Urban Flood Disaster Monitoring Services by Using Manhole with Built-in Antenna (Smart Manhole Cover)

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Keywords Smart manhole cover, Torrential Rain, Cloud, Sewage pipe, XRAIN

Abstract

As a joint project with Nihon Suido Consultants Co., Ltd., we started "Urban Flood Disaster Monitoring Services." Under this service, we detect early urban type flood disaster occurring risk and report and notify the updates to designated parties concerned.

These services are a cloud-based solution for an application for a disaster prevention information system for local governments in Japan. The water-level information in a sewage pipe is collected and transmitted for a manhole with built-in antenna (smart manhole cover). The smart manhole cover is an Internet of Things (IoT) device for sewage pipes. This is a first product of its kind in Japan's. Such collected data is later merged with the extended Radar Information Network (XRAIN) and the Geographic Information System (GIS) information. Such updates of "necessary information for disaster prevention" is provided in real-time.

Information management for water level data at sewage pipes, etc. had been difficult. Now, we collect such information by the said Internet of Things (IoT) device and put it on the Cloud to share among designated parties. Being on the Cloud, we can centrally manage disaster prevention information and datamine such information like rainfall and water levels, etc. and such data can be used for the prevention of disasters.

1 Preface

There have recently been many and frequent cases of flood damages in urban area in Japan due to heavy rains like torrential rains, etc. and natural hazards caused negative impacts to the lives of people and socio-economic activities. Against such urban flood disasters, there was progress on legal frameworks such as recent enactment of the Flood Prevention Act※1,and other related laws in Japan. Such legal frameworks helped both structural measures and non-structural measures. The former case refers to such actions as the building of rainwater reservoir facilities. The latter case refers to programs to publicize imminent flood damage risk, etc.

This paper introduces our Internet of Things (IoT) – based services called "Urban Flood Disaster Monitoring Services" and the IoT device – manhole with built-in antenna ("smart manhole cover" hereafter).

2 Urban Flood Disaster Monitoring Services

These services are based on the information gathered from extended Radar Information Network (XRAIN) – observed data by X-band MP radar, and water level information transmitted from our smart manhole cover. It grasps the "rainfall conditions (particularly local heavy rainfall)" and "water level conditions in sewage pipes." The services then show the "flood risk and significant other information necessary for rainwater control," "geographic information," and "critical information necessary for disaster prevention." Such information is shown on the Geographic Information System (GIS) and in real-time.

In addition, this information is uploaded to the cloud server to share with the designated parties concerned. In doing so, the cloud service provides a stormwater management support tool and pro-

motes facility management support, disaster prevention support, and central management of disaster prevention information. It also promotes the datamining of rainfall and water level information. Fig. 1 shows an image of urban flood disaster monitoring services and Fig. 2 shows an outline of these services.

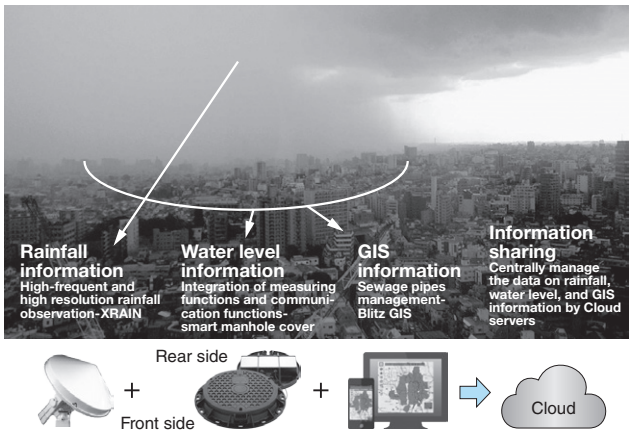


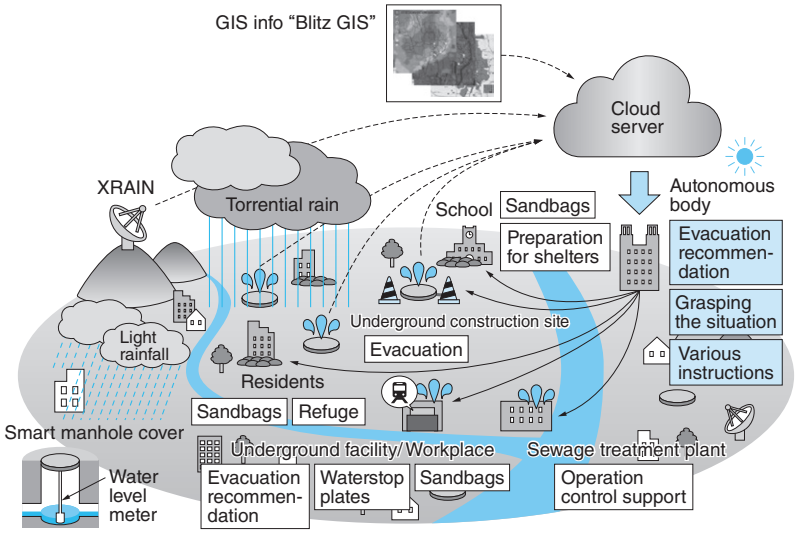
Fig. 1 Image of Urban Flood Disaster Monitoring Services

XRAIN, information of water level in sewage pipes, and GIS map data are centrally managed and shared by using the cloud servers in real time.

3 Smart Manhole Cover

The smart manhole cover is an IoT device for sewage pipes developed that we jointly development with Tokyo Metropolitan Sewerage Service Corporation and HINODE, Ltd. An antenna is accommodated in the surface of a manhole iron lid and sensor, battery cell, and communications equipment are integrated on the rear side. Information about water levels in sewage pipes is then transmitted via the mobile phone network as the cloud server collects such data. Those with the designated parties for the disaster prevention monitoring can manage/monitor the data at the office and the sewage pipe site or key monitoring point sites.

Formerly, real-time monitoring on the water level of sewage pipes was rarely conducted in Japan. A smart manhole cover can be installed very easily by simply replacing an existing manhole iron lid with this smart manhole cover. After replacement, real-time collection of water level information in sewage pipe can be easily assessed. Fig. 3 shows an outline of a smart manhole cover and Fig. 4 shows an external appearance of a smart manhole cover.



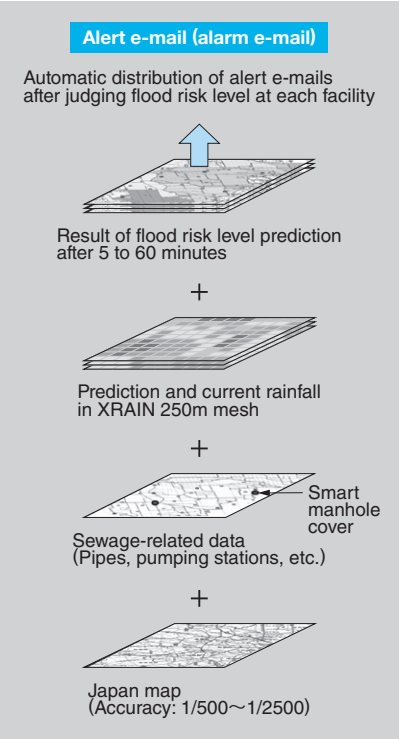


Fig. 2 Outline of Urban Flood Disaster Monitoring Services

Information about the rise of water level in the sewage pipe due to the influence of the torrential rain, etc. can be shared in real-time mode and alert information can be distributed. This information is useful in deciding evacuation orders, preparing sandbags, and giving sewage treatment facility operation control support.

4 Major Functions

The major functions of urban flood disaster monitoring services are a “stormwater management function” and an “information sharing function.”

The “stormwater management function” is used to provide a real-time display of information necessary for stormwater control such as rainfall information (present condition, forecast), water level information, and flood disaster risk. The “information sharing function” is used to share disaster prevention information among the designated parties. These services are accessible from desktop Personal Computers (PC) or laptops, tablet PCs, smartphones, etc. **Fig. 5** shows the functions of urban flood disaster monitoring services.

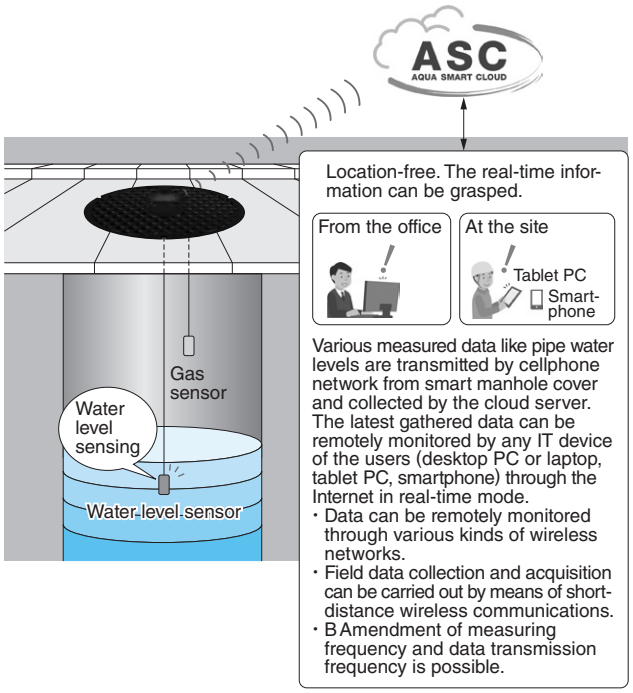
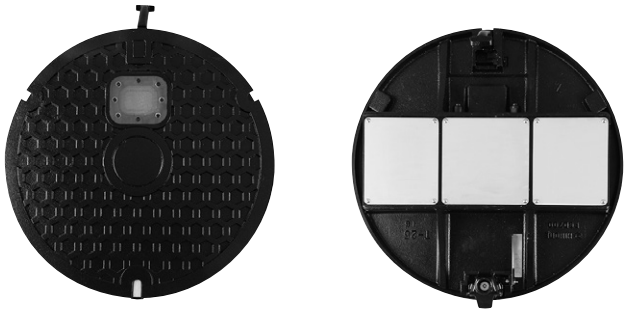


Fig. 3 **Outline of Smart Manhole Cover**

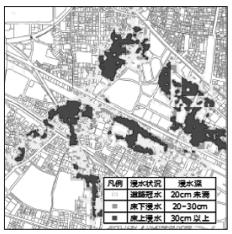
Sewage pipe information on real-time water level, etc. are transmitted and collected by the cloud servers. Such collected data are accessible by any devices.



(a) Front side (b) Rear side

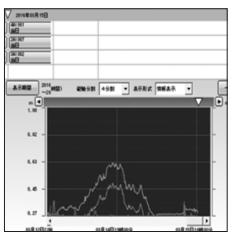
Fig. 4 **Smart Manhole Cover**

A plane antenna is embedded in the surface of a manhole lid. In the rear side, there are embedded items: a battery cell, a communication device, and a converter.

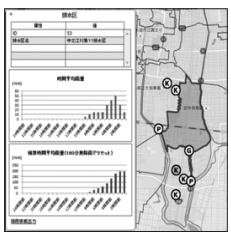


Display of flood risk level (Real-time flood hazard map)

Color-coded display according to rainfall conditions

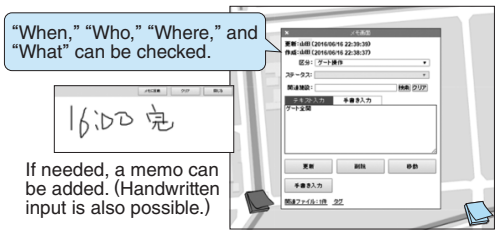


Transitive graph of sewage pipe water levels

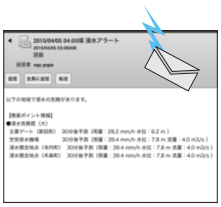


Transitive graph of rainfall levels and total rainfall amount in the past 24 hours (present condition, forecast)

(a) Stormwater control function



The result of actions can be recorded and classified at each site (color-coded display).



Alert e-mail can be distributed according to the situation such as exceeding the prescribed levels (water levels and flow rates) or measured water levels.

Photos, videos, and comments on site conditions can be entered.

(b) Information sharing function

Fig. 5 **Functions of Urban Flood Disaster Monitoring Services**

(a) The stormwater management function is used to provide a real-time display of information needed for stormwater control, such as rainfall information (present condition, forecast), water level information, and flood risk. (b) The information communization function is used to share disaster prevention information among the designated parties.

5 Postscript

As a non-structural measure against urban flood disasters which were on the rise recently in Japan, this paper introduced our urban flood disaster monitoring services and the features of our smart manhole cover.

Going forward, we will work on the wider penetration of this monitoring services in Japan. At the same time, we will develop another IoT-based service by using the IoT device developed through our long-standing sensing technologies as a supplier of such devices. In doing so, we will develop a better application of our IoT-based service.

(**Note**)

※1. The Flood Prevention Act in Japan was announced on May 20, 2015 and enacted on July 19, 2015, and the related laws were enacted on November 19, 2015.