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Study on Improvement of the Estimated Accuracy of the Sound Propagation Time in the Soil

土壌における音波伝搬時間の推定精度向上に関する検討

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1. Introduction

The drying up of aquatic resources generated for abnormal weather in all the countries of the world becomes the problem now. Therefore saving water of agriculture water occupying most of the water consumption is considered [1]. We studied about measuring the water distribution in the rooting zone of the plant using sound wave vibration [2-3]. This time, to observe a micro change of volume water content, we examined the estimated precision improvement of the propagation velocity that used a cross-correlation function method together with a grand total of the amplitude square method [4].

2. Estimation method for propagation velocity

2-1 Grand total of the amplitude square method

The amplitude of a received waveform provided from the vibration transmitted measurement is squared and grand total is calculated by adding a value provided every width ⊿t in the whole section for measurement time. For this value, propagation time is decided at the time which cross with the threshold set beforehand. There are two following characteristics of this method.

(a) By squaring the amplitude, high-frequency component become small so as to be able to ignore than the biggest amplitude.

(b) Because the change of the wave pattern is emphasized, calculation of the propagation time is stable in various measurement condition [4].

2-2 Combination of the cross-correlation function and the grand total of the amplitude square method

The grand total of the amplitude square method has a characteristic that unevenness of the calculated propagation time is relatively small. The grand total of the amplitude square method has a characteristic that unevenness of the spread time is calculated decreases. However, it is thought that the precision to measure a micro change of volume water content targeted for the measurement of this study does not reach for the present conditions. On the other hand, the cross-correlation function method is high in the estimated precision when a wave pattern is beautiful, but stability at calculated propagation time is remarkable, and it is confirmed to lower when the change of the waveform is a wave propagating the big soil. Therefore the propagation time calculation law that used both together was examined. The propagation speed of sound calculation procedures are as follows. Figure 1 shows an example of the amplitude square of a received wave and the grand total of the amplitude square.

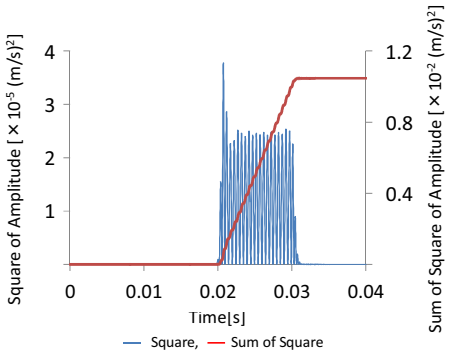

Fig. 1. An example of the amplitude square of a received waveform (blue line), and grand total of the amplitude square(red solid line).

The cross time when the wave pattern of a grand total of the amplitude square and the set threshold is done with propagation time and calculates a propagation velocity.

A propagation speed of sound level calculated by grand total of the amplitude square method mentioned above is assumed reference. Processing using the cross-correlation function often usually does the time when a correlative price is high with propagation time. However, plural

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candidates are picked in consideration of waveform being disturbed this time other than the peak time of the correlative value and calculate a propagation speed of sound level. Positive peaks of the neighborhood of a maximum peak of the correlative wave pattern are done with candidate time.

3. Soil propagation measurement

3-1 Experimental setup

Using a processing method spoken in a foregoing chapter for sound propagation measurement data using the commercial soil, it was compared with the result of the correlative processing. Experimental setup is shown in Fig.2.

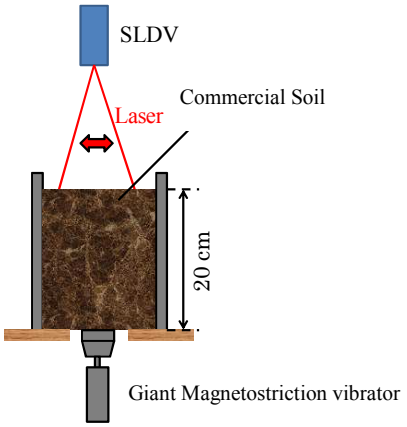

Fig. 2. Experimental setup for propagation velocity.

The soil fills a cylinder container made by acrylic to an altitude of 20cm in height and shall measure it after having added constant pressure. A giant magnetostriction vibrator (Moritex Corp., AA140J013-MS1) is used as a sound source from the bottom of a container and performed the vibration measurement of the soil surface using Scanning Laser Doppler Vibrometer (SLDV: Polytec Corp, PSV400-H4) from the direct top. The output waveform uses the burst wave of 1 kHz of sine wave, 10 cycles.

3-2 Propagation velocity estimation result

Propagation velocity of sound result of a measurement by the cross-correlation processing and propagation speed of sound result of a measurement by grand total of the amplitude square method are shown in Fig.3. Also, Table.1 shows the standard deviation of each processing method. When correlative processing is used in the case of this measurement from Fig.3, the result of grand total of the amplitude square method is stable, but it gets a peek that precision does not appear as a result of the correlative processing while stability is low.

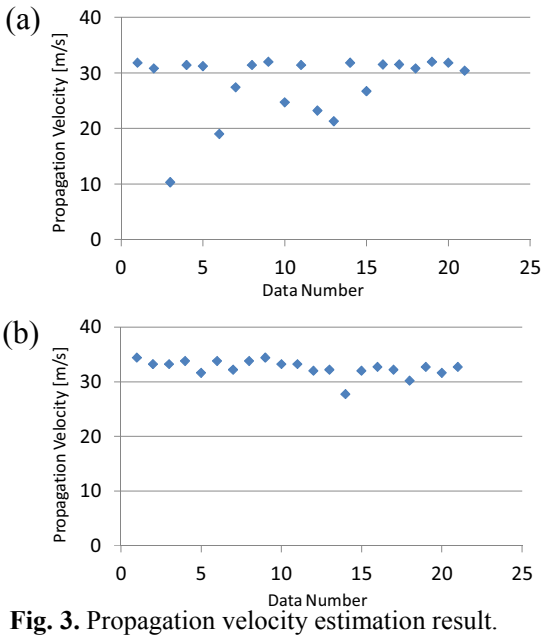

Fig. 3. Propagation velocity estimation result.
(a) Combination of cross-correlation processing,
(b) Grand total of amplitude square method.

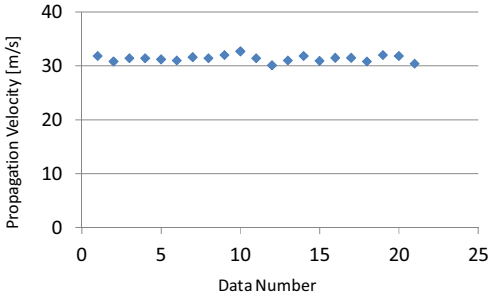

Fig. 4. Combination of cross-correlation processing and grand total of amplitude square method.

Table. 1. The standard deviation of each processing method.

	Combination of cross-correlation processing	Grand total of amplitude square method	Improved Method
Standard Deviation [m/s]	5.41	1.47	0.59

4. Conclusion

This time, we can confirm that stability and precision could be found in the medium that vibration such as the soil was hard to propagate by having examined the processing that used grand total of the amplitude square together with cross-correlation processing. In future, optimization of the threshold is going to be examined.

References

1. H.Hosoya, *et al.*: ICSA2008 Proc. (2008) 391.
2. Y.Nakagawa and T.Sugimoto: 2011 IEEE International Ultrasonics Symposium Proc. (2011) 748.
3. T.Sugimoto, *et.al.*: AIP Conf. Proc. **1433** (2012) 59.
4. H.Fujii and K. Adachi, Proc. Spring Acoust. Meet. (2012) 1421.