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Applying Artificial Neural Network to Analysis and Prediction of the Flow Field in Open Channel with Bend

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Abstract

In this paper the flow field in a 90° bend is analyzed numerically and also predicted using Artificial Neural Networks (ANN). In this study, first of all, for solving governing equations of flow, a computational fluid dynamic (ANSYS-CFX 12) code is used. Then, by presenting a 3D numerical model in 2 phases, variation of velocity field in different sections of a bend is studied. In addition results of numerical model are validated by experimental data. After that for prediction of velocity field in variable sections of bend, an ANN is trained based on Back-Error Propagation (BEP) technique. The inputs of the ANN are depth, radius and angle of different points of bend, and target outputs are corresponding velocities. Results of ANN test show that they have good agreement between actual and predicted data.
Keywords: Numerical study, Bend, Velocity field, Artificial Neural Network, Prediction.

1. INTRODUCTION

Studying of flow pattern in curved channels is more complex than straight channels. Presence of secondary currents and pressure gradient causes changing in flow field in curved channels. Before twentieth century, the sediment transport and velocity filed in bends was being studied hardly and done using one or two dimensional numerical models. With these conditions, only special problems of flow could be solved analytically and without computer [1]. Nouh and Townsend studied distribution of shear stress in stable channel bends. They found the cause of local asymmetry in the flow field is secondary currents had been made by stream curvature in channel bends [2]. With advent of the high-speed digital computer, during the twentieth century, CFD has developed. This provides the possibility of more accuracy and simpler prediction of flow fields. Demuren and Rodi presented a predictive numerical method which solves the full, 3D, two-fluid model equations in dispersed two phase flow using control volume discretization and also using a three-dimensional model and $k-\varepsilon$ model predicted the flow and transport of a neutral tracer in a meandering channel [3]. Demuren developed a 3D numerical scheme for calculation of turbulence flow in channels with varying cross section, bed topography and curvature [4]. Wu et al. using 3D numerical model, studied flow field and sediment transport in channel bends [5]. Also Duan et al. using an enhanced 2D model and assuming a channel with constant width and a fixed computational domain predicted evolution of meander [6]. Ruther and Olsen using 3D numerical model and finite-volume method solved the Reynolds-averaged Navier Stokes equations to studying of variation of bed level and flow field in 90° curved channel [7]. In another study Huang et al. proposed an algorithm to compute the 3Dsediment transport effect in channel bends [8].

One of the techniques that are used for prediction of flow pattern in curved channels is ANN. In a paper, Bhattacharya et al. used ANN in sedimentation modeling for the approach channel of the port area of Rotterdam. Also the influence of some factors on the sedimentation process such as waves, wind, tides, surge and river discharge were studied [9]. Also Bilgil and Altun Investigated the flow resistance in smooth open channels by using ANN. they presented an approach to estimate the friction coefficient via an ANN. The estimated value of the friction coefficient was used to predict the open channel flows in order to carry out a comparison between the proposed ANN based approach and the conventional ones [10]. Kocabas et al. presented an ANN approach for prediction of critical submergence of an intake in still water and open channel flow for permeable and impermeable bottom. Then they compared the experimental, ANN and MLR approaches results [11]. Yuhong and Wenxin investigated the application of ANN for prediction of friction factor of open channel flow. They used the Levenberg–Marquardt (LM) learning algorithm to train the model