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DEVELOPMENT OF EMERGENT MONITORING SYSTEM FOR LEAKAGE FROM THE DAM

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ABSTRACT

In this paper, the development of 24-hour monitoring system for leakage from the dam by using goods on the market will be introduced. From the middle of November in 2013, the IWAYA Dam Management Office had conducted 24-hour alert condition because of unexpected increasing leakage from the dam body and its shallow foundation. The initial monitoring system for leakage volume had some drawbacks in terms of conducting 24-hour alert condition. Some engineers of the IWAYA Dam assembled ad-hoc monitoring and alert system developed by using goods on the market, such as a smartphone.

1. GENERAL INFORMATION OF THE IWAYA DAM

The IWAYA Dam, located in Gero City of Gifu Prefecture in the middle of Japan completed its construction in 1977 as a multi-purpose dam. The type of the dam is a rock-fill dam, and Japan Water Agency (hereinafter referred to as JWA) has been managing and operating the dam since 1977.

Figure 1. Downstream view of the IWAYA Dam

The dam can reduce estimated flood discharge from 2,400m^3/sec to 300m^3/sec by using its flood control capacity of 50,000,000m^3. The IWAYA Dam supplies 17.63m^3/sec (maximum) as industrial water, 21.93m^3/sec (maximum) as municipal water, and 6.13 m^3/sec (maximum) as irrigation water. The dam also contributes to power generation. The power plant is operated by Chubu Electric Power Co. Inc. It generates 288,000kw (maximum) by using 335m^3/sec volume of water as turbine discharge.

Table 1 shows profile of the dam.

Table 1. Profile table of the IWAWA Dam

Items	Data
Height	127.5m
Length	336m
Volume of the dam	5,780,000m^3
Catchment area (direct)	265km^2
Catchment area (indirect)	770km^2
Reservoir area	4.26km^2
Gross storage capacity	173,500,000m^3
Effective storage capacity	150,000,000m^3

The dam has been managed and operated stably since completion of the dam construction. It has also worked as an attractive sightseeing spot of this area.

2. LEAKAGE PROBLEM

Monitoring leakage from the dam body and its shallow foundation is one of the important factors in order to grasp the status of rock-fill dams. The IWAYA Dam has been equipped with monitoring system for leakage volume since its construction. The volume of leakage from the dam body and its shallow foundation had recorded stable value of approximately 75 l/min for a long time. From the middle of November to early December in 2013, the volume of leakage had been increasing gradually, its value recorded approximately 170 l/min. As a result, the IWAYA Dam Management Office took 24-hour alert condition in preparation for unexpected increasing leakage from the dam body and its shallow foundation. The initial monitoring system for leakage volume was equipped only on-site alert function that meant officers needed to stay in the machine room at the management office throughout a day in order to monitor leakage and its alert. (see Figure 2) The number of officers of the IWAYA Dam Management Office was limited, as a result, many JWA officers from other offices were dispatched for the monitoring.

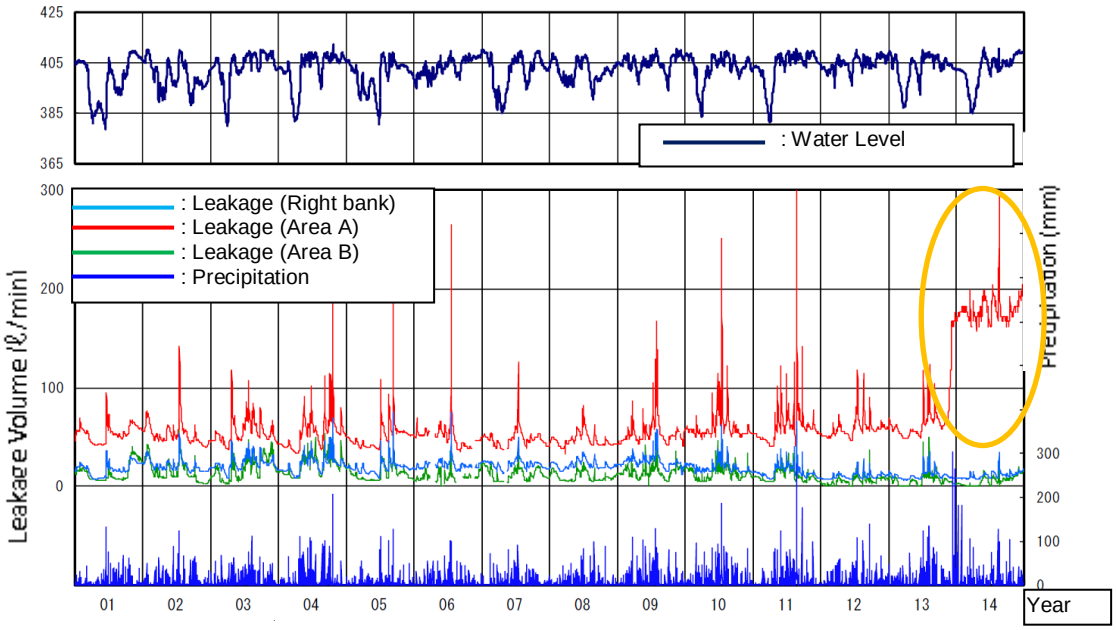

Figure 2. Leakage value of the IWAWA Dam

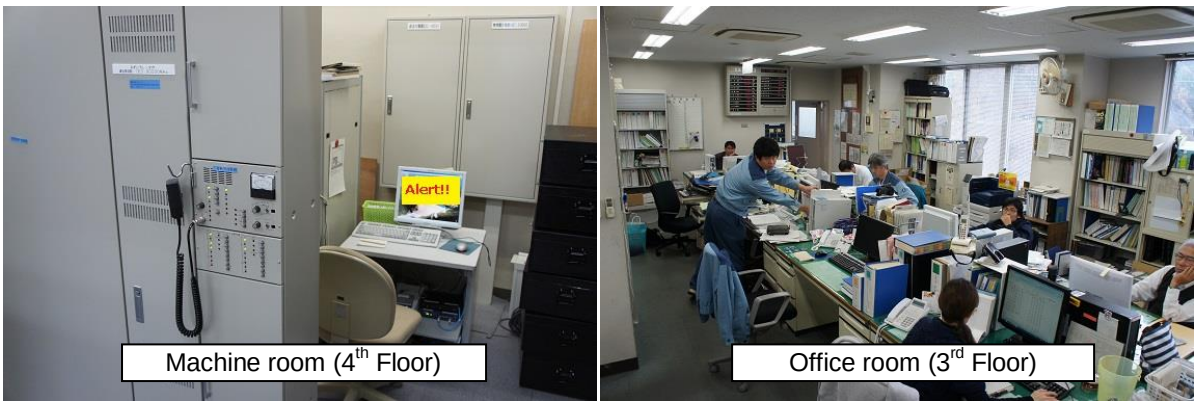

Figure 3. Figure of the machine room and the office room of the IWAYA Dam

3. FIRST SYSTEM CONSTRUCTED BY OFFICERS OF THE IWAYA DAM

3.1 Approach to the First System

Continuing above condition for long period raised some problems such as fatigues of officers, impediment of ordinary works, and so on. Some engineers of the IWAYA Dam Management Office formed a development team for a new system and took action to resolve these problems. They tried to plan two ways by using available devices which they already obtained.

3.1.1 First System : Camera system by smartphone

First approach is development of camera system by using a smartphone. Recently, almost all of smartphones on the market have been equipped with camera. As already mentioned, officers of JWA were required to stay in the machine room for checking various data displayed by the initial monitoring system all through a day. Therefore, it was considered that camera system can make officers free from 24-hour monitoring in the machine room. The development team found out an application which realizes the photos taken by a smartphone to be uploaded periodically to the private area of cloud on the Internet while keeping security. (see Figure 3)

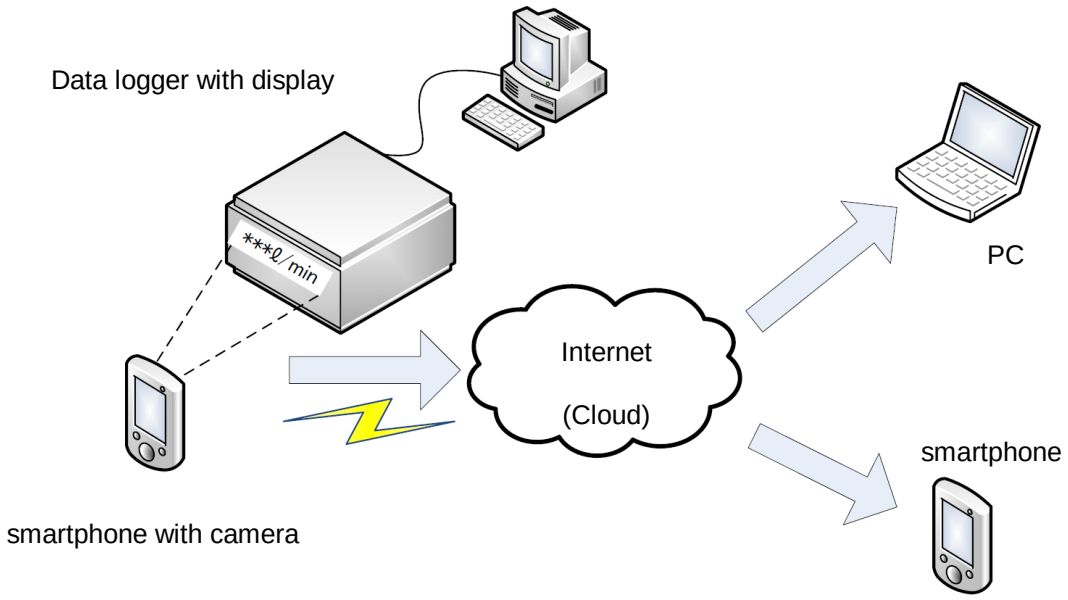

Figure 4. First system : Image of camera system by smartphone

By using the application, photos of data displayed by initial monitoring system were shared every five second. It enabled officers of the IWAYA Dam to refer to the data everywhere.

3.1.2 Announcement system by broadcast appliances

Second approach is to use broadcast appliances installed in normal buildings. In Japan, many buildings are equipped with broadcast appliances for noticing time tone, emergency alert for fire and earthquake, information from building owner, and so on. The IWAYA Dam Management Office building is also equipped with broadcast appliances. The initial monitoring system had speaker jack, the development team connected a speaker jack of the initial monitoring system to broadcast appliances of the IWAYA Dam Management Office building.

Before connecting to the broadcast appliances, alert from the initial monitoring system was heard only in the machine room of IWAYA Dam Management Office building. The structure of the IWAYA Dam Building consists of 1) machine room located on the 4th floor of the building, and 2) office room (clerk room) located on the 3rd floor of the building. Officers of the IWAYA Dam Management Office usually stay in the office room. Therefore, officers couldn't hear the alert warned by the initial monitoring system when they stay in the office room. The machine room is well air-conditioned for protecting machines that means it is too cold for long stay in the room.

After setting up this system, officers could realize the alert warned by the initial monitoring system when they stay in the office room and/or other rooms of the IWAYA Dam Office Management building.

3.2 Evaluation of the First System

This "First system" obtaining two approaches was developed by officer of JWA in a short term. The First system realized the officers of JWA to be able to notice the alert when they were not in the machine room, and could see the data even from outside of the office.

The First system was constructed by free of charge, because the development team constructed the system by using ordinary electric and electronic appliances which they already had. (ie broadcast system and smartphone). The system achieved easy maintenance. The duration of the construction of the system took only one day from its planning. But there was one drawback that was instability.

4. DEVELOPMENT OF IMPROVED SYSTEM (SECOND SYSTEM)

Officers of the development team of the system collected feedback from users of the system. It was easy to draw improvement opinions because devices used for the First system were accustomed to use. Based on the evaluation of the First system and opinions from users, the development team planned a improved system (Second system) with the manufacturer of the initial system. They identified required specification by using feedback of the First system.

4.1 Concept of improved system (Second system)

Needed functions identified by the development team are as follows:

- Real time alert notice function: if the alert is warned by the monitoring system, every officers can know that by e-mail to his/her mobile-phone / smart-phone with measurement values.
- Monitoring by video camera: officers can see the displayed data by video camera when they are even outside with improved stability methods.

4.2 Development of improved system (Second system)

The development team found alert notice system with simple contact output on the market. The alert notice system has function of sending e-mail based on the information from contact output. The system is utilized as real time alert notice function. At first, an officer needs to set particular value on the PC. Once the leakage water value surpasses the set value on the PC, the alert notice system sends e-mails to related officers of JWA with related data. (see Figure 4) Following that, installation of robust camera system was planned in order to realize continuous monitoring. The First system adopted Wi-Fi-connection for smartphone. This caused disconnection to the Internet from smartphone, and instability of running the application. For resolving the drawback, web-camera with wired connection was introduced. The web-camera realizes remote control so that users of the camera can easily change the direction of the camera. If user of the web-camera wants to communicate with the officer of the IWAYA Dam, it can be used as TV telephone system. Meanwhile, the user of the web-camera can copy the pictures from the system. Automatic connection procedure was added to the

system, so that it improved connection to the Internet by terminating sudden shutdown or disconnection to the Internet.

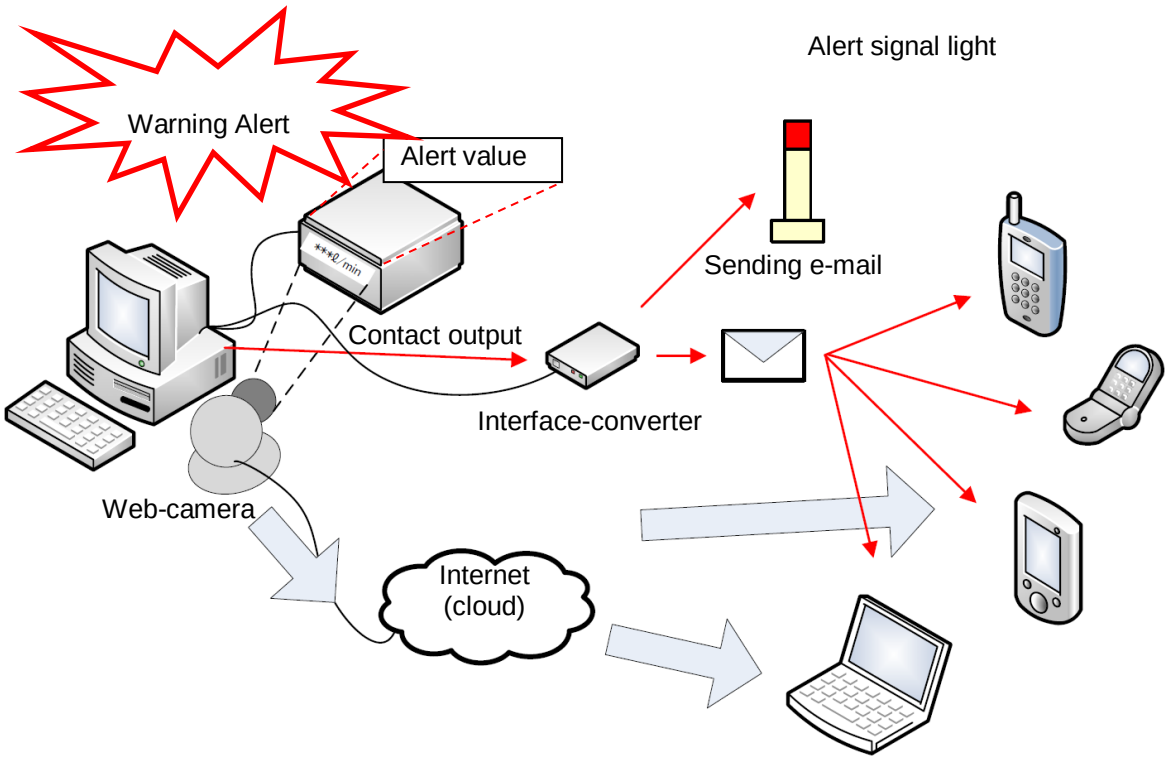

Figure 5. Configuration diagram of Real time alert notice function (Second system)

5. CONCLUSION

Regarding the situation of the leakage, officers of the IWAYA Dam formed the study team on leakage of the IWAYA Dam. The study team members are composed of academics, experts, and stakeholders. The study has took place four times so far. However, the study team has not yet been identified the cause of leakage. The study is still ongoing.

Along with unexpected increasing leakage from the dam body and its shallow foundation, demand of immediate treatment raised. Officers of the IWAYA Dam managed to assemble ad-hoc monitoring and alert system as a First system developed by using goods on the market, such as a smartphone.

The approach is also useful for blind spot such as narrow spot where human cannot enter and contributes to labour-saving. Rationalization is one of the important challenges for JWA. Officers of the IWAYA Dam introduced tablet device with the development of the improved system (Second system). As a result, 24-hours alert condition staying in the machine room was released. In addition, this system has successfully reduced daily task.

Technology is being developed day by day, as engineers for water resources management, we should introduce these technologies proactively.

6. ACKNOWLEDGEMENTS

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