VELOCITY DISTRIBUTION AND SECONDARY CURRENTS IN MEANDERING COMPOUND OPEN-CHANNEL FLOW WITH FLOODPLAINS

IEHISA NEZU[1], MICHIO SANJOU[2], TOMONORI DOI[3] and HOANG DUC QUANG[4]

[1] Professor, Department of Civil Engineering, Kyoto University, Kyoto, 606-8501, Japan
(Tel: +81-75-753-5081, Fax: +81-75-753-5066, e-mail: nezu@nezu.gee.kyoto-u.ac.jp)
[2] Research Associate, Department of Civil Engineering, Kyoto University
(Tel: +81-75-753-5082, Fax: +81-75-753-5066, e-mail: sanjou@nezu.gee.kyoto-u.ac.jp)
[3] Graduate Student, Department of Civil Engineering, Kyoto University
[4] Graduate Student, Department of Civil Engineering, Kyoto University

The object of the present study is to reveal fundamental hydrodynamic characteristics in a meandering compound open-channel flow with floodplains. This complex flow consists of a meandering main-channel flow and the associated straight floodplain flows, and thus the significant interactions are observed between the main-channel and floodplains as pointed out by Shiono & Muto(1998). It is therefore very important to investigate the flow structure in the meandering compound channels, because such interactions promote the generation of velocity shear and the development of secondary currents. In particular, it is inferred strongly that the distributions of velocity components and the bed-shear stress vary significantly in the transition region from the straight to meandering channels. Therefore, we highlighted a transition region from the straight to the meandering compound free-surface flows, and the detailed velocity measurements were conducted by using 3-D electromagnetic velocimetry. As the results, the hydrodynamic properties of the bed-shear stress, streamwise velocity component and secondary currents were examined in the straight to meandering compound open-channel flows.

Fig.1 shows the coordinate system of flume, in which the streamwise flow shape of the main-channel is defined as a sine curve, i.e., the sine-generated curve from the straight channel, $x \geq 0$; x is the streamwise coordinate along the floodplains (Fig.1). Velocity measurements were conducted at a lot of sections, i.e., 21 in the main-cha nne l, whose streamwise positions are given as a function of ϕ, in which ϕ is a phase angle of the sine curve. The present measurement region was between $\phi = 0^{\circ}$ and $\phi = 180^{\circ}$. y and z are the vertical and spanwise directions of floodplains; y=0 is at the main-channel bottom-bed and z=0 at the left-side bank of the floodplain. s is the streamwise curvilinear coordinate and n is its normal or spanwise coordinate of meandering main-channel (Fig.1). The sinuosity $Si \equiv L_s / L$ was 1.09 in the present meandering channel, which is in the same order of magnitude s observed in actual rivers. The glass beads of 2mm diameter were attached densely on the main-channel bed as roughness elements. In the present experiments, one hydraulic condition was intensively measured in the meandering overbank flow as shown in table 1, in which U_m is the bulk-mean velocity at the straight main-channel section.

Fig.2 shows the vertical contour lines of U at the typical spanwise positions of $n / B_m = 0.05, 0.45$ and 0.85. Around the entrance meandering section, $s / L_s = 0$, it is recognized that U becomes smaller closer to the channel bed at all spanwise positions. In contrast, around the cross-flow section of $s/L_s = 0.6$, there are low-speed regions caused by the cross effect between the meandering main-channel flow and the straight floodplain flow. It should be also noticed that the streamwise positions of these low-speed fluids vary in the spanwise direction, n. Fig.3 shows the distribution of the bed-shear stress τ_w, the value of which is normalized by the maximum one $\tau_{w,\max}$. Of particular significance is that a peak value of τ_w appears near the inside of the bend apex region, $\phi = 180°$, $s/L_s = 1.0$. This corresponds well to the steamwise velocity property near the bed, and it is therefore found that secondary currents have a significant effect on not only the velocity component but also the bed-shear stress.

REFERENCES

Complex flow mechanisms in compound meandering channels with overbank flow, *J. of Fluid Mech.*, Vol.376, pp.221-261.

Table 1. Hydraulic condition.

Q (l/s)	H (cm)	U_m (cm/s)	Re	Fr	D (cm)	H/D	B_m (cm)	B_{fl} (cm)	B_{fr} (cm)	Si
7.51	6.75	25.5	17200	0.3	4.75	1.42	20	20	60	1.09

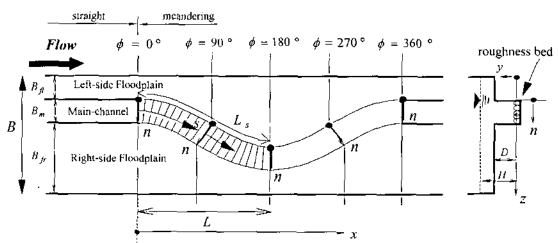

Fig. 1 Experimental flume and coordinate system.

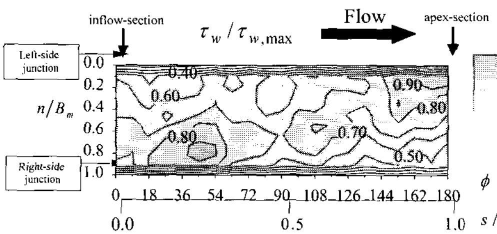

Fig. 3 Horizontal contour lines of the bed-shear stress.
Shiono, K. and Muto, Y., 1998.

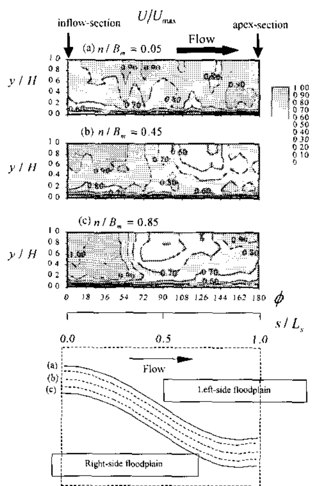

Fig.2 Vertical contour lines of time-averaged streamwise velocity