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Non-contact Inspection Method for Concrete Structure by using LRAD —Study on Angular Dependence and Crack Model Detection—

LRAD を用いたコンクリート構造物の非接触検査法 —角度依存性と模擬クラック検出の検討—

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1. Introduction

Nowadays, hammering method is the most popular for non-destructive testing of concrete. In this method, however, it is difficult to inspect the places where people cannot reach. Although methods of examination using a sound wave had been proposed as a non-contact inspection, the actual distance of measuring was not practical, because loudspeaker was used as a vibration source in past study. Therefore, we propose a new method using Scanning Laser Doppler Vibrometer(SLDV) and Long Range Acoustic Device (LRAD) which has a sharp directivity and a high sound pressure. We conducted experiments using concrete test pieces in which styroform boards as voids in concrete. In past our study, it was confirmed that an exploration from distance of 10 m was possible. This time, two kinds of measurements were performed. The first one was a verification of angular dependence, and the second one was an exploratory test of crack model.

2. Experiment Ⅰ : Angular Dependence

An ideal irradiation angle of the LRAD is perpendicular to the measurement surface. Considering about a bridge or high place, the irradiation angle of the LRAD must be set obliquely. Thus, a measurement limit of irradiation angle of the LRAD was examined.

2.1 Experimental setup

The experience using a concrete test piece(150×200×30 cm^3) which has a styroform board as a void was conducted to examine the angular dependence of LRAD. The experimental setup is shown in Fig.1. Here, the fundamental concept of our proposed method is described. The concrete surface is excited by a sound wave emitted by LRAD(LRAD Corp, LRAD-300X). The vibration velocity on the surface is measured two dimensionally by SLDV(Polytec Corp, PSV 400-H4). If a defect like a void exists near the surface , the platy site of concrete on the defect has a flexural resonance frequency. If a frequency contained within the waveform emitted by vibration source and the flexural resonance frequency are near, a flexural vibration is excited on the defective part. Therefore, a position of the defect is identified by the vibration velocity distribution.

In this experiment, the irradiation angle of LRAD is changed, and then the vibration velocity on the center position of the defective part is measured. The position of SLDV is fixed. A used waveform is linear up chirp which contains a wide frequency band (500-5000 Hz).The emitted sound pressure is approximately 100 dB near the concrete surface.

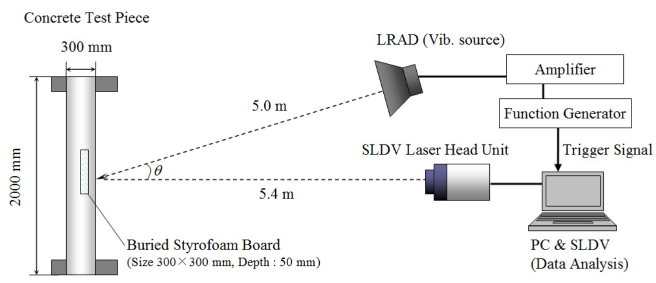

Fig.1 Experimental setup.

2.2 Experimental result

Fig.2 indicates the vibration velocity spectra on the defective part when the irradiation angle of the LRAD was changed. In this figure, the resonance peak can be clearly observed within 30 degree. However in 45 degree, the resonance peak cannot be distinguished with the noise level. Thus, this result suggests that the irradiation limit of the measurement exists from 30 to 45 degree.

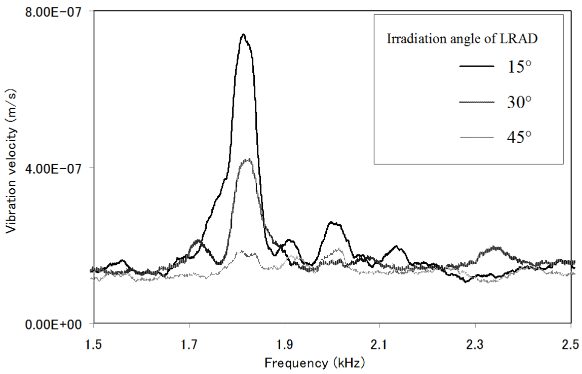

Fig.2 The vibration velocity spectra on the defective part when the irradiation angle of LRAD was changed.

3. Experimental Ⅱ: Crack model detection

Until now, styroform boards 25 mm thick are used for simulated void in past our exploration experiment. To examine whether a very thin crack is detectable or not, a concrete test piece in which crack models were used.

3.1 Experimental setup

The built concrete test piece(150×200×30 cm^3) involves crack models. The crack models were artificially simulated by using cylindrical concrete test pieces(ϕ 10×20 mm) which were divided in two by a compression test. The cylindrical concrete test pieces are shown in Photo.1. The adjusted void widths were 2.0 mm, 1.0 mm, 0.5 mm and 0 mm. The cylindrical concrete test pieces were coated with epoxy resin to fix the void widths and prevent infiltrating cement paste. To simulate planar crack 25 mm deep under surface, one side of the test piece was cut and buried.

Other setups are almost similar with the experiment in the preceding section.

3.2 Experimental result

Fig.3 represents the vibration spectra comparison between defective and healthy part.

At Fig.3(a), the void width is 0 mm. At Fig.3(b), the void width is 0.5 mm. By comparing Fig.3(a) and (b), it can be observed that there is distinct response around 3 kHz on the defective part in Fig.3(b). However, the differ response between defective and healthy part is hardly seen in Fig.3(a). Likewise, for other crack models(1.0 mm, 2.0 mm), clear responses from the defective parts can be observed.

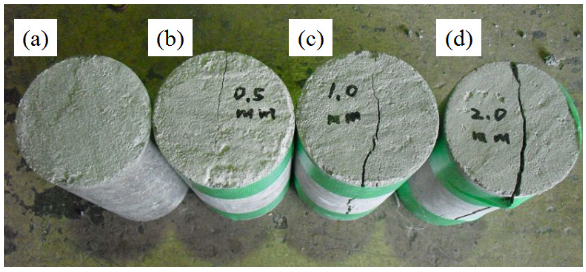

Photo.1 The divided cylindrical test pieces.
The void widths are (a) 0 mm, (b) 0.5 mm, (c) 1.0 mm and (d) 2.0 mm respectively.

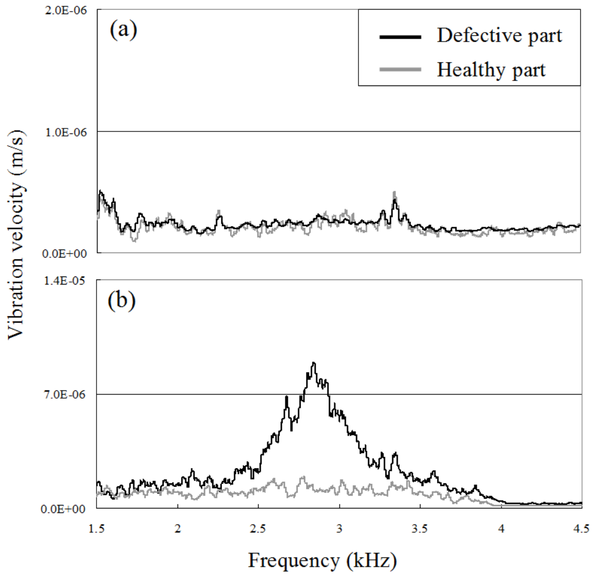

Fig.3 The vibration velocity spectra (buried depth : 25 mm). (a) Void width : 0 mm, (b) Void width : 0.5 mm.

4. Conclusions

This time, we considered angular dependence and crack model detection as a basic study of our proposed method. From these experimental results, we confirmed the present irradiation angular limit of the measurement and a crack is detectable as well as a void. As a future task, we will examine the detectable size and depth.

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References

1. K.Kaito, M.Masato, Y.Fujino and K.Kumazaka : Journal of Materials, Concrete Structures and Pavements(V), **690**, (2001), 121.
2. R.Akamatsu, T.Sugimoto, N.Utagawa, S.Tsujino : Proc. of the 10^{th} SEGJ International Symposium, (2011), 84.