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geophysical services

November 9, 2018

Brian Norton
Senior Planner
City of Riverside
Community and Economic Development Department - Planning Division
3900 Main Street, 3rd Floor

Subject: Report for Vibration Measurements at Trujillo Adobe

Dear Mr. Norton:

**GEO***Vision* Geophysical Services performed ground vibration measurements adjacent to Trujillo Adobe site at 3669 Center Street in Riverside, California. The objective of these measurements was to document vibration levels from vehicle traffic near this historic structure.

We performed our measurements on October 29, 2018 from 8:53 am and to 10:55 am PDT, during normal traffic conditions on Center Street. Vibration peak particle velocity (PPV, in units of inch per second or inch/second) was monitored on the ground surface near the southwest corner of Trujillo Adobe using two seismographs.

Our findings and observations are:

- Vibration was monitored during the passing of 70 trucks on nearby Center Street.
- The recorded data have a maximum PPV of 0.007 inch/second.
- **None of the measured vibrations exceeded the Caltrans Transportation and Construction Vibration Guidance Manual threshold of 0.08 inch/second for "extremely fragile historic buildings, ruins, ancient monuments" (see Transportation and Construction Vibration Guidance Manual, California Department of Transportation, September 2013, Table 19 on Page 38 and Appendix A, Table 2 on Page 11).**

Details of our measurements are provided below in this brief report.

## Measurements and Analysis

On October 29, 2018, our geophysicist Emily Feldman arrived at the site and set up the seismographs before 9am. Figure 1 shows the seismographs next to the SW corner of Trujillo Adobe. Figure 2 shows the Trujillo Adobe site, with Geovision's seismograph location shown and the 60' distance to Center Street indicated. Measurements were coordinated by Dr. Robert Nigbor, who also reviewed and analyzed the data.

Our seismograph systems were Instantel Micromates. Each three-component external vibration sensor was coupled to the soil using three soil spikes mounted to its base. The primary seismograph was configured to record in two separate ways; first, a continuous PPV histogram (PPV every minute) and second, automatically recording triggered events exceeding a PPV of 0.07 inch/second. This trigger level was determined to ensure that all events approaching the Caltrans threshold for ancient ruins and historic monuments were recorded.

The secondary seismograph was configured for manual triggering using the front panel keypad for start and stop. The operator observed approaching trucks via line-of-sight and manually triggered these recordings.

Recording was initiated at 8:53 am and concluded at 10:55 am. Table 1 documents the passing trucks observed during this recording period. Maximum PPV is provided for each truck passage event.

The seismographs allowed on-site viewing of basic data. Further detailed analysis was done later using Instantel's THOR software.

## Results

Figures 3 is a plot of the continuous, 1-minute PPV histogram from the primary seismograph. The horizontal time axis is synchronized with the truck observations in Table 1. Background vibrations (the minimum PPV values in the histogram) are 0.002 inch/second. Maximum PPV from a passing truck during our 2-hour measurement period was 0.007 inch/second.

None of the passing truck vibrations triggered an automatic recording, because their vibrations did not exceed the 0.07 inch/second trigger level. For this reason, the histogram data and manual recordings proved useful to further demonstrate the low levels of vibration. Figure 4 is a representative plot of the vibration signature of a passing truck, in this case a westbound heavy truck at 10:38 am. This graph shows the lower-amplitude background vibrations with the larger truck vibrations between 4-6 seconds, and peak velocity of 0.007 inch/second.

## Conclusion

We measured ground vibration at the southwest corner of Trujillo Adobe during the passing of 70 trucks on Center Street. The maximum measured vibration PPV of 0.007 inch/sec is less than 1/10 of the Caltrans Transportation and Construction Vibration Guidance Manual PPV threshold of 0.08 inch/second for "extremely fragile historic buildings, ruins, ancient monuments" (see Transportation and Construction Vibration Guidance Manual, California Department of Transportation, September 2013, Table 19 on Page 38 and Appendix A, Table 2 on Page 11).

In performing our professional services, GEOVision has used that degree of care and skill ordinarily exercised, under similar circumstances, by reputable members of their profession practicing in the same or similar locality. No warranty, express or implied, is made or intended by GEOVision's services or the professional opinions included in this report.

GEOVision appreciates this opportunity to be of service. Please contact me if you have any questions.

Sincerely,


Robert L. Nigbor PhD PE
Senior Engineer
GEOVision Geophysical Services

Ref: GEOVision Report 18454-01 rev. 3

*Figure 1: Photograph of the seismograph installations near the SW corner of Trujillo Adobe*


*Figure 2: Site view of Trujillo Adobe showing Geovision seismographs at the southwest corner and the 60' distance to edge of Center Street and 88' distance to center of nearest travel lane. (from Google Earth Pro)*

*Table 1: Observed trucks during vibration measurement period.*

| Trujillo Adobe Vibration Measurements, Observed Trucks | | | | | |
|---|---|---|---|---|---|
| *Observations transcribed from E. Feldman field notes, PPV data from UM13811 Histogram* | | | | | |
| **Time, PDT** | **Observed Truck** | **Maximum PPV, inch/sec** | **Time, PDT** | **Observed Truck** | **Maximum PPV, inch/sec** |
| 859 | WB cement truck | 0.003 | 1010 | WB trash truck | 0.004 |
| 902 | WB single axle truck | 0.003 | 1011 | EB trash truck, empty | 0.004 |
| 903 | WB dump truck | 0.004 | 1012 | EB dump truck | 0.005 |
| 904 | WB multi-axle truck | 0.004 | 1014 | WB truck | 0.003 |
| 904 | EB truck | 0.004 | 1015 | EB tow truck | 0.005 |
| 905 | Two EB Fedex trucks | 0.005 | 1015 | EB & WB trucks | 0.005 |
| 907 | pickup truck | 0.007 | 1018 | EB flatbed | 0.003 |
| 908 | Two EB Fedex trucks | 0.005 | 1018 | EB & WB trucks | 0.003 |
| 909 | fuel truck | 0.004 | 1019 | WB gas truck | 0.005 |
| 910 | truck leaving adjacent lot | 0.004 | 1019 | EB tow truck | 0.005 |
| 911 | WB & EB trucks | 0.005 | 1021 | WB empty truck | 0.003 |
| 913 | WB fast dump truck | 0.003 | 1024 | WB ttruck + EB 3-axle | 0.003 |
| 914 | EB slow truck | 0.007 | 1025 | EB & WB trucks | 0.005 |
| 916 | fuel truck | 0.004 | 1026 | WB truck | 0.004 |
| 920 | EB & WB fast trucks | 0.005 | 1029 | WB truck | 0.004 |
| 921 | EB truck | 0.005 | 1030 | Two EB heavy trucks | 0.004 |
| 924 | WB concrete truck | 0.003 | 1032 | WB loud truck | 0.004 |
| 925 | EB empty truck | 0.004 | 1033 | WB empty truck | 0.005 |
| 925 | EB truck | 0.004 | 1034 | EB truck | 0.006 |
| 926 | EB truck | 0.004 | 1036 | WB heavy truck | 0.003 |
| 927 | EB truck | 0.004 | 1038 | WB heavy truck | 0.007 |
| 930 | EB truck | 0.003 | 1040 | EB fuel truck | 0.004 |
| 931 | EB truck & WB fast truck | 0.003 | 1040 | EB fuel truck (second) | 0.004 |
| 935 | EB truck | 0.003 | 1042 | EB fuel truck | 0.003 |
| 937 | WB loud truck | 0.003 | 1043 | EB dumptruck | 0.004 |
| 938 | EB empty flatbed | 0.004 | 1044 | EB heavy truck | 0.004 |
| 948 | Two WB trucks | 0.003 | 1045 | WB septic tank pump truck | 0.004 |
| 952 | Two EB loaded trucks | 0.003 | 1048 | WB fast tow truck | 0.004 |
| 954 | Truck idling nearby | 0.006 | 1049 | WB dumpster truck | 0.004 |
| 957 | EB fast truck | 0.004 | 1050 | EB fast dumpster truck | 0.005 |
| 958 | WB truck | 0.005 | 1051 | EB fast dumpster truck | 0.005 |
| 1001 | EB concrete truck | 0.004 | 1052 | WB truck | 0.004 |
| 1002 | EB tow truck | 0.005 | 1053 | EB heavy truck | 0.004 |
| 1004 | EB dump truck | 0.004 | 1054 | WB heavy truck | 0.004 |
| 1008 | EB fuel truck | 0.004 | 1055 | Walking near seismograph | 0.006 |

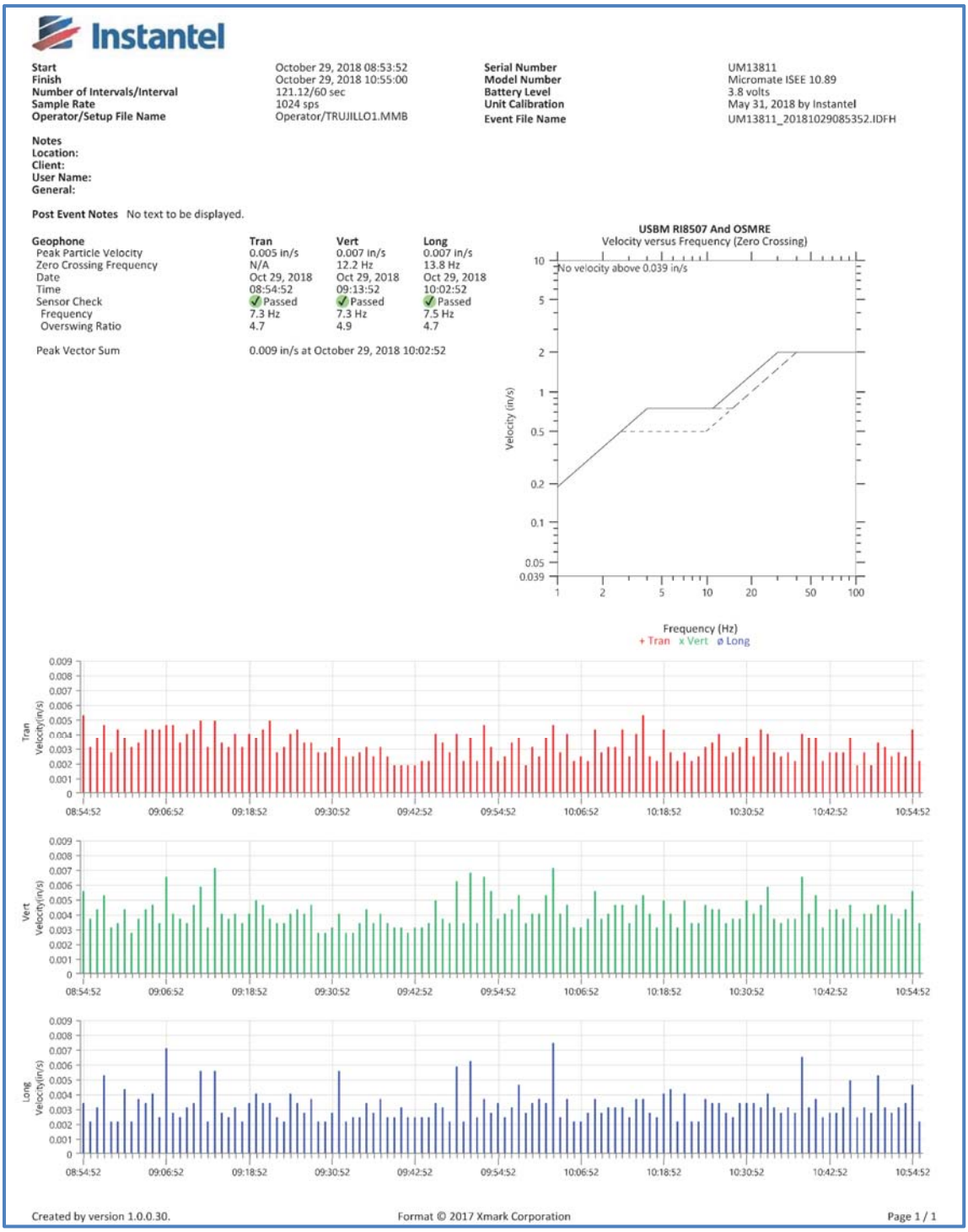


*Figure 3: Histogram of 1-minute PPV at Trujillo Adobe from 9-11am on 10/29/18*

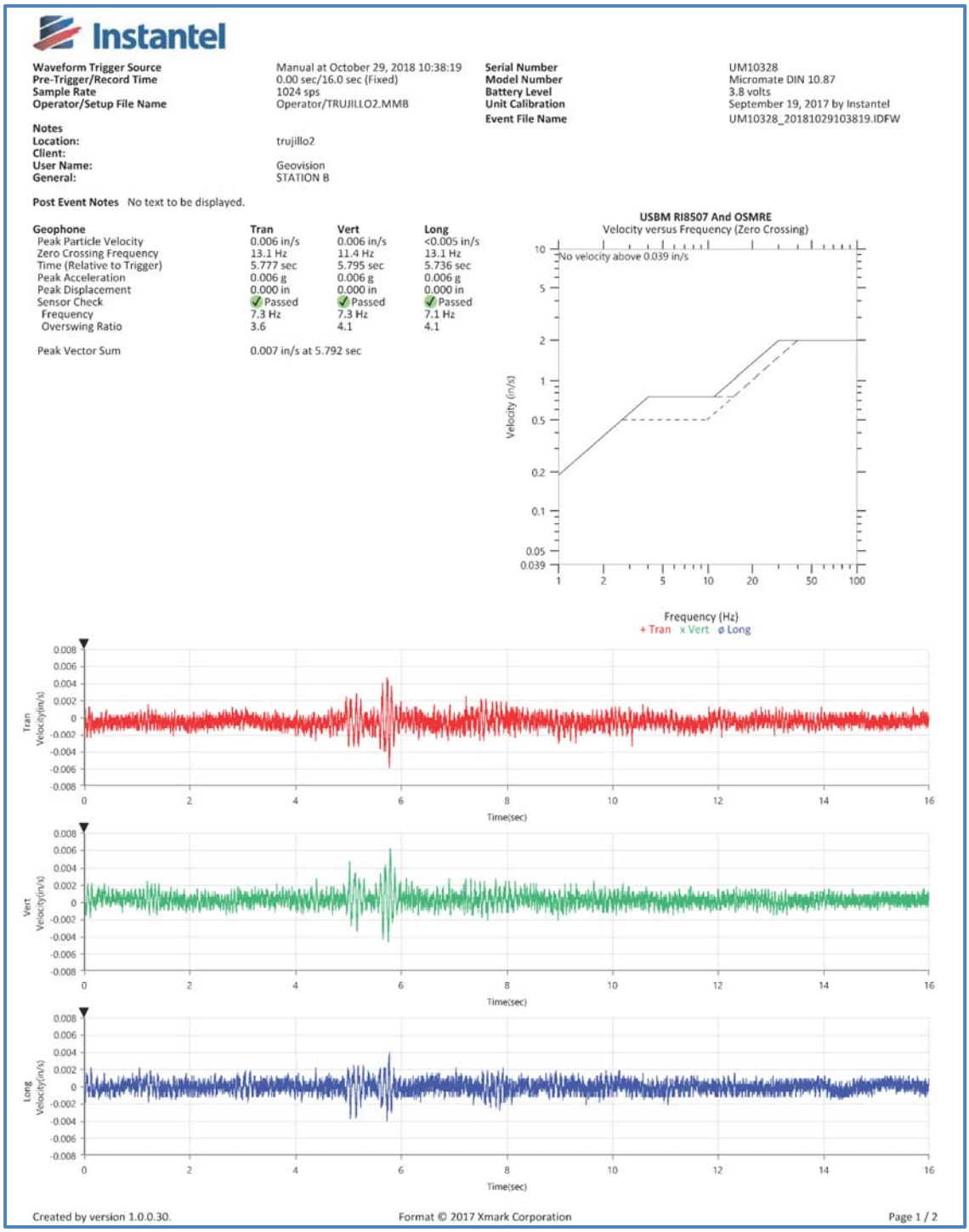


*Figure 4: Measured vibration signature of a passing westbound truck, 10:38 am on 10/29/18*

# ROBERT L. NIGBOR, Ph.D. P.E.

## Education

Ph.D. (1989) in Civil Engineering, University of Southern California, Los Angeles
M.S. (1987) in Civil Engineering, USC, Los Angeles
B.A. (1978) in Physics, Pomona College, Claremont, California

## Industry Experience

*Registered Professional Civil Engineer No. C046033, California*

2000-present *Director and Senior Scientist, GEOVision, Corona, California*

Advises management on both technical and management issues. Consults in earthquake and vibration engineering, for domestic and international industrial and government clients. Leads special projects involving earthquake engineering, vibration monitoring and mitigation. Projects include vibration monitoring and mitigation for historic structures, design of seismic monitoring and post-earthquake response system for the Trans-Alaska Pipeline, and nondestructive testing of structural components..

1989-1999 *President, Agbabian Associates, Pasadena, California*

Overall technical and corporate management of an engineering consulting firm specializing in advanced earthquake engineering and structural dynamics. Led expansion into geophysical, vibration, and seismological measurements, now a separate company GEOVision. Was project principal of many seismic analysis/design projects for bridges, buildings, and other structures.

1986-1989 *Partner, Fair Oaks Associates, Altadena, California*

1978-1986 *Instrumentation Engineer, Kinemetrics, Inc., Pasadena, California*

## Academic Experience

2004-2015 *Research Professor and Instructor, UCLA*

Supervises graduate students, teaches, and leads research activities in the area of structural dynamics and earthquake engineering. Manager and co-PI of the NEES@UCLA facility, focusing on dynamic testing and monitoring of buildings and other civil structures. Recent research projects include development of structural health monitoring and applications of rotational seismology to engineering. Instructor for CEE125 undergraduate course in Earthquake Engineering.

1999-2004 *Research Associate Professor, University of Southern California*

Developed, participated in, and supervised research in advanced technologies for structural dynamics and earthquake engineering. Supervised graduate students, taught courses in Structural Dynamics, and helped develop a new undergraduate program in CE/Information Technology. Significant research projects include:

- Co-PI of the NSF/NEES Equipment Site "Permanently Instrumented Field Sites for Study of Soil-Foundation-Structure Interaction";
- Co-PI of development of guidelines for installation of ANSS stations.

1992-1999 *Research Assistant Professor* (*Adjunct), University of Southern California*

Participated in research in earthquake engineering and experimental structural dynamics. Also taught both graduate and undergraduate courses.

## Service to the Profession

- Member, American Nuclear Society ANS 2.2 Committee for Nuclear Power Plant Seismic Instrumentation, 2008-present
- Member of Board of Directors/Senior Advisory Council of the Consortium of Organizations for Strong Motion Observation Systems (COSMOS), 1999-present
- Member, Instrumentation Committee, Incorporated Research Institutions for Seismology (IRIS), 2008-2014
- Structural Monitoring Coordinator, ANSS, 2008-2010
- Member of ASCE, EERI, SSA, COSMOS, NEES
- Organizing Committee Member for many conferences and workshops

## Representative Publications


Gavin, Henri P., and Robert L. Nigbor. Performance of the Base-Isolated Christchurch Women's Hospital in the September 4, 2010, Darfield Earthquake and the February 22, 2011, Christchurch Earthquake. Bridges 10 (2014): 9780784412374-049.

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Kamijo, N., H. Saito, K. Kusama, O. Kontani, R. Nigbor, "Seismic Tests of a Pile-Supported Structure in Liquefiable Sand Using Large-Scale Blast Excitation", Nuclear Engineering and Design, Volume 228, Issues 1-3, March 2004.

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Olsen, K., Nigbor, R., and T. Konno, "3-D Viscoelastic Wave Propagation in the Borrego Valley, California, Constrained by Borehole and Surface Data," BSSA 90, 1, 2000.

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Agbabian, M., Ginell, W., Masri, S., and R. Nigbor, "Evaluation of Earthquake Damage Mitigation Methods for Museum Objects," Studies in Conservation, Vol. 36, pp. 111-120, 1991.

Amini, A., Trifunac, M.D., and R. Nigbor, "A Note on the Noise Amplitude in Some Strong Motion Accelerographs," Soil Dynamics and Earthquake Engineering, Vol. 6, No. 3, 1987.