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Experimental analysis of flow motion in a large amplitude meandering bend

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The configuration of the stable bed topography strongly depends on the kinematics characteristics of the flow. Because of the irregular topography and the continuously changing plane shape, the analysis of the kinematic characteristics of a natural meandering stream is rather complex.

A large amount of research on flow in bends has been performed, but in most experimental investigations a fixed rectangular section with a smooth bed has been considered and, thus, different hydraulic conditions from the rough turbulent flow over a deformed bed have been analyzed. The major part of the experimental works have been carried out in constant curved channels (Rozovski, 1957; de Vriend, 1979; Steffler, 1984; Odgaard and Bergs, 1988) and only fully developed channel regions have been analyzed. On the basis of the experimental observations, some authors (Yen, 1971; Kikkawa et al., 1976; Francis and Asfari, 1978; Zimmerman and Kennedy, 1978; Engelund, 1984) have emphasized the importance of the effect of cross-circulation (or secondary current) on bed deformation, neglecting the effect of the convective accelerations associated to channel changing curvature. Other experimental works carried out in meandering channels (Hooke, 1975; Dietrich and Whiting, 1989; Whiting and Dietrich, 1993), apart from field observations (Lewin, 1972; Jackson, 1976; Bridge and Jarvis, 1977; Thompson, 1986), have highlighted the importance and the effect of the convective accelerations associated with downstream changing topography and their contribution to the total force balance for a meandering stream.

The studies carried out in constant curved channels have essentially analyzed the flow

field dynamics related to the formation of an unique central-region secondary circulation cell that, superimposed to the longitudinal flow motion, generates the so-called helicoidal motion. But, recent experimental results obtained in a strongly curved channel have highlighted the formation of a second counter-rotating cell near the free surface of the outer bank (Blanckaert and Graf, 2001; Booji, 2002; Blanckaert, 2002). Other recent findings obtained in a large amplitude meandering flume (Termini, 2004; Termini et al., 2004; Termini and Piraino, 2006) highlight the formation of two counter-rotating secondary circulation cells (central-region cell and the outer-bank cell) in the apex section of the flume.

The present work aims at improving the understanding of the flow along the meandering bend. The flow velocity data collected in a large amplitude meandering flume constructed at the Department of Hydraulic Engineering of Palermo's University (Italy) have been used in order to analyse the evolution of the secondary circulation motion along the flume. Particular attention is focused on the outer bank zone, where erosion occurs. Here, the formation of the outer-bank secondary circulation cell could affect the turbulent activity of flow and the distribution of the Reynolds stresses near the bank.