Ingeniería Mecánica
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REPORT

Response to seismic vibration in Guardian SismAlarm system

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1 INTRODUCTION

The present documents provides the results of seismic vibration tests performed at the Guardian SismAlarm system. The system was subjected to experimental vibrations in five different scenarios and its performance to provide an alarm in the presence of a possible earthquake was evaluated.

The Guardian SismAlarm consists of an innovative system for the early warning and analysis of earthquakes. Calibrated to a specific alarm threshold, the SismAlarm is able to recognize the primary wave of an earthquake. When the primary wave comes, the SismAlarm alerts people inside the building through a buzzer integrated into the device, allowing them to get ready for the arrival of the destructive secondary wave. Therefore the Guardian SismAlarm gives the chance to the people to get away from windows, lamps, bookcases, cabinets, or other objects that may harm when the secondary wave comes.

The seismic vibration tests were performed in the Laboratory of Mechanical Vibrations and Rotordynamics (LVMR), Department of Mechanical Engineering, at Universidad de Chile. The laboratory is directed by Dr. Ing Viviana Meruane, its mission is to develop better understanding of the dynamic characteristics of mechanical structures. The research focuses mainly on the characterization and application of mechanical vibrations, with emphasis on condition monitoring of structures and rotor systems.

The objective of the experimental tests is to evaluate the calibration of the accelerometer that controls the performance of the Guardian SismAlarm system.

2 DESCRIPTION OF THE EXPERIMENTAL SETUP

Figure 1 presents the experimental setup, it consists of a signal generator connected to a power amplifier and to an electrodynamic shaker, which produces a controlled base vibration. The Guardian SismAlarm system is mounted over the shaker and an accelerometer captures the base vibration to which the system is subjected. The acceleration is recorded by a data acquisition system.

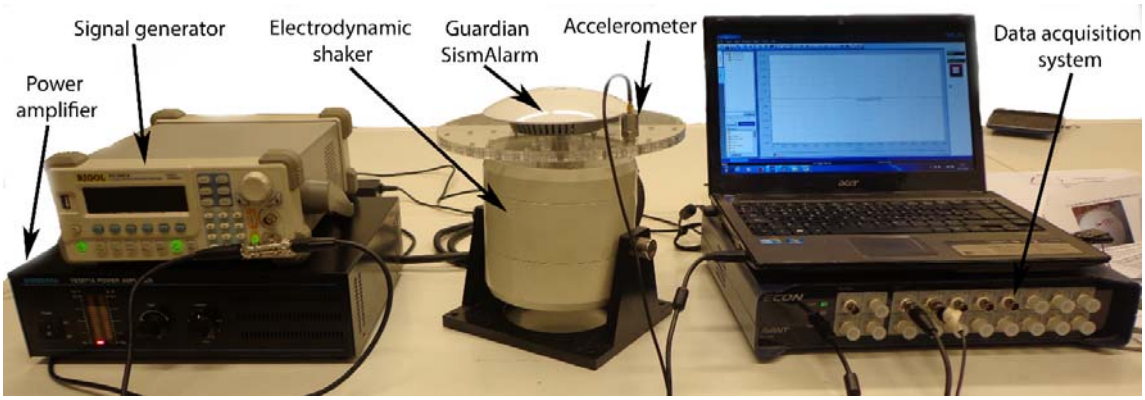

Figure 1 Experimental setup

The technical specification of the equipment is the following:

- Data acquisition system AVANT ECON MI-7016, 24 bits resolution, acquisition frequency up to 192 kHz per channel.
- Data acquisition software DAS ECON.
- Arbitrary Waveform Function Generator Rigol DG2041A, 14 bits vertical accuracy, 100 MHz maximum sampling rate, 512 kpts waveform length.
- Electrodynamic shaker JZK-20, force range 0 to 200N, frequency range 0 to 2kHz, vibration amplitude range +/-5mm, maximum acceleration 400m/s^2.
- Power amplifier YE5871A, DC input: 0 to15kHz..
- Accelerometer CA-YD-1182, sensitivity 100mV/g, frequency range 0.5-10000Hz, measurement range 0-50g.

3 DESCRIPTION OF THE EXPERIMENTAL TESTS

The system was subjected to experimental vibrations under five reference signals described below. Each signal was loaded to the arbitrary waveform function generator, which is connected to a power amplifier. The maximum vibration amplitude is selected by changing the amplification of the power amplifier.

The Guardian SismAlarm system has been calibrated to a specific alarm threshold, thus if the vibration exceeds a certain level then the system gives an alarm. Therefore, the system will no alarm in the case of a light earthquake, but it will alarm in the case of a medium to large earthquake.

Signal T1. Vibration noise due to the ignition of an air compressor. It represents a situation where the Guardian SismAlarm system is fixed on the wall, 1m over the air compressor, air compressor is switched on and off two times. The maximum vibration amplitude is 200mg and the duration is 20.48s.

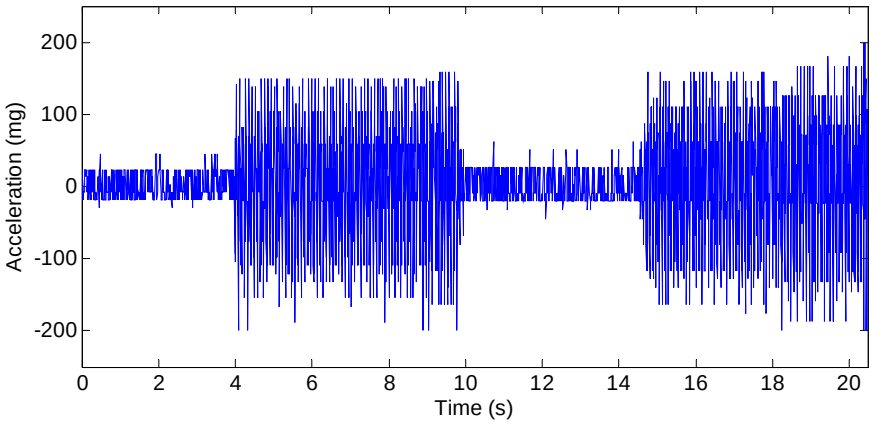

Figure 2 Acceleration time history of the reference signal denoted "T1".

Signal T2. Vibration noise due to the washing machine. It represents a situation where the Guardian SismAlarm system is supported to the top of the washing machine during initial washing mode with half load. The maximum vibration amplitude is 200mg and the duration is 20.48s.

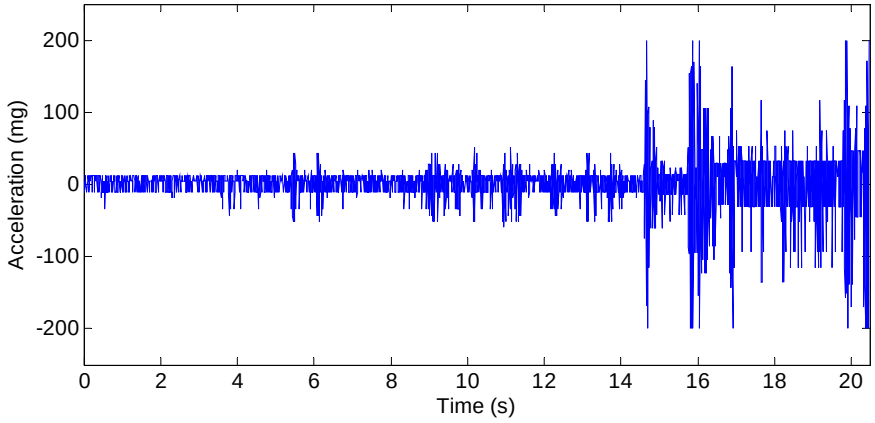

Figure 3 Acceleration time history of the reference signal denoted "T2".

Signal T3. Vibration noise due to the washing machine. It represents a situation where the Guardian SismAlarm system is supported to the top of the washing machine in spin-dryer mode with half load. The maximum vibration amplitude is 200mg and the duration is 20.48s.

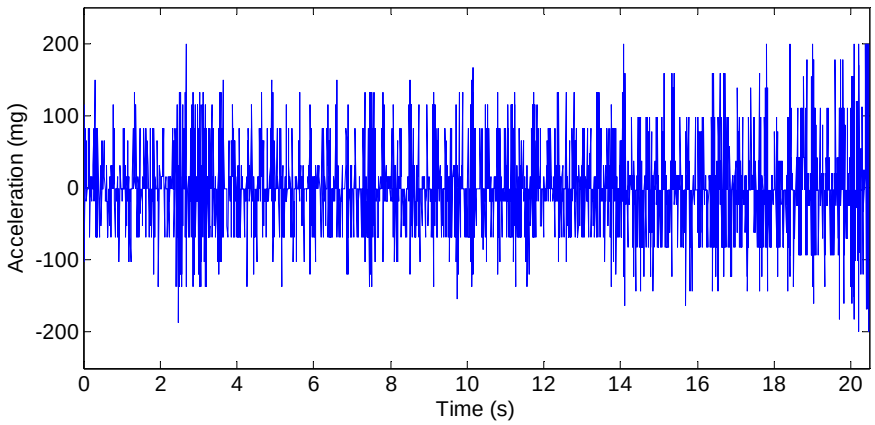

Figure 4 Acceleration time history of the reference signal denoted "T3".

Signal T4. Light earthquake occurred in May 2012 in the central zone of Chile, with an approximate amplitude of grade four in Richter scale. The maximum vibration amplitude is 200mg and the duration is 65s.

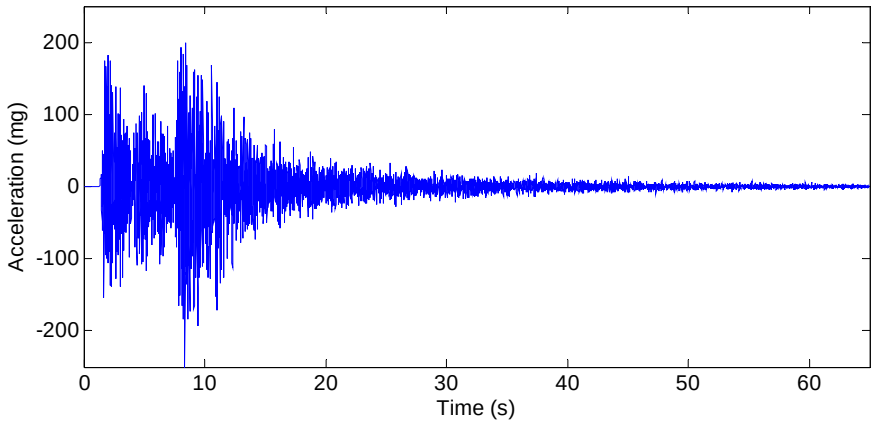

Figure 5 Acceleration time history of the reference signal denoted "T4".

Signal T5. Heavy earthquake, previous signal was scaled to reach an approximate amplitude of grade seven in Richter scale. The maximum vibration amplitude is 700mg and the duration is 65s.

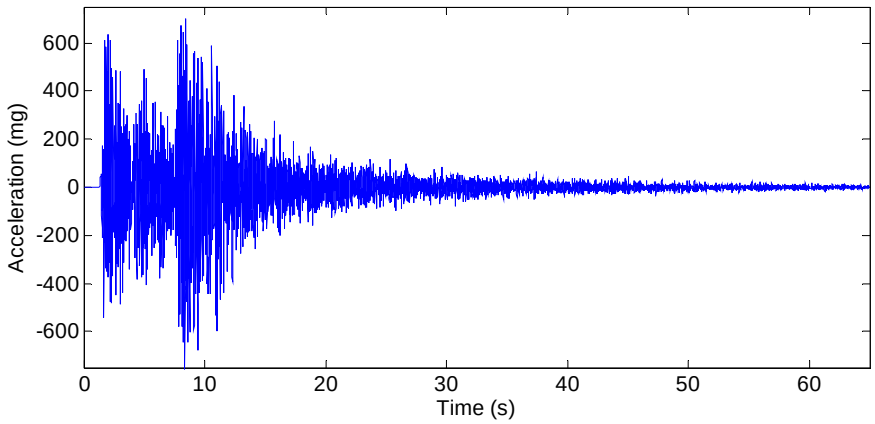

Figure 6 Acceleration time history of the reference signal denoted "T5".

4 RESULTS

For each reference signal, the test was repeated 10 times, evaluating the performance of the Guardian SismAlarm system. For reference signals T1 to T4, the system should not give an alarm, whereas for reference signal T5 the system should give an alarm. Therefore, at each case, it was evaluated if the system provided or not an alarm. If the system performs as expected the test is marked as “pass”, if not is marked as “Not pass”.

In the case of signal T5, the Guardian SismAlarm system gave an alarm at the arrival of the primary wave, which is 7 seconds before the arrival of the secondary wave. The secondary wave arrives at time 7.5 seconds in Figure 6.

Table 1 summarizes the results of each test, a tick indicates that the Guardian SismAlarm system responded as expected.

Table 1 Performance of the Guardian SismAlarm system at each test

Reference signal	Test expectation	Pass/Not pass									
		1	2	3	4	5	6	7	8	9	10
T1	no alarm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
T2	no alarm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
T3	no alarm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
T4	no alarm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
T5	alarm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

T1, T2 and T3: vibration noise, T4: light earthquake under Guardian SismAlarm threshold, T5: Heavy earthquake over Guardian SismAlarm threshold.

5 CONCLUSIONS

The Guardian SismAlarm system responded as expected in all tests performed. Therefore, it can be concluded that the calibration of the accelerometer that controls this system is working properly.

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