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The Vertical Profile of Transverse Velocity of Secondary Flow in Meandering Channels

THE VERTICAL PROFILE OF TRANSVERSE VELOCITY OF SECONDARY FLOW IN MEANDERING CHANNELS

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The study of flow in curved channels is relevant for understanding river flow characteristics, since most natural rivers tend to meander. At the curvature of the natural river, the water is subjected to centrifugal force creating a pressure gradient normal to the direction of the flow. This causes the water surface to flow outwards, while near the bottom the transverse velocity has an inner flow. This creates a helical transverse velocity profile known as the secondary flow. These secondary flows change the overall characteristics of the main flow and have strong effects on the sediment transport and bank erosion in rivers. In the case of contaminant diffusion, mixing by secondary flow causes stronger transverse mixing. The knowledge of secondary currents in a curved channel will increase the understanding of the mechanism of flow in natural river bends. In this study, the problem of flow characteristics in meandering channels has been studied using numerical methods. For analysis a 3D computational fluid dynamics program was used to simulate the flow structure in the meandering channels.

The numerical simulation was conducted by FLOW-3D for the channel. FLOW-3D is a computational fluid dynamics program able to calculate the 3D Navier-Stokes equations.(Flow Science, 1999) The model was run using a Large Eddy Simulation approach, due to its slight superiority in computing time-averaged secondary velocities compared with the Reynolds-Averaged Navier -Stokes equations (Stoesser, 2010). Using former experimental results of meandering channel (Seo and Lee, 2006) to compare with the simulated results, the model was verified for application. The roughness height was one of the variable boundary conditions, and thus was changed for the accurate comparison with the velocity profiles.

Using the calibrated conditions, additional measurement comparisons of the velocity profile was conducted by changing the boundary conditions, sinuosity and width to depth ratio of the channel. The results were similar with the transverse velocity profile of the experimental data. Then an equation of vertical profile for transverse velocity of the secondary current was proposed as follows.

$$\frac{v}{\overline{u}} = A\left(S_n\right)^B \left(\frac{W}{H}\right)^C \eta(\eta - E) - F$$

$$E = D\left(S_n\right)^{-0.29}\left(\frac{W}{H}\right)^{0.31} \qquad F = E\left(S_n\right)^{-0.29}\left(\frac{W}{H}\right)^{0.31}$$

$$A = 0.2 \sim 0.6,\ \ B = -4 \sim -5,\ \ C = 2 \sim 3,\ \ D = 0.2 \sim 0.4,\ \ E = -0.6 \sim 0.6$$

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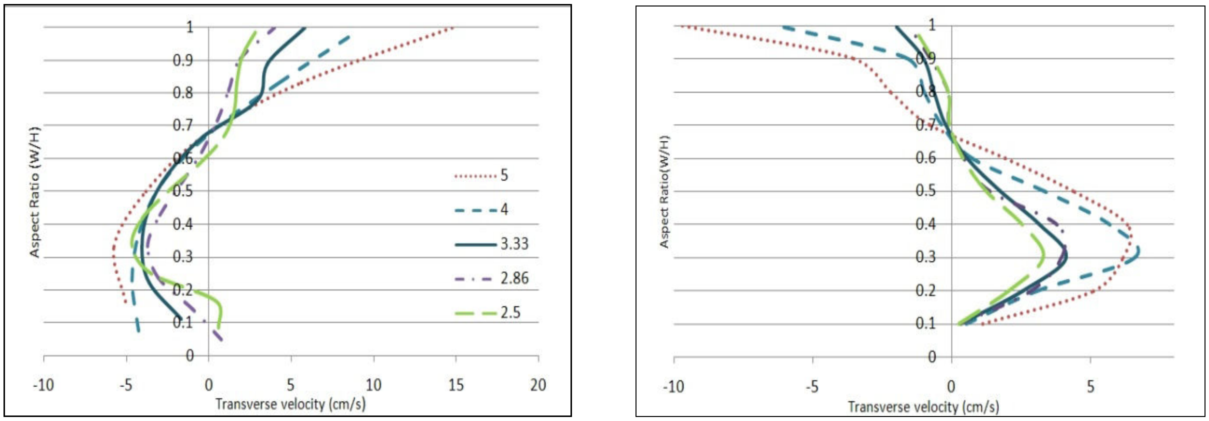

(a) First meander section (b) Second meander section

Figure 1 Simulated transverse velocity profiles according to aspect ratio

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