Direct solution to problems of hydraulic jump in horizontal triangular channels

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ABSTRACT

The specific force equation has many applications in open channel flow problems. Quantifying of the hydraulic jump phenomenon is an important application of this equation. This equation has a direct solution only for the rectangular channels. The trial and error procedure as well as the graphical solution are the existing methods of solving hydraulic jump equations. No direct solutions are available in technical literature for sequent depth ratios in horizontal triangular channels because it is presumed that the governing equation is a quintic equation. In the present study, considering physical concepts this quintic equation has been reduced to a quartic equation. In the next step, this quartic equation has been converted to a resolvent cubic equation and two quadratic equations. This research shows these steps clearly to reach an acceptable physical analytic solution for sequent depth ratios in horizontal triangular channels.

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1. Introduction

A hydraulic jump is formed in a channel whenever supercritical flow changes to subcritical flow in a short distance. In this transition, water surface rises abruptly, surface rollers are formed, intense mixing occurs, air is entrained, and usually a large amount of energy is dissipated. Therefore, a hydraulic jump may be used to dissipate energy, to mix chemicals, or to act as an aeration device [1].

A hydraulic jump may be used in triangular ditch irrigation to raise the downstream water surface [2]. The experimental studies of Argyropoulous (1961) on hydraulic jumps in horizontal triangular channels have shown that the sequent depth ratio calculated by the specific force equation agrees closely with the experimental data [3]. Thus the specific force equation may be used to explain the hydraulic jump phenomenon in a triangular channel.

The expression of specific force (hydrostatic force plus inertial force) as a function of water depth is the starting point of the present work. The specific force equation in a horizontal triangular open channel is made dimensionless, writing it as a function of the sequent depth ratio and Froude number. The inversion of such a function involves the solution of the quintic equations. Considering physical concept, this quintic equation can be reduced to a quartic equation. This quartic equation can be solved using a classical method such as Ferrari’s solution [4–6], but further manipulations based on the algebraic analysis and physical meaning of some terms make the final result much more friendly to use for design engineers.

2. Sequent depth ratio

The flow depths upstream and downstream of the jump are called sequent depths. An expression for sequent depth ratio in horizontal channels of regular shapes can be obtained by using the specific force equation as [7].

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