Overall Utilization of Information and Communication Technologies in Excavation Work and Management at Yoneshiro-gawa River, A First-class River

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Abstract -

We obtained various effects about 'Efficiency, Quality, Safety, Improving the work environment and Human resource development' through overall utilization of Information and Communication Technologies (hereinafter referred to as ICTs) in the excavation work and management at Yoneshiro-gawa River, a first-class river.

At the topographic surveying stage, we used the UAV and made three-dimensional topographical data. At the excavation stage (most excavations are under water), we used the machine controlled system and at the same time introduced a new system by which we could automatically grasp the amount of excavation (finished work). At the delivery stage, we could automatically get a predetermined form showing the work done by the excavation.

Keywords -

Overall utilization of ICTs; Underwater excavation; New system using excavation history data; New-3K [Kyuyo:salary, Kyuka:vacation, Kibo:hope]

1 Introduction

Recently in Japan, due to the effects of global climate change, we are facing severe and frequent disasters and need to take measures to prevent floods. In general, short-term measures are to cut and remove trees along the river and to excavate the bottom of the river in order to improve the flow of water in the river.

As one such measure against flood, we implemented the flood control project of cutting and removing the trees and excavating the bottom of the river in the Yoneshiro-gawa River at Noshiro city, Akita prefecture, Japan. In the process of this project, we used various ICTs. In particular, the use of 3D-machine controlled system in excavation work in muddy water was effective for efficiency and safety. On the other hand, we discovered the difficulty of understanding new rules on the usage and the management of these new technologies.

2 Construction overview

We cut the trees in an area of 300,000m2. And in part of the area where the trees were cut and removed, we set up a pilot area. This area was dug down to a certain depth, so it is difficult for trees to grow up in this area. The area was designed so that usually there is water, and once it rains and the water level rises, the mud at the bottom of the area is washed away. To construct this pilot area, we utilized various ICTs. (Figure 1, 2)

The construction project was done from 3th April 2019 to 31th January 2020. The cost was 250,000,000JPY. The supervisor was NOSHIRO work office of River and National Highway, Tohoku Regional Development Bureau, MLIT.JP. The contractor was OHMORI CONSTRUCTION Co., Ltd.

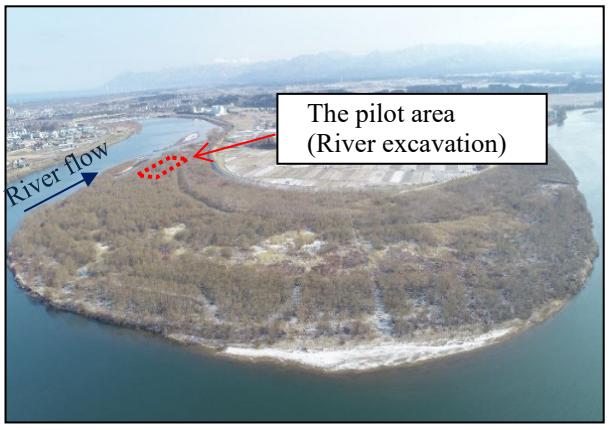


Figure 1. View of construction site (Before work)

2.1 Utilization status of ICTs in Construction

At the construction area we utilized several ICTs through the process of topographic survey, excavation and delivery.

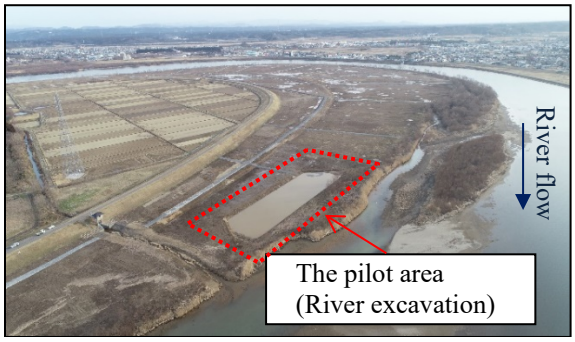


Figure 2. The pilot area (River excavation) (After work)

2.1.1 3 dimensional survey

At the area of river excavation we utilized the UAV and took many photographs (700 photos) from the air(Figure 3,4). And many photographs (689 photos) were converted to 3 dimensional topographic data by the software(Table 1). And the 3 dimensional data were used for next excavation process.

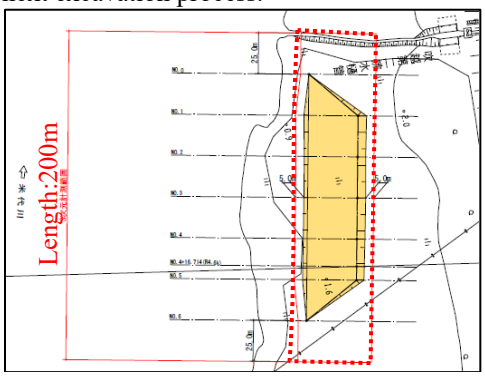


Figure 3. The area of 3D survey

Figure 4. The UAV surveying
(UAV, monitor, flight control system)

Table 1. Equipment and software used

UAV	EAMS ROBOTICS UAV-E470SU1
Software of Photogrammetry	Agisoft Metashape
Software of 3D design	SITE-Scope Sitec3D (KENSETSU SYSTEM)

2.1.2 3 dimensional excavation

At the process of the river excavation (volume: 5,400m3) we utilized 3 dimensional machine controlled system. We didn't need elevation stakes, markers which are usually installed on site to show operator how much to excavate. Especially, because it was difficult to see the status of excavation in the muddy water, it was much more useful to use this 3 dimensional machine controlled system (Figure 5). In the clear water, operator and surveyor could see the status of the ground and check certain situation, but on the other hand in muddy water, they couldn't see nothing about the ground.

Table 2. Construction Information

Type	Earthwork River excavation
Place	R4.4k+80m- R4.6k+40m
Volume_ Excavation	5,400m3

Figure 5. ICT construction (3D-machine control)
(Appearance Guidance and the monitor which shows the excavation status in operation room)

2.1.3 Management of the excavation

By using the machine controlled system, we introduced a new system by which we could automatically grasp the amount of excavation required.

The system is that the position data of the bucket is converted to the data of the amount of excavation (finished work) and then sent to the clouded server and stored. And the data is automatically compared to the design date and shows the difference by colors, green color is completed and red is not. (Figure 6)

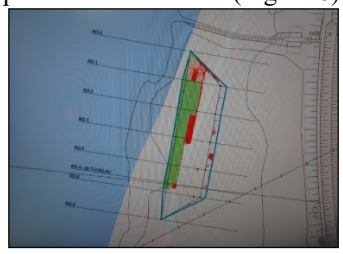


Figure 6. The monitor which shows instantly the excavation status at office connected to the site via internet

We could use this data for the management of excavation work. Previously, we needed to survey the level of the ground after finishing the excavation works to grasp the amount of the work. But by using this system, we need not to do such these survey and recording in the field required. (Figure 7)

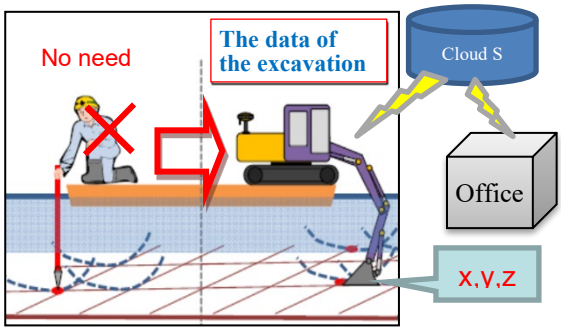


Figure 7. The image of the comparison of the previous method and new one

3 Analysis of effects and challenges

Through these works by using ICTs, we obtained effects about the efficiency, the quality, the safety, the improving of the work environment and the human resource development.

3.1 Quantitative analysis of the effect

In order to measure the effect on efficiency, we investigated the amount of work in each work that utilized ICTs. The amount of work was calculated as the total number of each work times multiplied by the number of each workers related. The amount of work by the normal method was calculated on the basis of the work experienced in the past, assuming the normal work.

Through all process the efficiency increased by 20%. The efficiency increased in each processes of the survey, the3dimensional design, the excavation and the inspection. But because of the growth of the data, the efficiency declined in the electronic delivery process. (Figure 8)

By the way, the average efficiency of 17 construction sites (excavation work) in Japan last year (2019s) increased 15%. (Figure 9) It shows that our work was more effective.

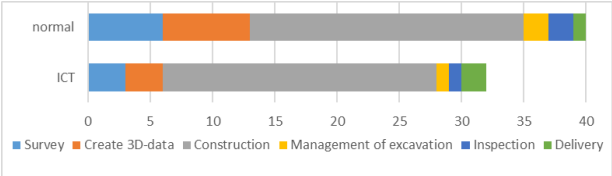


Figure 8. The efficiency of our work (Upper: Normal method, Lower: Utilize ICT)

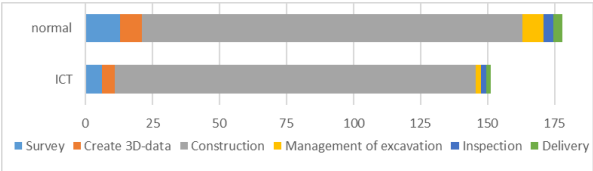


Figure 9. The average efficiency of 17 works (Upper: Normal method, Lower: Utilize ICT)

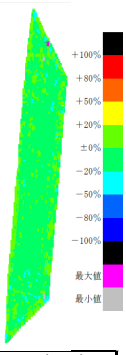
3.2 Quantitative analysis of the quality

The accuracy of excavation work passed all standard values. (Table 3)

- ✓ The average of finished height was -20mm, thought the standard value was +-40.
- ✓ And both the maximum and minimum value passed enough. Etc.

Table 3. Results of the accuracy

Mesurement Item			Standard value	In-house value
Flat Field elevation difference	Average	−20mm	±50	±40
	Maximum	57mm	±300	±240
	Minimun	−137mm	±300	±240
	Number of data	3880	over1point／m2 (3750points)	over1point／m2 (3750points)
	Area	3750㎡	—	—
	Number of failed data	0	within0.3% (11points)	within0.3% (11points)
Slope Field elevation difference	Average	−6mm	±70	±56
	Maximum	70mm	±300	±240
	Minimun	−144mm	±300	±240
	Number of data	1152	orer1point／m2 (928points)	over1point／m2 (928points)
	Area	928㎡	—	—
	Number of failed data	0	within0.3% (3points)	within0.3% (3points)



	Number of data within the standard value (ratio)		
	80～50%	50～20%	20%～
Variation at flat	0/3880 (0.0%)	102/3880(2.6%)	3778/3880(97.3%)
Varietion at slope	0/1152 (0.0%)	48/1152(4.1%)	1104/1152(95.8%)

3.3 Quantitative analysis of effect

We conducted a questionnaire survey on satisfaction with ICTs utilization at each 5 processes. Especially, "The management of the amount of excavation work" was the best score. And "The 3 dimensional excavation work" was the second best. The others were middle score (Figure 10). This means that the system (explained in 2.1.3), which can catch and record the data of the status of construction automatically, is much more useful than the usual method that surveyor need to survey many times constantly.

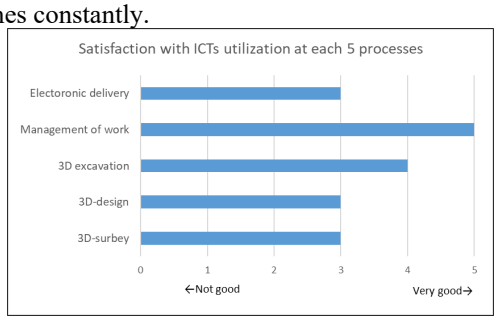


Figure 10. Satisfaction with ICTs utilization at each process

3.4 Other effects

In addition to the above, we obtained the following effects through utilization of several ICTs in this project.

1. The pictures taken by UAV made it easy to understand the whole view of the construction, so we could use it as a reference material for the meetings among the parties concerned.
2. We have improved safety as we have reduced the work done near construction machinery.
3. Young staffs were familiar with digital devices and could easily use them. (Perhaps enjoying!) This mean that we could assign young employees who don't have enough civil engineering skills this work. And this work could be done at home, so it is more efficient.

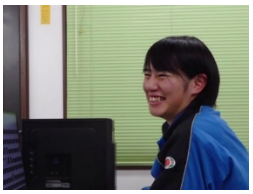


Figure11. Young staff easily used 3 dimensional data

3.5 Challenges to effectiveness

On the other hand, there were several challenges to effectiveness through the utilization of ICTs.

1. The new rule of the management of excavation work was newly created, so it was difficult to understand.
2. The excavated riverbed changed easily due to changes in water level, and the accuracy of the finished work required was normal. By relaxing the required accuracy, there is a possibility that productivity will be further improved.
3. This time, it was not a place with water flow, but when excavating in a river with water flow, a method of confirming the completed shape will be needed.

4 To conclude

Through the use of ICT in a series of processes, a certain level of efficiency and quality improvement has been achieved as a whole. Since it is a new technology and a new relationship, it is expected that the effects will be further improved by getting used to it. At that time, in order to promote the spread to smaller-scale construction, it is desirable to develop human resources for engineers who work together with both the public and private sectors.

The UAV survey this time was on flat land, but in the future it will help to expand the range of UAV utilization by developing the know-how and data for implementation on undulations and slopes.

Finally, increasing the opportunities for young people including women to play active roles by improving the work environment is very important in Japan, where the declining birthrate (declining young employee) and aging population are becoming issues. Especially in the construction industry, which was said to be 3K (KITSUI:hard, KITANAI:dirty, KIKEN:dangerous), the declining birthrate (declining young employee) and aging population are outstanding. Therefore, it is highly desired that the introduction of ICT will expand the opportunities for young people to play active roles and realize the new 3K (KYUYO:salary, KYUKA;vacation, KIBO:hope).

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