RIFFLE-POOL STRUCTURE IN DAILY LANDSCAPE AND SAND BARS FORMED DURING FLOOD

TETSURO TSUJIMOTO[1], ATSUKO TERAMOTO[2] and HIROMICHI MATSUI[3]

[1]Professor, Department of Civil Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8603, Aichi, Japan
(Tel: +81-52-789-4625, Fax: +81-52-789-3727, e-mail: ttsujimoto@genv.nagoya-u.ac.jp)
[2]Research Associate, Department of Civil Engineering,
Matsue College of Technology, Matsue 690-8518, Shimane, Japan
[3] Engineer, Okumura Corporation, Japan

When we discuss the river ecosystem, the importance of riffle-pool structure is demonstrated because it supports habitats for various organisms. Riffle-pool structure is observed in low-water stage when sand bars are formed during flood. In the segment where sand bars develop, the riffle-pool structure appears and it provides a favorable habitat for fish, attached algae and benthic animals, which are essential organisms in this segment. The existence of riffle-pool structure is closely related to bar formation. Under the condition that alternate bars develop during flood, the flow after flood (during low water stage) shows riffle-pool structure. The riffle is roughly defined as a part where the Froude number is larger than unity (shallow and rapid), while the pool is the area with deep and tranquil flow. They appear depending on the geometry of bars formed during flood.

In this paper, equilibrium geometry of sand bar for large discharge corresponding to flood, and the hydraulic properties of flow over that morphology at the lower discharge, are investigated by laboratory experiment and numerical simulation.

Though there are several types of sand bars, alternate bars are focused on because the riffle-pool structure is most dominantly observed for such regimes. The regime during flood where alternate bars develop is focused on, though it includes the condition that initially double-row bars develop and then it changes to alternate bars. After the bars become fully developed, the flow behaviors with dried-up part of bars are investigated where we can recognize the riffle-pool structure. In this study, the flume experiment and the numerical calculations are conducted to be complementary each other. By the flume experiment, we will find the characteristics of the phenomena from samples, and by reproducing the results of numerical simulation, we will be possible to understand the results as general properties.

The condition discussed in this study was set from the constraint of the setup in the laboratory. In this study, the flume width is 0.5m with the bed slope of 1/100. Postulating that the flume is around 1/100 scale model, the diameter of bed material is selected as d=0.88mm, which corresponds to gravels with the diameter around 10cm. One pattern with the discharge of Q=0.001m^3/s in the model flume is that alternate bars develop from an initially flattened bed, and the other with Q=0.002m^3/s is that initially double-row bars appear but finally they grow to alternate bars. Discharge Q=0.001m^3/s in the model corresponds 100m^3/s in the prototype, and it is regarded as a flood where the sand bars are formed. After the sand bars develop fully, the discharge is decreased to the low-water stage with the order of 10^{-4}m^3/s in the model scale, which corresponds to the order of $10m^3/s$ in the prototype. Then, we will discuss the characteristics of riffle-pool structure there both experimentally and numerically.

The experiment was conducted in a flume with adjustable slope at Nagoya University, 20m long and 0.5m wide. It has 16m long alluvial reach with 8cm in depth. While, in numerical simulation, the depth averaged 2D model is employed. The equilibrium bedload-transport rate formula is employed and it is divided into the longitudinal and the transverse components in order to describe the bed deformation process by taking account of the direction of sediment and the correction of bottom flow direction from the depth-averaged flow. Then the bed deformation is calculated based on 2D equation of continuity of sediment transport with slope correction by collapse.

When the alternate bars develop from initially flattened bed, thalweg at low water stage crosses the bar-front line and the riffle-pool structure becomes predominant. When the alternate bar develop via double-row bars, the thalweg with low water stage exists along the bar-front line, and the riffle-pool structure becomes faded with the increase of the discharge at low eater stage. Such characteristics found in the flume experiments, which are simply samples, have been reproduced by numerical simulation, and we are assure that those characteristics must appear as prototype in the field.

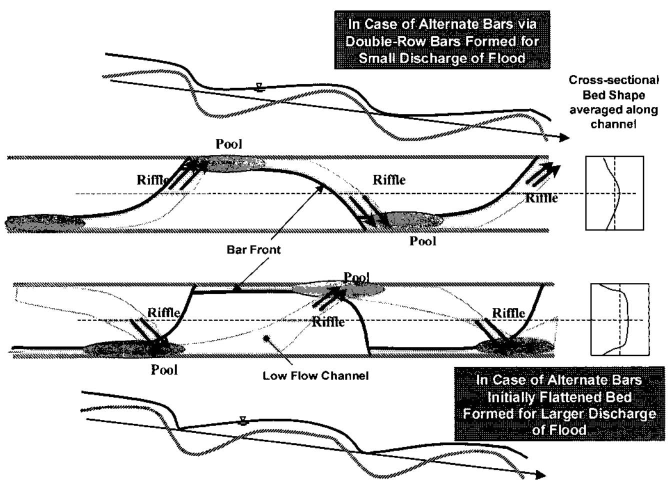

Fig. Two types of riffle-pool structure corresponding to differences of characteristics of alternate bars development