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Numerical simulation of braided channels with aspect ratio larger than 1000

TAKEBAYASHI, Hiroshi[1*], Masaharu Fujita[1]

[1]Disaster Prevention Research Institute, Kyoto University

Rivers all over the world face to a rapid climate change because of the global warming phenomena. Climate change will change the precipitation characteristics, sediment production characteristics and vegetation growth characteristics. As a result, water discharge, sediment transport rate and sediment size of bed material in downstream area will be changed. These spatiotemporal changes of water discharge, sediment transport rate and sediment size will change the geometric characteristics of channels and bed configuration. Braided channels produce diversified physical environment and it is considered that the diversity of the physical environment must affect on the quality of ecosystem in the river. Hence, the temporal changes of the bed configuration and geometric characteristics of bars affects on the quality of ecosystem. In this study, effects of increase and decrease in water and sediment supplies on geometry of braided streams with large aspect ratio (larger than 1000) are discussed by use of results of horizontal two dimensional bed deformation analysis.

The straight rectangular open channel with the constant channel slope is used as the calculation domain. The bed slope is 0.0032. The channel width is 1000m. These values are decided by channel characteristics of the Tagliamento River at the upstream area of Pinzano. The braided width is used for the channel width here. Hence, the channel width includes the potential channel area; the vegetated area along the river is included in the calculation area. The bed materials are treated as both non-uniform sediment and uniform sediment with a particle mean diameter of 2 cm. The distribution is decided by the results of field survey performed in Sep. 2009. Growth and wash away process of vegetation is considered in the model. 1200m3/s, 1800m3/s and 600m3/s are selected as the water discharges in the analysis. All hydraulic conditions are located in the formative conditions of braided stream (Takebayashi H. and Egashira S. (2000)). Water discharge in Case 1 is 1200 m3/s and the aspect ratio is 1204. Vegetation growth is considered and the bed material is treated as uniform sediment. Water discharge in Case 2 is 1.5 times as that in Case 1. Sediment transport rate at upstream boundary is calculated by use of the equilibrium sediment transport formula. As a result, the sediment discharge at upstream boundary in Case 2 is 2.7 times as that in Case 1. Water discharge and sediment discharge at upstream end in Case 3 are 0.5 times and 0.02 times as those in Case 1, respectively. Water and sediment discharges in Case 4 are the same as that in Case 2. However, vegetation growth is neglected in Case 4. Water discharge in Case 5 is the same as that in Case 1. However, bed material is treated as non-uniform sediment in Case 5.

The results are summarized as follows:

(1) The numerical model can reproduce the periodical multiple row bars which has 7 rows in the first stage of the bed deformation. The periodical bars are transformed to irregular braided channels.

(2) When water and sediment supplies are increased, the number of channels is decreased. In addition, when water and sediment supplies are increased, two or three large channels which have the nearly same scale are formed. These results show that the size distribution of habitats is changed very well due to the change of water and sediment supply conditions.

(3) When water discharge becomes half, sediment transport rate decreased to 2%, because sediment transport rate decreases rapidly near critical shear stress.

(4) When vegetation growth is neglected, the maximum scale of islands becomes smaller.

(5) When bed material has wide size distribution, the scale of the islands and the submerged bars becomes large. Furthermore, width-depth ratio of each channel becomes large, because armoring phenomena of bed material is developed in channels and bed degradation is suppressed.

Keywords: Braided channel, Numerical analysis, Aspect ratio, Vegetation, Tagliamento River, Multiple row bar