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March 15, 2013

Mr. Paul A. Zilio, P.E.
BLISS & NYITRAY, INC.
800 Douglas Road, Suite 300
Coral Gables, Florida 33134

Re: Report of Vibration Monitoring
MARC and AHC3 Buildings
Florida International University
11200 SW 8th Street
Miami-Dade County, Florida
KACO Project No. 12307

Dear Mr. Zilio:

KACO, an NV5, Inc. company, presents this letter report of vibration monitoring at the Management and Advanced Research Center (MARC) and Academic Health Center 3 (AHC3) buildings at the Florida International University Campus, 11200 SW 8th Street, Miami, Florida. The work was performed in accordance with our authorized Proposal No. 12-445 dated November 30, 2012. The monitoring was requested as a result of complaints of building vibrations by occupants of campus buildings, including the two subject buildings on or before November of 2012.

PURPOSE

This purpose of the monitoring was to measure and evaluate vibration perceived by occupants of the two buildings and determine where possible the source of the vibration and whether vibration levels had the potential for creating defects in the structures.

SCOPE OF WORK

Our scope of work included installation and monitoring of four instruments at the two subject buildings to measure ground vibration levels, evaluation of the data recorded, and preparation of this report.

INSTRUMENT INSTALLATION

The vibrations produced during the measurement period were recorded with four (4) SSU 3000EZ-plus seismographs. The **SAFEGUARD SEISMIC UNIT 3000EZ-plus** is a self-contained

portable seismograph developed specifically for use in measuring the side effects from activities such as those produced by blasting, pile driving, and vibratory compaction. The seismograph digitally samples three ground motion channels at a rate of over 1,000 samples per second, high enough to permit accurate measurements. For this study, the unit was set to record single vibration events. Immediately following an event, the instrument produced a waveform seismogram. In addition, the instrument printed pre-programmed information, including date, time, location, operator's name and company, triggering levels for vibration, and recording time. Analysis by the unit provided the maximum peak particle velocity in each of three mutually perpendicular components (longitudinal, transverse, and vertical), as well as the associated one-half wave frequency and resultant peak particle velocity.

All instruments were equipped with X10/X100 amplifiers in order to provide sufficient signal for analysis. For this project the X10 amplification setting was used. The instruments were installed on January 9, 2013 and located as follows:

1. SSU 3000EZ-plus seismograph Serial No. 8809 was located along the east wall of the 5th floor of the MARC Building adjacent to the west stairway entrance. The geophone of the instrument was attached to the concrete floor slab in the area.

2. SSU 3000EZ-plus seismograph Serial No. 8793 was located at the northeast corner, ground level of the MARC Building adjacent to the ground level roadway. The geophone of the instrument was buried.

3. SSU 3000EZ-plus seismograph Serial No. 8766 was located along the west wall of the 5th floor conference room of the AHC3 Building. The geophone of the instrument was attached to the concrete floor slab in the area.

4. SSU 3000EZ-plus seismograph Serial No. 8718 was located on the ground level at the approximate center of the AHC3 Building which is along the south side of the structure. The geophone of the instrument was buried.

The units were configured to run for 24-hour periods to measure ground vibration levels produced by outside sources. Measurements were made from January 9, 2013 through February 12, 2013 when the units were removed. The units were set such that the measured peak particle velocity and frequency of each recorded event is compared to the United States Bureau of Mines/Office of Surface Mining and Reclamation blasting level criteria. This function allowed immediate examination of vibration with respect to damage probability criteria, in order to evaluate the effects of the blast.

The seismographic records are appended to this report and are summarized and discussed below.

RESULTS

The measurements made during the monitoring period are summarized in the table below. The data for the events are presented in terms of a peak particle velocity measured in ips, as well as the measured vibration frequency in Hz. Where possible the likely source for the vibration event is also identified. Events correlated to quarry blasting sources are highlighted. As indicated in the table, the majority of the triggered events were the result of blasting operations associated with nearby construction materials mining activity. Others were correlated to internal building activity near the unit.

It should be noted that to facilitate easier signal processing and analysis, the seismograms resulting from the vibration events were amplified by a factor of 10. In essence this increases the instrument sensitivity so that very small vibrations are not missed, and allows better visual appreciation of the graph of the event. As an example, the first event in the table below (3:48 p.m. on January 9, 2013) had an actual peak particle velocity of 0.2003 ips but would show in the appended seismograph records with a peak particle velocity of 2.003 ips.

Table 1 – Summary of Vibration Monitoring for FIU MARC and AHC3 Buildings

Date	Time	Location	Maximum Peak Particle Velocity/ Frequency	Correlated Source
1/9/2013	3:48 p.m.	AHC3 – Interior	0.2003 in./sec.* @ 13.9 Hz	Internal Building Excitation
1/10/2013	12:47 p.m.	MARC - Interior	0.0220 in./sec.* @ 2.5 Hz	Internal Building Excitation
1/10/2013	12:47 p.m.	AHC3 - Interior	0.0173 in./sec.* @ 2.2 Hz	Internal Building Excitation
1/10/2013	1:15 p.m.	AHC3 – Interior	0.0135 in./sec.* @ 2.5 Hz	Dyno Nobel – Cemex SCL
1/11/2013	11:43 a.m.	MARC – Interior	0.0150 in./sec.* @ 2.6 Hz	Vulcan Materials Co.
1/11/2013	11:43 a.m.	AHC3 – Interior	0.0123 in./sec.* @ 2.6 Hz	Vulcan Materials Co.
1/17/2013	11:31 a.m.	MARC – Interior	0.0330 in./sec.* @ 2.5 Hz	Vulcan Materials Co.
1/17/2013	11:32 a.m.	AHC3 – Interior	0.0245 in./sec.* @ 2.5 Hz	Vulcan Materials Co.
1/17/2013	12:58 p.m.	AHC3 – Interior	0.0178 in./sec.* @ 2.6 Hz	Austin Powder – Tarmac
1/17/2013	12:58 p.m.	MARC – Interior	0.0160 in./sec.* @ 2.8 Hz	Austin Powder – Tarmac
1/18/2013	10:59 a.m.	MARC – Interior	0.0133 in./sec.* @ 2.6 Hz	Vulcan Materials Co.

1/18/2013	10:59 a.m.	AHC3 – Interior	0.0140 in./sec.* @ 2.2 Hz	Vulcan Materials Co.
1/22/2013	11:02 a.m.	MARC – Interior	0.0130 in./sec.* @ 7.2 Hz	Internal - Repetitive Motion
1/22/2013	3:18 p.m.	MARC – Interior	0.0150 in./sec.* @ 2.7 Hz	Dyno Nobel – Cemex FEC
1/23/2013	9:16 a.m.	AHC3 – Exterior	0.0245 in./sec.* @ 1.5 Hz	Internal Building Activity near unit
1/23/2013	10:58:25 a.m.	AHC3 – Exterior	0.0170 in./sec.* @ 9.8 Hz	Internal Building Activity near unit
1/23/2013	10:59:12 a.m.	AHC3 – Exterior	0.0105 in./sec.* @ 27.8 Hz	Internal Building Activity near unit
1/23/2013	10:59:52 a.m.	AHC3 – Exterior	0.0113 in./sec.* @ 2.3 Hz	Internal Building Activity near unit
1/23/2013	3:04 p.m.	MARC – Interior	0.0118 in./sec.* @ 0.8 Hz	Dyno Nobel – Cemex FEC
1/23/2013	3:04 p.m.	AHC3 - Interior	0.0113 in./sec.* @ 1.9 Hz	Dyno Nobel – Cemex FEC
1/25/2013	12:00 p.m.	MARC – Interior	0.0198 in./sec.* @ 2.5 Hz	Austin Powder – Tarmac
1/25/2013	12:01 p.m.	AHC3 – Interior	0.0160 in./sec.* @ 2.5 Hz	Austin Powder – Tarmac
1/28/2013	2:58 p.m.	AHC3 - Exterior	0.0130 in./sec.* @ 0.3 Hz	Internal Building Activity near unit
1/29/2013	12:06 p.m.	Marc – Interior	0.0133 in./sec.* @ 0.8 Hz	Vulcan Materials Co.
1/29/2013	12:07 p.m.	AHC3 – Interior	0.0183 in./sec.* @ 2.3 Hz	Vulcan Materials Co.
1/30/2013	3:01 p.m.	AHC3 – Exterior	0.0108 in./sec.* @ 0.5 Hz	Internal Building Activity near unit
1/31/2013	11:16 a.m.	MARC – Interior	0.0138 in./sec.* @ 1.2 Hz	Dyno Nobel – Cemex SCL
1/31/2013	11:16 a.m.	MARC – Exterior	0.0173 in./sec.* @ 23.8 Hz	Dyno Nobel – Cemex SCL
1/31/2013	3:01 p.m.	AHC3 – Exterior	0.0108 in./sec.* @ 0.5 Hz	Internal Building Activity near unit
1/31/2013	3:02 p.m.	AHC3 – Exterior	0.0108 in./sec.* @ 0.4 Hz	WRQ – 6
2/1/2013	1:37 p.m.	MARC – Interior	0.0135 in./sec.* @ 0.9 Hz	Dyno Nobel – Cemex FEC
2/1/2013	1:37 p.m.	AHC3 – Exterior	0.0108 in./sec.* @ 1.0 Hz	Dyno Nobel – Cemex FEC
2/4/2013	1:00 p.m.	MARC – Interior	0.0120 in./sec.* @ 1.2 Hz	Dyno Nobel – Cemex SCL

2/4/2013	1:00 p.m.	MARC– Exterior	0.0160 in./sec.* @ 20.8 Hz	Dyno Nobel – Cemex SCL
2/4/2013	1:01 p.m.	AHC3 – Interior	0.0103 in./sec.* @ 2.6 Hz	Dyno Nobel – Cemex SCL
2/5/2013	12:51 p.m.	MARC – Interior	0.0145 in./sec.* @ 1.7 Hz	Dyno Nobel – Cemex FEC
2/5/2013	12:51 p.m.	AHC3 – Interior	0.0143 in./sec.* @ 1.9 Hz	Dyno Nobel – Cemex FEC
2/7/2013	11:15 a.m.	MARC – Interior	0.0260 in./sec.* @ 1.2 Hz	Vulcan Materials Co.
2/7/2013	11:15 a.m.	MARC – Exterior	0.0150 in./sec.* @ 1.0 Hz	Vulcan Materials Co.
2/7/2013	11:16 a.m.	AHC3 – Interior	0.0153 in./sec.* @ 1.6 Hz	Vulcan Materials Co.
2/7/2013	11:16 a.m.	AHC3 – Exterior	0.0130 in./sec.* @ 1.0 Hz	Vulcan Materials Co.
2/7/2013	2:41 p.m.	MARC – Interior	0.0143 in./sec.* @ 15.2 Hz	Internal Building Activity near unit
2/7/2013	2:57 p.m.	MARC – Interior	0.0140 in./sec.* @ 16.7 Hz	Internal Building Activity near unit
2/8/2013	2:41 p.m.	MARC - Interior	0.0140 in./sec.* 3.6 Hz	Internal Building Activity near unit

DISCUSSION AND CONCLUSION

The vibration records indicate the majority of the events at the interior and exterior of the monitored structures were related to vibration produced by mining operations within the Lakebelt area of western Miami-Dade County. The operations in the Lakebelt produce limerock aggregate materials for construction and utilize blasting as part of the excavation pre-treatment process. Blast energy not used for rock breakage propagates outward from the source as vibration. The levels of vibrations allowed at locations outside of the mining operations are regulated solely by the State of Florida, Division of State Fire Marshal.

The most authoritative publications on blasting vibration and building damage potential have been made by the United States Bureau of Mines, Department of the Interior (USBM). The USBM's reports have studied multiple aspects of vibration and structures with over 70 years of evaluations. The studies conducted have culminated in a series of reports with recommended limits to assist in the prevention of damage to buildings. The most applicable to this evaluation is Report of Investigations No. 8507, Structure Response and Damage Produced from Surface Mine Blasting (Siskind et al, 1980). The report established frequency dependent particle velocity levels to limit damage in fragile building materials. The most fragile materials include plaster on lath and drywall construction materials. In addition, the limits were published to limit or prevent

threshold damage. This type of damage is the most minor cosmetic defect that would be observed such as peeling of paint, extension of existing defects or the formation of new defects at the junctions of building materials. Limits established In RI 8507 are shown in the Figure 1 below.

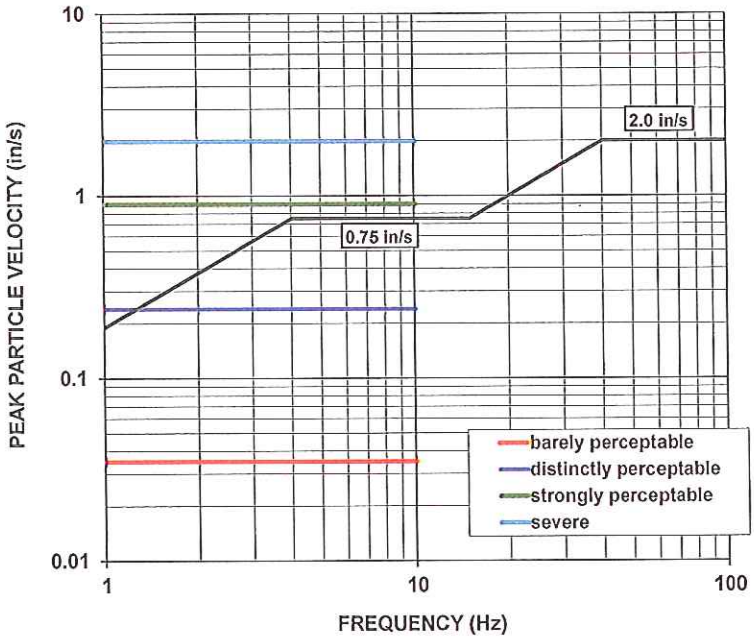

Figure 1 – USBM Vibration Damage Criteria

The State of Florida has adopted these limits on vibration for mining operations. In addition, all blasts detonated are required to be monitored by independent vibration consulting firms. Those measurements are required to be at the closest location to the blasting site. FIU facilities are significantly farther away.

The USBM limits refer to ground motions rather than structure response, since it is generally accepted that the level of vibration felt at the building foundation is typically amplified as the wave propagates up the building to higher floors. This is consistent with the majority of the FIU building complaints being on floors 4 through 6.

From the data collected, the maximum blast induced vibration level was 0.0173 ips at 23.8 Hz (MARC Building exterior at 11:16 a.m. on 1/31/13). This is correlated to a blast event at the Dyno Nobel-Cemex SCL quarry. At a frequency of around 23 Hz, the limiting ppv would be about 1.15 ips according to the USBM chart. This maximum recorded ground ppv of 0.0173 ips therefore represents only 1.5 percent of the USBM damage criteria limit. This result is not surprising since the State Fire Marshall limits typically reference the closest building to the blast site, whereas the MARC and AHC3 buildings are on the order of four or more miles from the closest quarry operation "as the crow flies". The smallest vibration level recorded was 0.0103 ips at 2.6 Hz (AHC3 interior at 1:01 p.m. on 2/4/13). This vibration record is also correlated to a blast event at the Dyno Nobel-Cemex SCL quarry. Based on the USBM chart the measured

peak particle velocity is only 2.1 percent of the damage criteria limit of about 0.5 ips corresponding to a frequency of 2.6 Hz.

The measurements made also show that, at the structures, there is vibration that comes from internal and on-site sources. In fact, the highest vibration level measured from any source during the study was from internal vibration that occurred unrelated to a blasting event (ACH3 exterior on 1/9/13 at 3:48 pm). Vibration from internal activity, air conditioning unit vibration and other mechanical sources are typical in large engineered structures. Vibrations from construction activities on nearby FIU projects could also generate vibrations recorded by the instruments.

It is noteworthy that human response to vibration is very keen, and vibrations with ppvs as low as about 0.03 ips can be perceptible to humans.

CONCLUSION

Based upon the measurements made during the monitoring period, we conclude that the vibrations that FIU building occupants reported feeling in recent months are related to outside vibration levels from blasting operations for mining operations within the Lakebelt area of Miami-Dade County located to the northwest of the campus. In addition, the measured levels are well within the standards and limits of the State. While human perception of the vibration has caused concern, it is our opinion that there is no potential for creating any defects in any of the FIU structures from the ongoing quarrying activities provided such activities adhere to the vibration limits set by the State.

REPORT LIMITATIONS

This consulting report has been prepared for the exclusive use of the current project owners, and other members of the project team for the specific application to this project. This report has been prepared in accordance with generally accepted local engineering practices. No other warranty is expressed or implied.

The opinions, discussions, and conclusions presented in this report are based in part upon the data collected from the field exploration and the information provided by others.

CLOSURE

We appreciate the opportunity to provide engineering services for your project. If you have questions about information contained in this report, please contact the undersigned.

Sincerely,

KADERABEK COMPANY

Garfield L. Wray, P.E.
Senior Engineer
Florida Registration No. 49734

Attachment: Seismograph Records

Distribution: Original & 1 Copy to Addressee via US Mail
Copy via Email
Copy to KACO File

References

Siskind, D. E., M. S. Stagg, J. W. Kopp, and C. H. Dowding, 1980s, "Structure Response and Damage Produced by Ground Vibrations from Surface Blasting", Report of Investigation 8507, U.S. Bureau of Mines, Washington, DC.

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