Sustainable and Safe Dams Around the World – Tournier, Bennett & Bibeau (Eds)

Application of mechanical facilities support system using tablet terminals for dam management

T. Yoshida
Kyuyoshinogawa Estuary Barrage Operation and Maintenance Office, Japan Water Agency, Tokushima Japan

Y. Matsumoto
Tonegawa-karyu Integrated Operation and Maintenance Office, Japan Water Agency, Ibaraki, Japan

K. Sasaki
Kawakami Dam Construction Office, Japan Water Agency, Mie, Japan

ABSTRACT: Activities of operation and maintenance of mechanical facilities for dam management are quite diverse, which include inspection work, support for troubleshooting, and others. There are many management offices, in which only one mechanical engineer is assigned. Therefore, needs for support in improvement of operation and maintenance work, support for troubleshooting, and technical support for young mechanical engineers were growing. To cope with those, we are building a management support system of mechanical facilities using tablet terminals and WEB applications. It helps works such as inputting inspection data, accessing various dates through the network, and several supports by videophone. This paper reports its function and the method of the application.

RÉSUMÉ: Les activités d'exploitation et de maintenance des installations mécaniques pour la gestion des barrages sont très diverses, notamment le travail d'inspection, l'assistance au dépannage et d'autres tâches. Il existe de nombreux endroits dans lesquels un seul ingénieur spécialisé en mécanique est présent. Par conséquent, les besoins de soutien pour l'amélioration de l'exploitation et des travaux de maintenance, la prise en charge du dépannage et l'assistance technique pour les jeunes ingénieurs mécaniciens étaient en augmentation. Pour y faire face, nous construisons un système de gestion des installations mécaniques utilisant des tablettes électroniques et des applications WEB. Ce système aide les travaux tels que la saisie des données d'inspection, la consultation pour diverses dates à travers le réseau et l'accès à plusieurs ressources par vidéophone. Cet article présente sa fonction et sa méthode d'utilisation.

1 INTRODUCTION

IoT is an abbreviation for the phrase Internet of Things, and it refers to connecting all kinds of things to the internet.

This definition is rather abstract, but things are connected to the internet via sensors, computers, telecommunication functionality, and more, in an effort to create new mechanisms for things such as household appliances, cars, stores, factories, and so on. In recent years, the cost of sensors and terminals has gone down, and the internet environment has

developed, making it more widely-used. To give one example, IoT technology is utilized to enable people to monitor and operate their household appliances even when they are away from home, and in factories, the factory lines can be monitored from a remote location using sensors. Even in the civil engineering field, its utilization is expanding in ways such as remotely operated bulldozers, and there are even current examples that drones are being used in the management of dams, but there is still a lot of room to further implement IoT technology.

2 SHIKOKU WATER AGENCY STRUCTURE

In Shikoku, the Japan Water Agency has a Yoshino River Bureau which controls the Yoshino River water system, the Ikeda Integrated Operation and Maintenance Office that manages dams upstream (Ikeda, Sameura, Shingu, and Tomisato Dams), the Kagawa Canal Management and Construction Office that manages water diverted from the Ikeda Dam for use in Kagawa, and the Kyuyoshinogawa Estuary Barrage Operation Office that manages the estuary weirs for the Kyuyoshino and Imagire Rivers that branch off downstream from the Yoshino. (Figure. 1)

2.1 *Mechanical equipment at Ikeda Integrated Operation and Maintenance Office*

Integrated management of four dams: Ikeda Dam, Sameura Dam (Figure. 2), Shingu Dam, and Tomisato Dam is operated by the Ikeda Integrated Operation and Maintenance office. Mechanical equipment for all dams amounts to a total of 44 outlet works and 29 other facilities such as inland drain pumps.

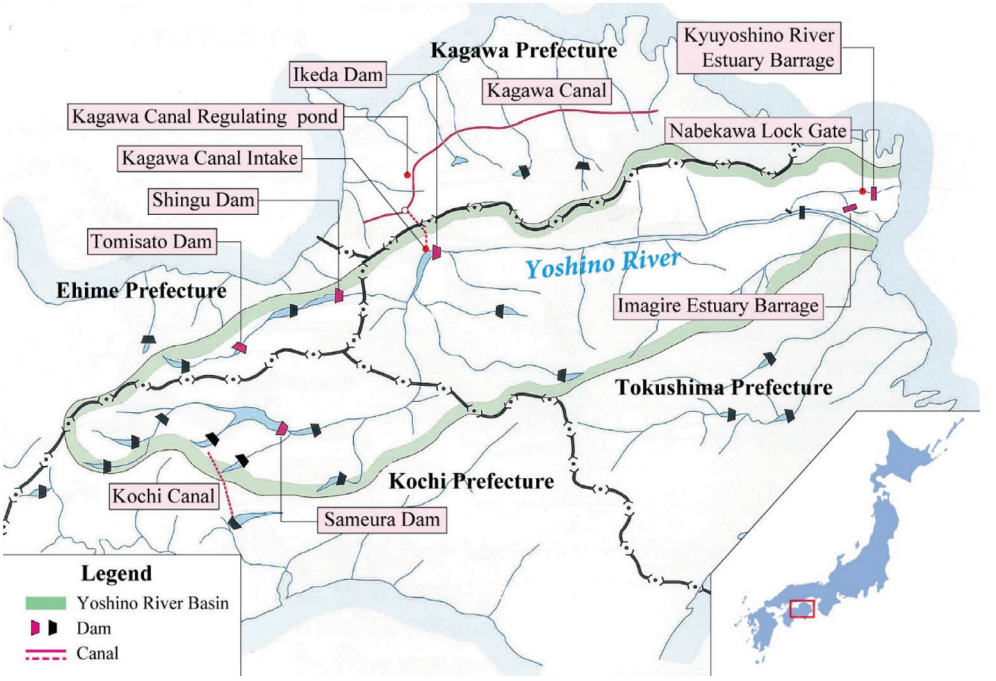

Figure 1. Project Map

Figure 2. Sameura Dam

Each dam manager is in touch with the administrative staff based at the Integrated Operation and Maintenance Office at the Ikeda Dam, and each management station maintains and manages the mechanical facilities.

2.2 *Machinery at Kagawa Canal Management and Construction Office*

The Kagawa Canal Management and Construction Office manages canal intake, regulating ponds, and the Kagawa Canal Main Channel. The total number of mechanical facilities is 158 gate bulb facilities, six debris removal machines, and four irrigation pumping station pumps.

The manager of the Kagawa office is in charge of maintaining and managing these mechanical facilities located over a total area of 46.6km.

2.3 *Machinery at Kyuyoshinogawa Estuary Barrage Operation Office*

Kyuyoshinogawa Estuary Barrage Operation Office manages the Kyuyoshino River Estuary Barrage (Figure. 3), Imagire Estuary Barrage and Nabekawa Lock Gate. The total number of mechanical facilities managed include 13 outlet works and six lock gates.

The Kyuyoshinogawa Estuary Barrage Operation Office manager manages and maintains the mechanical facilities located at these three facilities.

Figure 3. Kyuyoshino River Estuary Barrage

3 ISSUES WITH MANAGING AND MAINTAINING THE MECHANICAL FACILITIES

3.1 *Issues with efficiency and information-sharing when inspecting mechanical facilities*

In the past, inspection reports were done by sending in inspection data after returning to the management office from each inspection site, by either sending an e-mail or a printed paper report to each office. Under this system, if there were any instructions with regards to the content or results of the inspection, there would have to be a second inspection several days later, so there was an issue with efficiency, and the time it took to make a report meant information wasn't being shared quickly, so another challenge was the issue of speed in sharing reports.

3.2 *Issues with accuracy and speed when responding to incidents*

Response to incidents (status checks, working to restore operations, supervising restoration work, etc.) when there is a mechanical failure at a facility, in particular the initial response, is handled by the facility manager alone in most cases, and it is difficult for inexperienced staff to judge the cause of incidents and make decisions on their own.

Additionally, it's difficult to report the situation at an incident site to the other sites over the phone, and e-mail requires returning to the management office, so there were issues with accuracy and speed.

3.3 *Issues with bringing items like technical drawings to the field*

When going to check on gate facilities and so on in the field, paper materials such as facility plans, instruction manuals, and other printed materials can't all be brought to the field because they get damaged easily and are cumbersome. Further, there were also issues of having to go from the field back to the management office to check technical drawings.

4 CREATION OF A DAM MECHANICAL FACILITY MANAGEMENT SUPPORT SYSTEM

4.1 *Dam mechanical facility management support system outline*

The dam mechanical facility management support system ("the system") was made with tablet terminals and a web application in order to improve efficiency and speed of information-sharing with regards to routine checks, as well as to improve support for initial responses to mechanical failures for the managers of the facilities, and to make gate facility documentation viewable on PDF.

The web app used in this system converts and displays forms such as tables used in routine checks that were created in Excel and makes them usable on a tablet terminal internet browser, and it allows not only display but also pull-down menu functions and character input functions.

The system also effectively utilizes the tablet terminal functions such as videophone functionality, and shooting of photos and videos.

4.2 *Structure of the dam mechanical equipment management support system*

The system is composed of servers, tablet terminals, a web app, and internet lines. In the Shikoku network, dedicated optical lines are in use at the Yoshinogawa Headquarters, the Ikeda Integrated Management Office, the Kagawa Water Management Office, and the Kyuyoshinogawa Estuary Barrage Operation Office and a UTM (Unified Threat Management) is installed in the entry to the server, so it is a closed network that is not open to the greater internet, giving it strong security. Further, user ID and password authentication makes it possible to access the registration and browsing of documents from the other side (Figure. 4)

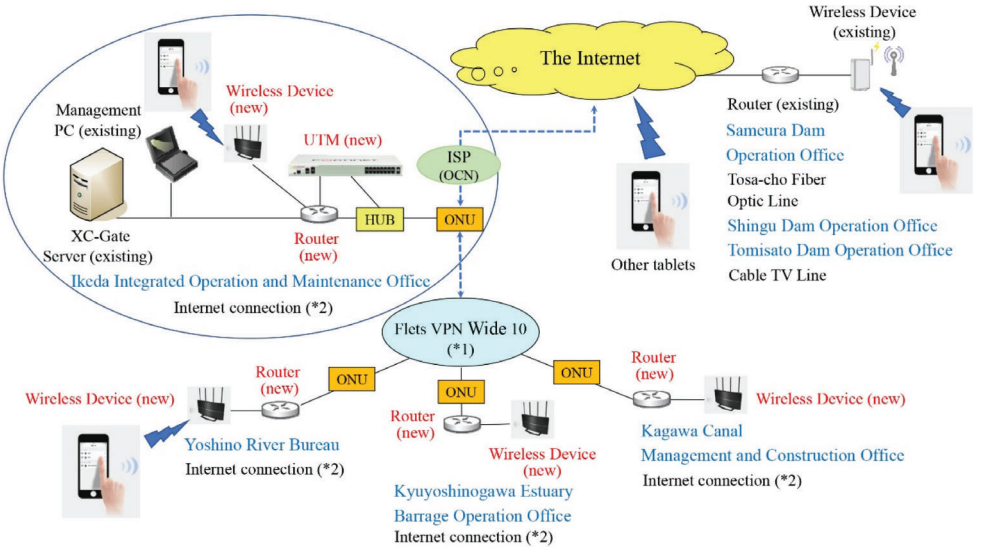

Figure 4. Dam Mechanical Facilities Management Support System - Shikoku Water Agency *1: Virtual Private Network (VPN) *2: Flets Hikari Next Family High-speed Type

4.3 *Dam mechanical facilities management support system characteristics*

– Simultaneous viewing and editing

As long as tablet terminals can connect to the internet, and even if a tablet or smartphone hasn't installed any special software, the web app allows them to access the VPN line server and engage in simultaneous viewing and editing.

Updates of the web app are also done via unified management on the server, so devices don't have to be updated individually, and management is easy.

– Generic software is used to create forms

Creation of forms such as inspection charts and more are made with a system that uses data imported from Microsoft Excel, so it's possible to create forms using the operation technology of Excel, and there was no need to develop a system just to create a new form, and employees can easily create and edit forms.

– Can be used offline

Even if the user is in a place where they can't connect to the internet, server form data entered into the tablet is temporarily stored on the tablet terminal, and can be sent to the server afterwards when it's possible to connect, so it can even be used at remote dams and places in the mountains where there isn't a good telecommunications environment.

5 WAYS THE DAM MECHANICAL FACILITIES MANAGEMENT SUPPORT SYSTEM IS USED

5.1 *Using the web app*

Since data entered on the tablet terminals can be viewed on multiple tablets, data in the server can immediately be shared. Additionally, the system supports not only data but it also automatically saves it as Excel data, so it is easy to create graphs based on the Excel data.

– Monthly inspections, yearly inspections, and so on with data entry and viewing onsite (Figure. 5)

Figure 5. Entering data onsite

– Inspecting current values, assigning pass/fail to measured data.
– Onsite data entry and viewing of operation data in regular dam inspection materials.
– Onsite data entry and viewing of incident reports, etc.
– Viewing PDFs of technical drawings and books (Figure. 6)
– Automatic saving of photos (Figure. 7)
– Direct input of signatures and memos on inspection results, etc. (Figure. 8)

5.2 *Utilizing the basic functionality of the tablet*

Utilizing the standard functionality of the tablets, the tablets can be used to report and check status, and supply various kinds of support, sharing information immediately.

– Videophone, e-mail
– Shooting photos, video

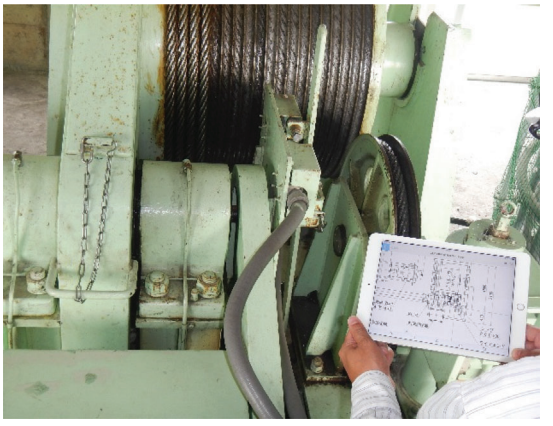

Figure 6. Looking at a PDF of a technical drawing

Figure 7. Automatic saving of photos

Figure 8. Adding handwritten notes and signatures

6 RESULTS FROM USING THE DAM MECHANICAL FACILITY SUPPORT SYSTEM

6.1 *Improved efficiency of machine inspection, faster information-sharing*

Compared to the old way of reporting inspections, the current method of directly inputting data into a tablet terminal onsite has resulted in prevention of transcription errors and improved efficiency. The inspection data can be viewed by other tablets in all locations in real time, so information sharing speed has been increased.

Additionally, by entering measurement data at the time of inspection it is possible to confirm abnormal values immediately by checking the measurement data pass/fail decision functionality (Figure. 9), and by entering the inspection check sheet it is possible to check it against the previous result (Figure. 10) so this has reduced check omissions, and has improved our ability to prevent malfunctions before they happen.

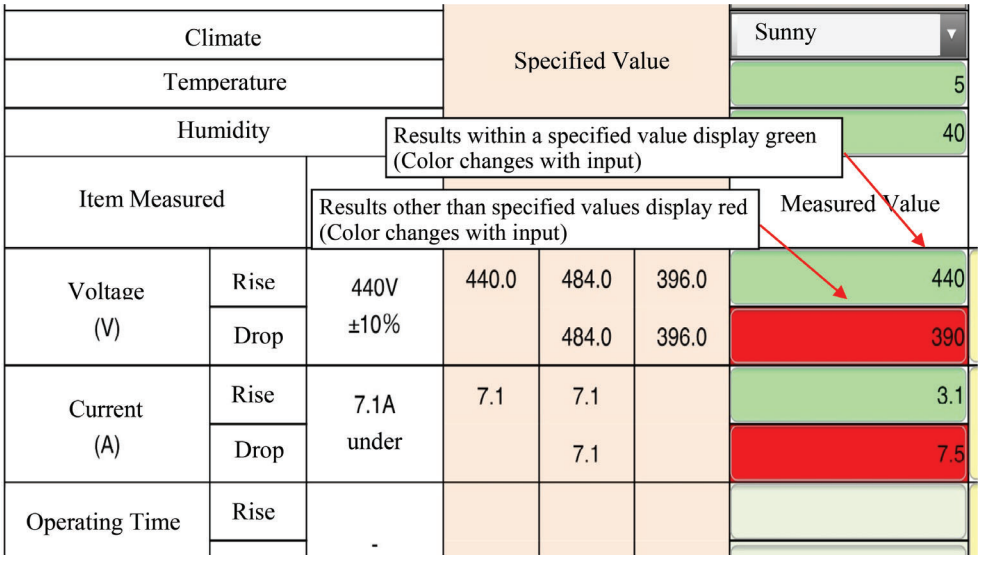

Figure 9. Measurement data entry screen

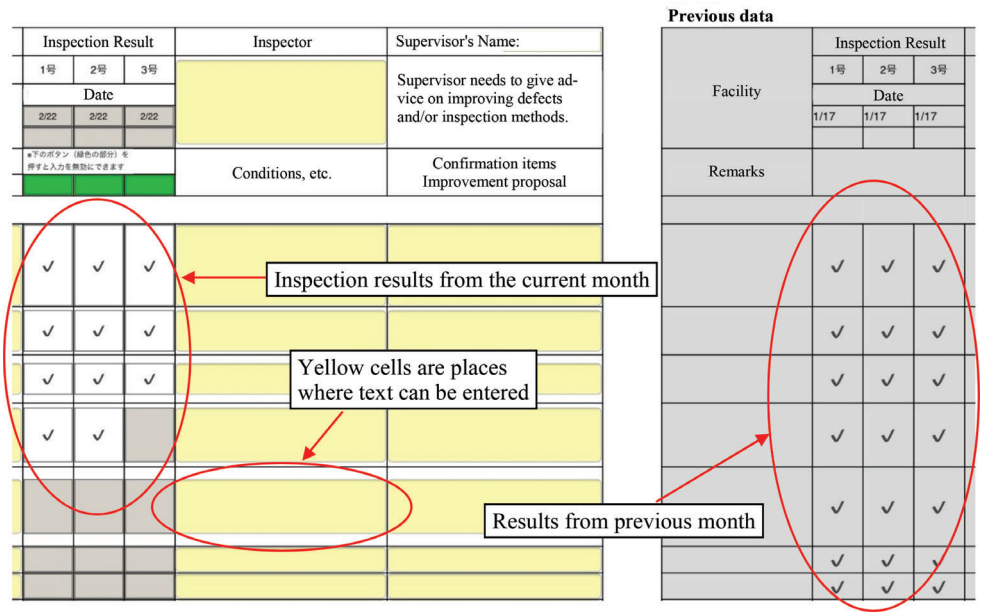

Figure 10. Inspection form data entry screen

6.2 *Improved support for each site, reduced barriers between professions*

When an incident occurs, such as flooding or an earthquake, report forms can be entered directly into the tablets onsite, and photos taken onsite can automatically be attached to the report form, so it's possible to report on the situation quickly. Additionally, machinery managers located in remote areas can use the videophone function to determine the causes of

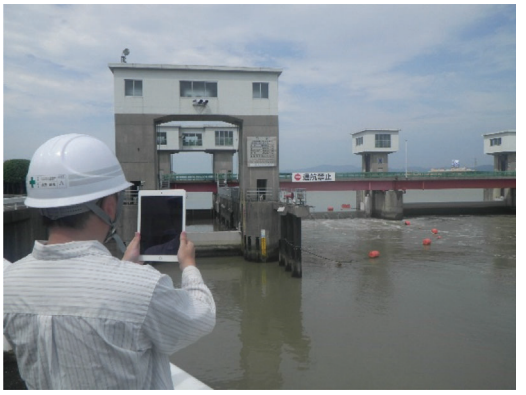

Figure 11. Reporting on the situation onsite

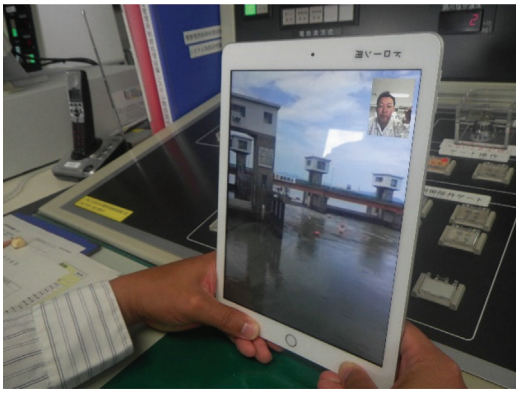

Figure 12. Giving instructions to people onsite

incidents and decide on a response by sending images and talking in real-time, enabling appropriate support regardless of years of experience or profession. (Figures 11, 12)

6.3 *Converting technical drawings to PDF/streamlining production of inspection reports*

By converting a large number of paper materials used to confirm status to PDF and storing them in the server, it's possible for users to easily view them in the field via the tablet terminals. This has greatly reduced the burden of onsite checks. Additionally, inspection check sheets, measurement data, and other inspection reports and survey materials from regular dam surveys are automatically converted to deliverables from data that is input at the site, so the production of reports has been streamlined and sped up.

7 COMPARISON OF MAINTENANCE COST

The Shikoku network purchases its own software and equipment and owns and operates it ("on-premises") but because this web app uses a cloud service, we made a comparison of maintenance costs required to shift to cloud services in the future. (Table 1)

Table 1. Annual maintenance cost comparison chart

Item	On-premises	Cloud Service
Maintenance Cost	Dedicated Line Use Fees	Service Use Fees
	¥6,588 per month per location	¥5,760 per month per license
	¥26,352 per month/4 locations	¥115,200 per month for 20 licenses
	¥316,224 per year	¥1,382,400 per year
Update Cost	¥1,188,000 every six years	¥0
Annual Totals	¥514,224	¥1,382,400

The result was that on-premises requires dedicated line use fees and update fees, while cloud services require service use fees, and after comparing the two, we concluded that it would be appropriate to continue on-premises operations.

8 TOWARDS FURTHER UTILIZATION

We think of this system as a first step towards the realization of Smart Operation Smart Maintenance as promoted by the Japan Water Agency. Having built this system, we can use the existing tablet terminals and web app for equipment maintenance, disaster preparedness, civil engineering management, and more, and it can also be used to break down walls between people with different levels of experience and different professions, creating a system where anyone can effectively respond onsite.

IoT technology will continue to develop and new technologies will be developed in the future. We will consider adding new functionality to our tablets and system as it becomes available, taking into consideration reliability, operability, cost, and so on.

9 CONCLUSIONS

Generally speaking, each of our dam machinery facilities have just one machinery manager, so we needed to streamline the creation of inspection reports, speed up inspection result sharing, improve support during incidents, and digitize mechanical facility plans.

In order to solve these challenges, we created a dam mechanical facilities management support system with a server, tablet terminals, a web application, and an internet connection, and did so in such a way that a single server was able to handle the entire Shikoku Water Agency.

By bringing tablet terminals into the field and entering data directly, the report-making process was streamlined, eliminating the need to create separate inspection reports and making it possible to share inspection reports on the spot. Additionally, video phone technology made it possible to provide a variety of support services, and it is now possible to conduct checks in the field smoothly thanks to the digitization of mechanical facility plans.

In order to continue making the best use of these functionalities, we plan to hold regular briefing sessions and classes to create an environment where everyone can use the system. Additionally, as tablet technology will likely continue to be developed, we plan to add new functionality to the current system as it comes available.

Finally, while our machinery managers are limited, this technology which utilizes familiar tablet technology enables improved work efficiency and quicker incident responses without adversely impacting the quality of maintenance and management. We plan to continue developing and improving this system.