An Experimental Study of Flow Structure in Fixed Bed Meandering River

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Abstract

In this study, an effort was made to understand flow structure and in particular secondary currents inside the river meander. For this purpose, a physical model was used. Three dimensional flow velocities were measured using ADV in 360 different nodal points. From the result of this study, some secondary currents were recognized inside the meander and situation of vortices changes spatially along the meander. Also direction of secondary currents is towards outer bank from entrance to middle of the meander and it is vice versa from middle to the end of the meander. Above information helps engineers to protect river meanders where the secondary currents cause erosion.

Keywords: Flow structure, meander, secondary currents, ADV.

1. INTRODUCTION

Understandig of flow structure in rivers meanders is an important subject in the area of hydraulic engineering. Therefor researches on hydraulics and morphology of meandring rivers is essential. The spiral motion of the water body in a channel bend that is called the secondary current, thus it influences on the water flow and the sediment movement. Since water flows in a river bend, transversal slope is generated in water surface due to centrifugal force, as a result a pressure difference is generated between two banks of river meander. Because of these forces and nonuniform distribution of velocity in flow depth, secondary current is generated which cause particles of water surface move towards outer bank and sediment particles move towards inner bank. Combining of this secondary current with longtitudal component of flow generate a three dimensional complicate flow structure that is named helical flow. This flow has main role in morphological changes in meandering interals. Because of redistribution of longtitudal momentum and transfer of maximum velocity towards outer bank, helical flow causes erosion in outer bank and the eroded particles is transferred towards inner bank by near the bed flow and sedimentation is occurred in this region. Thorne, Hey and Newson [1] reported that Leopold and Wolman (1957) disscused about natural continuous channel forms from straight through to meandering and braided systems and they clarified difference between meandering and braiding systems on basis of formative discharge and channel slope. According to Thorne, Hey and Newson [1], Yalin (1972) assumed that in straight channels, secondary flow was controlled by a single large cell extending across the whole width. Also they reported, Hey (1976) showed that in straight channels, secondary current features twin cells of secondary circulation by field and flume observations. A number of studies for example by Bathurst et al. [2,3], Bridge and Jarvis [4], Parker, Sawai and Ikeda [5], Parker and Andrews [6], Odgard and Bergs [7] have attempted to investigate the secondary flow in river meander. Blanckaert and De Vriend [8], analysed turbulence structue of the secondary currents in curved open channel flow. Rüther and Olsen [9] used a CFD model to simulate the formation, development, and migration of free forming meander bends in a laboratory channel. Ana Maria A.F da Silva [10] described causes that the shape of a river changes with the passage of time and why and how do a river change to meander. However, in spite of the importance of flow structure in the river meanders, their characteristics have not been investigated sufficiently in detail. Because of the variation of sediment concentration whithin the river meander is greatly affected by variation of velocity components in vertical, radial and tangential flow directions. In this paper, three dimensional flow velocity were measured inside the river meander and characteristics of streamlines and vortices in each cross section and whole domain of the river meander were analysised from the experimental data.