3Pa2-8

Proceedings of Symposium on Ultrasonic Electronics, Vol. 32 (2011) pp. 343-344
8-10 November, 2011

Non-Contact Acoustic Imaging Method using SLDV and LRAD
— Basic Study on the Non-Destructive Inspection for Concrete —
SLDV と LRAD を用いた非接触音響映像法
— コンクリート非破壊検査のための基礎研究 —

Ryo Akamatsu[1 ‡], Tsuneyoshi Sugimoto[1], Hiraku Kawasaki[2], Noriyuki Utagawa[3], Shuichi Tsujino[3] ([1]Faculty of Eng., Toin Univ. of Yokohama; [2]IHI Inspection & Instrumentation Co., Ltd.; [3]SATO KOGYO Co., Ltd.)
赤松 亮[1 ‡], 杉本 恒美[1], 川崎 拓[2], 歌川 紀之[3], 辻野 修一[3] ([1]桐蔭横浜大 工, [2]IHI 検査計測, [3]佐藤工業)

1. Introduction

At present, hammering method is the most representative as inspection for shallow area under concrete surface. In this method, a tester needs to hit the concrete directly by hammer. Therefore, it is difficult to inspect the place where people can not reach. In contrast, we have studied non-contact acoustic method using vibration of a sound wave and a Scanning Laser Doppler Vibrometer (SLDV) for extremely shallow under ground.[1,2,3,4)] We propose to apply this method with an inspection for defect of concrete. This time, we conducted two experiments using a concrete test piece which includes a styrofoam board as a cavity in the concrete. The purpose of first experiment is to confirm feasibility of imaging at short distance. And the purpose of second experiment is to test in practical situations that we needs long distance between the target and a vibration source.

2. Exploration Method using SLDV [5)]

The fundamental concept of the exploration method using a SLDV (Polytec Corp, PSV400-H4) is shown in Fig.1. SLDV measures two-dimensionally the vibration velocity of the concrete surface excited by a sound wave from a vibration source. The vibration velocity of the ground surface in the vertical direction is measured by SLDV. The acoustic impedance of a cavity is distinctly different from that of the concrete used as the propagation medium. Therefore, this difference influences the propagation characteristic, so it can be imaged. In addition, for getting a strong response from the cavity, a wave form which has a characteristic frequency of the concrete on the cavity has to be sent. This time, a Long Range Acoustic Device (LRAD Corp, LRAD-100X) is used as a vibration source.

LRAD has a characteristic to keep high sound pressure at the long distance unlike a normal speaker (loud, flat). Therefore, long range inspection will be anticipated using LRAD.

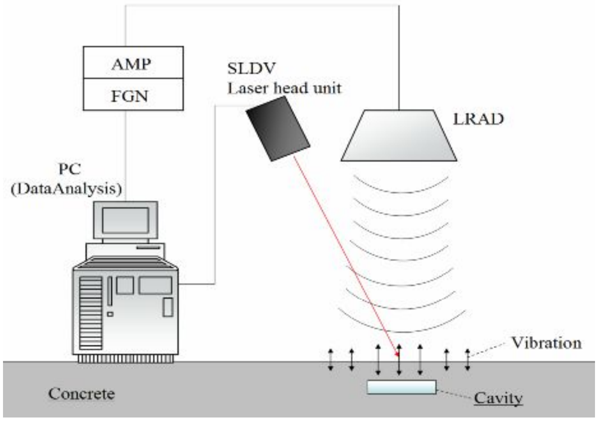

Fig.1 The fundamental concept of the exploration method.

3. Fundamental Experiment at the Short Distance

3.1 Experimental Setup

At first, for confirming the effectiveness of the previous method for concrete, we conducted an experiment using a concrete test piece at relativity near distance. The experimental setup was taken a similar setup as Fig.1. The distance between the LRAD and concrete surface is about 1 m. A thickness of the concrete test piece is 20 cm. And the concrete test piece includes a styrofoam boad ($30\times30\times15$ cm^3) in 5 cm depth. For maximizing the effect of energy of acoustic propagation, we confronted the LRAD with the concrete test piece as exactly as possible. Therefore, irradiation angle of laser from the LRAD is slightly oblique. Output waves are mainly linear up chirp and white noise. The sound pressure is about 105 dB near the surface of the concrete test piece. The area for scanning are about 50×50 cm and the number of the scanned points is 195(13×15).

---

ryoaiueo@gmail.com

3.2 Experimental result

Distribution imaging of vibration velocity is shown in Fig.2. The grid pattern in Fig.2(a) shows actual scan area, and the white flame shows the position of the embedded object. Fig.2(b) shows a distribution imaging of vibration velocity. This image was acquired at 2198 Hz. We were able to acquire such a response of embedded object around 2.2 kHz and 2.55 kHz.

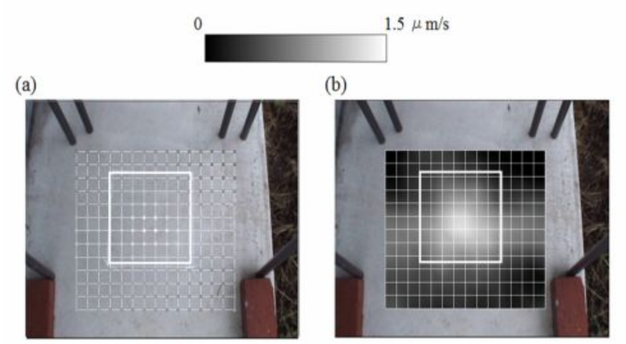

Fig.2 Experimental result. (a) Scan area and position of embedded object by CCD and (b) Imaging result by SLDV. Output wave : Chirp(2100 – 2500 Hz) Imaging frequency : 2198 Hz

4. The Imaging Experiment at the Long Distance

4.1 Experimental setup

In preceding section, we established the feasibility of this method at relativity near distance. Next, we conducted an experiment at farther distance. The experimental setup is shown in Fig.3. The distance between the LRAD and the concrete test piece is 10 m. A styrofoam boad (30×30×2.5 cm^3) is embedded in 5 cm depth of the concrete test piece (150×200×30 cm^3). In this experiment, a LRAD (LRAD Corp, LRAD-300X) is used. The LRAD-300X can emit more powerful sound pressure than the LRAD-100X. The sound pressure is about 110 dB near the surface of the concrete test piece.

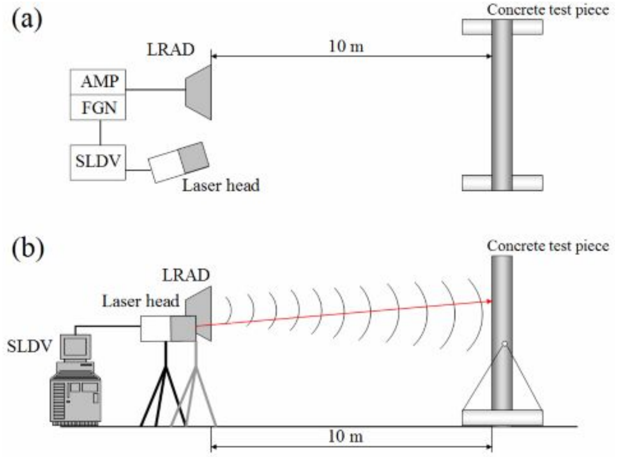

Fig.3 Experimental setup. (a)Upper view and (b) Side view.

4.2 Experimental result

Figure 4 shows the distribution imaging of vibration. This image was acquired at 2004 Hz. Compared to the previous experimental result, although measurement distance is farther, this result is more clear. This difference is thought to be due to situations of the embedded styrofoam boards and concrete test piece.

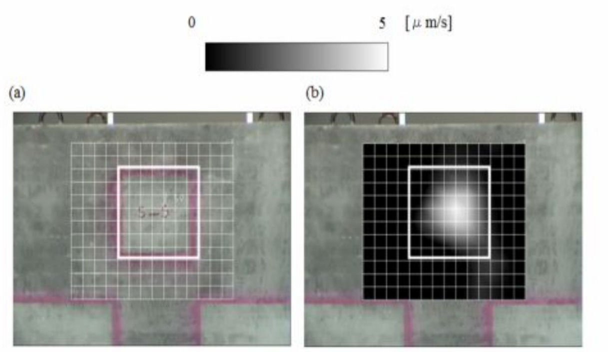

Fig.4 Experimental result. (a) Scan area and position of the embedded object by CCD and (b) Imaging result by SLDV. Output wave : Chirp (1900-2100 Hz) Imaging frequency 2004 Hz.

5. Conclusion

We proposed a new method of non-contact acoustic imaging method for non-destructive inspection using SLDV and LRAD. As experimental results a styrofoam that is substituted as a cavity in the concrete was clearly imaged far distance (10 m). It means the possibilities of new inspection for concrete. As our future task, we will examine how deep and how much size of a cavity in the concrete we can inspect by this method.

Acknowledgement

This work was supported by JST, Seeds excavation examination A (2009 No.04-186) and Ministry of Land, Infrastructure and Transport, technology research development to contribute to improvement of the quality of the road policy (2010 Feasibility Study).

References

1. T.Abe and T.Sugimoto, Proc. Spring Meet. Acoustical Society of Japan (2008) pp1413 [in Japanese]
2. T.Abe and T.Sugimoto, Jpn. J. Appl. Phys. 48 (2009) 07GC07.
3. T.Abe and T.Sugimoto, Jpn. J. Appl. Phys. 49 (2010) 07HC15.
4. T.Sugimoto and T.Abe, Jpn. J. Appl. Phys. 50 (2011) 07HC18.
5. R.Akamatsu and T.Sugimoto, Proc. Spring Meet. Acoustical Society of Japan (2011) pp1569-1570 [in Japanese]