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Evaluation of Various Turbulence Models in Predicting Flow Behavior in Meandering Channels

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Abstract

Several turbulence models have been developed in the past years. However, it is a must to appraise the generality and precision of the models for distinct hydraulic phenomena. This survey evaluates the performance of five different turbulence models in predicting flow behavior in an open channel bend. Accordingly, 3D numerical simulations were carried out using a computational fluid dynamics code that employs the finite volume method to solve the governing equations. Their accuracies were analyzed with observed data from experimental studies of an ordinary 90° open channel bend, and the best suited turbulence models were introduced.

Keywords: turbulence models, meandering channel, two-phase flow, volume of fluid

Introduction

Meandering is “a self-induced plan deformation of a stream, under ideal conditions, is periodic and anti-symmetrical with respect to an axis . , say.” as defined by Yalin (1992). One of the distinctive characteristics of flow pattern in a meandering open channel is its secondary flow and therefore its helical motion that is the main cause of river morphology and the tendency to create a succession of shoals and deeps along its path. The physical definition of the phenomenon has been identified as the decrease of flow velocities by secondary currents that are formed due to disequilibrium in pressure gradient and changes force at an arbitrary section. These changes modify the shape of bank, and the amount of bed erosion in river meanders. Moreover, helical motion induces concentrated bank erosion. However, according to Blanckaert and de Vriend (2003), this substantially differs depending on the structure's section shape and morphodynamics in sharp bends.

Numerous experimental and numerical investigations have been carried out by researchers to analyze the characteristics of flow in open channel bends. Rozovskii (1957) has conducted a series of experiments on a tight 180° bend of rectangular cross section with straight inlet, and outlet reaches. He measured velocity profiles near the walls and noticed that the maximum velocities occur below the water surface. Furthermore, as a recent experimental investigation, Akhtari (2009 and 2010) has carried out several studies on 30°, 60° and 90° strongly-curved open channel bends with a central radius of 60(..) and a 1.5 ratio of curvature radius to channel width considering five different discharge values. He has gathered extensive data like velocity and water depth profiles, and concluded that in a distance equal to channel width from the bend entry and bend exit, water surface was not being affected by the curvature.