STUDY ON FLOW CHARACTERISTICS IN THE CAVITY OF STRAIGHT OPEN CHANNEL SIDE WALL

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1.Introduction

A embayment is connected to the main stream of a river, and is a topography that looks like a pond surrounded by river structures. In order to preserve the environment inside the wand, it is necessary to understand the flow structure inside the embayment.

In this study, in order to understand the essence of open channel flow with a cavity on the side wall, we performed detailed flow velocity measurement in the flow field and focused on the coherent structure formed there, and clarified its characteristics, and create a conceptual model of the flow.

For this purpose, the following three tasks are performed. 1st. Clarify the detailed three-dimensional flow velocity characteristics of the flow field. 2nd. Clarify the spatiotemporal characteristics of the tissue structure formed in the flow field. 3rd. Clarify the correlation between the behavior of the coherent structure and the flow velocity distribution. 4th. Create a conceptual model of the flow field.

2.EXPERIMENTAL METHOD

In this study, a straight open channel made of total acrylic resin with a length of 10m, a width of 60cm and a height of 15cm is used. A 15 cm wide, 6 cm high and 1 m long board made of PVC resin was laid on the right back side of the canal, and a 30 cm long space was provided at 5 m from the upstream to serve as a cavity flow. Figure 1 shows an overview of the experimental channel, and Figure 2 shows an overview of the channel cavity. PTV (Particle Tracking Velocimetry) using fine particles was adopted for flow velocity measurement. The fluorescent dye injection method was adopted for visualization of the internal flow.

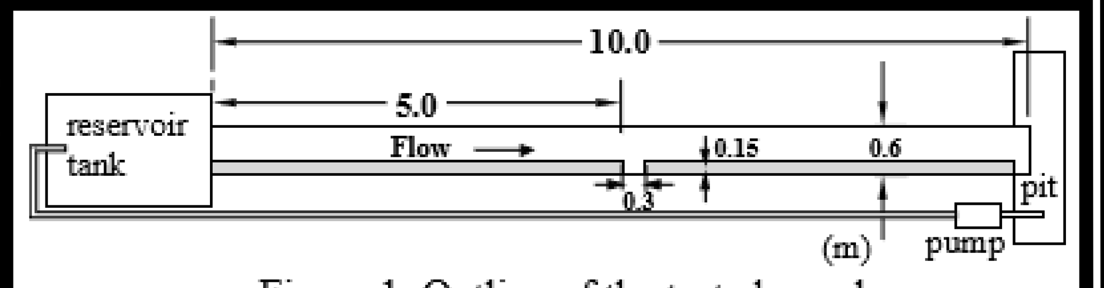

Figure 1. Outline of the test channel

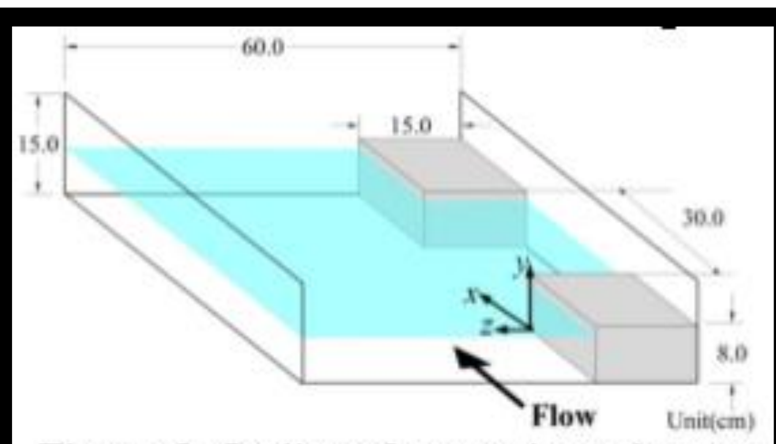

Figure. 2. Outline of water channel recess

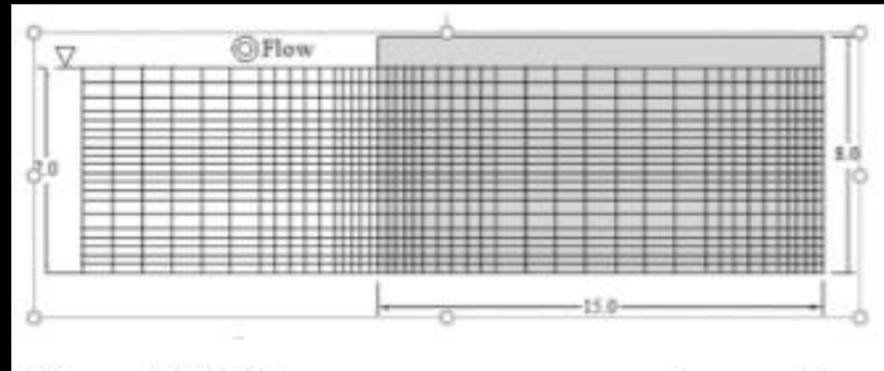

Figure 3. PTV measurement cross section position

3.RESULT

✓From the mean primary velocity distribution (*U*) in Figure 4, the inside of the cavity is relatively slow. In the vicinity of it, a reverse flow area is confirmed. A remarkable shear layer is formed at the boundary with the high-speed region.

✓ In the flow velocity vector (*U*, *W*) in Figure5, it was presumed that a clockwise circulating flow was formed near the downstream in the side wall cavity. In the velocity vector of y = 5.5cm and y = 6.8cm, the formation of anti-clockwise circulating flow was confirmed at the corner of the upstream side wall in the side wall cavity.

✓In the Reynolds stress distribution (-*uw*) in Fig. 6, it was confirmed that the boundary between the side wall cavity and the main stream had a positive region, and a negative region was formed at the downstream corner of the cavity.

✓In Figure 7, as indicated by the red dashed line, a vortex structure with a vertical axis of rotation was observed at the boundary with the main stream, and its scale was observed to increase in the downstream direction. It is also clear that the overall scale increases with approaching the water surface. Furthermore, it was observed that this vortex structure transported the fluid from the main stream side to the inside of the cavity by the vortex motion in the clockwise direction, and thus formed a circulating flow clockwise in the cavity. In addition, a small vortex structure around the anti-clockwise direction was observed in the upstream corner near the water surface.

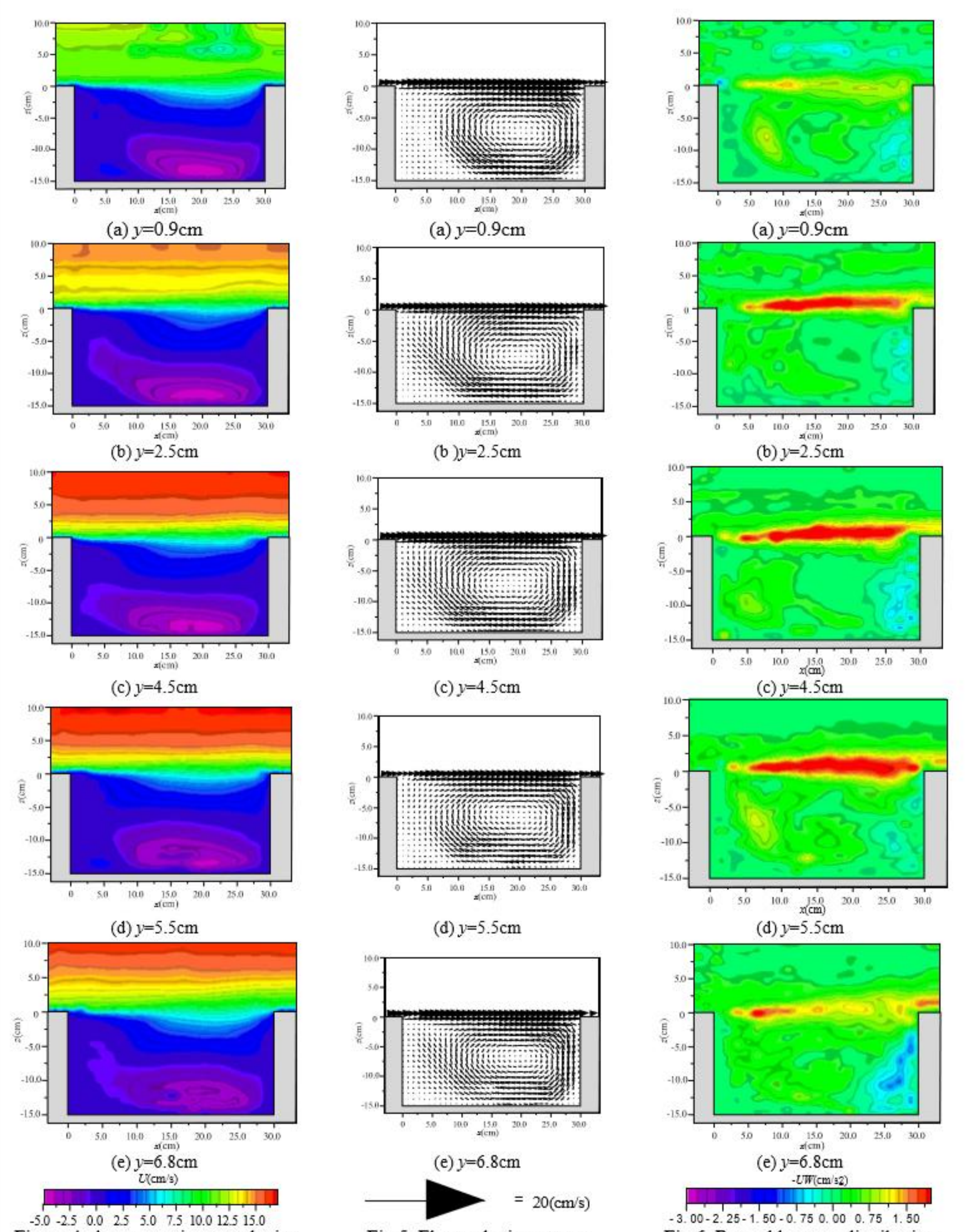

Figure 4. Average primary velocity distribution (*U*)
Fig 5. Flow velocity vector distribution (*U*, *W*)
Fig 6. Reynolds stress distribution (-*uw*)

✓ In Figure 8, the cross-section of the longitudinal vortex structure was observed at the boundary between the mainstream and the cavity on the side wall, as indicated by the red dashed line. It was observed that this vortex structure transports fluid from the main stream to the cavity or vice versa due to the vortex motion. This longitudinal vortex structure corresponds to the vortex shape observed in horizontal cross section. Furthermore, it was observed that this longitudinal vortex structure became larger in the downstream direction.

✓Figure 9 shows a conceptual model of the flow of the open channel cavity. In this flow, two shear layers, a vertical shear layer $\partial u/\partial y$ and a horizontal shear layer $\partial u/\partial z$, are formed at the downstream end of the open channel side wall. As a result, a vertical vortex structure group is formed downstream. This longitudinal vortex structure develops downstream and plays an important role in transverse fluid transport at the boundary area between the cavity and the main stream. This longitudinal vortex structure forms a region with strong turbulence intensity and high Reynolds stress in the boundary region. Fluid transport from the main stream to the cavity generates a circulating flow in the clockwise direction and a secondary circulating flow in the anti-clockwise direction inside the cavity.

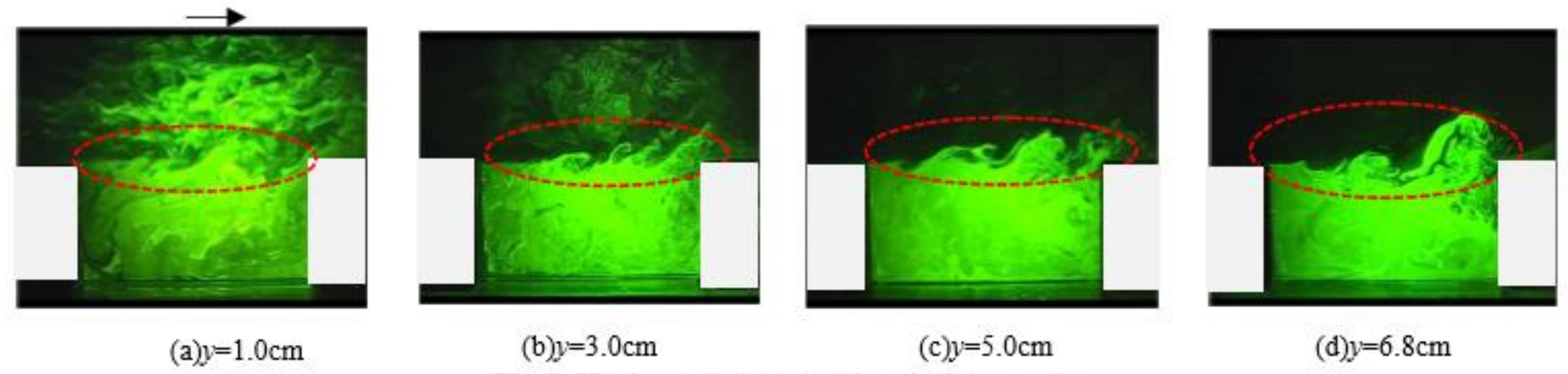

Fig 7. Horizontal cross-sectional view results

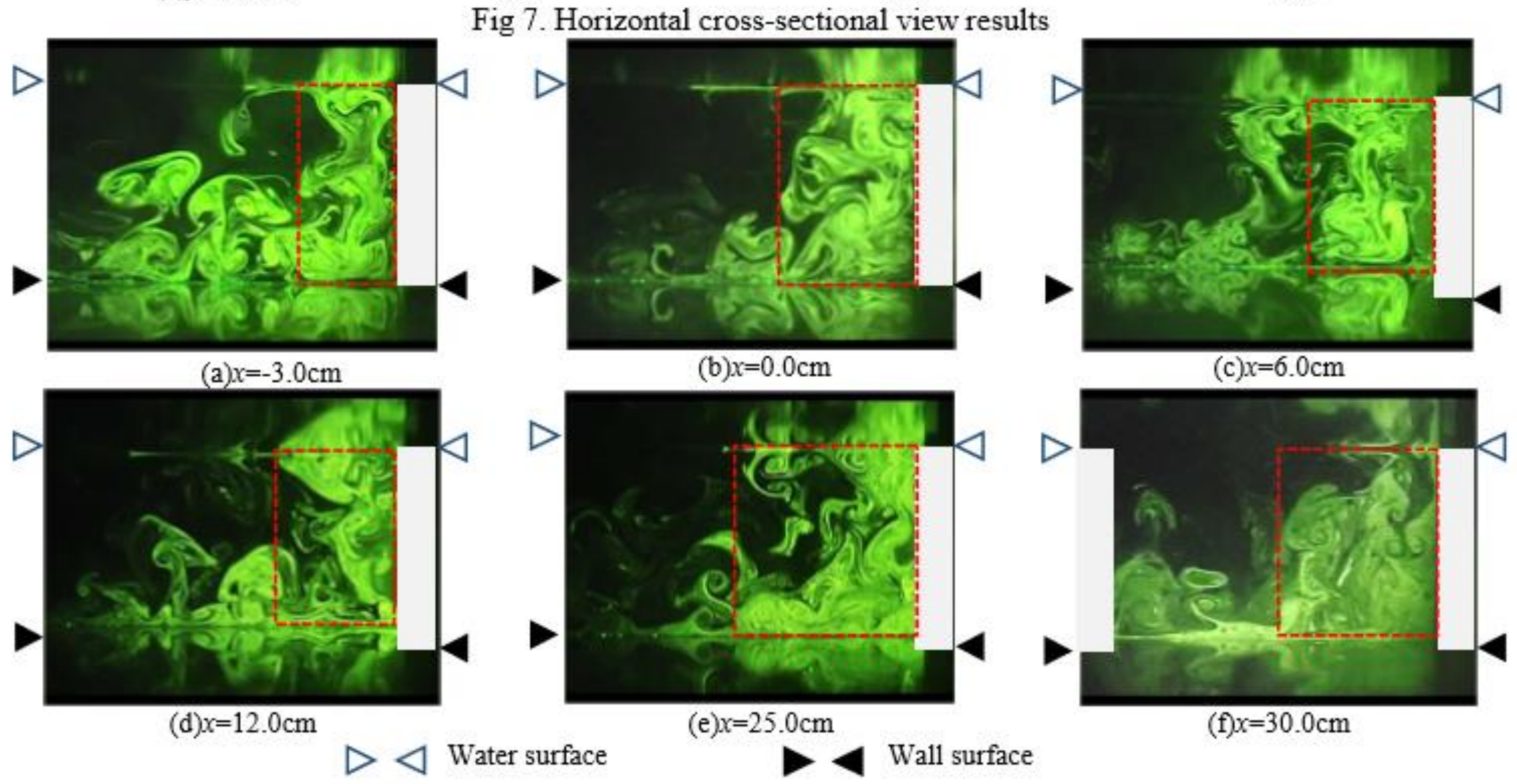

Figure 8. Results of cross-sectional view

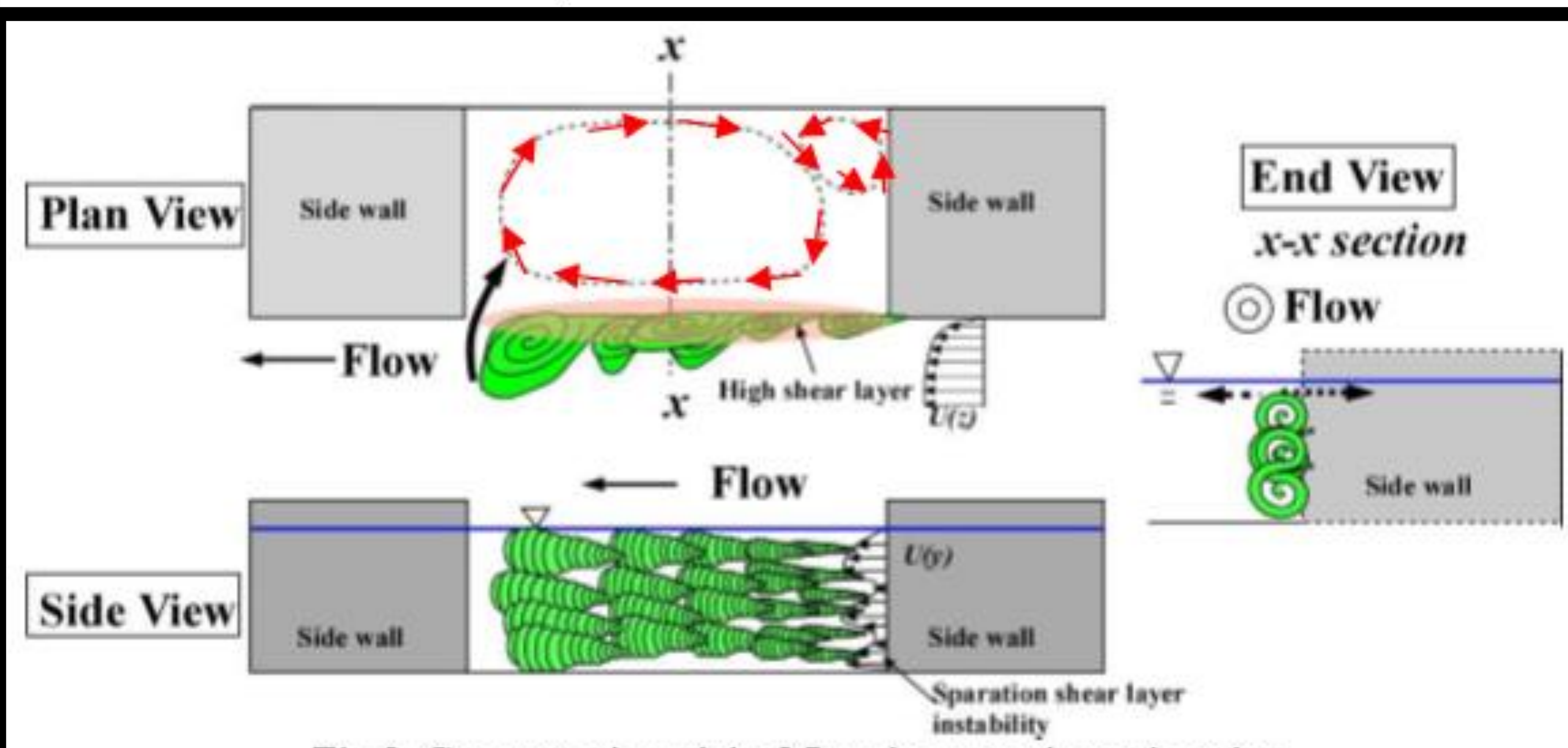

Fig 9. Conceptual model of flow in open channel cavity

4.CONCLUSION

✓ The cavity in the open channel becomes a relatively low-speed region, and a circulating flow in the clockwise direction is formed inside the cavity. As the water gets closer to the water surface, a small circulating flow forms in the anti-clock wise direction.

✓A remarkable shear layer was formed at the boundary between the open channel and the depression, and it was revealed that the turbulence strength (u_{rms}, w_{rms}) and Reynolds stress (-*uw*) were high.

✓A longitudinal vertical structure group is formed in the boundary area between the main stream and the cavity due to the coexistence of two shear layers. It was guessed that this longitudinal vortex structure group formed a large-scale circulating flowinside the cavity due to the generation of strong turbulence and the fluid transport from the main stream to the cavity due to the fluid motion.

REFERENCE

Watanabe, K., Saga, T., Kunihiro, E. (2006) Inner structure of hericoidal flow turbulent open channel flow with longitudinal ridge elements, *Journal of Japan Society of Civil Engineers Ser.B1, Hydraulic engineering*Vol.62, No.2, pp.186-200.