FLOW STRUCTURES AND SEDIMENT DEPOSITION IN CONCAVITY ZONES OF COMPOUND OPEN CHANNELS

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Recently, after frequent flood disasters, excavation of riverbed is implemented to increase river conveyance. In compound rivers, a part of flood plain is excavated to expand flow cross-sectional area. These improvement works make dry riverbeds or wetlands along riversides, and at the same time, provide good environment for ecology. This excavation of the flood plain makes three-stage flow, which is composed of a main channel, a flood plain and a mid-level concavity land. In order to maintain this type of concavity in the flood plain, it is necessary to understand the flow structures in this complex river condition. In this study, we investigated three-dimensional flow structures in an concavity zone in a compound open channel experimentally. We picked up the concavity shape, the relative level of concavity bed and the existence of spur dikes as design items and investigated their effects on the flow structures in the concavity zone by using PIV method. Furthermore, sediment deposition tests was conducted in the same laboratory flume and the relation of flow structures to sediment transport process was considered.

The experiments were conducted in a 4m long and 0.3m wide rectangular flume. A rectangular flood plain was set on the right-hand side of the flume. The width was 0.1m and the height of was 0.04m. The concavity zone was located 2.0m downstream from the channel entrance. The cases A1 and A2 have rectangular concavity with 0.1m lateral and 0.15m longitudinal lengths. The cases B1 and B2 have trapezoidal concavity and two spur dikes. The longitudinal length at the sidewall was 0.25m and that at the interface was 0.35m. In the cases A1 and B1, the level of the concavity bed is 0.02m higher than the main-channel bed. In all cases, the discharge Q was 0.0038m^3/s and the water depth h was set to 0.06m by adjusting the downstream weir.

The time-averaged flow structures in concavity zones on flood plains are clearly revealed by using PIV method. The relative level of the concavity bed against the main channel bed was considered as a control parameter. The transverse vortex coexists with the vertical vortex in the concavity zone. In rectangular concavity case, the longitudinal scale of the transverse vortex becomes larger relative to the vertical vortex with an increase of the depth of the concavity. As a result, the flow pattern near the bed becomes very different from each other (see Fig.1 and Fig.2). The reattachment length of the transverse vortex is 4 to 5 times of the step height.

In trapezoidal concavity with spur dikes which simulates the actual river situation, skew step produces inclined transverse vortex and generates different flow patterns from the normal step case as shown in Fig.3. In the region between spur dikes, the velocity vectors show very complicated flow structures near the bed of the concavity, as shown in Fig.3. The bed level difference provides dissimilar flow structures. Consequently, outward currents are significant at the interfacial region in the case of B1 whereas inward currents are remarkable in the forefront region near the bed and in the central region over the spur dike.

Sand deposition rate was measured for each case by the sand-mixed flow experiments. The sediment deposition rate in the concavity is much affected by the relative bed level. When the bed level of the concavity is the same as the main-channel bed, the bed load and the suspended load are transported from the main channel into the concavity. When the bed level of the concavity is higher than the main-channel bed, the flood-plain sediment load is transported from the concavity to the main channel. These features are well related to the 3-d flow structures in the concavity zones.

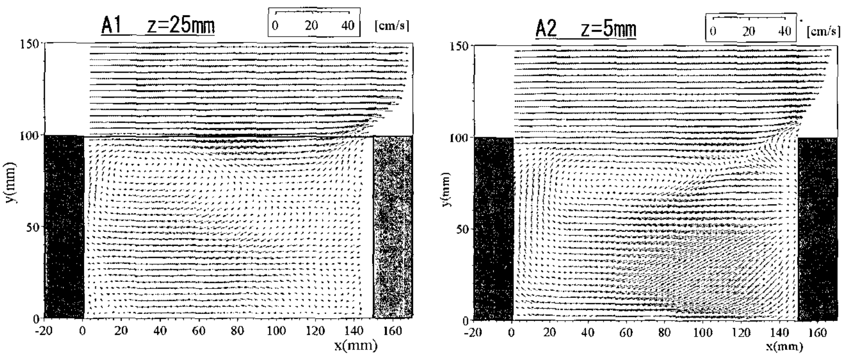

Fig. 1 Velocity vectors in horizontal planes for forefront and central region (Case A1 and A2 near the concavity bed)

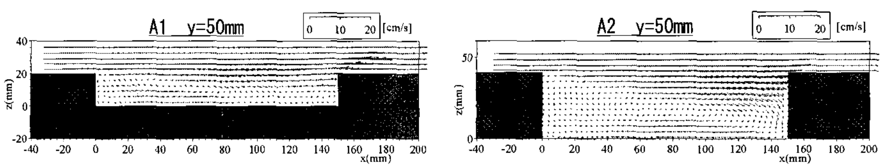

Fig. 2 Velocity vectors in vertical planes (Case A1 and A2 at y=50mm)

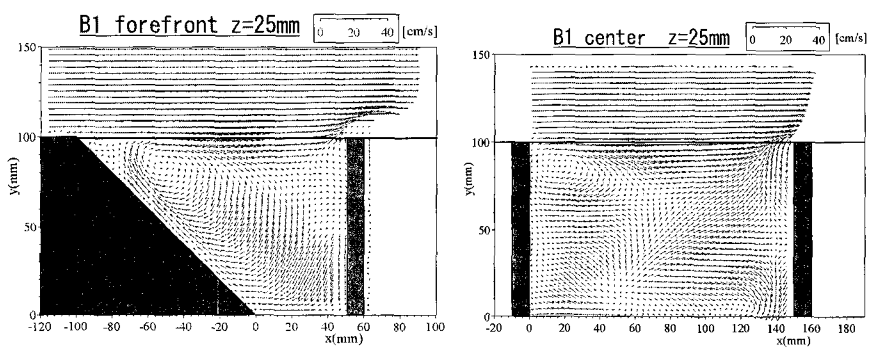

Fig. 3 Velocity vectors in horizontal planes for forefront and central region (Case B1 z=25mm and 35mm)