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DETECTION OF INFLOW SEDIMENT IN WATER FOR ELECTRIC FIELD COMMUNICATION USING AQUEDUCT

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Abstract. *The water pipe bursts and sediment flows in water (inflow sediment) when an earth quake occurs. When sediment flows into water pipe, electric field communication accuracy may be affected but inflow sediment detection by water works is not easy. In this study, we investigated effect of inflow sediment in water for electric field communication using aqueduct. This study's results suggest that sediment seems to flow in water when induced voltage on electric field communication device using aqueduct's receiving terminal is larger than usual.*
Keywords: Electric field communication, Aqueduct, Disaster management

1. **Introduction.** Earth quake with an intensity seven on the Japanese scale of one to seven occurred in Kumamoto, Japan, 2016. The water pipe bursts and sediment flows in water (inflow sediment) when an earth quake occurs. Inflow sediment detection by water works is not easy because the water works needs a lot of people to detect a fault location of water pipe network.

When disaster happens, specifying fault location of water pipe network is delayed because of manpower shortage. We need an automatic system for inflow sediment detection data transmission to water works.

In recent years, research on leak detection and smart meters has been actively conducted [1-3]. However, a method for automatically collecting inflow of sediment into water pipe data acquired by smart meters via the Internet has not yet been established. In previous study, we proposed that water leakage detection system used electric field communication [4,5]. We investigated feasibility about electric field communication using aqueduct.

Electric field communication technology using dielectric polarization of dielectrics applies the Intra-Body Communication technology [6,7]. Figures 1-3 show overview of electric field communication using aqueduct. This system used water in water pipe (aqueduct) as a data transmission path and connected outdoor water meter to indoor wireless LAN. The data of the water meter is modulated and transmitted to the receiving terminal through the water pipe as a transmission path. This data is demodulated at the receiving terminal and then sent to the Waterworks Bureau via the Internet. If Waterworks Bureau will use this system, they can be data collection without checking water meter directly. Previous study's results suggested that the aqueduct 1.2 meters long can connect outdoor water meter to indoor and electric field communication using aqueduct is feasible.

In this study, we examine the effects on communication when sediment flows into the water pipe. The water pipe bursts and sediment (for example, wet sand) flows in water (inflow sediment) when an earth quake occurs. Inflow sediment detection by Waterworks Bureau is difficult for the reasons mentioned before and when sediment flows into water pipe, electric field communication accuracy may be affected.

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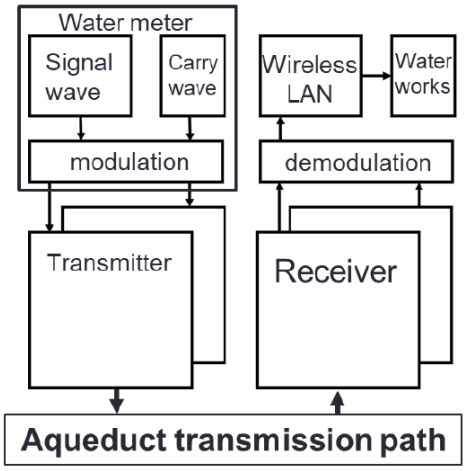

FIGURE 1. Overview of electric field communication using aqueduct

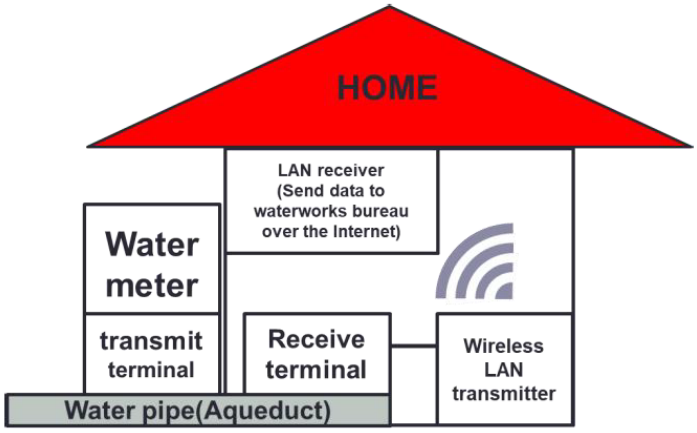

FIGURE 2. Connection flow from smart water meter to the Internet

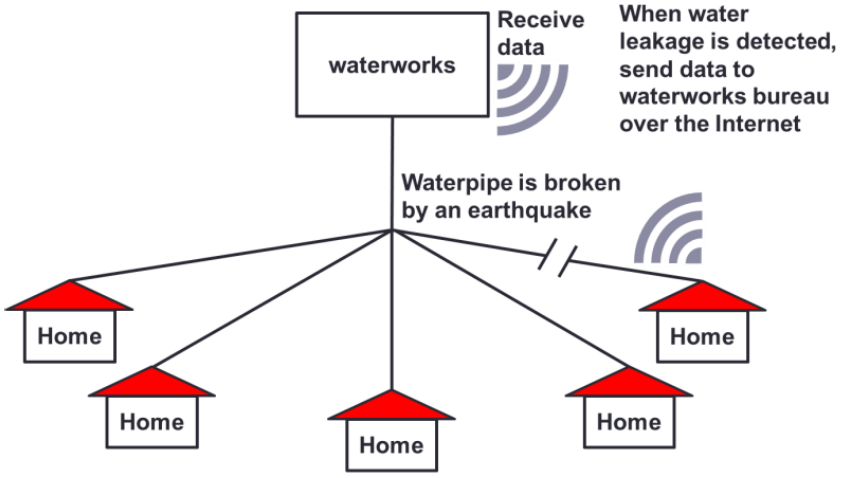

FIGURE 3. Outline of water leakage detection system

We need an inflow sediment detection and automatic system construction for inflow sediment detection data transmission to water works. In this study, we investigated whether it could be detected when sediment flowed into the water pipe.

2. **Methodologies.** Figure 4 shows the photograph of the experimental condition in the anechoic chamber. Water pipe is located between terminals. Terminals position is water pipe's bottom or top. We used PVC water pipe (called aqueduct) as a transmission path. We applied input voltage (1 MHz, 10 Vp-p) between the electrodes of transmitting terminal. The distance between terminals is 20-120 mm.

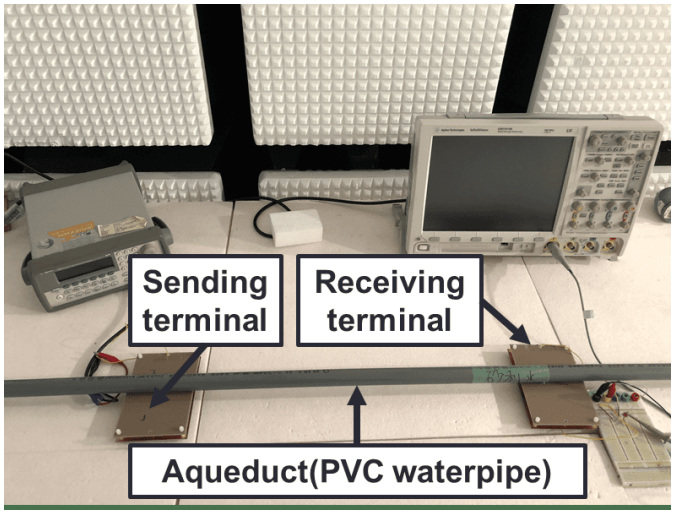

FIGURE 4. Photograph of the experimental condition in the anechoic chamber

Figure 5 shows the transmitter terminals of electric field communication device using aqueduct. The terminals are modeled by a pair of parallel plate electrodes made of copper plate. The gap distance between the electrodes is 10 mm. We measured induced voltage between the electrodes of receiving terminal. Figure 6 shows sectional view of aqueduct. (A) is air only, (B) is water only, (C) is sediment only, (D) is half-air and half-sediment, and (E) is half-water and half-sediment.

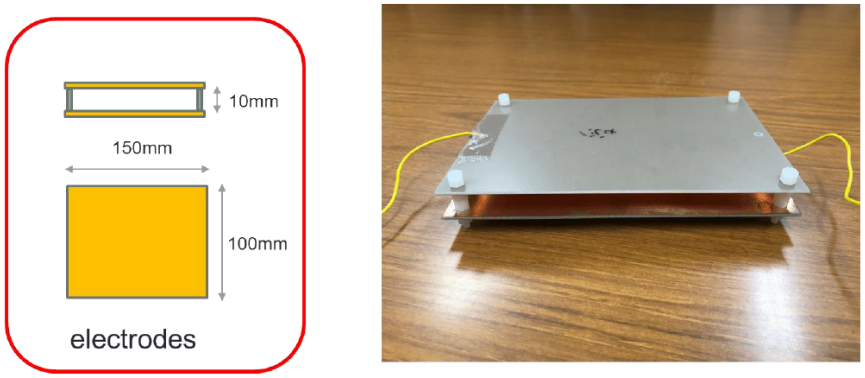

FIGURE 5. The terminals of electric field communication device using aqueduct

3. **Results.** The experimental results are shown in Figures 7-10. The vertical axis shows the induced voltage on the receiving terminal and the horizontal axis shows the distance between terminals.

Figure 7 shows the induced voltage comparison of two conditions, air only and water only in water pipe. Water only result is larger than air only result. This result suggests that electric field is coupled through the aqueduct, and it is not direct electric field coupling between electrodes.

Figure 8 shows the induced voltage comparison of water only, air only and full sediment. We used wet sand as the sediment. Full sediment result is larger than air and water only

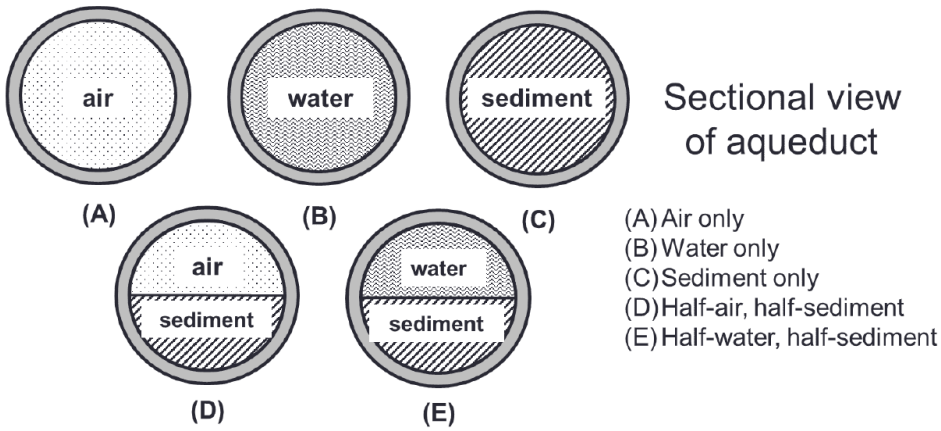

FIGURE 6. Sectional view of aqueduct

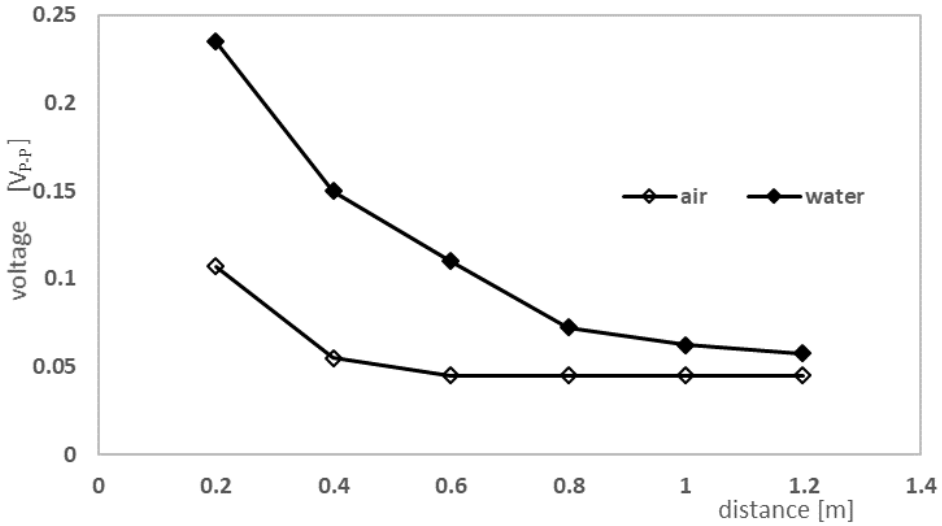

FIGURE 7. Induced voltage comparison of two conditions, air only and water only

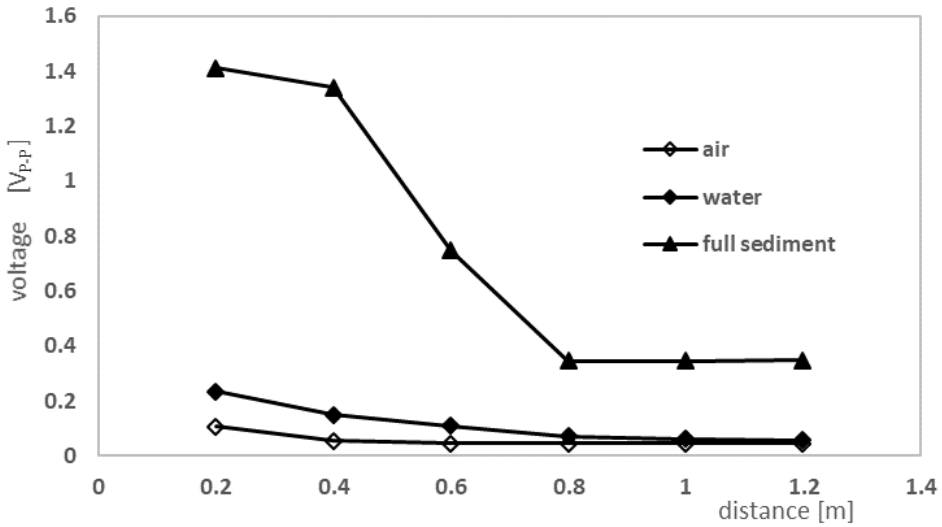

FIGURE 8. Induced voltage comparison of water only, air only and full sediment

results. This result suggested that if sediment is purchased in the aqueduct, the induced voltage will rise.

Figure 9 shows the induced voltage comparison of four conditions (air, water, half sediment-half air and half sediment-half water) when the electrode is placed bottom of the water pipe and Figure 10 shows the induced voltage comparison of four conditions (air, water, half sediment-half air and half sediment-half water) when the electrode is placed top of the water pipe. Comparing the two results, we found that the induced voltage was higher when the electrode was placed water pipe's bottom than water pipe's top. In addition, when only half of the water was in the water pipe, the induced voltage was higher when the electrode was placed bottom of the water pipe than that when the

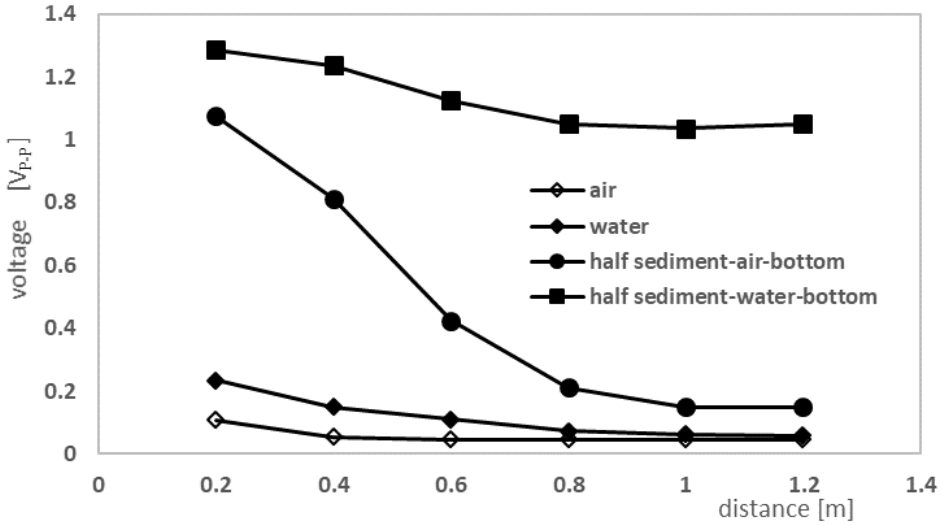

FIGURE 9. Induced voltage comparison of four conditions (air, water, half sediment-half air and half sediment-half water) when the electrode is placed bottom of the water pipe

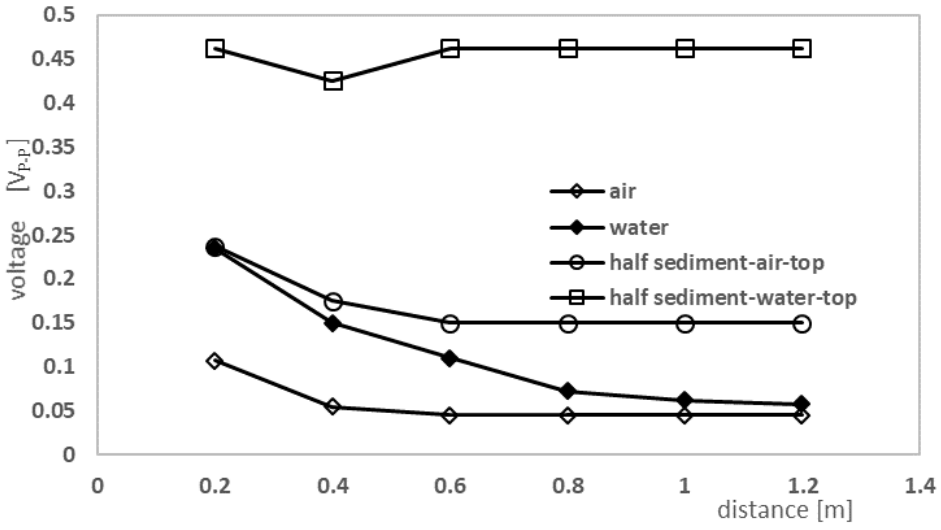

FIGURE 10. Induced voltage comparison of four conditions (air, water, half sediment-half air and half sediment-half water) when the electrode is placed top of the water pipe

electrode was placed top of the water pipe. This result shows that the electrode and water in the water pipe are coupled in electric field.

In any result, the induced voltage on receiving terminal increased when the sediment flowed in aqueduct. From the above results, it is considered possible to detect when sediment flows into the water pipe.

4. **Conclusions.** We investigated effect of inflow sediment in water for electric field communication using aqueduct. In any result, the induced voltage on receiving terminal increased when the sediment flowed in aqueduct. From the above results, it is considered possible to detect when sediment flows into the water pipe. As a future study, we plan to study the effects of water pipe shape, effects of water flow rate in water pipe, measurement of the electrical constant of the water supply under each condition and water pipe network's equivalent circuit design.

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