Technical Note

New Solution Method for Water Surface Profile along a Side Weir in a Circular Channel

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Abstract: Side weirs are commonly installed along the sides of open channels. Computation of water surface depth over side weirs is essential to determine their discharge. Analytical solutions for water surface profiles along a rectangular side weir are available only for triangular, rectangular and trapezoidal primary channels on the basis of constant specific energy. Given that circular channels are an important application in sewer systems, this research presents an elegant semianalytical solution (which involves incomplete elliptic integrals) for establishing the water surface profile along a rectangular side weir located in a circular. The solution is a useful computational tool for the evaluation and design of rectangular side weirs in open circular channels. **DOI: 10.1061/(ASCE)IR.1943-4774.0000483.** *© 2012 American Society of Civil Engineers.*

CE Database subject headings: Weirs; Channels; Sewers; Water surface profiles.

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Introduction

Side weirs are used for diverting excess water from a primary channel into a side channel, controlling water level in channels, and are also used as storm overflows from urban sewage systems. Side weirs of different shapes are located in the wall of open channels with different cross sections. Lateral outflow occurs when the water surface elevation in the channel rises above the weir crest elevation. Most previous theoretical analysis and experimental research is related to flow over rectangular side weirs in rectangular (Coleman and Smith 1923; De Marchi 1934; Frazer 1954; Collinge 1957; Ranga Raju et al. 1979; Delo and Saul 1989; Uyumaz and Smith 1991; Yüksel 2004; Venutelli 2008; Vatankhah and Bijankhan 2009; Emiroglu et al. 2011), triangular (Uyumaz 1992), trapezoidal (Chong 1991; Vatankhah 2011) and circular (Allen 1957; Uyumaz and Muslu 1985; Uyumaz and Muslu 1987; Hager 1987) primary channels.

The aim of this study is to present a semianalytical approach to integrate the governing equation for spatially-varied flow with decreasing discharge over a rectangular side weir located in a circular channel. De Marchi (1934) was the first to obtain an analytical solution for establishing the water surface profile over a rectangular side weir in a rectangular primary channel based on constant specific energy, weir coefficient and velocity distribution coefficient along the side weir. Venutelli (2008) presented a semianalytical iterative solution for solving the governing equation for this scenario, enabling incorporation of variations along the side weir. Vatankhah (2011) extended De Marchi's solution for a trapezoidal primary channel and obtained an analytical solution for the water surface profile over a rectangular side weir. This solution is also valid for triangular and rectangular primary channels.

The previously presented literature review demonstrates that there are analytical and semianalytical solutions only for triangular, rectangular and trapezoidal channels. In practice, circular sections possess important applications in sewer systems. In the present study, the governing equation of a rectangular side weir in a circular channel was integrated using a novel semianalytical approach.

The following sections present geometric characteristics of the circular channel and water surface equation for a side weir. This paper then presents an integration approach for the dynamic equation, followed by an analysis for the slope of the water surface profile along the side weir and conclusions.

Geometric Properties of a Circular Cross Section

The geometry of a circular cross section is shown in Fig. 1. The top width and section area, which correspond to the flow depth y, are required for water surface computations. The top width of the water surface, T, can be expressed as

$$T = D\sin(\theta/2) \tag{1}$$

The flow area of the channel, A, for flow depth y, can be computed as

$$A = \frac{D^2}{8}[\theta - \sin(\theta)] \tag{2}$$

where D = channel diameter and θ = water surface angle in radians: $= 2\cos^{-1}(1 - 2y/D)$.

Water Surface Equation for a Rectangular Side Weir

Referring to Fig. 2, at any section x, for a small bottom slope and hydrostatic pressure distribution, the well-known specific energy relationship for open channels, E, can be written as (Chow 1959)

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