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Assessment of stage–discharge predictors for compound open-channels

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ABSTRACT

The accurate prediction of flood levels and velocities is a prerequisite to any appropriate management of river valleys, where the mitigation of environmental, economic or human losses caused by flood events is of paramount importance. During these events, rivers frequently acquire a compound channel configuration.

Due to the 3D nature of compound channel flows, the stage–discharge curves are not as easily predicted as in single channels. Despite the availability of 2D and 3D flow models that may solve this question, 1D methods are often preferred due to the reduced data required and to the much shorter processing time. In the last five decades, important research efforts have been devoted to the improvement of 1D predictors of stage–discharge curves in compound channels. In this study, the accuracy of seven of those methods is assessed by comparing their predictions with a large experimental dataset, comprising symmetrical and asymmetrical compound channels with vertical and inclined main channel sidewalls, and smooth and rough floodplains. To the authors' best knowledge, this is the most comprehensive assessment of stage–discharge predictors for straight compound channels since it involves the highest number of predictors applied to the widest data set.

It was concluded that the methods that account for the momentum transfer between the main channel and the floodplains display considerably better results than the traditional methods. For relative depth (ratio between floodplain and main channel flow depths) higher than 0.25, predicted discharges for the methods that account for the turbulent momentum exchange are within 5% of observed values. Depending on whether the flow depth or the flow discharge is the pertinent variable, two different methods seem to be the most appropriate to produce precise and safe predictions.

1. Introduction

This study focuses in the prediction of stage–discharge curves in straight compound channels. In nature, compound channels are composed of one main channel and one or two lateral floodplains. The fields surrounding the main channel are prone to inundation during flood events, causing serious disasters, which may involve important environmental, economic or human losses. The accurate prediction of flood levels is a prerequisite to any appropriate management of river valleys intended to eliminate or mitigate such losses.

Pioneering works on the flow structure in a compound open channel, identifying the momentum transfer between the main channel and the floodplain flows, are those of Sellin [23] and Zheleznyakov [27]. It involves the interaction of vortices with vertical and horizontal axes, affecting the streamwise velocities and the channel conveyance or transport capacity [16]. Due to this complexity, the flow discharge of a compound channel at a given flow depth is not as easily predicted as for single channels [19]. Nowadays, 2D and 3D flow models may include and predict the most important features of compound channel flows. However, 1D methods are often preferred due to the reduced data required and the much shorter processing time. The proper consideration of the momentum transfer is unavoidable, as pointed out by Bousmar and Zech [5].

The assessment of existing 1D stage–discharge predictors in straight compound channels is the specific objective of present study. Besides the traditional Single and Divided Channel Methods (SCM and DCM, respectively), that ignore the effect of momentum transfer, five other methods are evaluated, namely, the Debord Method, DM [17], the Coherence Method, COHM [1], the Weighted Divided Channel Method, WDCM [12], the Apparent Shear Stress Method, ASSM [13] and the Exchange Discharge Model, EDM [5].

Several studies on the performance of stage–discharge predictors can be found in the literature. Using 40 laboratory experimental relations between the flow discharge and the flow depth, Prinos and

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