Matsumoto, Kensaku; Tamaki, Haruo; Nagura, Hiroshi; Kobatake, Shigeki; Akiyama, Keishirou

A Study Of Riverbed Deformation Process By 3D Laser Scanner

A STUDY OF RIVERBED DEFORMATION PROCESS BY 3D LASER SCANNER

KENSAKU MATSUMOTO

Department of Civil Engineering, Gunma University, 1-5-1, Tenjin-chyo, Kiryu-shi, Gunma, 376-8515, Japan

HARUO TAMAKI

Mathematical Assist Design Laboratory, 1-101, Yoshizawa-chyo, Ota-shi, Gunma 373-0019, Japan

HIROSHI NAGURA

Mathematical Assist Design Laboratory, 1-101, Yoshizawa-chyo, Ota-shi, Gunma 373-0019, Japan

SHIGEKI KOBATAKE

Department of Civil Engineering, Gunma University, 1-5-1, Tenjin-chyo, Kiryu-shi, Gunma, 376-8515, Japan

KEISHIROU AKIYAMA

Department of Civil Engineering, Gunma University, 1-5-1, Tenjin-chyo, Kiryu-shi, Gunma, 376-8515, Japan

3-dimensional shape of the landform of the riverbed was measured by 3D Laser Scanner. Surface information measured by 3D Laser Scanner is very useful to obtain the shape of the distribution of san-bar, water route, and vegetation. By comparison of the landform of the riverbed between before and after flood, fluctuation value of the local scouring around the bridge pier, the influence of the flood and the riverbed deformation process were indicated.

1 Outline of the field measurement by the 3D Laser Scanner

1.1. *Outline of the 3D Laser Scanner*

Obtaining the landform of the riverbed with high accuracy is very important to understand the mechanism of the riverbed deformation process. Usually, the cross-sectional survey is done by various intervals to obtain the landform of the riverbed. Although the cross-sectional survey is useful, it is very difficult to obtain the surface information by cost-concerned. Detailed surface information is demanded to understand the mechanism of the riverbed deformation process.

In this study, two types of the 3D Laser Scanner were used. Riegl LPM-2K was used for long-range measurement. And Riegl LMS-Z210 was used for middle-range measurement. LPM-2K can measure the area of the range of about 2km radius. LMS-Z210 can measure the area of about 300m radius. Although the range of the LMS-Z210 is shorter than LPM-2K, LMS-Z210 has advantage of the measurement speed than LPM-2K. LPM-2K and LMS-Z210 measures 2 and 8,000 data for a second respectively.

Another advantage from the cross-sectional survey is that the 3D Laser Scanner can measure object area from remote location. This advantage means that the 3D Laser Scanner can measure the object area where is too danger to enter by human from safety remote area. It also means that we can measure the landform of the riverbed even if the water route parts the riverbed. The 3D Laser Scanner is waterproof. Therefore, we can perform the measurement by the 3D Laser Scanner in rainy condition. The most important problem is that the 3D Laser Scanner can't measure the object under the water. Although measurement of the landform under the water is very important for river engineering, we focused on the landform of the riverbed above the water surface.

1.2. *Outline of measurement field*

We selected Kinu River, which is located in the north of Tokyo in Japan as the object area of field measurement by the 3D Laser Scanner. Kinu River is one of tributaries in Tone River, which has the most large basin in Japan. Kinu River flows through the Tochigi prefecture. The area of the river basin of the Kinu River is 1,760.1k㎡. The length of the river channel is 176.7km. In this study we focused on two measurement sites in Kinu River. It is Daidouizumi and Ishige sites. The bed material in Daidouizumi site is sand and gravel mixed. In Ishige site bed material is sand only. The medium grain size d_{50} in Daidouizumi and Ishige site is 100mm and 1mm respectively. The averaged bed slope is 1/700 in Daidouizumi site, and 1/1,400 in Ishige site respectively. We measured the local scouring around the bridge pier in Ishige site. And in Daidouizumi site, we measured the landform of the riverbed widely.

Table 1 shows the history of floods and measurements in Daidouizumi and Ishige sites in Kinu River.

Table 1. History of the floods and the field measurement by 3D Laser Scanner in Kinu River

	Flood	Discharge(㎥/s)	Measurement
2001/9/11	Flood-A	2,400	
2001/12/20			Measurement-A
2002/7/11	Flood-B	2,800	
2002/8/8			Measurement-B

Two floods occurred during our observation. Both of the floods were relatively large scale. We call them Flood-A and B in this paper. During Flood-A and Flood-B first field measurement by the 3D Laser Scanner was performed. Then second field measurement was performed after Flood-B. The landform of the riverbed in Daidouizumi and the shape of the local scouring around the bridge pier were measured in each measurement. Comparison between results of the Measurement-A and the Measurement-B was discussed as follows.

2 Measurement results by 3D Laser Scanner

2.1. Verification of accuracy

Fig.1 is a measurement result by the 3D Laser Scanner in Daidouizumi site. Horizontal axis is the flow direction. Left side is the downstream. Right side is the upstream. Vertical axis is cross-sectional direction. Unit is meter.

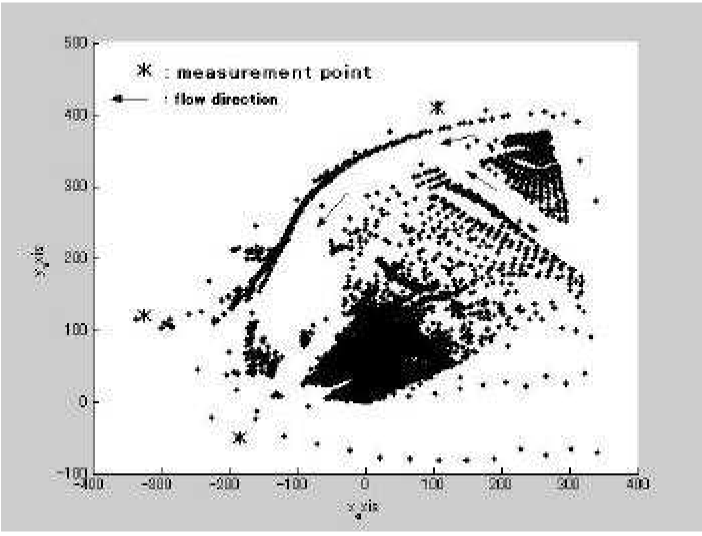

Figure 1. Data distribution of the measurement-A by the 3D Laser Scanner in Daidouizumi site in Kinu River (2001/12/20)

Black dots mean the points where measurement data was obtained. White blank regions mean area where measurement data was not obtained because of existence of the water or obstacles. In this case, obstacles mean vegetation or rugged ground. Three asterisks in Fig.1 mean the location of the 3D Laser Scanner. The closer from the 3D Laser Scanner the more data is obtained. Measurement results from three asterisk points were used for complementation. Almost 190,000 data is in Fig.1. Three arrows in white region show the flow direction. Water routes join at the confluence point of about (150,300).

We checked the accuracy of the measurement result by the 3D Laser Scanner. Fig.2 shows comparison of measurement results between the 3D Laser Scanner and the cross-sectional survey. Horizontal axis is direction of the cross-section. Left side is the left bank. Right side is the right bank. Vertical axis is relative height. Solid line shows the measurement result by the 3D Laser Scanner. And dashed line shows the result by the cross-sectional survey. There is no data of the measurement result by 3D Laser Scanner from about 270 to 330 of horizontal axis. In this area measurement data by the 3D Laser Scanner were not able to obtain because of existence of the water.

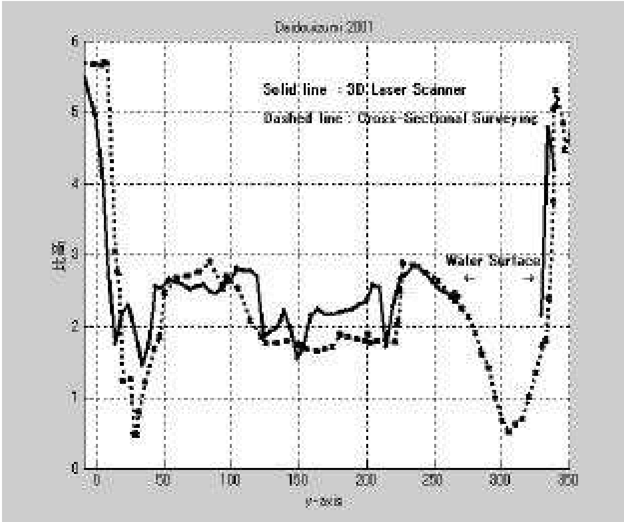

Figure 2. Comparison of measurement results between the 3D Laser Scanner and the cross-sectional survey.

Extracted cross-section is –25 of the horizontal axis. The water area shows the water route along the right bank. Result of comparison seems that the measured landform of the riverbed agrees except the region from about 150 to 220 of horizontal axis. There is vegetation in this area. A treatment algorithm for discrimination of the measurement objects has been conducted in measurement data by the 3D Laser Scanner. But Fig.2 shows that the trimming of the vegetation is not complete. Improvement of the trimming algorithm is necessary for accuracy in future.

A large advantage of the 3D Laser Scanner is that the measurement data by 3D Laser Scanner has surface information. Therefore, we can extract any section from surface information.

2.2. Measurement of local scouring around bridge pier

The 3D Laser Scanner that we used in this study is portable type like usual surveying instrument. The portable type is more advantageous than the other type that scans from airplane or helicopter in respect of usability. For example, it is impossible to measure the local scouring around bridge pier by airplane type Laser Scanner because of the scanning laser is shielded by bridge girder.

Fig.3 shows the situation of local scouring around the bridge pier in Ishige site. And Fig.4 shows the side view of the data distribution of measurement result of the shape of the local scouring corresponding to Fig.3 by the 3D Laser Scanner. The black dots of Fig.4 are the equal meaning of the one of the Fig.1. The gathering of horizontally distribution with high-density is the grand. Data above the grand level shows the vegetation. And data under the grand shows the shape of the scouring hall.

Figure 3. Local scouring around bridge pier in Ishige site (2002/8/8)

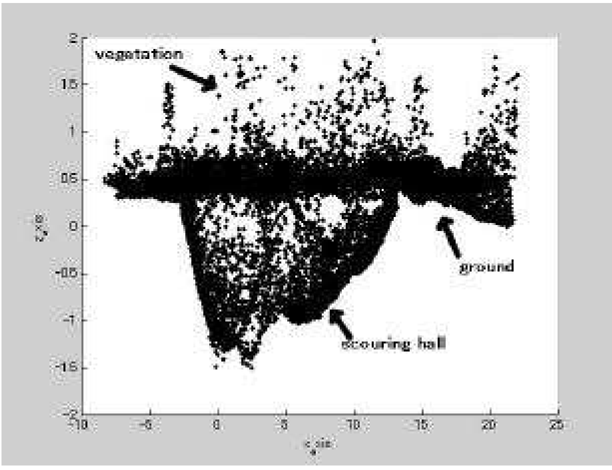

Figure 4. Data distribution of local scouring around bridge pier in Ishige site (2002/8/8)

The shape of the scouring hall was measured in detail because there was no water in this scouring hall. Fig.5 shows the contour plot corresponding to Fig.4. The measurement data has been complemented to make the surface information. Surface information was calculated by neighboring three data. Fig.5 was constructed by that surface information. The interval of the contour line is 0.1m in Fig.5. Basic level in Fig.5 means the height where the 3D Laser Scanner located. The maximum depth is about −1.2m distributed in right and left area along the bridge pier. The shape of the local scouring is almost horseshoe shape. But the top of the horseshoe shape is leans to right bank side slightly. It can be guessed that the mainstream direction of the flood was flowed from right bank side to left bank side around this bridge pier. This local scouring occurred by Flood-A in table 1. After Flood-B, measurement was done again.

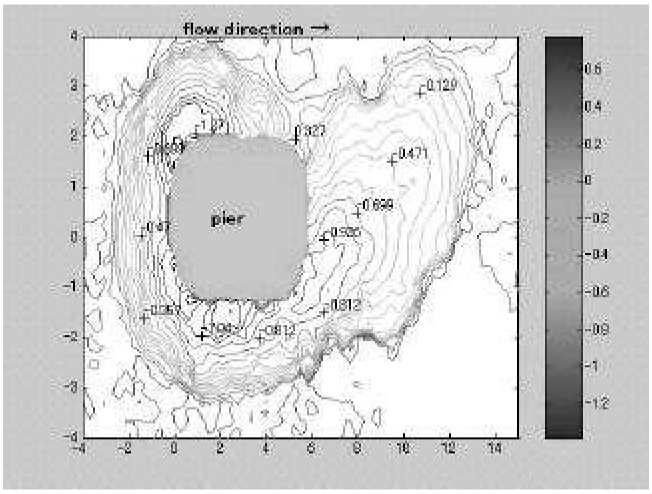

Figure 5. Contour plot of the shape of the local scouring around the bridge pier in Ishige site (2002/8/8)

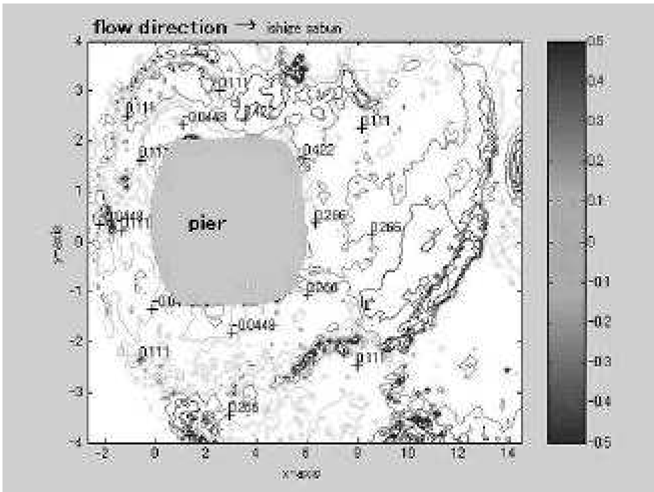

Figure 6. Contour plot of the fluctuation value of shape of the local scouring around the bridge pier in Ishige site calculated by 2001-2002

Fig.6 shows the fluctuation value of the shape of the local scouring around the bridge pier in Ishige site calculated by the result of Measurement-A minus the result of the Measurement B. therefore, the positive value area means scouring and the negative value area means the accumulation. According to Fig.6 scouring and accumulation occurred within 0.5m. Accumulation area distributes in front of the pier. The rear of the pier and along the accumulation area, scouring area distributes. Refilling might have occurred in the accumulation area in front of the pier. Detailed information about influence of the Flood-B was showed by difference between before and after the flood.

3 Extraction of the landform deformation process during the flood by the 3D Laser Scanner with detailed surface information

Fig.7 shows the data distribution in Daidouizumi site in 2001 and 2002. Fig.7 (1) is the result of Measurement-A. And Fig.7 (2) is the result of Measurement-B.

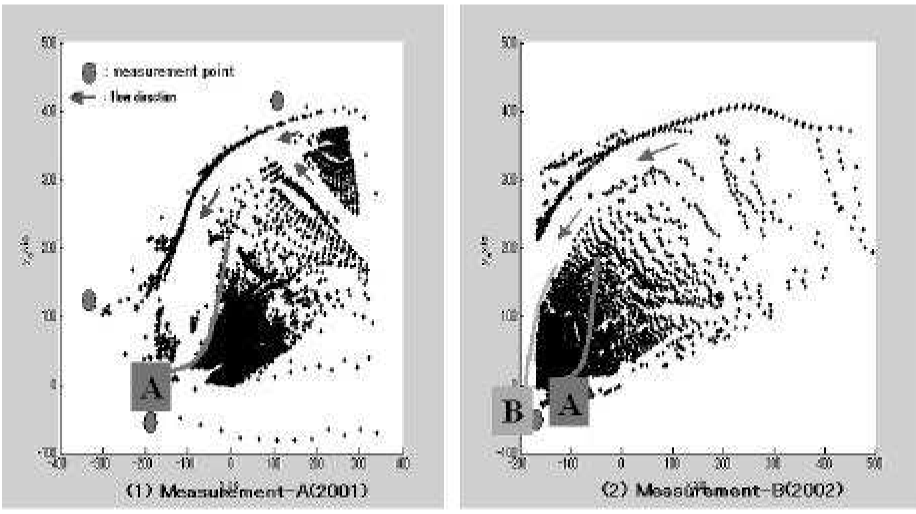

Figure 7. Contour plot of the fluctuation value the shape of the local scouring around the bridge pier in Ishige site calculated by 2001-2002.

In Fig. 7 (1), the left side shape of the water route has appeared as line-A. In Fig.7 (2), the left side shape of the water route moved to downstream direction from line-A to line-B. The line-A that is the left side shape of the water route in Fig. 7 (1) has been put on Fig. 7 (2).

To confirm the landform of the riverbed more in detail Fig.7 (2) was complemented. Detailed surface information of the landform of the riverbed that is corresponding to Fig. 7 (2) is Fig. 8. The line-A and the line-B have also been put on Fig. 8. The shape of line-A and line-B is almost same. And we found the same shape during the line-A and the line-B. That line is drawn as line-C in Fig. 8. Movement of the left side of the water route from the line-A to the line-B occurred during the Flood-B. Existence of the line-C indicates that some steady flow condition that caused the shape of the line-C occurred during the Flood-B. The reason of the occurrence of the steady flow is not clear. But we can guess some conditions or useful knowledge that might have occurred during the flood by the detailed surface information calculated by the measurement results by 3D Laser Scanner provides useful knowledge for river engineering. sometimes.

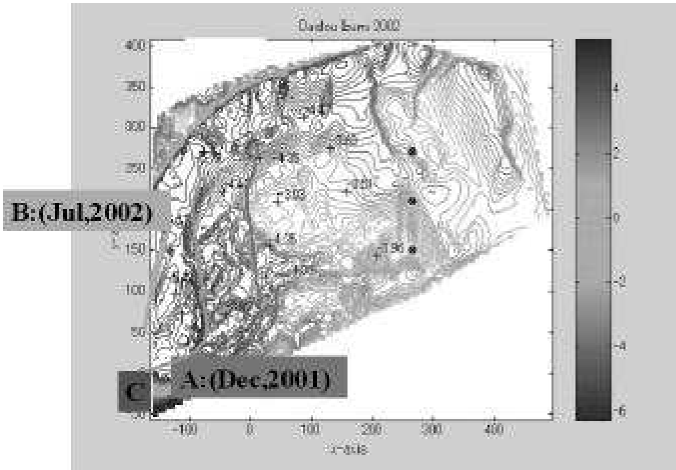

Figure 8. Contour plot of the landform of the riverbed in Daidouizumi site with complementation for detailed surface information (2002/8/8)

4 Conclusion

The 3D Laser Scanner was applied to measurement of the landform of the riverbed and the local scouring around the bridge pier. The accuracy of the 3D Laser Scanner that was examined by comparison with the cross-sectional survey showed good agreement. The shape of the local scouring indicated the direction of the mainstream flow during the flood. And the shape of the water route on the sandbar indicated the existence of the steady flow condition during the flood, too. These results show that the 3D Laser Scanner is useful for river engineering.

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