
Remote building vibration measurement using Ommatidia Q2 Laser Doppler Vibrometer

Keywords: laser vibrometry, buildings, ambient excitation, structural monitoring

1. Introduction

The dynamic characterization of buildings is relevant both for structural assessment and for the analysis of their response to external actions such as wind, traffic, or seismic excitation. However, its measurement presents a significant experimental challenge, since the expected vibrations typically lie in the low-frequency range, in many cases below 10 Hz, and with very low amplitudes. In addition, in this type of structure it is not straightforward to apply a controlled excitation that adequately represents the global behavior of the building, which makes measurement under ambient excitation particularly relevant.

The objective of this study was to evaluate whether Ommatidia's Q2 multibeam Laser Doppler Vibrometer is capable of measuring real building vibrations remotely and without contact under ambient excitation.



Figure 1. Ommatidia's Q2 Laser Doppler Vibrometer.

2. Q2 system concept for building vibrometry applications

The equipment used in this test was the Ommatidia Q2 multibeam Laser Doppler Vibrometer, based on FMCW (Frequency Modulated Continuous Wave) Laser RADAR technology. It was used in vibrometry mode, which allows the non-contact measurement of the velocity or displacement of a surface in 65 simultaneous points arranged in a line. This has an obvious advantage over scanning vibrometers because the excitation is random and we have all point in phase.

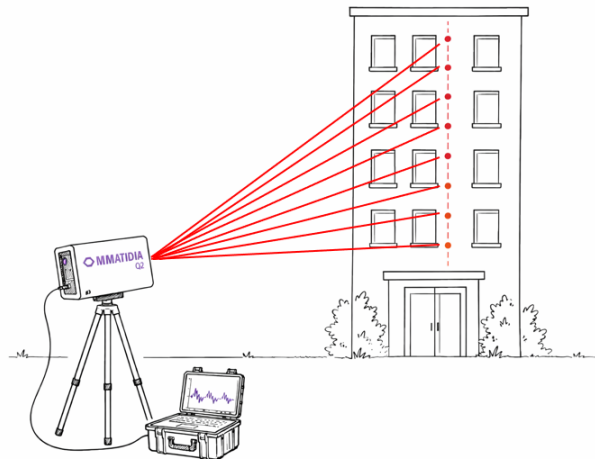


Figure 2. Schematic representation of the remote building vibration measurement configuration.

The system incorporates multichannel coherent detection, with 65 simultaneous laser beams for signal acquisition.

The main Q2 specifications and characteristics relevant to this test are as follows:

- Multi-point vibrometry: sampling at up to 40 kHz (selectable) over 65 simultaneous points, with a velocity range of ± 15.5 mm/s.
- Integrated accelerometer: bandwidth of 2,000 Hz, sampling rate of 4,000 Hz, and noise level of $22.5 \mu\text{g}/\sqrt{\text{Hz}}$. **As we will see, having this integrated accelerometer is crucial in vibrations measurements in buildings, as the environment is not vibration-clean because of traffic, wind, engines, etc, and one frequently needs to identify and subtract those sources of vibration.**
- Pointing aid and autofocus: Full-HD RGB camera (1920 × 1080) with autofocus.
- Robust industrial design: IP54 protection and atmospheric compensation for pressure, temperature, and humidity.
- Comprehensive connectivity: Gigabit Ethernet, GPS synchronization, analog inputs/outputs, and digital output.
- Unified software: control through the Ommatidia Atelier™ platform.
- Open format data (HDF5).

In this work, the long-acquisition mode in static vibrometry was used, suitable for recording continuous time series over several minutes on a fixed beam line. This mode prioritizes temporal stability and spectral resolution, making it particularly useful for identifying low-frequency, very low-amplitude components under ambient excitation.

3. Data acquisition and measurement workflow

The Q2 system was positioned at an approximate distance of 25 m from the monitored structural element (geothermal heating system chimney, Figure 3). The chimney is a hollow structure made of concrete slabs with dimensions (2m x 1m x 35m). The measurement was performed on a vertical line of the building, with no artificial excitation, so that the recorded response corresponded exclusively to ambient excitation. No reflective adhesive or paint was applied on the surface of the chimney.



Figure 3. Experimental setup used for remote building measurement with Ommatidia Q2.

Data acquisition was performed using the Q2 vibrometry mode – static long modal analysis, configured as shown in the image below. Three acquisitions of 300s were performed along a vertical line on the building.

To discriminate which spectral features are coming from real vibrations of the chimney and which are environmental vibrations transmitted to the instrument or from the moving parts of the instrument itself (cooling fans) we have extracted also the spectra of the internal triaxial accelerometer (Figure 4). A very simple comparison shows that the peaks at 5, 10 and 110Hz are in both graphs so they cannot come from chimney vibrations. In fact, the peaks at 110 Hz are known to be coming from the internal fans, while the peaks at 5 and 10Hz are probably vibrations of the ground due to pump or engines

present in urban environment and only the peak at 1.7Hz can be attributed to the chimney that we are measuring.

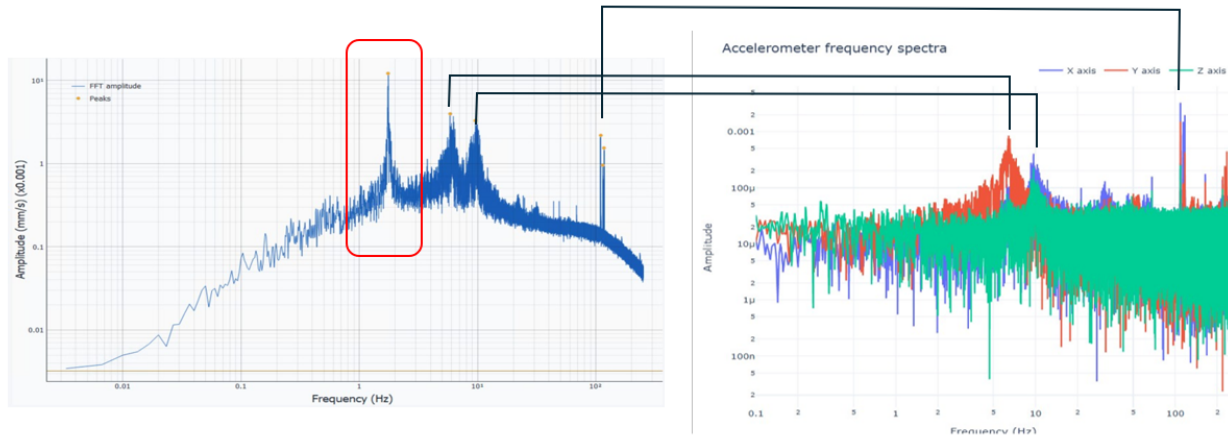


Figure 5. Raw measurement obtained by the vibrometer (left) and the 3 vibration signals from the internal accelerometer (right). Only the peak at 1.7Hz can be attributed to the chimney that we are measuring.

6. Conclusion

Overall, the obtained results validate the capability of the Ommatidia Q2 to perform remote, fast non-contact measurement of real building vibration. The internal accelerometer that the instrument has is key to discriminate real signal from environmental vibrations.