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Basic Study on Acoustic Imaging of Water Distribution in the Soil using Propagation Velocity of Sound
伝搬音速による土壌水分分布の音響映像に関する基礎研究

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1. Introduction

Now, the serious water shortage occurs in a lot of countries. The cause is the increase of the population, an economic development and worldwide abnormal weather. However, the most of water is used as agriculture water. Therefore, many studies about the saving of the agricultural water are performed. The irrigation system using the difference of soil water potential as one of the researches attracts attention. This method has the nature to keep water content inside ground constant. However, effective saving water is not able to be performed, because the water distribution in soil is difficult to grasp. Therefore, we propose a method of monitoring and imaging of the water content in the rooting zone using a sound vibration and the Scanning Laser Doppler Vibrometer (SLDV; Polytec Corp, PSV400-H4). This time, we study about the influence to the propagation velocity when changing the volume water content of the water distribution.

2. Summary of water distribution measurement

The schematic figure for water distribution measurement using SLDV and giant magnetostrictive vibrator is shown in **Fig.1**. SLDV measures the vibration of ground surface excited by sound wave caused from vibration source. Using the vibration waveform and the output waveform calculates the propagation velocity from vibration source to the measurement point. There is a difference in the average of propagation velocity (sand: about 130 m/s, water: about 1500 m/s) in sand and water. When passing water distribution, the propagation velocity becomes fast. Using this phenomenon, water distribution can be estimates.

3. The Experiment of the Measurement of the Water Distribution

3.1 Experimental Setup (When installing water distribution in the sand surface)

Figure 1 shows an experimental setup (The side view of the sand tank). There are nine holes to set up the sound source which was covered with the rubber in the sand tank base. It sends vibration with the giant magnetostrictive vibrator to have installed in the hole of the sand tank base. SLDV measures the vibration of ground surface excited by sound wave caused from vibratory source. The plastic container (40×50×30 cm) which is made from acrylic in the laboratory that had been filled with sand of uniform particle size (200 to 300 μm) was used for this experiment. In this experiment, it measures the status of the water distribution by the change of the vibration propagation. The making method of the moisture distribution is shown below. First, the plastic container is filled with the sand into the plastic container. Next, the water of the fixed quantity is pour into the container. Finally, a plastic container is removed after having put it in the sand tank upside down. This time, we study that there was a difference in the propagation velocity, when the water-content of the water distribution is 150 ml and 250 ml. Water distribution is installed on the surface of the sand tank and it measured. Experiment method is shown as follows. The output waveform uses the burst wave of 2 kHz of sine wave, 3 cycles. The scan area of SLDV is 17×23 points, the point interval are about 1.75 cm wide and about 1.8 cm long.

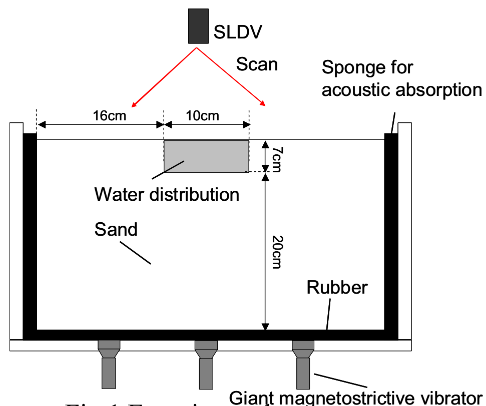

Fig.1 Experimental setup.

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3.2 The Experiment Result

Result of imaging in the speed of sound range common sound-velocity distribution from 150 m/s to 180 m/s is shown in **Fig.2**. From this figure, we can confirm that the propagation velocity of 250ml is faster than 150ml. We think that the water-content of the water distribution in ground can be estimated by the non-contact using the difference of such a propagation velocity.

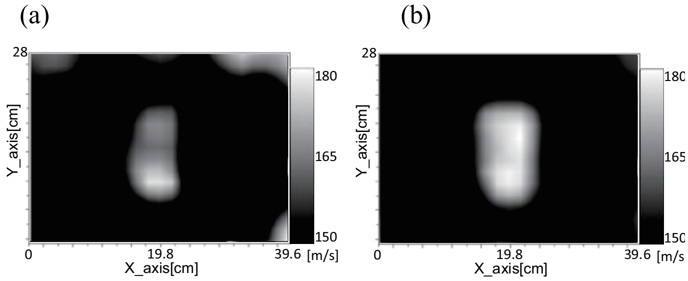

Fig.2 The result of imaging of propagation-velocity distribution.
(a) 150m/s, (b) 250m/s.

3.3. Experimental Setup (When using negative pressure irrigation)

Figure 3 shows an experimental setup. The porous pipe which is made from ceramic is installed in the about 18 cm height from the sand tank base and the level control tank is installed in the position with the low of about 20 cm from the height of the porous pipe. The rate of the water which is supplied to ground by this height is decided. The method of experimenting is same as the method of experimenting to the above. However, this time, the measurement time must be made short because to measure temporally changing water distribution. Therefore, using the sound source position is only under the porous pipe. The vibration measurement measured in the interval of 10 minutes and measured until 90 minutes. A result of imaging in each time is shown in **Fig.4**. From this figure, we can confirm that water distribution is temporally changed.

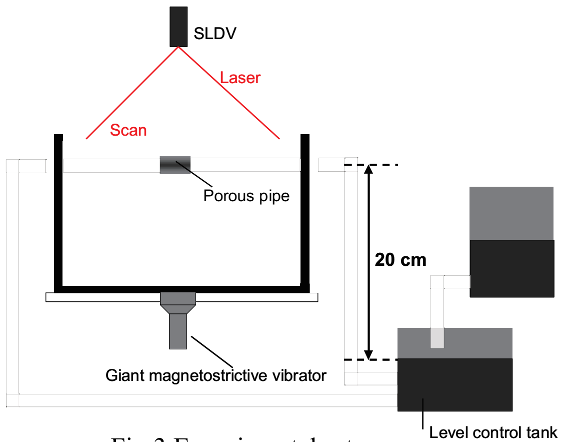

Fig.3 Experimental setup.

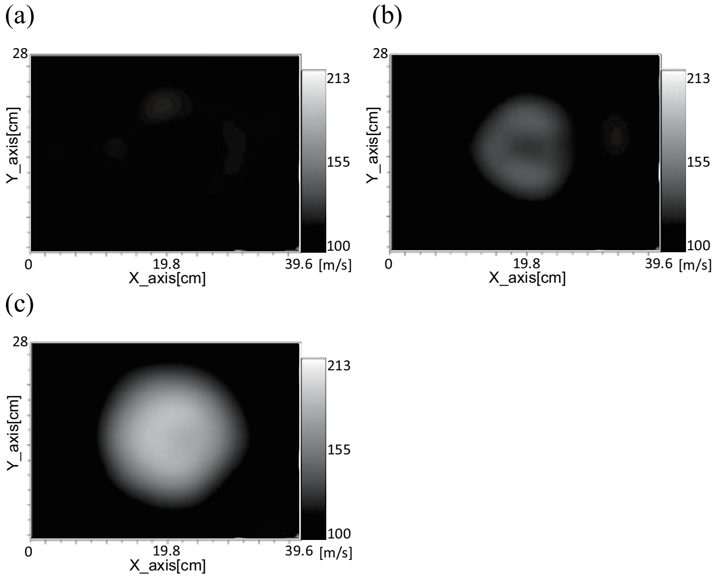

Fig.4 The result of imaging of propagation-velocity distribution and it's temporal change.
(a) 10 minutes, (b) 20 minutes, (c) 40minutes.

4. Conclusion

This time, we can confirm that the used vibration velocity distribution image was a very effective imaging method to the water distribution which is in the shallow position near the ground surface. Also, in the experiment which used negative pressure irrigation, we can confirm that it was caught in the water distribution which changes time wise by measuring at both of the vibration measurement. In the future, we plan to improve calculation precision with the propagation velocity and intend to review the improvement of the estimated precision of the volume water content by the vibration measurement. And, we intend to examine whether our method can apply even in the case that a plant is growing up in soil for gardening.

References

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