Flow Measurement and Instrumentation 29 (2013) 61–64

Contents lists available at SciVerse ScienceDirect

Flow Measurement and Instrumentation

journal homepage: www.elsevier.com/locate/flowmeasinst

Direct solution for discharge in generalized trapezoidal free overfall

Ali R. Vatankhah

Department of Irrigation and Reclamation Engineering, University College of Agriculture and Natural Resources, University of Tehran, P.O. Box 4111, Karaj 31587-77871, Iran

ARTICLE INFO

Article history:
Received 14 June 2012
Received in revised form
1 August 2012
Accepted 19 September 2012
Available online 23 October 2012

Keywords:
Free overfall
Flow measurement
Generalized trapezoidal section
Sharp-crested weir
Direct solution
Experimental data

ABSTRACT

In open channels, free overfall can be used as a discharge measuring structure by a single measurement of depth at the end of the channel. If the slope of channel is negative, zero or mild, the flow at upstream of end section will be critical and end depth value depends only on the shape of the approach channel and its critical depth. This research presents a theoretical end depth–discharge (EDD) relationship for free overfall (end section) in a horizontal open channel with generalized trapezoidal section. The generalized trapezoidal shape reduces to the commonly used trapezoidal section as well as to the Δ-shaped section. Two direct discharge equations in terms of end depth for subcritical flows are proposed by simulating free overfall as a weir without crest. Experimental data are then used to verify the proposed EDD relationships. The calculated discharges, using the proposed EDD relationships, show excellent agreement with the experimental data.

1. Introduction

An overfall or vertical drop is a common phenomenon in both artificial and natural channels. Flow at an abrupt end of a long channel is known as overfall. If it is not submerged by the tail water, it is referred to as a free overfall [1]. Free overfall is used as a flow-measuring structure for different shapes of the channels [2]. The end depth–discharge (EDD) relationship for channels with different shapes has been extensively studied by various researchers. The main focus of this study is on direct discharge equations in terms of end depth for subcritical flows in trapezoidal and Δ-shaped sections.

Diskin [3] derived an equation of end depth for a trapezoidal free overfall using the momentum approach. His results were not sufficiently accurate to be used for the flow discharge measurements. Rajaratnam and Muralidhar [4], and Neogy [5] studied trapezoidal free overfall in mildly sloping channels based on the momentum approach by assuming a zero pressure distribution at the brink section. Ali and Sykes [6] also applied the free-vortex approach to calculate the end depth in horizontal trapezoidal channels. They assumed that the value of the end-depth ratio (EDR) in a trapezoidal channel varies from 0.673 to 0.798, which are the values of this ratio for rectangular and triangular channels, respectively. Subramanya and Keshava Murthy [7] used Boussinesq approximation method to determine the EDR in horizontal trapezoidal channels. Keller and Fong [8] derived a sixth-degree equation linking the end depth to the critical depth, which requires an iterative numerical solution. They assumed that the trapezoidal section is a combination of a rectangular section and a triangular section. Terzidis and Anastasiadou-Partheniou [9,10] suggested an empirical equation of the EDR in horizontal trapezoidal channels. Gupta et al. [11] obtained empirical equations for the end-depth ratio (EDR$=$0.745) and the discharge.

Anastasiadou-Partheniou and Hatzigiannakis [12] investigated the free overfall in a trapezoidal channel using the sharp-crested weir (with zero crest height). They took into account the streamline inclination and curvature at the end section and derived a generalized end-depth–discharge relationship for subcritical and supercritical flows. Pagliara [13] also gave an empirical equation of the EDR in horizontal trapezoidal channels. Dey and Ravi Kumar [14] studied on the free overfall in horizontal Δ-shaped (equilateral triangle) channels using the momentum and weir approaches. They proposed implicit discharge relationships.

The above literature review reveals that the *direct solutions* based on the weir approach have not been obtained for prediction of discharge for the free overfall occurring in the horizontal trapezoidal and Δ-shaped open channels. Current research deals with direct solutions for discharge from known value of end depth in subcritical flow regime in a horizontal channel with generalized trapezoidal section. The generalized trapezoidal shape reduces to the trapezoidal section as well as to Δ-shaped section. The success of the proposed direct solutions in this study is demonstrated by comparing the results with experimental data.

2. End-depth–discharge relationship

The flow of a free overfall in a channel can be assumed to be similar to the flow over a weir of zero height [15–21]. Thus,

E-mail address: arvatan@ut.ac.ir

0955-5986/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.flowmeasinst.2012.09.006