FLOW STRUCTURE AND SEDIMENT TRANSPORT IN ESTUARY: A CASE STUDY OF THE TOJINGAWA RIVER, JAPAN

Ryuichi HIRAKAWA (Maebashi Institute of Technology, Japan) and Terunori OHMOTO (Kumamoto University, Japan)

Introduction

Observations of suspended sediment concentration, salinity and current were made in the Tojingawa river estuary, Northern Kumamoto prefecture, Japan. The estuarine reaches are approximately 11 km in length, and are formed a compound channel by clay and silt. Flow measurements were undertaken in a straight part (Nezu and Rodi, 1986; Tominaga and Nezu, 1991; Shiono and Muto, 1998; Ishigaki et al., 2001) to investigate the effect of stratification on secondary flow in well-mixed estuary. In previous studies, few studies have examined the flow structure and lateral sediment transport in the tidal zone.

Several studies have been conducted on the transverse flow mechanism in open channel flow. For example, DNS has been applied to a rectangular open channel flow with an aspect ratio of 2, which is said to be the most basic flow that generates a secondary currents, and the secondary currents structure has been elucidated by changing the inclination angle of the side wall (Figure 1). Furthermore, the three-dimensional turbulent structure at the corner of the open channel was studied by directly observing the swirling vortex using the vortex structure extraction method (Hayashi et al., 2006). It has been shown that the basic structure in which a pair of secondary currents occurs at such corners is not limited to solid corners and water corners, but is also universal in trapezoidal cross sections with inclined side walls.

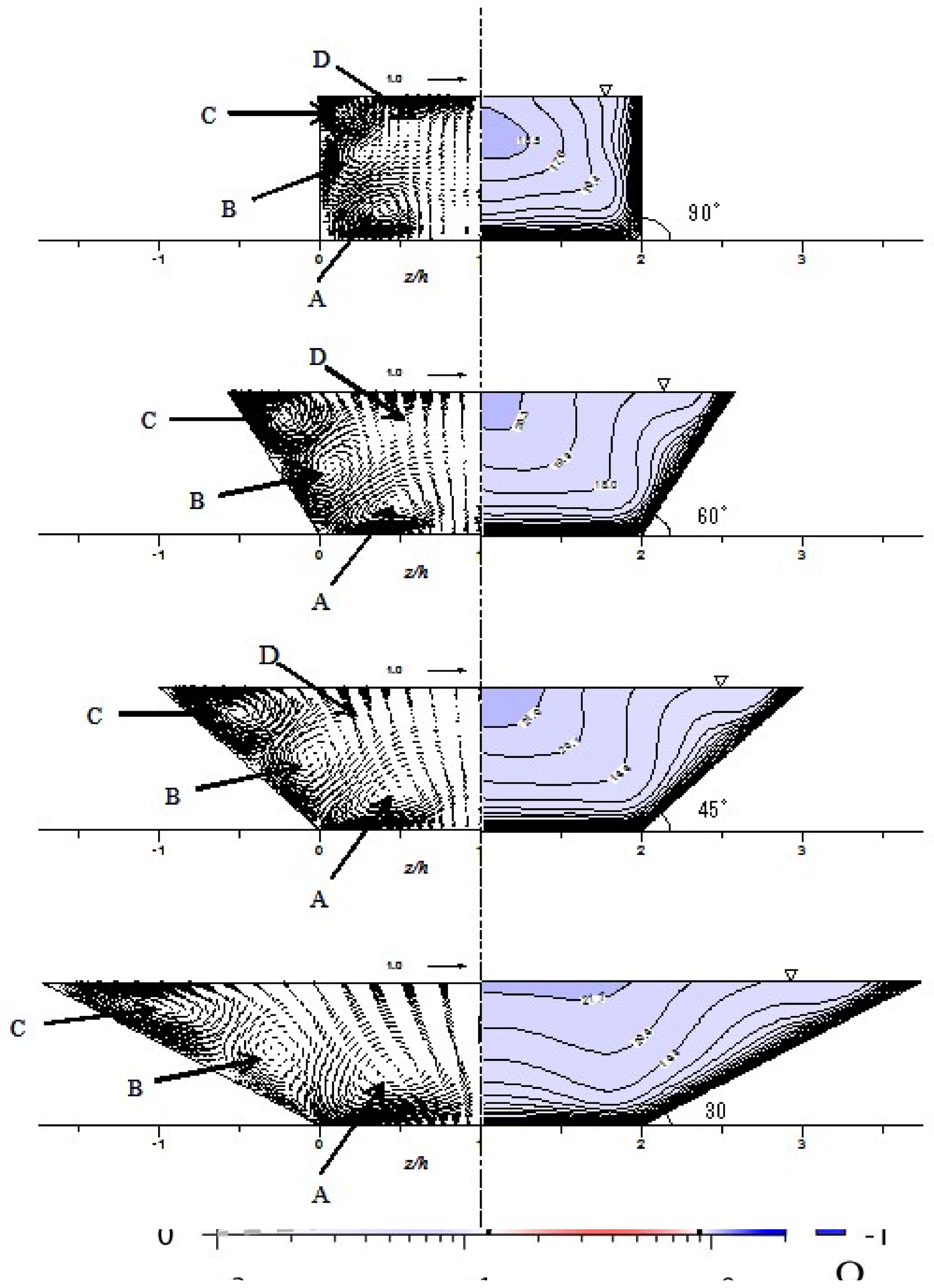

Figure 1. Distribution of secondary flow vector and main flow velocity due to the difference of the inclination angle of the side wall.

In the present study, it aimed to clarify the carrier mechanism of the clay and silt to the direction of the crossing.

Study area and methods

The survey point is about 3.9 km from the estuary, the river width is 46 m, and the width of the low water channel is about 20 m. The cross-sectional shape is a compound channel consisting of a straight double-sided embankment and a trapezoidal cross section with a gentle slope on the lower channel.

The observation dates are November 20, 2010 and December 3, 2010. As shown in figure 2, the tide level difference between the ebb tide and the flood tide was almost the same day.

ADCP measurements were carried out with a RDI Stream Pro ADCP. Multiparameter water quality sondes was used to measure water quality.

The tide gate at the estuary was always open during observation.

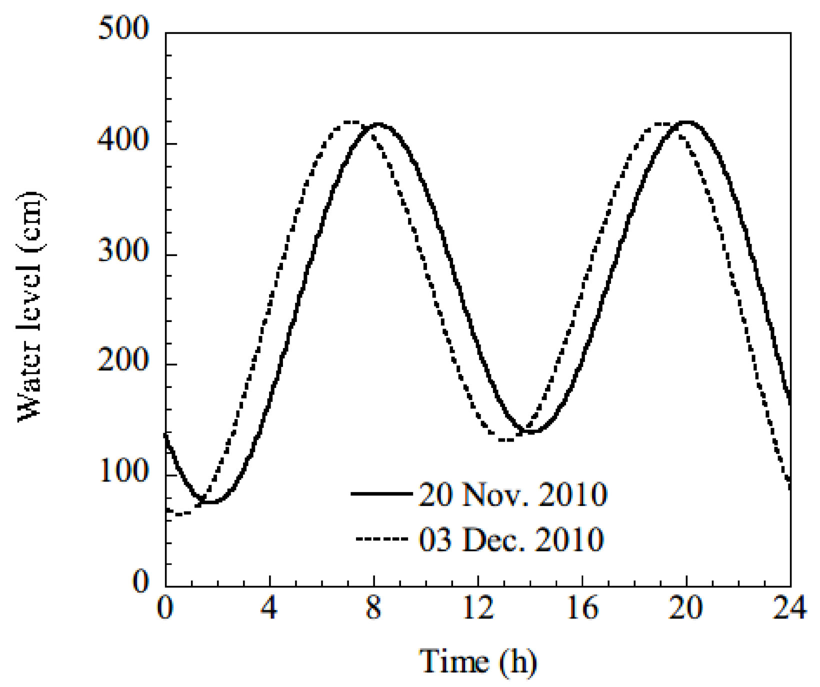

Figure 2. The tide levels on the observation day.

Results

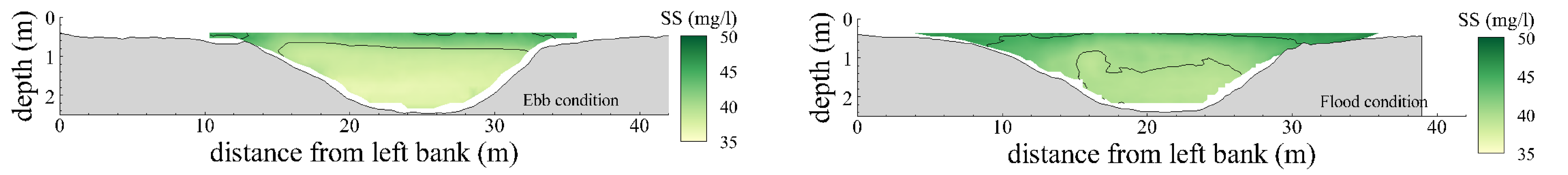

Figure 3. Sediment concentration along the cross-section of a stream.

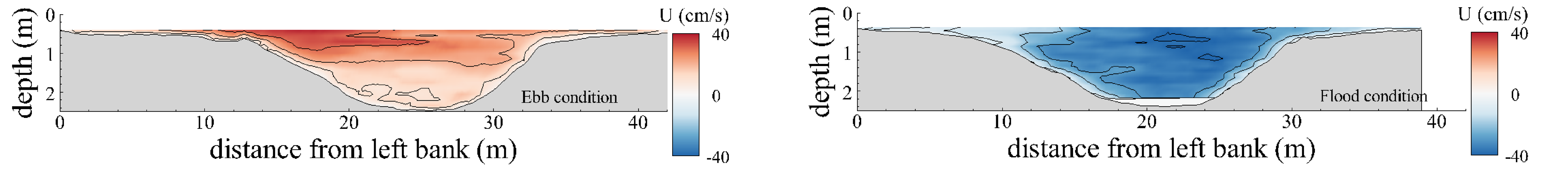

Figure 4. Main current velocity along the cross-section of a stream.

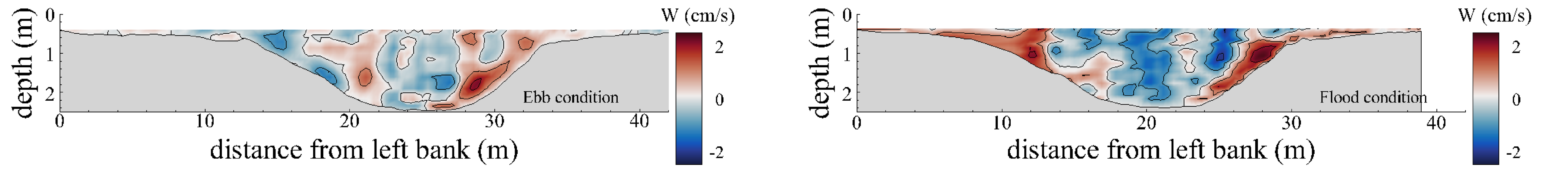

Figure 5. Vertical flow velocity along the cross-section of a stream.

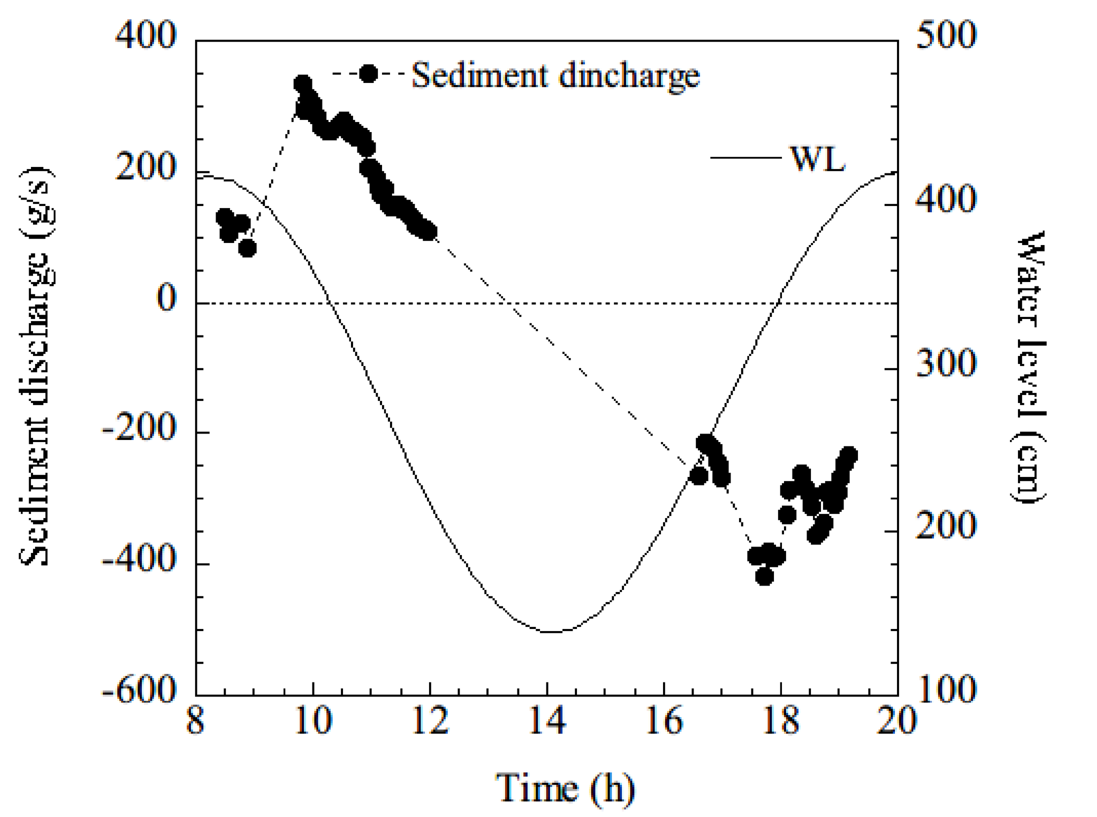

Figure 6. Distributions of sedimentation flux and water level..

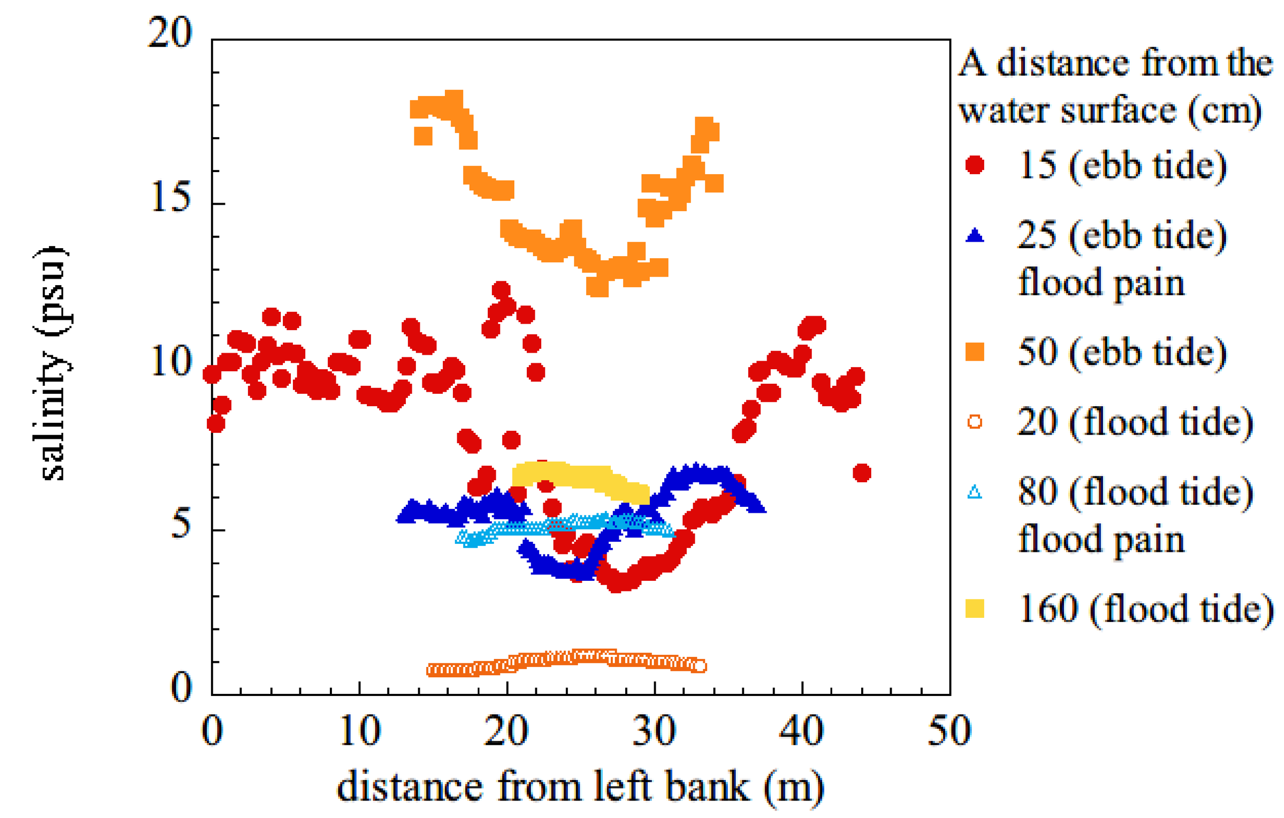

Figure 7. Salinity distributions on the cross section.

- ✓ The main current velocity U is fast in the vicinity of the surface of the water as shown in figure 4 and the maximum flow velocity position moves to the left bank side. The vertical flow velocity W is upward in the vicinity of the right bank of the low flow channel. It is thought that the secondary current cell is formed in this point (Figure 5).
- ✓ The downward current is suggested from the main current velocity U distribution at the flood tide of shown in figure 4 in the vicinity of the central of the channel. In the vertical flow W, the downward current is caused in the central of the low flow channel (Fiugre5). This proved that the maximum flow velocity position at the main current velocity U dropped.
- ✓ Figure 7 shows a salinity in the central part of a low flow channel, and had risen from there to the flood plain at an ebb strongest tide. This is thought that it is because there are a lot of ratios of the fresh water in half depth from the surface.

Conclusion

1. The measured data showed that at the ebb tide, the vertical velocity was slow, and the phenomenon that the maximum velocity point of the main velocity decreased did not appear. It was also shown that the secondary current cell affected the main flow velocity and sediment concentration in the central part of the low flow channel and at the shore..
2. The position of maximum flow velocity in the low flow channel convected downward on flood tide. It was suggested that the fine sediment transported from the upstream flowed down as suspended soil.
3. Salinity profiles showed a cross-channel salinity gradient at ebb tide have a sharp inclination than at flood tide. The salinity profiles produce an effective transverse flow velocity distribution for natural compound channels.