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“Technical Research and Development for Improving Quality of Road Policy” Summary of the Study

No.	Theme	Representative of Researchers
No.22-3	Research and development about the non-contact acoustic inspection method for non-destructive testing	Toin Univ. of Yokohama Prof. Tsuneyoshi Sugimoto

Research and development which conduct an investigation experiment with a concrete test object and the real concrete structures in order to clarify the basic characteristic, applicable condition, etc. for the purpose of the study of the non-contact acoustic inspection method for non-destructive testing.

1. Background and Object

Recent years, the long-range acoustic device (LRAD; Long Range Acoustic Device) which can be generated over 100dB as a sound pressure at the 10meters distance or more was developed. And also, Scanning Laser Doppler Vibrometer) of high sensitivity in which two-dimensional vibrating measurement is possible was developed on the outdoors, such as earth surface and the concrete surface. Therefore, in the position 10 meters or more away from the device, it is a situation where a possibility that non-destructive measurement can be performed by non-contact is predicted. The purpose of this research is to develop the acoustic inspection system of non-contact and a wide area, and to mainly attain utilization of the non-contact acoustic investigation system for non-destructive tests for a concrete structure by control which combined the high sensitivity laser Doppler vibrometer and long-range acoustic device.

2. Activity in Research Period

It became clear from the result of Feasibility Study (FS) evaluation test for the non-contact sound investigating method to be able to investigate the cavity defect inside concrete even from a long distance. Therefore, in this research, basic investigation about the defect of a concrete structure was conducted, and the crack model object and the circular defect model object were listed as an examination object which should be investigated. Then, the following four points were studied. (1) Improvement examination of defect detection algorithm, (2) the examination about measurement high precision and improvement in the speed using laser Doppler vibrometer, (3) the examination about the acoustic far-field control using high power directional sound source, and (4) the experiment using concrete test objects and real concrete structures were conducted.

3. Result

(1) Improvement in the measurement sensitivity and speed by the device of a transmitted waveform

The sensitivity improvement of 15 dB or more was able to be made by using a tone burst wave as an emitted wave using the difference of the propagation velocity of an air borne sound and laser light (as shown in Fig.1). This means the improvement of measurement speed simultaneously for the purpose of the ability to reduce the number of times of an average.

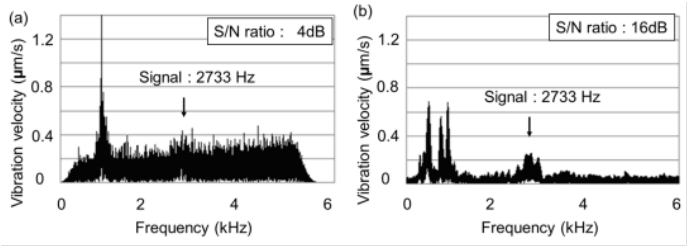

Fig.1. Vibration velocity spectra on the damaged part. (a) chirp wave, (b) Tone burst wave with time gate.

(2) Defect detection algorithm using vibration energy ratio

Only when there was a defective part, distribution (namely, vibrational energy) had arisen in the vibration velocity spectrum, and since it was not necessarily a single spectral peak, the defective detection algorithm using a vibrational energy ratio was introduced. It assumed that the threshold value with a healthy value was around 3.6 dB from the measurement data of the concrete 供試 object, and when it applied to the real concrete structure and having been compared with the hammer method, the good result of having been mostly similar was able to be obtained (Fig.2).

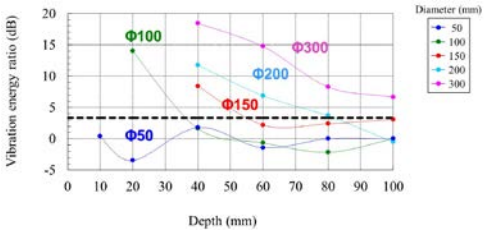

Fig.2. Vibration energy ratio between the defective and healthy part.

(3)The improvement of the angular dependence by high power ultrasonic sound source.

When LRAD was used as a sound source, in order to obtain a good measurement result, it depend on the target size and resonance frequency, and it is necessary to emit the sound within ±30 degrees to the subject. However, in order that angular dependence might improve to about ±60 double degrees by using a strong ultrasonic wave sound source, together with LDV measurement, it became clear that the measuring range is very wide (as shown in Fig.3).

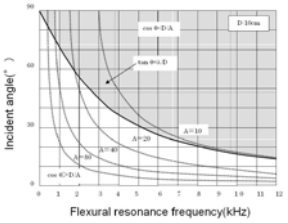

Fig.3.Angular dependence of parametric speaker.

(4) The investigation experiment using a concrete test object and a real concrete structures

It was checked that the size and the depth of a defect which can be investigated are almost more equivalent to what is depended on the usual hammer method than the experimental result (5 m of distance) using a circular test object. Moreover, it was checked that can be acquired with crack width and it can investigate by the acoustic investigating method at least 0 mm from the experimental result (5 m of distance) using crack test objects. Furthermore, it became clear that it is equivalent to the result which the investigation experiment using a real concrete structure also carries out Hokuriku National Expressway, N2U-Bridge, and depends it on the usual hammer method also outdoors (as shown in Fig.4).

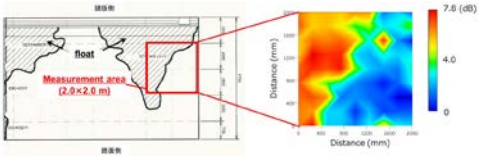

Fig.4. Experimental results. (a) Hammer method (slash part :float), (b) Non contact acoustic inspection method using vibration energy ratio.

4. Papers for Presentation

(1) T. Sugimoto, R. Akamatsu, N. Utagawa and S. Tsujino, “Non Contact Acoustic Exploration Method for Concrete using SLDV and LRAD”, Acoustics 2012 Nantes, Proceedings pp.835-839, 2012.04.24

(2) T. Sugimoto, R. Akamatsu, N. Utagawa and S. Tsujino, “Non Contact Long Distance Exploration M ethod for Concrete using SLDV and LRAD”, Acoustics 2012 Hong Kong, Proceedings 6pages, 2012.05.17

(3) R.Akamatsu, T. Sugimoto, N. Utagawa, S.Tsujino, “Study on the no-contact defect detection method using a long range acoustic device, Non-destructive testing for concrete structures、Vol.4, pp.31-36 (2 012.08) (in Japanese)

(4) Ryo Akamatsu, Tsuneyoshi Sugimoto, Noriyuki Utagawa, and Kageyoshi Katakura, "Proposal of Non Contact Inspection Method for Concrete Structures, Using High-Power Directional Sound Source and Scanning Laser Doppler Vibrometer", Jpn. J. Appl. Phys., Vol.52, 07HC12 (2013.07)

(5) Kageyoshi Katakura, Ryo Akamatsu, Tsuneyoshi Sugimoto, and Noriyuki Utagawa, "Study on detectable size and depth of defects in noncontact acoustic inspection ", Jpn. J. Appl. Phys., Vol.53, 07KC15 (2014.07)

5. Practice of the Study and Future Subject

Immediate development of the non-destructive test method by non-contact [from the long distance to a concrete structure] is becoming a era demanded not only from the check spot but from the general public. From these research findings, the caused vibrating phenomenon strikes the non-contact acoustic investigating method, it is the same bending vibration as check, and it became clear to strike even distance of 5 m or more and to have defective investigation accuracy comparable as check. Therefore, it is expectable that this technique is the technique of it not only being able to filling the fundamental demand performance of long distance non-contact non-destroying investigation, but is the technique of the ability to substitute for the hammer method in the sense of truth. Since it is not a problem which cannot solve what needs to improve a noise problem, measurement speed, etc. in constructing a practical use system, it can be said that the possibility of realization is very high.

6. Contribution to Improving Quality of Road Policy

If this system is utilized in practical use as a system, while contributing to the increase in efficiency of the daily check of public concrete structures, such as a road and a bridge, or a periodic check, and improvement in investigation accuracy, it can contribute to safety reservation of public traffic greatly. Moreover, it is expected that check will become measurable according to remote control, and will bring about a big change worldwide in addition to our country in safety and a disaster prevention side also in the check work etc. which are obliged to change of difficult height work and dangerous work, and a traffic route, etc. conventionally.

7. Reference Website

http://www.cc.toin.ac.jp/sc/sugimoto/