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Influence of riparian emergent rigid vegetation on hydrodynamic characteristics of compound river

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Objectives

A natural river is usually a compound channel consisting of a main channel and a floodplain, while in the near-bank waterfront area of the river, that is, the bank slope of the main channel, vegetation such as trees and shrubs are often distributed. Vegetation on the bank slope can slow down the speed of water flow, reduce the scouring of the river bank, and stabilize the river situation. However, during the flood period, vegetation will reduce the flood-carrying capacity of the river channel by changing the original water flow structure inside the shoal and channel, and converting the energy of part of the water flow in the river channel into the turbulent kinetic energy generated near the vegetation. Therefore, it is of great significance to reveal the disturbance effect of the vegetation on the bank slope of the compound river channel on the water flow, and then analyze the interests of the vegetation on the bank slope.

Methods

In this paper, the vegetation is used as the wall boundary, and the Reynolds stress model is used to close the turbulent flow control equation to establish a three-dimensional mathematical model of the hydrodynamics of the vegetation channel. And the model was used to simulate the flow structure of the river channel with non-submerged vegetation planted on the bank slope under the conditions of different bank slope ratios of the compound channel.As shown in Figure 1, the main types of boundary conditions are velocity inlet, free flow outlet, symmetric boundary and wall boundary. The specific case settings are shown in Table 1.

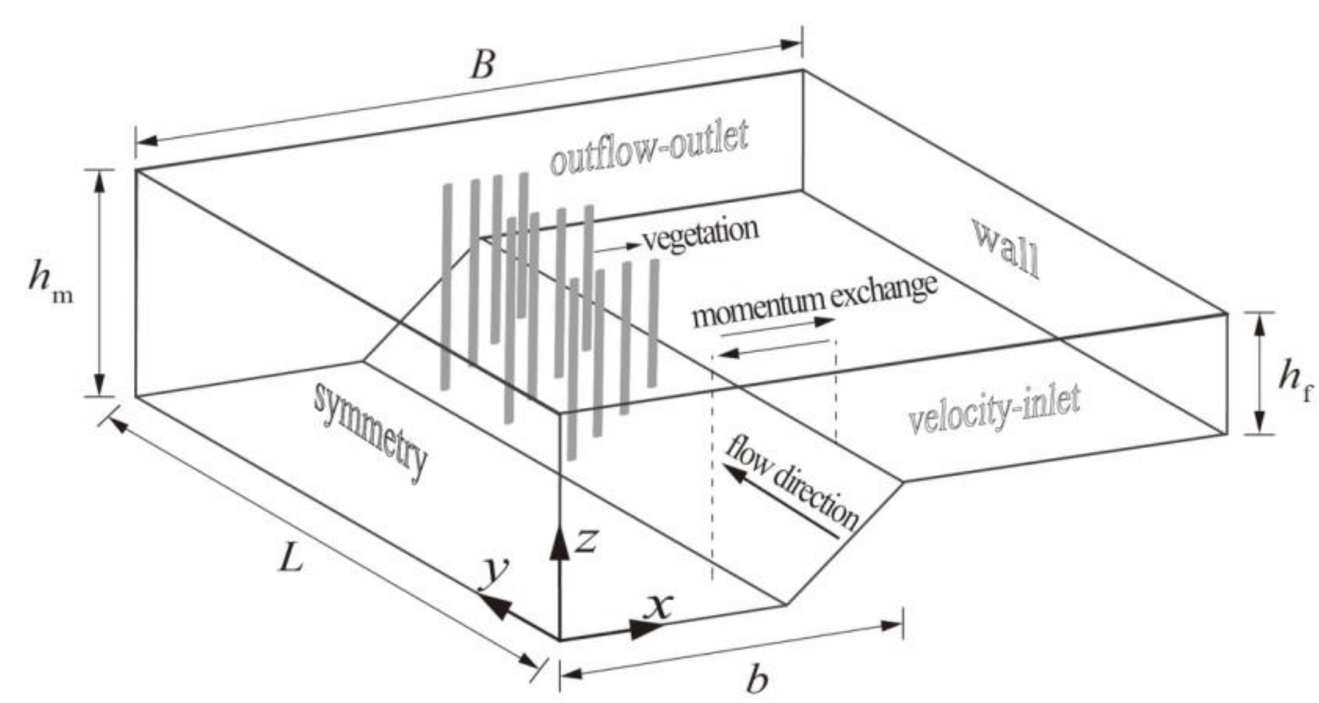

Figure 1. Schematic diagram of model calculation domain and boundary conditions

Table 1. Numerical simulation conditions

Case	Slope ratio	Slope vegetation layout	The number of vegetation on the bank slope	Vegetation height /m
1	1:1	No vegetation	0	—
2	1:1	Emergent vegetation	4	0.8
3	1:1.5	No vegetation	0	—
4	1:1.5	Emergent vegetation	6	0.8
5	1:2	No vegetation	0	—
6	1:2	Emergent vegetation	8	0.8

Results

Figure 2 shows the secondary flow distribution. When there is no vegetation on the bank slope, a pair of secondary flow eddies with opposite directions exist in the junction area between the floodplain and the main channel. When the bank-to-slope ratio is gradually reduced, the influence range of the vortex in the horizontal direction is further reduced, and the shape of the secondary flow is gradually blurred. The vegetation on the bank slope can promote the generation of secondary flow eddies, expand the influence range of the secondary flow, and increase the lateral momentum exchange between the floodplain and the main channel.

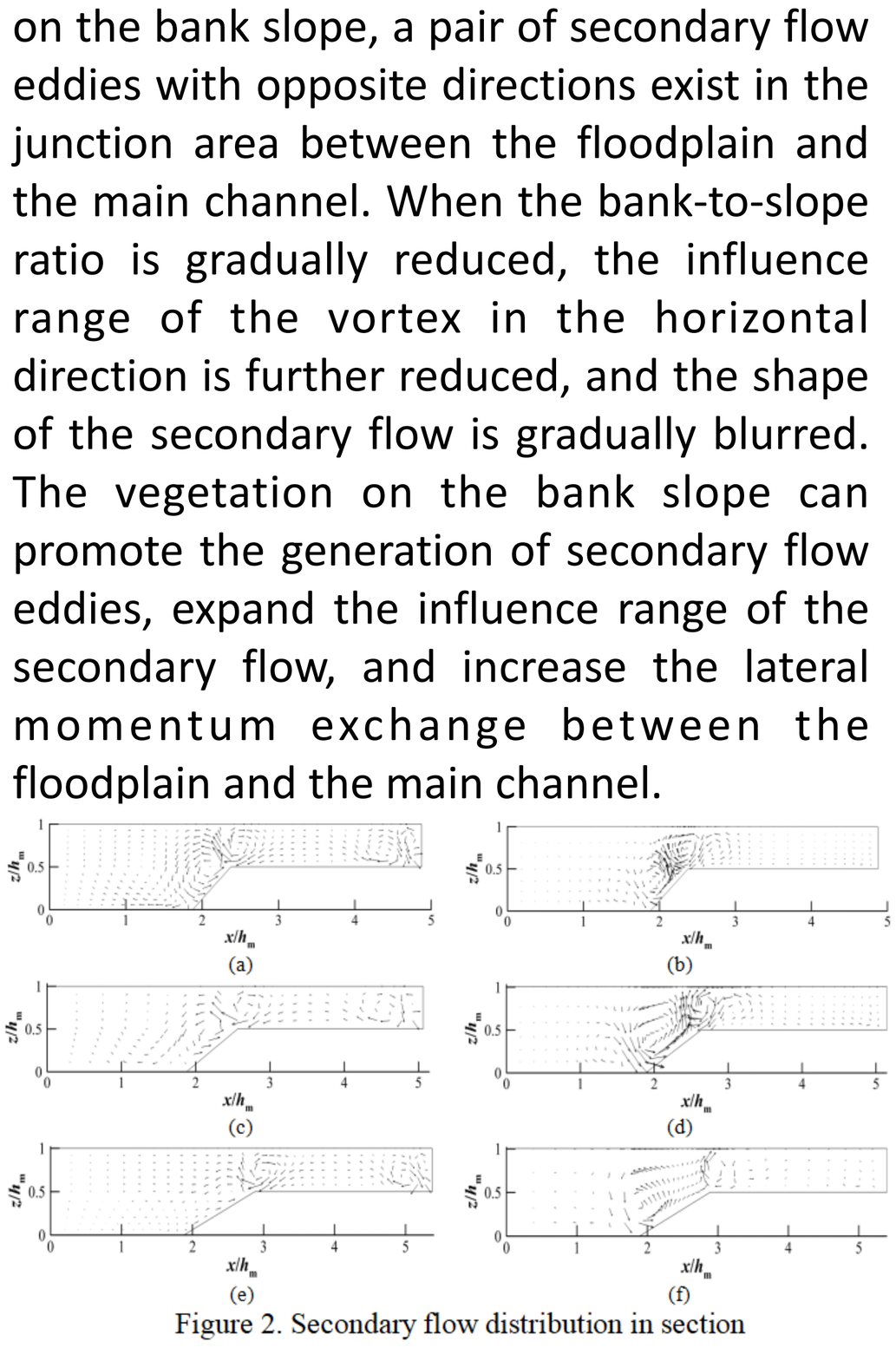

Figure 2. Secondary flow distribution in section

Planting vegetation on the bank slope, the shear stress of the main trough and the floodplain bed increased to some extent. This phenomenon is the opposite in the vegetation area on the bank slope. When there is no vegetation, the shear stress of the river bed is relatively large. After the vegetation is planted on the bank slope, the shear stress of the river bed is greatly reduced and even approaches zero.

Conclusions

The established model was used to study the influence of emerged rigid vegetation on the bank slope on water flow. From the simulation results, the vegetation on the bank slope increases the momentum exchange between the floodplain and the main channel, which reduces the flow velocity and the shear stress of the river bed in the bank slope area. The number, intensity and extent of secondary flow vortices all increased. In addition, the turbulence in the vegetation area is weakened, while the turbulence exchange in the surrounding area adjacent to the vegetation is intense.