Water surface profile along a side weir in a parabolic channel

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A B S T R A C T

A side weir is an overflow structure set into the side of a channel. This structure is used for water level control in channels, diverting excess water from a main channel into a side channel and as storm overflows from urban sewage systems. Computation of water surface profile over the side weirs is essential to determine the flow rate of the side weir. Discharge estimation of the side weir is still an important research subject. Most previous research works for the side weir were carried out in main channels with rectangular, triangular, trapezoidal and circular cross sections. Analytical solutions for water surface profile along a rectangular side weir are available only for the special cases of rectangular and trapezoidal main channels on the basis of a constant specific energy. No analytical solution is available for a rectangular side weir located in a parabolic channel. This research presents an elegant analytical solution for establishing the water surface profile along a side weir located in a parabolic channel which involves the use of incomplete elliptic integrals. The solution, which yields a direct computation, should be a useful computational tool for evaluation and design of rectangular side weirs in parabolic channels.

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1. Introduction

Side weirs with different shapes are located in the wall of open channels with different cross sections. Lateral outflow takes place when the water surface in the main channel rises above the weir crest. Flow over a side weir is a typical case of spatially varied flow (SVF) with decreasing flow rate. These hydraulic structures are widely used in irrigation, drainage, sewer networks and flood protection. Side weirs have been researched extensively by many researchers. Most of the previous theoretical analysis and experimental research are limited to the flow over side weirs in rectangular main channels [among them: [1–12]], in circular main channels [13–16], in triangular main channels [17,18] and in trapezoidal main channels [19,20]. As noted almost all the researchers have studied the hydraulic characteristics of a rectangular side weir located in a rectangular main channel.

Due to the use of various shapes of the side weir and the different main channel cross sections, it is expected that much research studies have been conducted for different geometric shapes. Recently, the discharge coefficients for sharp-crested and broad-crested trapezoidal side weirs under subcritical flow conditions in a rectangular channel are investigated [21,22]. In these two researches by combination of triangular side weir and rectangular side weir, the discharge per unit length of a trapezoidal side weir is calculated independent of side slope of the side weir. The discharge per unit length of a trapezoidal side weir depends on side slope of the side weir and considering the side slope effects only in discharge coefficient, Csw, is not representative. Indeed one cannot add the discharge per unit length of a triangular side weir and a rectangular side weir together to get the discharge per unit length of a trapezoidal side weir. In this way, the side slope of the trapezoidal side weir disappears from the resulting equation for discharge per unit length of the trapezoidal side weir, which is incorrect.

To estimate the outflow over a side weir, the water surface profile over the side weir needs to be determined. The main focus of this study is on analytical integration of the governing dynamic equation for spatially varied flow with decreasing discharge over a rectangular side weir. It should be noted that a complete analytical solution of the governing dynamic equation for the side weir in an open channel is not possible due to the many variables involved. However, a direct integration of the governing dynamic equation is possible by considering some basic assumptions.

De Marchi [2] was the first that obtained an analytical solution for establishing the water surface profile along a rectangular side weir in a rectangular main channel based on the constant specific energy, constant weir coefficient and constant velocity distribution coefficient along the side weir. Venutelli [10] also presented a semi-analytical iterative solution for solving the governing dynamic equation for a rectangular side weir in a rectangular main channel that enables to incorporate the variations along the side weir. Vatankhah [16] presented a new semi-analytical...