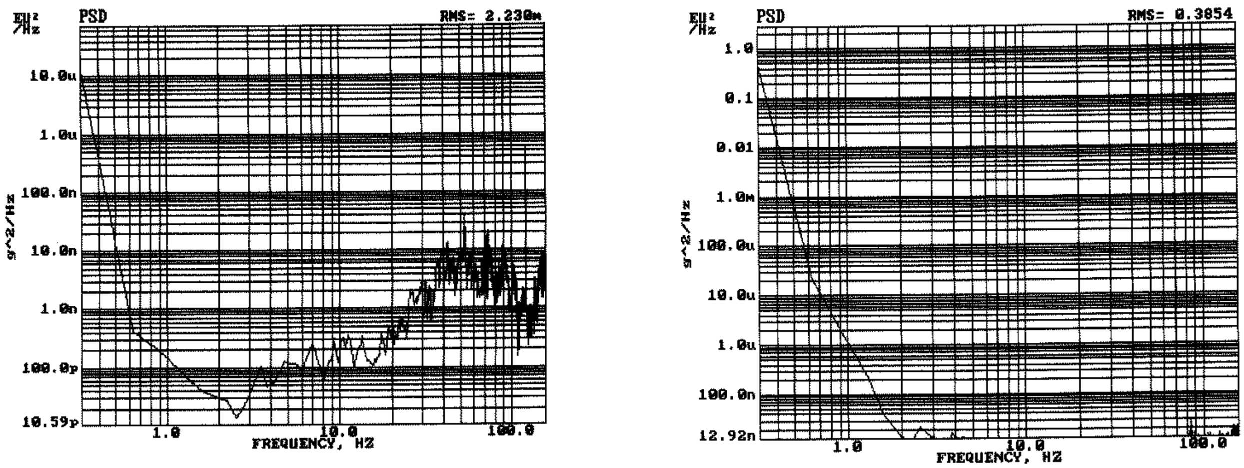

FIGURE 1. The power spectral density vs. frequency for the southeast corner of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building.

data and printed a graph of the power spectral density. These graphs are reproduced in Figures 1 – 6 and discussed below.

3. DATA ANALYSIS AND TABLE MOTION

The sampling rate of the spectrum analyzer was 320 Hz for all of the data sets. This gives an upper limit of 160 Hz for the frequencies measured. The integration time for all the data sets was 1.5625 sec (500 cycles at 320 cycles per second). This gives a lower limit of 1.28 Hz for the frequencies measured.

The tables that are to go on the inertial slab are $4' \times 12' \times 12''$ thick Newport model RS2000. These tables are expected to have peak resonances at about 130 Hz. At this point, the "Q" value (a unitless measure of the how table differs from an ideal rigid body at the peak resonance) will be on the order of 20. Away from resonance, the Q value will be about 1. An estimate of the maximum relative motion from one end of the table to the other induced by vibration is given by:

$$\mathrm{RM}_{max} = g\Big(\frac{1}{32\pi^3}\Big)^{1/2} \cdot \Big(\frac{\mathrm{Q}}{\nu_{res}}\Big)^{1/2} \cdot (\mathrm{PSD})^{1/2} \cdot 2$$

In this equation, PSD is the power spectral density. It should be noted that the values here are dominated by the Q value at resonance and its associated PSD. Even though the PSD is largest around 50 Hz in most of the data sets, Q is about 1, and as a result, the relative motion is actually lower than at resonance. Relative motion at resonance is about 81 nm.

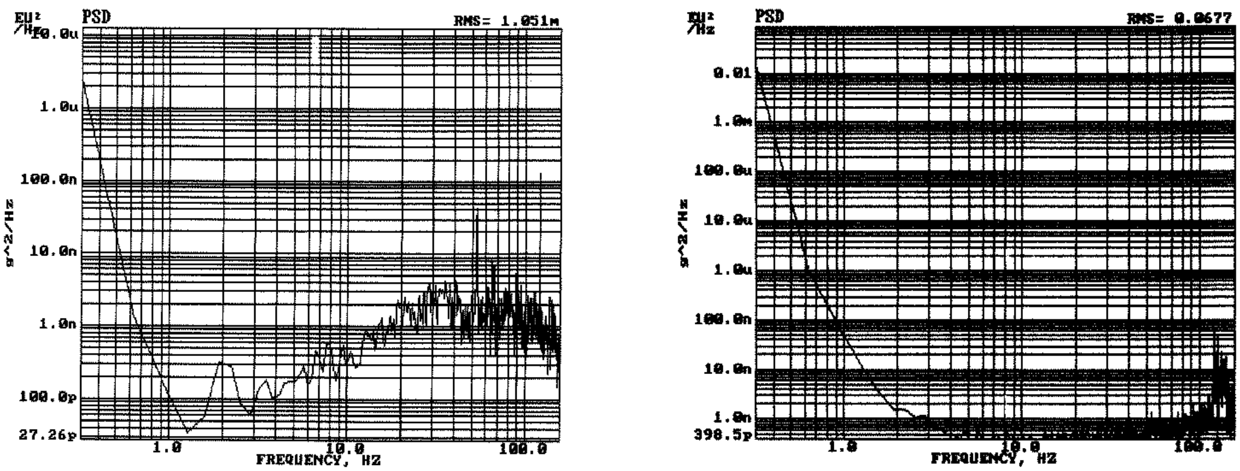

FIGURE 2. The power spectral density vs. frequency for the northeast corner of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building.

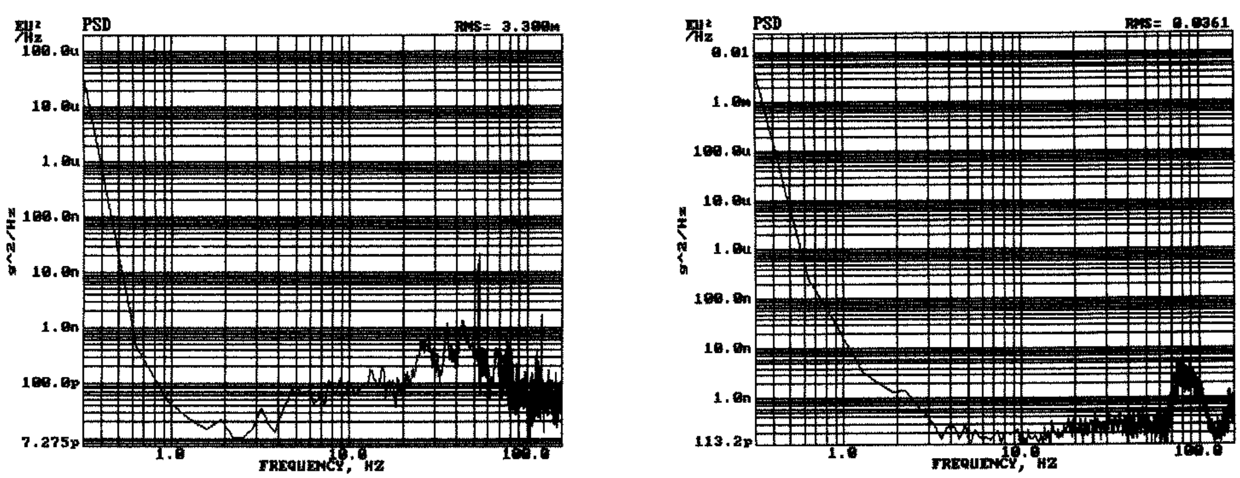

FIGURE 3. The power spectral density vs. frequency for the northwest corner of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building.

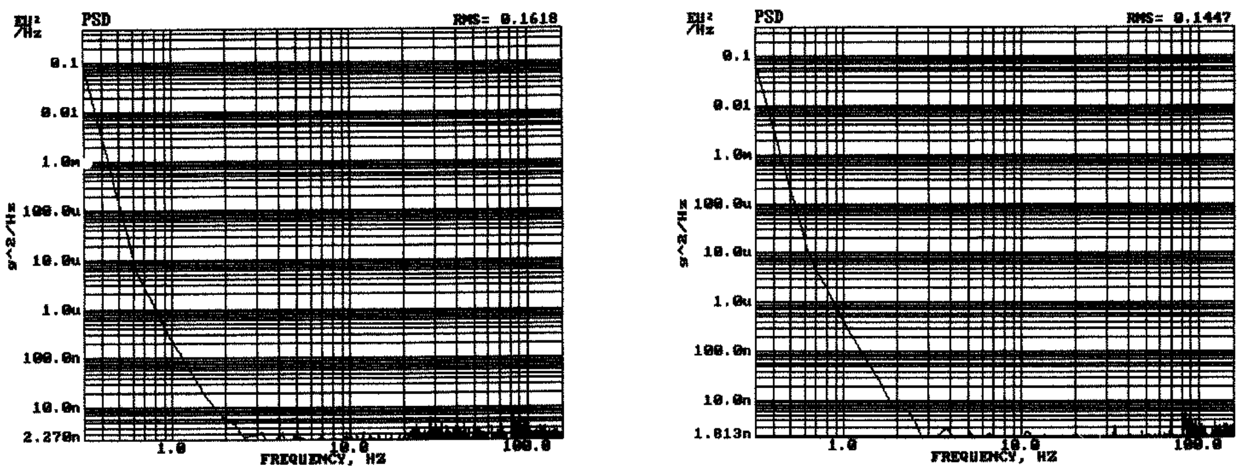

FIGURE 4. The power spectral density vs. frequency for the southwest corner of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building.

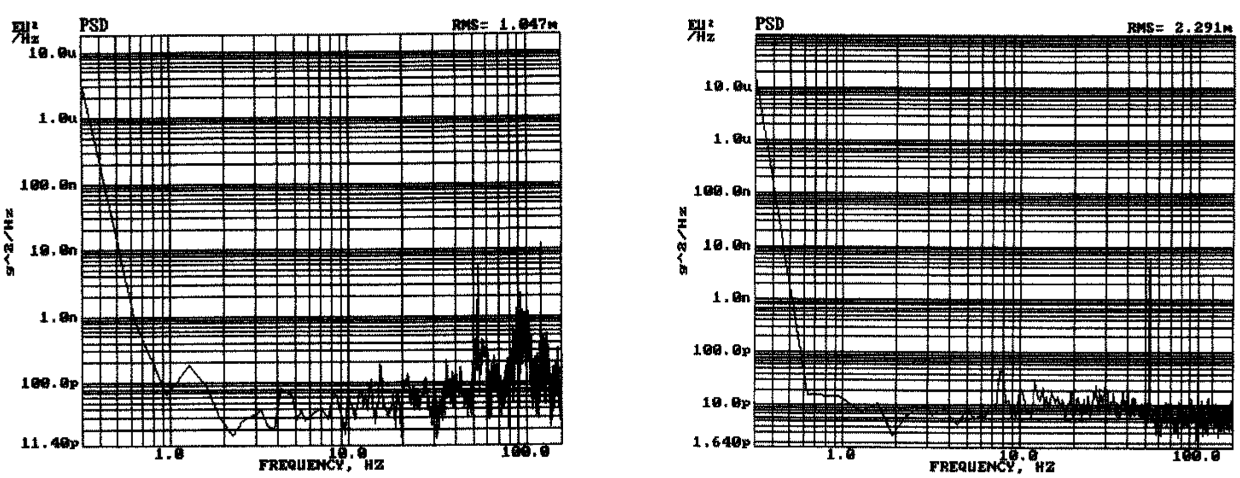

FIGURE 5. The power spectral density vs. frequency for the center of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building.

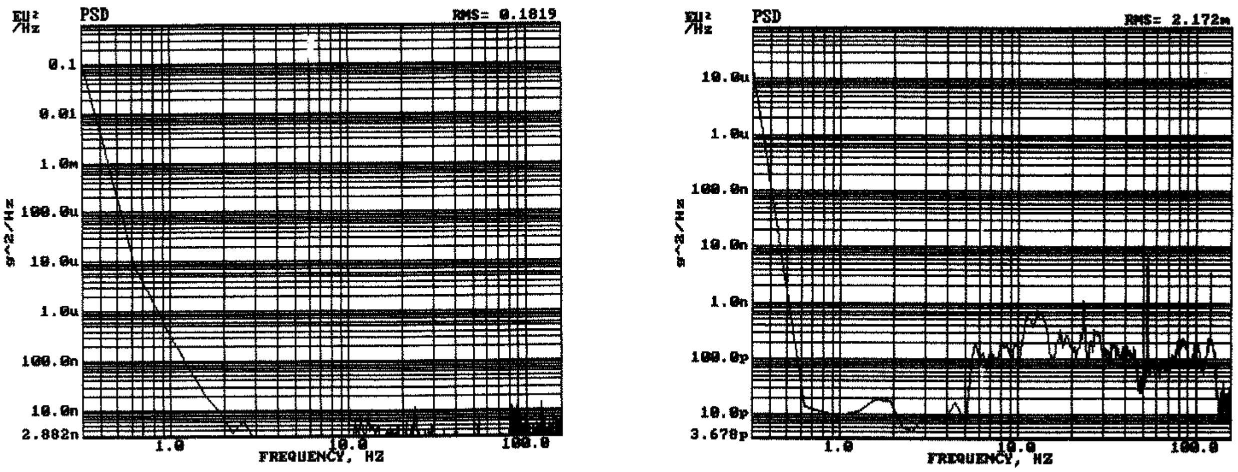

FIGURE 6. The power spectral density vs. frequency for the center of the inertial slab. The left panel is data in the vertical direction and the right panel is data in the horizontal direction. A construction crew was working at the east end of the building and the 100 inch telescope dome was rotating at maximum speed.

4. CONCLUSION

It should be noted that this analysis is preliminary. It would be very enlightening to see if the magnitude of the PSD gets lower at higher frequencies. This could be accomplished by running the spectrum analyzer at a higher sampling rate. A longer integration time would enable one to investigate the vibrations at lower frequencies. It was noted by S. Ridgway that the Mark III group could measure the vibration from the 100-inch telescope dome, five times further away than these measurements were made. Upon inspection of Figures 5 and 6, however, the present measurements showed no effect. It is possible that a lower frequency analysis might shed some light on this dilemma.

5. REFERENCES

Data Physics, "Operating Guide: Model DP420 Power Spectrum Analyzer"
Wilcoxon Research, Inc., "Operating Guide: Model 731A Seismic Accelerometer and Model P31 Power Unit/Amplifier", Operating Instructions 90225, Rev. B2, October 1994