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Measurement of reflection characteristics of road surfaces using airborne ultrasound
空中超音波を用いた路面の反射特性の計測

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1. Introduction

Ultrasonic measurement is widely used to recognized environmental information. The distance or Doppler velocity of an object is measured from the echo reflected from the object[1, 2]. Then, echoes not from the object such as wall, road, typically causes an artifact and degrades the acuracy of measurement.

In this report, echoes from various road surfaces are evaluated. Then, measurement of reflection characteristics of road surfaces are studied.

2. Measurement configuration

The measurement setup of ultrasonic echoes from road surfaces is illustrated in **Fig. 1**. The loudspeaker and the microphone were arranged at 500 mm above the road surface. Then, they were declined at approximately 25 degree angle. Those fronts faced the point which is 1000 mm from the point under the loudspeaker and the microphone. The directionality of the loud speaker is broad in perpendicular direction and narrow in horizontal direction.

To improve the signal-to-noise ratio (SNR) of the echo, pulse compression using a maximum-length sequence (M-sequence) was employed[2]. An M-sequence is one of the binary pseudo-random sequences. The amplitude of transmitted ultrasound was modulated by the M-sequence. 1 sine wave in ultrasound was assigned to 1 binary word in the M-sequence. The frequency of ultrasound was 50 kHz. The order of M-sequence was 10th. The received signal was correlated with the reference signal which corresponds to the M-sequence in the computer.

3. Echo from road surface

Echoes from road surfaces of asphalt pavement and block pavement were measured, as illustrated in **Fig. 2 and 3**. The amplitude and the distance in the figure indicate the sound pressure and the distance from the loudspeaker and the microphone, respectively. Large waves around 500

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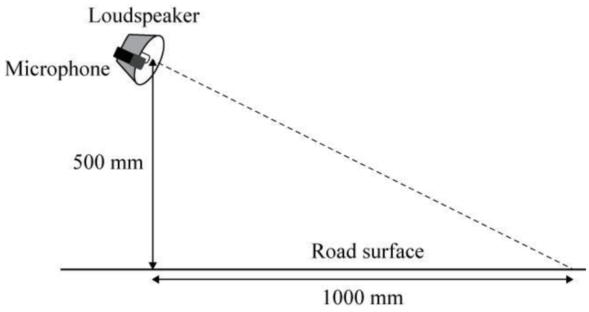

Fig. 1 Arrangement of loudspeaker and microphone.

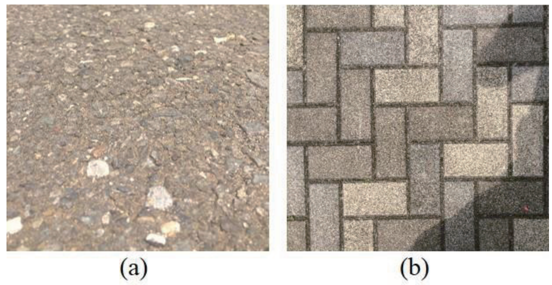

Fig. 2 Measured road surfaces, (a): asphalt pavement, (b): block pavement.

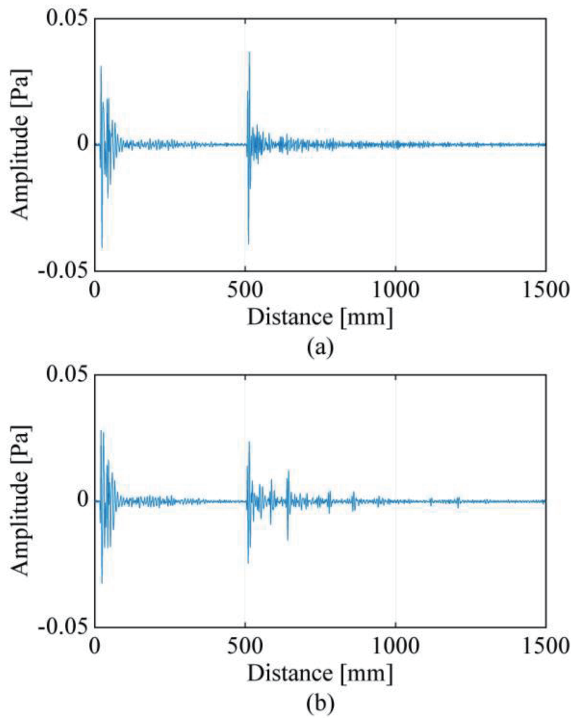

Fig. 3 Echoes reflected from road surfaces, (a): asphalt pavement, (b): block pavement.

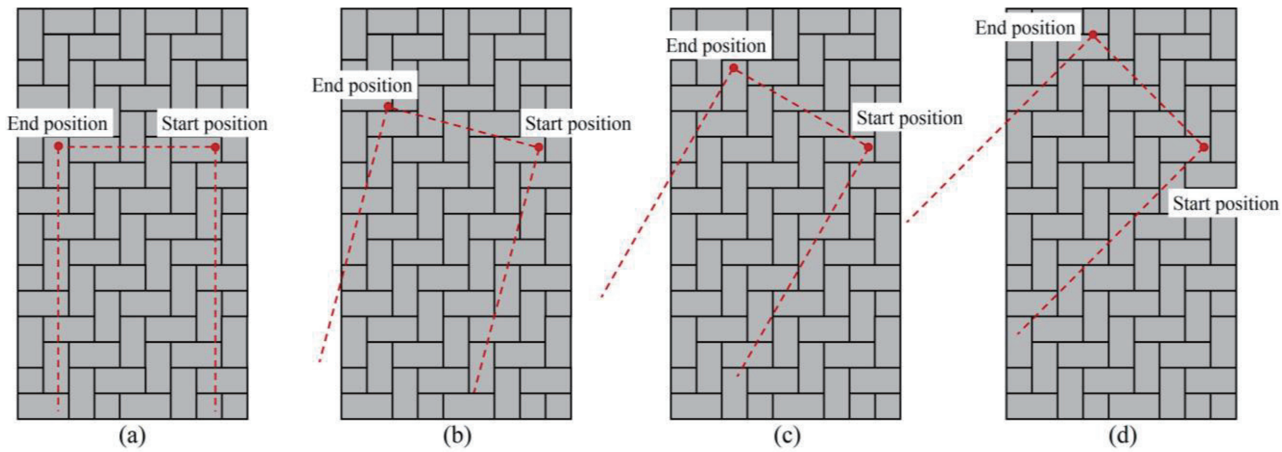

Fig. 4 Scanned area of block pavement, (a): measured direction of 0 degree, (b): measured direction of 15 degree, (c): measured direction of 30 degree, (d): measured direction of 45 degree.

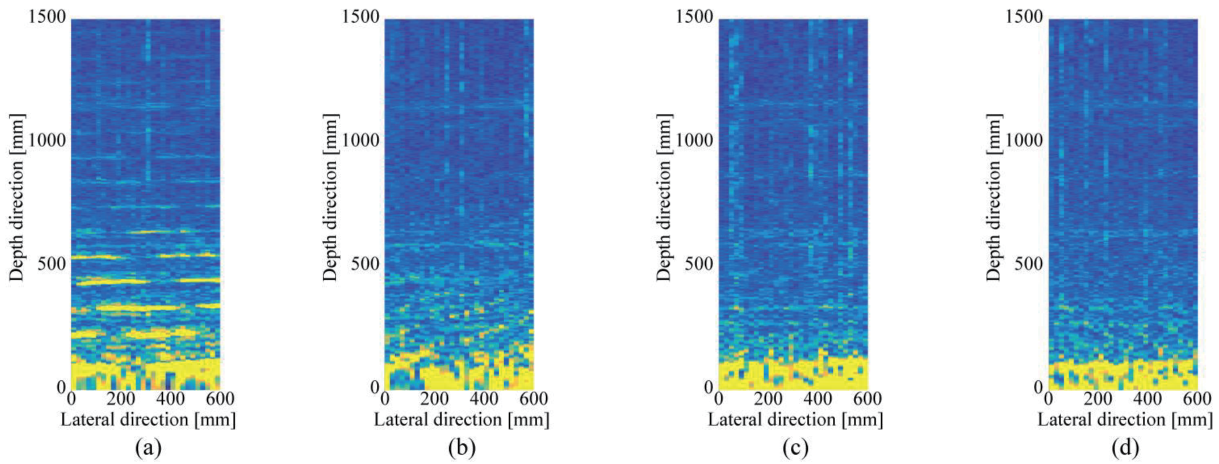

Fig. 5 B-mode images of block pavement, (a): measured direction of 0 degree, (b): measured direction of 15 degree, (c): measured direction of 30 degree, (d): measured direction of 45 degree.

mm are echoes from road surfaces just under the loudspeaker and the microphone. In asphalt pavement, there are random echoes from asperity of the road surface from 500 mm. In block pavement, there are small random echoes from surface asperity and large echoes from grooves of blocks which were orthogonal to the propagation direction of ultrasound.

4. Measurement of block groove

B-mode images of block pavement ware formed by scanning of the loudspeaker and the microphone. The scan length and pitch were 600 and 20 mm, respectively. Measured directions were changed from 0 to 45 degree angle to block grooves, as illustrated in **Fig. 4**. Amplitudes of echoes from road surfaces were calculated by Hilbert transformation. Formed B-mode images are illustrated in **Fig. 5**. Lengths of lateral and depth direction in the figure indicate lengths on road surfaces.

In the case of 0 degree, arrangement of brocks can be recognized. In the case of 15 degree, only near grooves can be recognized. In the cases of 30 and 45 degrees, however, grooves can not be recognized. When echoes from block grooves are larger than those from surface asperity, arrangement of block grooves can be measured.

5. Conclusions

We have been studied about ultrasonic echoes reflected from various road surfaces. In this report, echoes from road surfaces of asphalt pavement and block pavement are evaluated. Surface asperity or arrangement of block grooves in road surfaces can be measured by reflection characteristics.

References

1. S. Hirata and M. K. Kurosawa: Ultrasonics **52** (2012) 873.
2. Y. Ikari, S. Hirata and H. Hachiya: Jpn. J. Appl. Phys. **54** (2015) 07HC14.