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STUDY ON THE BEHAVIOR OF SANDBAR IN A RIVER CHANNEL AT THE BABAMEGAWA RIVER

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ABSTRACT: A flood disaster was frequently happened resulting from local heavy rainfall in Japan. Many farmlands and housing were damaged terribly in 2017 and 2018. A high water level was observed in the Babamegawa River which was the largest Class B river. The embankment on the left bank at Babamegawa River was collapsed owing to scouring was caused by a sandbar at the downstream side. Like this, streamflow was greatly influenced by a sandbar, so it was important to understand the behavior of the sandbar. However, only one percent of rivers were conducted Periodic Vertical and Cross-sectional Survey while all Class A river were conducted measurement mainly because there were too many Class B river to measure. In this study, it was carried out that investigation using UAV to manage rivers easily. The Sandbar was taken the photographs from 150 m above the ground from September 2017 to November 2018 and The sandbars' area, length, and width were calculated with SfM (Structure from Motion technique). These data were investigated sharply when the water level was decreased below ordinary. Moreover, it was important to remark the width of sandbar as a contraction of channel and loss of sandbar were needed to grasp for river management. It was found that the embankment was broken to slip by losing base performing the numerical calculation.

Keywords: The Babamegawa River, Sandbar, Unmanned Aerial Vehicle, River management, Water level

1. INTRODUCTION

Local heavy rain was caused by flood damage in July and August 2017, May 2018 in Akita prefecture. A high water level was observed in the Babamegawa River. Babamegawa River is the largest Class B rivers in Alita prefecture. Such flood damage by local heavy rain was happened in Japan [1]. The left-hand side had erosion due to this damage in the Babamegawa River. Sandbar on Channel was caused by meandered flow. And sandbar was caused by a transition in the channel and destroyed. It was important to grasp the sandbar shape and channel conditions for channel management. According to research by the Ministry of Land, Infrastructure, Transport, and Tourism [2], all class A rivers were implemented longitudinal and transverse survey. On the other hand, class B rivers were implemented only 1 percent of the whole. Because class B rivers were many in Japan. River patrol was conducted once or nothing per week in class B rivers.

In previous studies, the river management method was proposed that numerical calculation using a universal model [3]. It investigated the evolution of micro-topography on a small region of riverbank of the Shonai River [4]. This study proposed to maintain channel using UAV (Unmanned Aerial Vehicle). Data filling was lacking in class B rivers. Many studies using UAV were implemented in Japan. For example, it had surveyed in an inaccessible area using UAV [5]. On the coast, it conducted nearshore topography monitoring by using UAV [6]. UAV was also used in the river. The method was a maintenance management system [7].

This study proposed to evaluate quantitatively the relationship between the behavior of sandbar and water level using UAV at Babamegawa River that left side embankment was broken by the flood. Generally, the behavior of the sandbar was surveyed three-dimensionally. In this study, surveying was carried out two-dimensionally for

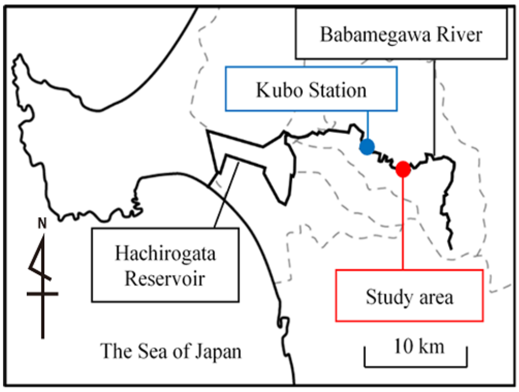

Fig.1The outline diagram of Babamegawa River.

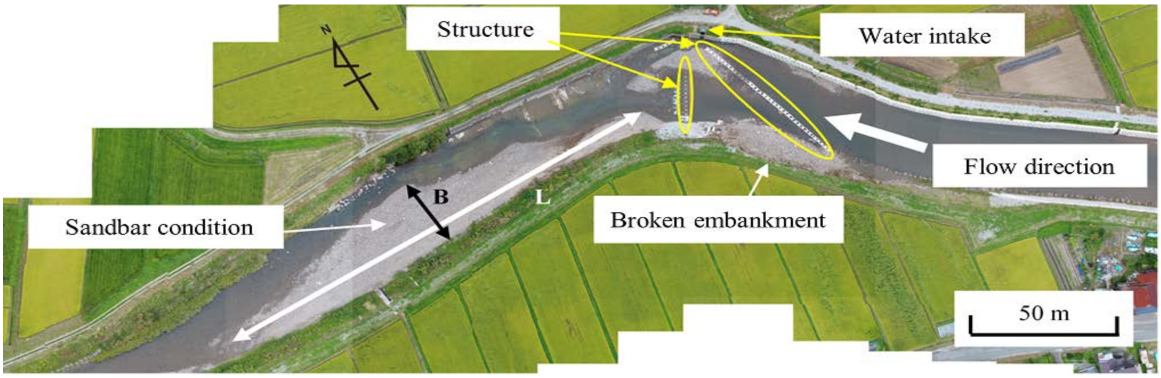

Fig.2 The state of the study area.

simple river management. The method will make it possible to examine easier and shorter than cross-sectioning. Firstly, aerial photographs were taken using UAV. Then, these photographs captured SfM (Structure from Motion) technique. Finally, the behavior of the sandbar grasped by measuring Sandbar area, length, and width. Also, carried out numerical calculation about the embankment at the Babamegawa River, it investigated flow velocity and riverbed variation.

2. RESEARCH SUBMIT

Babamegawa River is the largest class B rivers. Figure 1 shows that the outline diagram of the Babamegawa River. Akita It was originated from Babametake in Gojome Town, Minami-Akita-gun, Akita Prefecture, combines the surrounding tributaries into the Hachirogata Reservoir, pours into the Sea of Japan through the Funakoshi channel. The drainage area was 910.5 km^2 and the mainline flow path extending was 47.5 km [8].

Target was the Babamegawa River in the Hiranoshita area. It was about 300 m in length. Figure 2 shows the state of the study area. This river width was about 30 m. The left-hand side was broken due to heavy local rain damage in July and August 2017. There is the intake for agricultural work in right-hand side curved parts. The flow path was narrowed by the crossing structure so that water could be accumulated even at a low water level. Therefore, the sandbar was generated near the intake. Figure 3 shows the situation of sandbar conditions. Even if one year had passed since this damage, the situation of erosion damage still could be seen. The water level used data from Kubo station located several kilometers downstream from the study area.

3. RESEARCH METHOD

3.1 UAV Surveying

At first, about 30 aerial photographs were taken

Fig.3 Sandbar condition. (August 22, 2018)

along a river from ground to 150 m height. Then, aerial photographs were taken to overlap 80 % of the photographs horizontally and vertically. It was taken aerial photographs from September 2017 to November 2018. This study was chosen 5 times in case of low water level and high-water level.

3.1 SfM(Structure from Motion) Technique

At the first, it combined the aerial photographs were taken. The behavior of the sandbar formation grasped from the aerial photographs. Sandbar area A, length L, and width B were measured in this area. L was the maximum length of the sandbar parallel to the flow path. B was the maximum length of sandbar perpendicular to the flow path.

4. RESULT AND CONSIDERATION

4.1 Relationship between Water Level and Sandbar condition.

The sandbar was formed on the river channel. Then, river embankment erosion occurred immediately after water flow. Therefore, it was important to grasp the form of Sandbar [9]. And, the hydrological conditions under which the form of sandbar changes was confirmed by the experiments [10]. It needs to examine sandbar shape and flow near the flood peak. Therefore, it was a necessary consideration before and after events such as near precipitation. It was considered the relationship

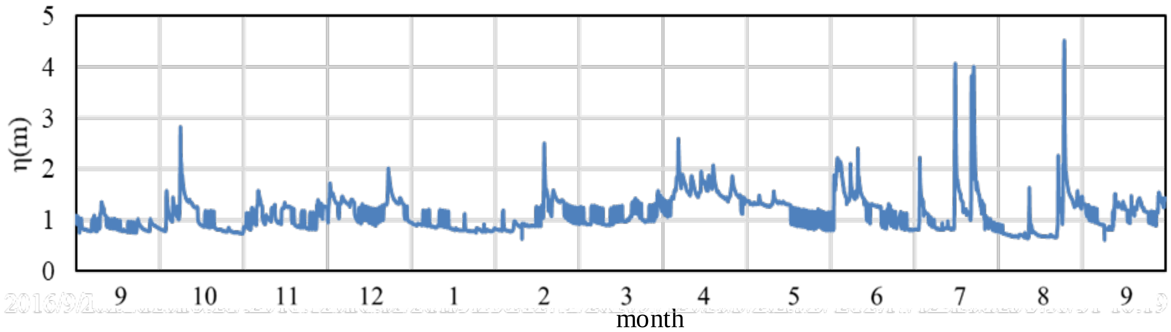

Fig.4 Water level fluctuation from September, 2016 to September, 2017.

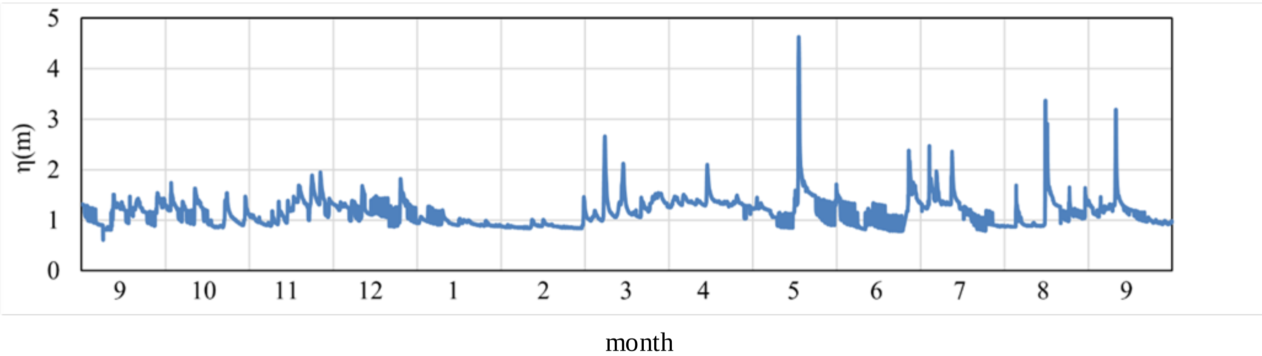

Fig.5 Water level fluctuation from September, 2017 to September, 2018.

between water level and sandbar behavior. The water level was measured at Kubo station. In Figure 4, a maximum of 4.51 m was observed on August 25, 2017. Besides, the water level exceeding the flood risk water level was observed because of the effects of torrential rain. Looking at Figure 5, a maximum water level of 4.63 m was observed on May 18, 2018, far exceeding the flood danger level. Besides, water levels as high as the flood danger level were observed from August to September. Akita Prefecture has a feature that the water level rises from March to April because of the effect of snowmelt.

4.2 UAV Surveying

A, *L*, and *B* were derived for the area enclosed by the broken line shown in Figure 2. Figure 6 shows the condition of the sandbar on September 11, 2017. The river spreads so that *A* extends to 3124.4 m^2 and B extends to 26.3 m, and it occupied most of the flow path. η was 0.81 m, which was lower than the ordinary water level.

Figure 7 shows the sandbar condition on August 3, 2018. *A* was 2947.0 m^2 and *B* was 19.4 m, and from September 11, 2017, *A* was 177.4 m^2, and *B* was 6.9 m. η was 0.88 m, which was close to the ordinary water level in the study area.

Figure 8 shows the condition of the sandbar on August 22, 2018. The *A* decreased from 2947.0 m^2 to 1159.7 m^2, and the flow path of the river was a minimum of 18.0 m, extending to about 60 % of the river width. Also, η was 1.18 m higher than the ordinary water level, and the sandbar became smaller because the water level rose due to rainfall.

Figure 9 shows the condition of the sandbar on September 7, 2018. *A* decreased to 1153.1 m^2, *L* decreased 2.0 m, and *B* decreased 1.5 m. Also, since the water level was 1.24 m and the water level had risen from August 22, the sandbar on the water surface was decreasing. Sandbar on the water surface decreased because the water level was rising due to the rainfall on August 15 on August 22 and September 7 when the field observation was examined.

Figure 10 shows the condition of the sandbar on November 28, 2018. It again narrowed the channel of the river. However, *A* was 1665.2 m^2, *L* was 132 m, *B* was 16.7 m, and it was thought that the sandbar has flowed out, and η was 0.89 m, which was the ordinary water level.

Figure 11 shows the condition of the sandbar on December 13, 2018. *A*, *L* and *B* could not be derived because the sandbars to be observed were removed by dredging.

4.3 Relationship between Water Level and Sandbar Area

The relationship between sandbar area, length, and width was examined.

Figure 12 shows the relationship between the

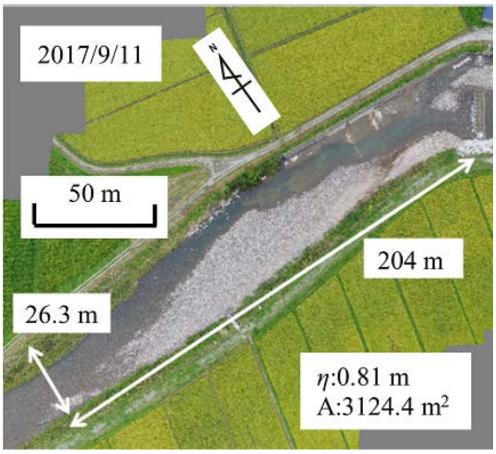

Fig.6 Sandbar condition. (September 11,2017)

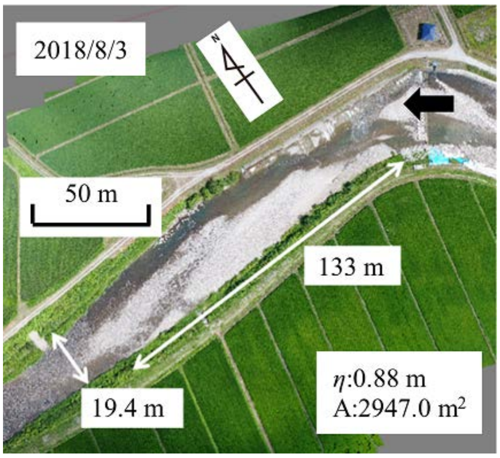

Fig.7 Sandbar condition. (August 3,2018)

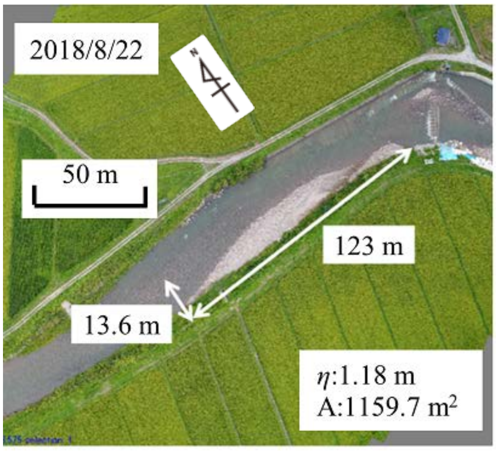

Fig.8 Sandbar condition. (August 22,2018)

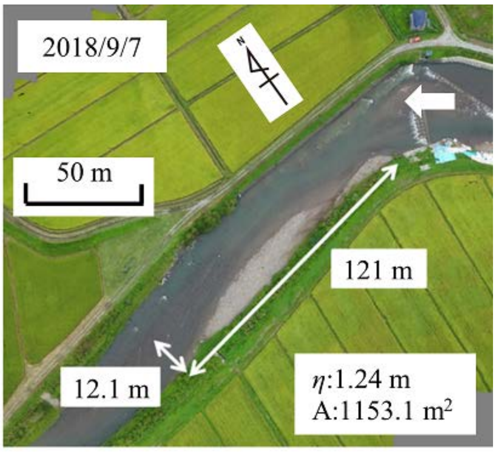

Fig.9 Sandbar condition. (September 7,2018)

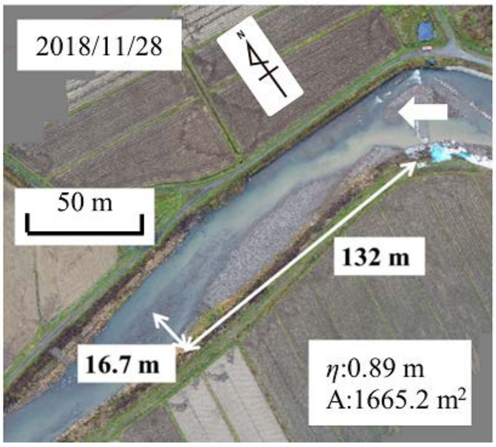

Fig.10 Sandbar condition. (November 28,2018)

Fig.11 Sandbar condition. (December 1,2018)

water level and the sandbar area. When the water level was lower than the ordinary water level (0.89 m), *A* increased rapidly but decreased gradually when the water level rose.

Figure 13 shows the relationship between the sandbar area and width. The *B* also increased as the *A* increased. Therefore, it was considered that the *B* greatly affected the *A* change.

Besides, Figure 14 shows the relationship among *A*, *L*, and *B*. Compared to data on August 3, 2018, with November 28, 2018, *B* was decreased due to decreasing *A*, while *L* was unchanged. *A* was reduced by 1281.8 m^2, so it was expected that sandbar was drained by flood when the water level

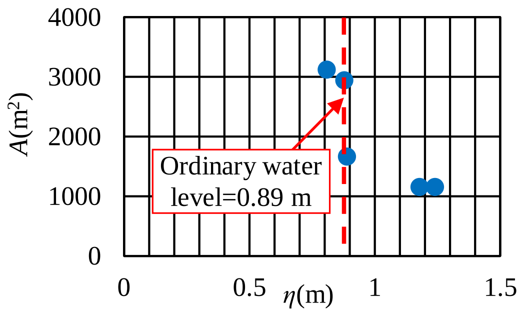

Fig.12 Relationship between water level and Sandbar area.

was observed more than 3.1 m such as August 15and September 9, 2018.

5. NUMERICAL CALCULATION

5.1 Outline

Numerical calculation clarifying a cause that theleft side embankment at the target area had been broken was carried out. Equation (1) is an equation of continuity.

$$\frac{\partial h}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0 \quad (1)$$

where h is depth, t is time and u and v are average flow velocity of x and y-direction.

Equation (2) is a motion equation.

$$\frac{\partial (uh)}{\partial t} + \frac{\partial (hu^2)}{\partial x} + \frac{\partial (huv)}{\partial y} = -hg\frac{\partial H}{\partial x} - \frac{\tau_x}{\rho} + D^x \quad (2)$$

$$\frac{\partial (vh)}{\partial t} + \frac{\partial (huv)}{\partial x} + \frac{\partial (hv^2)}{\partial y} = -hg\frac{\partial H}{\partial y} - \frac{\tau_y}{\rho} + D^y \quad (3)$$

where g is gravitational acceleration, h is water level, τ_x and τ_y is a shearing force at the riverbed of x and y direction and D^x and D^y are diffusion terms.

The topographic condition was set to be based on Ikemori et al. [11]. Data of discharge observed from August 24, 2017, 18:00 to August 25, 2017, 18:00 was used. Figure 15 shows the variation of discharge. Manning's roughness was set in 0.03 in the riverbed and 0.04 at the installed location of the Filter Unit. The grain size was set in 7.8 mm as central grain size and the calculation time step was set in 0.1 s [12].

5.2 RESULT

Figure 16 shows a flow vector at the peak of discharge. A flow vector near the left side embankment was increased and the riverbed near this embankment was scoured. So, the left side embankment was broken to slip because the

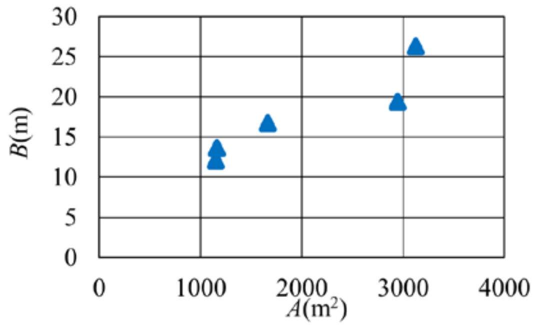

Fig.13 Relationship between sandbar width and area.

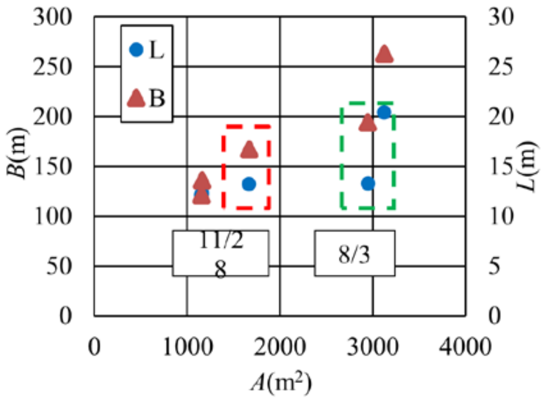

Fig.14 Relationship among sandbar width, length and area.

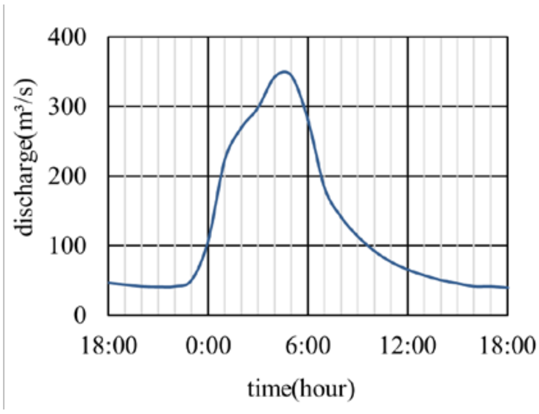

Fig.15 Used discharge variation. (August 24, 2017, 18:00 ~ August 25, 2017, 18:00)

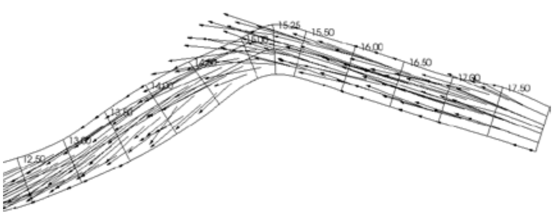

Fig.16 A flow vector at the peak of discharge. (August 25, 2017 5:00)

Fig.17 state of the broken embankment on August 28, 2017.

riverbed was scoured off and the embankment was lost the base. Trace of the flood had not been observed around the study area. So, the surrounding region had not been damaged by the flood. Figure 17 shows the embankment condition after the flood when August 28, 2017.

6. CONCLUSION

It would be concluding as follows.

1) It was possible to grasp the behavior of the sandbar on the water surface and measure the sandbar area, length, and width.
2) The sandbar was increased sharply when the water level falls below 0.89 m, while the sandbar was decreased gently when the water level rises due to rainfall.
3) Evaluation of sandbar width was important to grasp for the river management.
4) The left side embankment was broken to slip because the riverbed scoured off.

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