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Validation of Applicability of Surface-wave Method Using Giant-magnetostriction Vibrator as Seismic Source
超磁歪振動子を震源に用いた表面波探査の有効性の検証

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1. Introduction

Seismic velocity structure in the ground is able to be required by surface-wave methods. The surface-wave methods are underground exploration methods using frequency dispersion of Rayleigh waves which are artificially emitted. In general, the Rayleigh waves are artificially emitted by hammering. However, the Rayleigh waves which are emitted by hammering are low-frequency seismic waves. In surface-wave methods using low-frequency seismic waves, the exploration accuracy of ultrashallow underground is bad even though the exploration accuracy of deep underground is good. To improve the exploration accuracy of ultrashallow underground, another seismic source is needed as a seismic sources. Therefore, we considered that the exploration accuracy of ultrashallow underground was improved by using a giant-magnetostriction vibrator which was able to emit high-frequency Rayleigh waves as a seismic source. This vibrator consists of a giant-magnetostriction element, which transforms along the magnetic field.1) The response of this element is faster than that of a piezoelectric element, and the maximum displacement of the giant-magnetostriction element is larger than that of the piezoelectric element.2) This vibrator can generate an arbitrary waveform. In this study, surface-wave methods were performed by using this vibrator as a seismic source. As a result, we indicated that the giant-magnetostriction vibrator was effective as a seismic source to improve the exploration accuracy of ultrashallow underground.

2. Experiment of Surface-wave Method

Fig.1 shows a schematic of the experimental setup. Seventeen geophones were used as receivers. These geophones were set as shown in **Fig.1**. For convenience, these receiving points are called R0–R17. As a seismic source, a giant-magnetostriction vibrator was used. The vibrator was set at a distance of 15 cm from R0 as shown in **Fig.1**, and generated Rayleigh waves. First, the function generator generated voltage waveforms, and they were converted into electric current waveforms. The electric current waveforms were input into the vibrator. The vibrator generated Rayleigh waves. The received signals, which were obtained from the geophones, were amplified and amplified data was analyzed on a PC. The sampling frequency was 5 kHz, and the measurement time was 1.23 s. As an input waveform, an up-chirp waveform whose frequency was 0-100 Hz was used. This input time was 1 s. To verify the applicability of surface wave method by using this vibrator as a seismic source, the experimental result was compared with the experimental result by hammering.

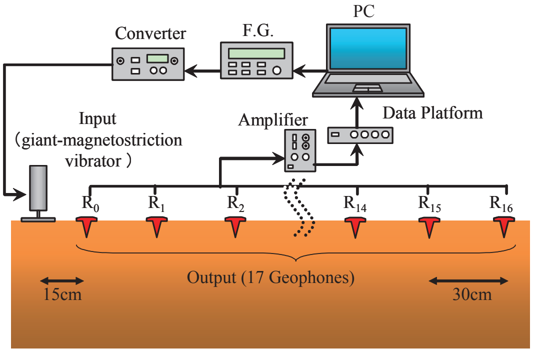

Fig.1 Schematic of the experimental setup.

3. Results and Discussion

Fig.2 shows received waveforms. **Fig.2(a)** shows the experimental result by using a giant-magnetostriction vibrator as a seismic source. **Fig.2(b)** shows the experimental result by hammering. In **Fig.2**, the frequency dispersions of Rayleigh waves are shown. By using these waveforms, the phase velocity - frequency images of waveform data were converted through the multi-channel analysis of surface waves.3,4) **Fig.3** shows the phase velocity - frequency images. **Fig.3(a)** shows the experimental result by using this vibrator as a seismic source. **Fig.3(b)** shows the experimental result by hammering. The dark areas show precise areas of phase velocity - frequency images. In **Fig.3(a)**, the dark areas change little. In **Fig.3(b)**, the dark areas change greatly when the dark area is at the frequency over 40 Hz. These experiments were performed on the general loamy layer of the Kanto Plain. It is impossible to consider that the dark areas change greatly. Therefore, surface-wave methods by using a giant-magnetostriction vibrator as a seismic source are high-precision at the frequency over 40 Hz. The frequency affects the exploration depth. The high-frequency Rayleigh waves affect the exploration

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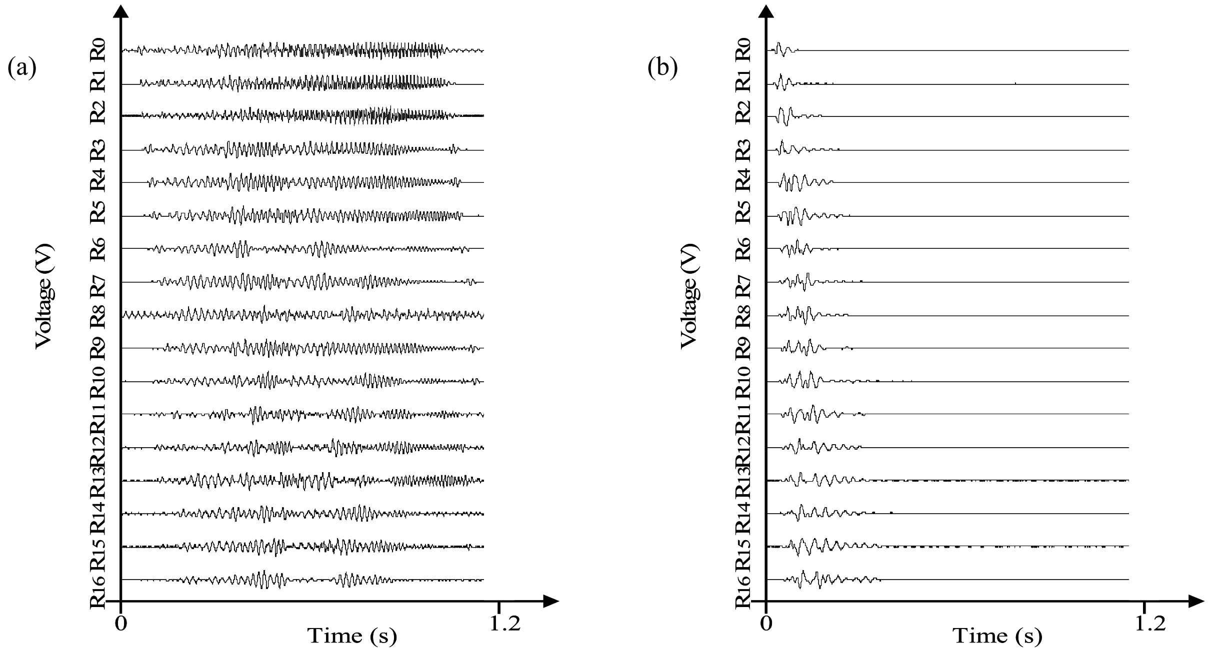

Fig.2 Received waveforms.
(a) experimental result by using a giant-magnetostriction as a seismic source. (b) experimental result by hammering.

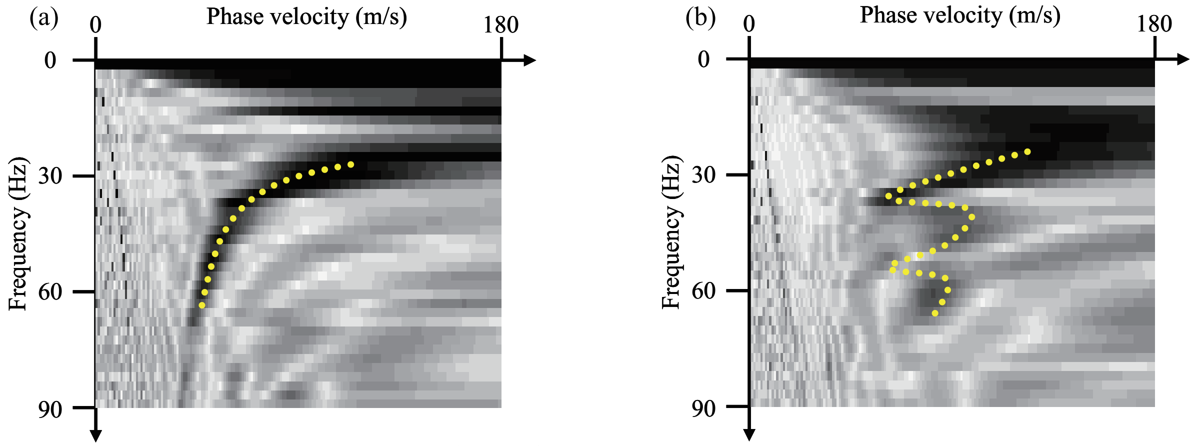

Fig.3 Phase velocity - frequency images.
(a) experimental result by using a giant-magnetostriction as a seismic source. (b) experimental result by hammering.

accuracy of ultrashallow underground. The surface-wave methods by using a giant-magnetostriction vibrator as a seismic source are high-precision at ultra-shallow areas. In addition, as shown **Fig.3(a),** the surface-wave methods by using a giant-magnetostriction vibrator as seismic source are high-precision at the frequency under 72 Hz. It is generically considered that the Rayleigh waves propagate underground at the depth of one third of the wavelength. The velocity of the Rayleigh waves at the frequency under 72 Hz is 45 m/s. The wavelength of these Rayleigh waves is 63 cm. This indicates that it is high-precision at the depth over 22 cm.

4. Conclusion

In this study, surface-wave methods by using a giant-magnetostriction vibrator as a seismic source were performed. To verify the applicability of surface wave methods by using this vibrator as a seismic source, the experimental result was compared with the experimental result by hammering. As a result, it was indicated that the giant-magnetostriction vibrator was effective as a seismic source to improve the exploration accuracy of ultrashallow underground on the surface-wave methods.

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