1P2-2

Study on movement measurement by noncontact acoustic inspection method using correlation processing

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1. Introduction

The noncontact acoustic inspection (NCAI) method using acoustic irradiation induced vibration and a scanning laser Doppler vibrometer (SLDV) is a long-distance, non-contact method for inspecting internal defects (cracks and cavities) in the surface layer of concrete structures, etc., using the same flexural resonance phenomenon as that of tapping inspection[1-12]. On the other hand, with the declining birthrate and aging population, there is a need for labor-saving and automation of inspection work. Therefore, there has been an increasing demand for the realization of measurement while moving, even at low speeds. Therefore, a fundamental study was conducted on the feasibility of moving measurement using the NCAI method with multiple laser Doppler vibrometer(LDV)s without a scanning mechanism.

2. Basic setup for movement measurement by NCAI method

Fig. 1 shows the basic setup for the NCAI-based movement measurement. Four portable LDVs (VGO-200, Polytec GmbH) without scanning mechanism were used in this experiment, and a long-range acoustic device (LRAD100X, Genasys Inc.) was used as the sound source. Since the LDVs are Doppler effect measurement devices, they can detect surface vibration caused by acoustic irradiation even while moving, as long as the laser beam is perpendicular to the surface to be measured. A concrete specimen with a simulated cavity defect as shown in **Fig. 2** was used as the measurement object (only a defect with a diameter of 300 mm was used in this experiment). A multitone burst wave (pulse width 3 ms, frequency interval 200 Hz, total wave length 59 ms) in the frequency range 500-4100 Hz was used as the excitation waveform, as shown in **Fig. 3**. Four LDVs were placed vertically on a moving cart and manually moved with the sound source for measurement. The sound pressure on the specimen surface was set to 120 dB (maximum Z characteristic value).

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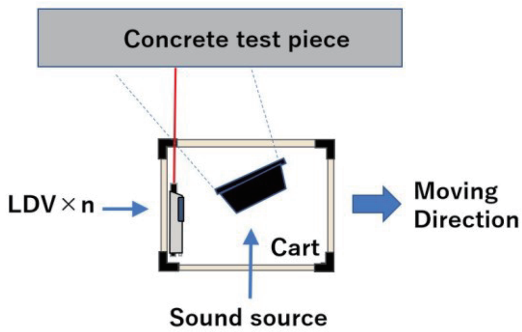

Fig. 1. Basic setup for movement measurement by NCAI method (Top view).

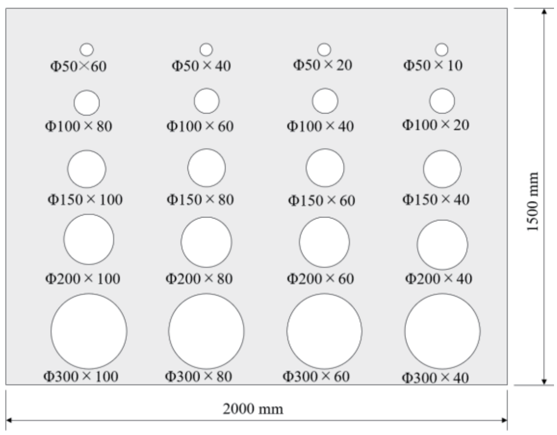

Fig. 2. Concrete specimen with buried simulated defects.

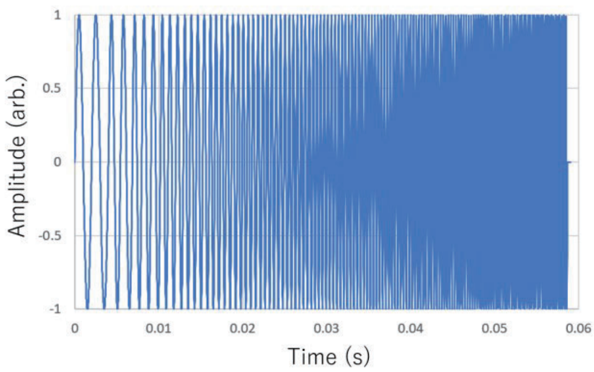

Fig. 3. Example of excitation waveform (multi-tone burst wave.

3. Example of experimental results

The measurement area is shown in **Fig. 4**. The simulated defects in the measurement area were 300 mm in diameter and 40 mm, 60 mm, and 80 mm deep. The moving speed was varied in three steps (approximately in the range of 1 to 2 km/h). The speed of movement was estimated using a laser rangefinder, but because the movement was done manually, the speed was not constant over the entire measurement area. In order to extract the resonance vibration buried in the noise caused by the movement, the square of the correlation value between the excitation waveform and the waveform measured by the LDV (correlation energy value) was used for imaging, instead of the conventional vibration energy ratio. **Fig. 5** shows an example of the video results obtained by displaying the square of the correlation value with the excitation waveform (a bandpass filter was also used here for the resonance frequencies of the simulated defect: 820 to 920, 1730 to 1830, 2080 to 2180, and 2740 to 2840 Hz). From this figure, it can be seen that in addition to the 40 mm depth, defects with a depth of 60 mm can also be detected.

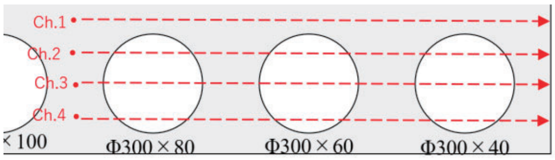

Fig. 4. Measurement area.

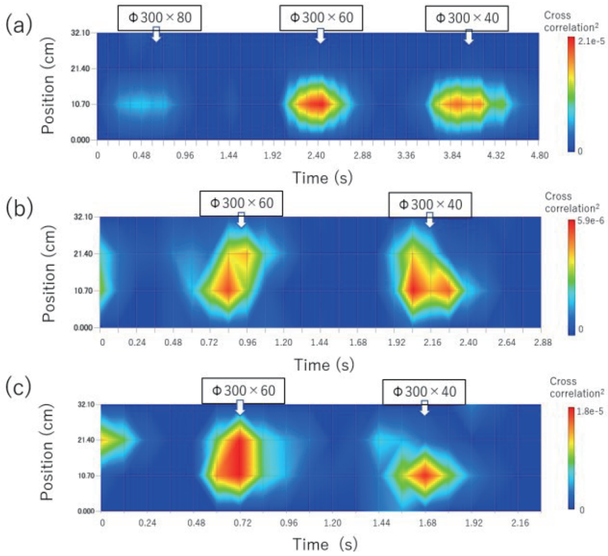

Fig. 5. Example of the squared display of correlation values for movement measurement, (a) Moving speed 0.28 m/s=1.01 km/h (164 points (41x4)), (b) Moving speed 0.44 m/s=1.59 km/h (100 points(25x4)), and, (c) Moving speed 0.58 m/s=2.08 km/h (80 points(20x4)).

4. Conclusions

A fundamental verification experiment of the moving measurement using the NCAI method was conducted using multiple LDVs. The experimental results show that although the noise increases in proportion to the moving speed, defects with a diameter of 300 mm and a depth of 60 mm can be detected while the LDVs and the sound source are moving together. In this verification experiment, the maximum speed during the moving measurement was about 2 km/h, but the experiment was conducted under conditions where vibration countermeasures during movement were not yet sufficient. Therefore, it could be possible to achieve even faster and more accurate movement measurements with active and passive vibration suppression measures.

Acknowledgment

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