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# Briefing: Water surface profile over side weir in a trapezoidal channel

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**Side weirs or lateral weirs are widely used for water level control in water treatment plants and irrigation and drainage systems. The side weir is a fixed structure installed at one side of a channel to divert flow laterally. Computation of the water surface profile along the side weir is essential in determination of the discharge over the side weir. An analytical solution of the dynamic equation for spatially varied flow with decreasing discharge, in prismatic channels with a side weir, is available in the technical literature only for the special case of a rectangular channel based on the constant specific energy assumption. However, in irrigation networks, the most common irrigation channels are of trapezoidal cross-section. This paper presents an elegant analytical solution for establishing the water surface profile along a side weir in a trapezoidal channel. Since triangular and rectangular cross-sections are special cases of the trapezoidal cross-section, the proposed analytical solution is also applicable to these cross-sections. The solution, which yields a direct computation of the flow profile in subcritical and supercritical flow regimes, should be a useful engineering tool for the evaluation and design of side weirs in open channels.**

## Notation

| | |
|---|---|
| $A$ | cross-sectional area |
| $C_w$ | discharge coefficient |
| $E$ | specific energy |
| $\boldsymbol{g}$ | gravitational acceleration |
| $L$ | side weir length |
| $P$ | side weir height |
| $q_s$ | discharge for unit width of the weir |
| $Q$ | discharge of main channel at distance $x$ |
| $Q_1$ | discharge at section 1 in the main channel |
| $Q_s$ | discharge over the side weir |
| $S_0$ | bed slope of the channel |
| $S_f$ | friction losses |
| $T$ | width of the channel at the water surface |
| $x$ | distance from upstream of the weir |
| $y$ | depth of flow |
| $z$ | side slope of the channel |
| $\alpha$ | velocity distribution coefficient |
| $\varepsilon$ | dimensionless bottom width ($= b/E$) |
| $\eta$ | dimensionless flow depth ($= y/E$) |
| $\kappa$ | dimensionless weir height ($= P/E$) |
| $\lambda$ | parameter that depends on discharge coefficient ($= 4\alpha^{1/2}C_w/3$) |
| $\chi$ | dimensionless distance ($= x/E$) |

## 1. Introduction

Side weirs are widely used in irrigation, drainage, sewer networks and flood protection. Flow over side weirs is a typical case of spatially varied flow with decreasing flow rate. The side weir has received considerable attention and has been the subject of many investigations. Most of the previous experimental studies and theoretical analyses are limited to the flow over side weirs in rectangular (e.g. Allen, 1957; Coleman and Smith, 1923; Collinge, 1957; De Marchi, 1934; Delo and Saul, 1989; Emiroglu *et al.*, 2011; Frazer, 1954; Ranga Raju *et al.*, 1979; Uyumaz and Smith, 1991; Vatankhah and Bijankhan, 2009; Venutelli, 2008; Yüksel, 2004) and circular channels (Hager, 1987; Uyumaz and Muslu, 1985, 1987).

The main focus of the current study is analytical integration of the governing equation for spatially varied flow with decreasing discharge over a side weir. It is important to note that a complete analytical solution of the governing equation for a side weir in an open channel is not possible due to the many variables involved. However, an analytical integration of the governing equation is possible by considering some assumptions.

De Marchi (1934) first obtained an analytical solution for establishing the water surface profile along a side weir in a rectangular channel based on constant specific energy, a constant weir coefficient and a constant velocity distribution coefficient along the side weir. Venutelli (2008) also presented a semi-analytical iterative solution for solving the governing dynamic equation for a side weir in a rectangular channel that allowed the incorporation of variations along the side weir.

A review of the literature reveals that there are analytical and semi-analytical solutions only for rectangular channels. In prac-