Flow and Bed Variation Utilizes Vegetated Groyne

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1. Introduction

There are many groynes have been constructed for river bank erosion protection in Japanese rivers. In recent years, local scouring occurs, sediments deposited by the expansion of vegetation in the river channel are the problem that makes the control of the river has become difficult. Even in Shigenobu River that's phenomenon has occurred. Therefore, development needs to be done to reduce the problems that occur in Shigenobu river by utilizing the existing groyne and plants that always grow in the vicinity. This study focuses on clarifying the function of the existing groyne in Shigenobu river, verify that vegetated groyne is more effective for stabilizing the flow of the river from the existing groyne and has an effect or not for the river pathway. For that, investigation was held with on-site survey and two-dimensional flow condition analysis, in case with the existing groyne and simulation be a vegetated groyne with variation density. Furthermore, the objectives also proposed to make proposals for maintaining the capability of the existing groyne and stabilize river channel by proposing new vegetated groyne.

2. Methodology

In the present study, investigation around the target groyne was conducted by on-site survey. The target groynes are located in 6.2-6.6 km section from the estuary. There are two of the concrete block impermeable groynes. The simulation of this research organized by eliminating the top half of the existing groyne and set up a vegetation in the head becomes the vegetated groyne (permeable groyne) as seen in Figure 1. It is considered and proposed to prevent the advancement of polarization of river channels by adding the water flow capacity at the time of flooding.

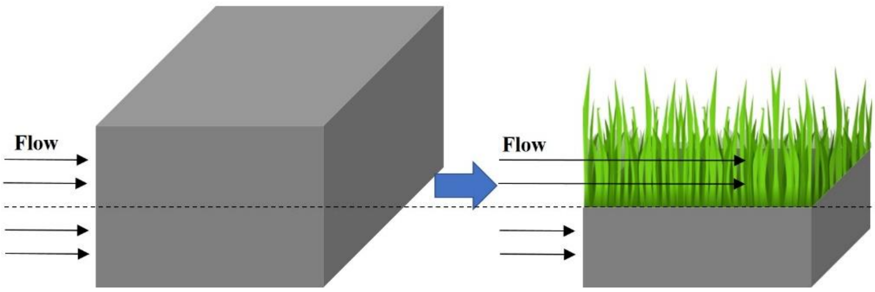

Figure 1. Illustration simulated by eliminating the top half of the existing groyne becomes vegetated groyne.

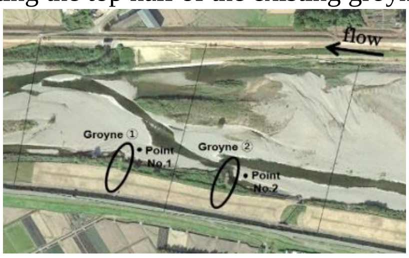

Figure 2. Layout of the target groyne

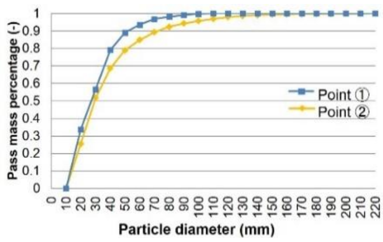

Figure 3. Particle size distribution

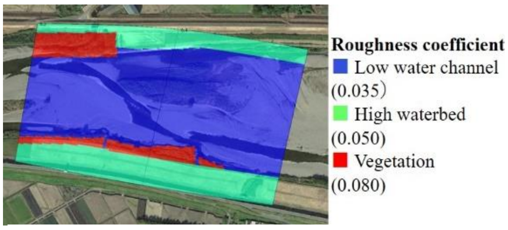

Figure 4. Roughness coefficient value.

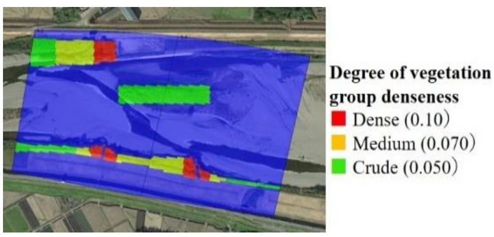

Figure 5. Degree of vegetation group denseness.

In this research, we focused analysis the result of field investigation with numerical simulations. In field measurements, surface riverbed images were taking with drone to estimate the optimal particle size distribution around the groyne. The images were analyzed by Matlab based software (BASEGRAIN) for particle size distribution of the riverbed gravel surface layer. The bed surface images were taken in two points around the groyne as seen in Figure 2. In point No.1 the riverbed particle size was found within the range 10 ~ 110 mm. On the other hand, in the point No.2, was found the bed particle size up to 10 ~ 220 mm. The particle size for point No.1 is 27 mm and the particle size for point No.2 is 28 mm. The averages particle size distribution that passing mass percentage is 0.5 and the bed particle size is set to 27.5 mm. It shown in Figure 3. After that, riverbed changes and flow velocity analysis was conducted using river simulation software called iRIC. Mesh was created from river bed data using numerical data of cross-section survey results according to the regular longitudinal cross-section survey guidelines set by the Ministry of Land, Infrastructure and Transport River Bureau. As for the numerical mesh, transverse direction was divided into 100. The distance section for mainstream direction is 200 m and divided into 40. The result of field investigation was using so vegetation is considered either by defining a separate roughness coefficient in the cells where vegetation is found (Fischer et.al. 2008). The roughness coefficient in this study using the value already set by Matsuyama River National Highway Office. The roughness coefficient of the low waterway is 0.035. As there are many cultivated land

and bushes, there are a value 0.05 for the high aqueduct to adapt to either, vegetation is placed only in the part where trees are conspicuous, and the value is 0.08 as seen in Figure 4. Figure 5 shows the degree of vegetation group denseness. For analyze the flow rate in this study, two patterns of water level were used. There is calm water and time of flooding. The flow rate in normal water is 24 hours from 15:00 on October 21, 2013 until 14:00 on October 22. The average flow rate is about 3.8 m^3/s. The flow rate at the time of flooding is 24 hours from October 24, 2013 to October 25, 18:00, which recorded the peak flow value of the latest year among the existing data of the Ministry of Land, Infrastructure and Transport. The average flow rate is about 800 m^3/s.

3. Results and Discussion

In the present study, analysis was conducted by using iRIC (show in Fig.6 and Fig.7). There are variations for existing groyne and simulation with vegetated groyne (vegetation density 0,5). In case of flow rate is low during calm water, it does not penetrate in the permeable section of the vegetated groyne, so it can be confirmed that there is no big difference in the river bed fluctuation amount compared to the existing groyne. Therefore, it can be expected that the vegetated groyne will exert the same effect as the existing groyne at the time of normal water (calm water). Figure 6 shows that in case for existing groynes, local scouring is seen near the tip of the groyne and sediment deposition occur on the downstream side of the groyne. Local scouring and sediment deposition are also observed in the vicinity of the vegetated groyne. Also, reduction of bed level is seen in both cases. River bed changes occur not only around the groyne, but also widely. However, the local scouring on the left bank side is decreasing. Figure 7 shows that since water control does not pass through, the speed on the downstream side of the groyne is slowing down. Permeate flow is seen on the downstream side of the vegetated groyne and the difference of flow velocity on the center side of the river.

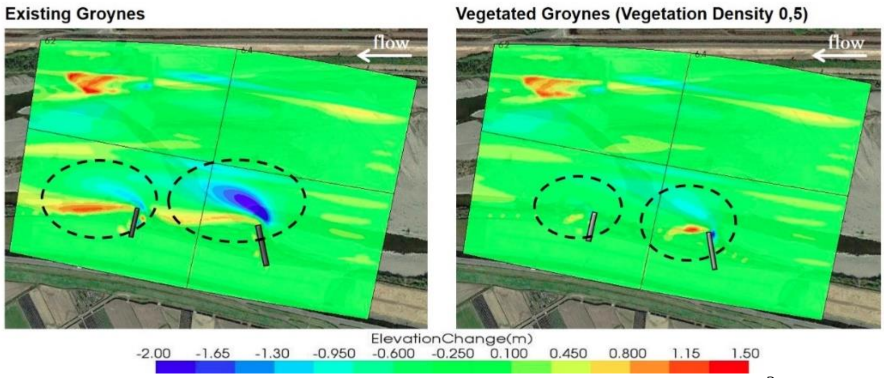

Figure 6. Riverbed change in case of flooding (about 800m^3/s).

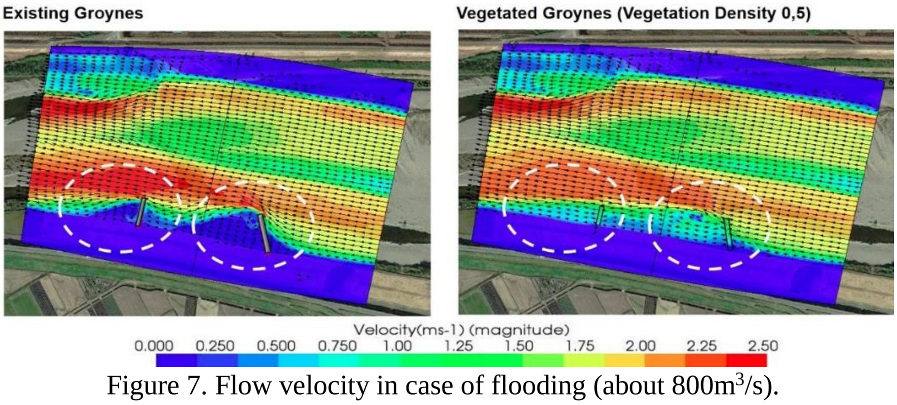

Figure 7. Flow velocity in case of flooding (about 800m^3/s).

4. Conclusions

This study is investigated the effect of the existing and vegetated groynes in Shigenobu River by means of numerical simulation. As a result, vegetated groynes have an effect of stabilization of river channels by decreasing sediment deposit and scouring. In the future, accuracy of the analysis performed for this study must be considered. Also, developed the innovative methodology for experimental and numerical study of vegetated groyne and improvement of the existing groynes that can be applied to the river should be proposed.

References

Fischer-Antze, T., Olsen, N. R. B., & Gutknecht, D. (2008). Three-dimensional CFD modeling of morphological bed changes in the Danube River. *Water Resources Research*. http://doi.org/10.1029/2007WR006402