INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY
ISSN: 2454-132X
Impact factor: 4.295
(Volume 3, Issue 6)
Available online at www.ijariit.com

Flow over a Rectangular Side Weir under Subcritical Conditions

Mohd Rafeeque
Azad Institute of Engineering and Technology Lucknow, Uttar Pradesh
Mohdrafeeque72@gmail.com

Mohd Rehan
Azad Institute of Engineering and Technology Lucknow, Uttar Pradesh
saeedrehan936@gmail.com

Mohd Noorain Afridi
Azad Institute of Engineering and Technology Lucknow, Uttar Pradesh
mohammadnurainafridi@gmail.com

Mohd Noman
Azad Institute of Engineering and Technology Lucknow, Uttar Pradesh
nomancivil22@gmail.com

Maaz Allah Khan
Azad Institute of Engineering and Technology Lucknow, Uttar Pradesh
maazallah@rediffmail.com

***Abstract:** A side weir is set into the side of the main channel it is an overflow weir have been extensively used in hydraulic and environmental engineering application. They typically are used for water level control in canal system, diverting excess water into relief channels during floods. An example of a situation of spatially varied flow is the flow over a side weir.*

***Keywords:** Side Weir, Types of Weir, Subcritical Flow, Rectangular Side Weir*.

INTRODUCTION

Side weir is a hydraulic structure widely used in drainage and irrigation system and wastewater treatment plants. It is built on the side of the main channel and free spatially varied flow with decreasing discharge is the dominant regime over this hydraulic structure. The main mechanism of side weir is deviation of water from straight direction and sending it to side weir.

WHAT IS WEIR

A weir is a concrete or masonry structure which is constructed across the horizontal width of the river that changes or alters the flow characteristics of the water and usually results in a change in the vertical height of the river level. Weirs are constructed as an obstruction to flow of water which is commonly used to prevent flooding, measure discharge and make rivers navigable. The term Dam &Weir are synonymous in some places, but normally there is a clear difference made between the structures. A dam is usually specifically designed to collect and confine (water) behind a wall, while a weir is designed to alter the river flow characteristics.

TYPES OF WEIR

Weir is classified according to:

1. TYPES OF WEIRS BASED ON SHAPE OF

THE OPENING
- Rectangular weir
- Triangular weir
- Trapezoidal weir

2. TYPES OF WEIRS BASED ON SHAPE OF

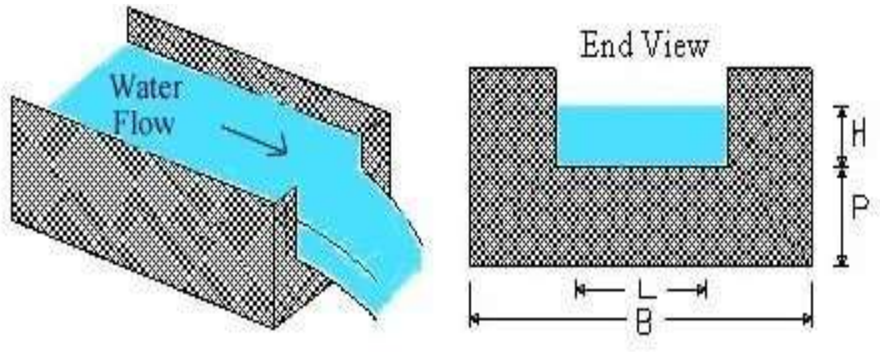
THE CREST
- Sharp-crested weir
- Broad-crested weir
- Narrow-crested weir
- Ogee-shaped weir

3. TYPES OF WEIR BASED ON END

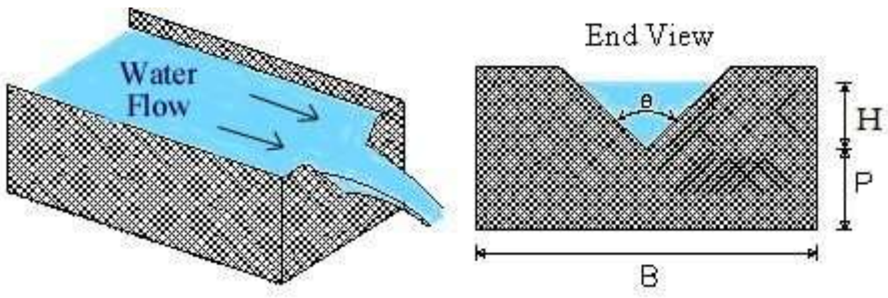
CONTRACTION
- Weir with end contraction (Contracted weir)
- Weir without end contraction (Suppressed weir)

Classification Based on Shape of Opening

Rectangular Weir
It is a standard shape of the weir. The top edge of weir may be sharply crested or narrow crested. It is generally suitable for larger flowing channels.



Triangular Weir
It is also called V-notch weir because the shape of the weir is actually reverse triangle like V. This type of weirs is well suitable for measuring discharge over small flows with greater accuracy.



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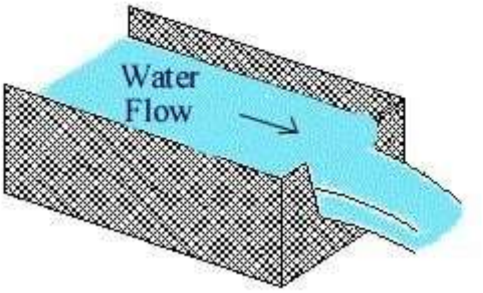
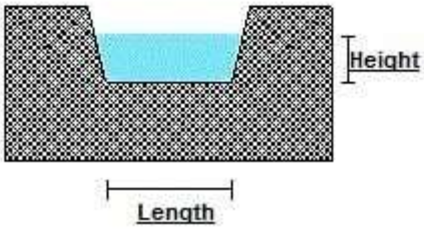
Trapezoidal Weir

This is trapezoidal in shape and is the modification of rectangular weir with slightly higher capacity for same crest strength. The sides are inclined outwards with a slope 1:4 (horizontal: vertical)

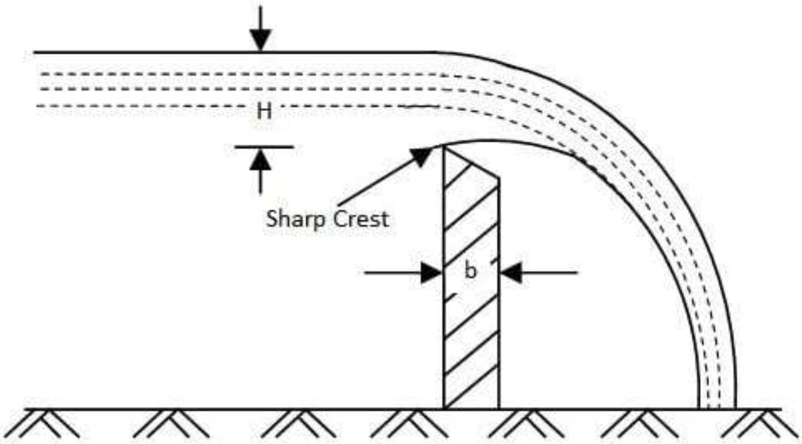




Classification according to the shape of the crest:

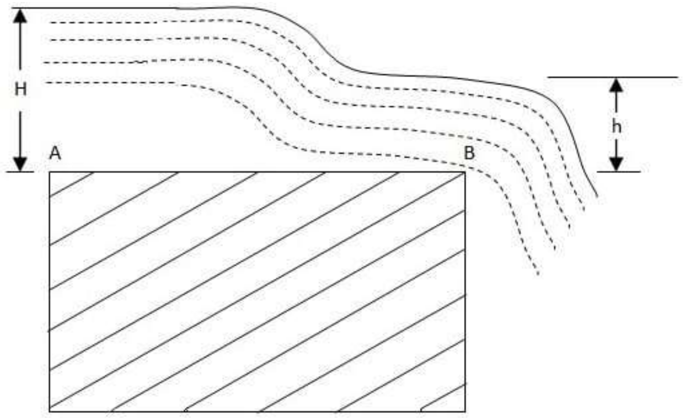
Sharp-crested weir:

The water will springs clear of the crest due to the crest of the weir is very sharp, the weir plate is bevelled at the crest edges to obtain necessary thickness. And weir plate should be made of smooth metal which is free from rust and nicks. Flow over the sharp-crested weir is similar as a rectangular weir.



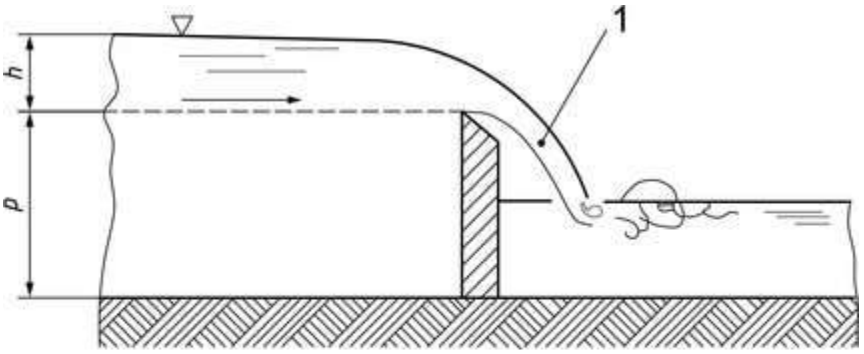
Broad-crested Weir

Head loss will be small in case of the broad crested weir. These are constructed only in rectangular shape and are suitable for the larger flows.



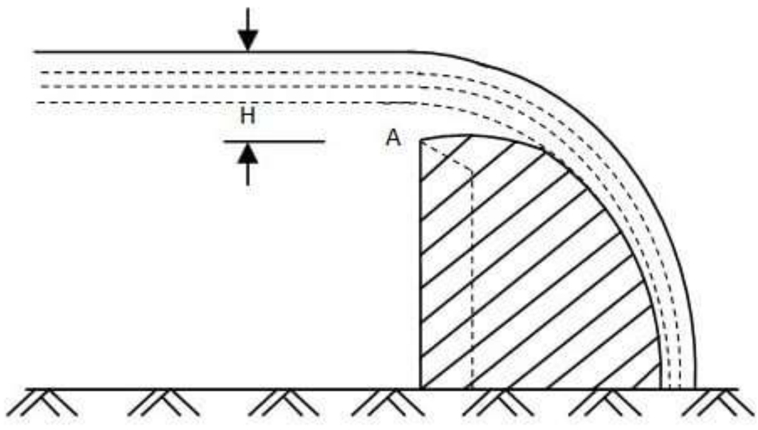
Narrow-crested Weir

The discharge over the narrow crested weir is similar to discharge over the rectangular weir, it is similar to rectangular weir with a narrow shaped crest at the top.



Ogee-shaped Weir

Flow over ogee weir is also similar to flow over the rectangular weir. The crest of the ogee weir is slightly risen and falls into parabolic form, generally, ogee shaped weirs are provided for the spillway of a storage dam.



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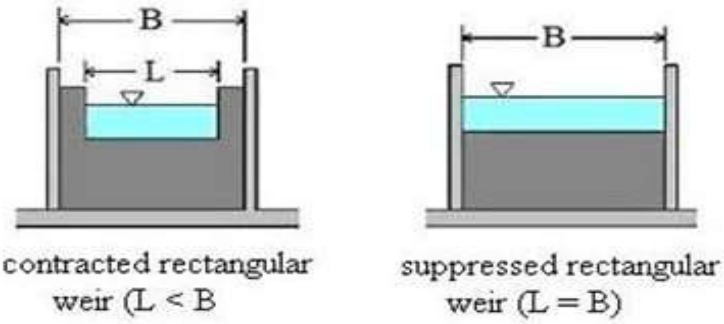
Classification based on end contractions:

Contracted Weir

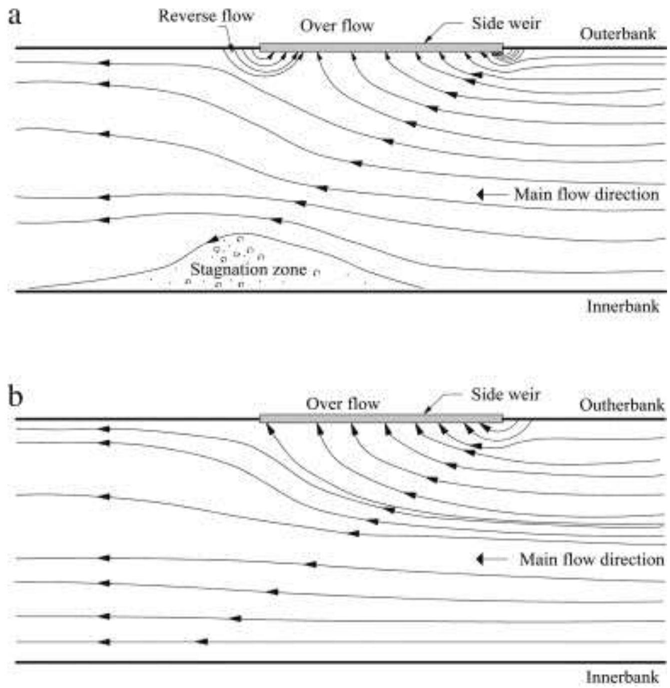
In contracted weir head loss will occur, the crest is cut in the form of the notch and then it is similar to the rectangular weir.

Suppressed Weir

The crest is running all the way across the channel so the head loss will be negligible.



FLOW OVER A RECTANGULAR SIDE WEIR



Rectangular weir is built on the side of the main channel which deviates water from straight direction and sends it to the side weir, due to this the ultimate(downstream) discharge is decreasing in the main channel. It means, if a flow with discharge (Q_1) crosses a side weir, then its discharge (Q_2) will be reduced because of spilling over side weir (Q_W). For subcritical condition the depth of water increases, while passing side weir, it is represented in Fig.1.

Equation (1) shows the specific energy in a rectangular channel. It is key to solve some hydraulic problems such as determination of side weir's discharge.

$$E = y + \frac{Q^2}{(2b^2 g y^2)} \qquad (1)$$

Where Q is the discharge of fluid, E is specific energy, g is the gravitational constant, y is the depth of water and b is the width of the main channel.

Equation (2) shows the common formula used for weirs and is derived based on some assumption. For obtain the discharge of side weir, it is important to calculate discharge coefficient (Cm). This coefficient mainly depends on Froude number, the ratio of the water depth to the height of the weir, ratio of the length of the side weir to the width of the main channel and angle of deviation. The equation (3) to (5) define the deflection angle of water flow. The effect of deflection angle is implied by the dimensionless ratio length of side weir to the width of the main channel (L/b), that's why parameter (Ψ) is not considered in discharge coefficient equation (4).

$$\frac{dQ}{dx} = \frac{2}{3} C_m \sqrt{2g}(y - w)^{1.5} \qquad (2)$$

$$\Psi = \sqrt{1 - (\frac{U}{V_m})^2} \qquad (3)$$

Here, the axis along this weir is denoted by x, U and V_w are the abbreviations of velocity of the main channel and spilling flow, (Ψ) is the angle of deviation($\cos \Psi = \frac{U}{V_m}$ in Fig.1-b), the height of side weir is w and C_m is the discharge coefficient of weir.

Equation (4) is obtained by the combination of equation (1) and (2), It is evident that the other form of equation (1) is equation (5).

$$\frac{dE}{dx} + \left(\frac{Q^2}{gb^2y^3} - 1\right)\frac{dy}{dx} = \frac{2Q}{3gb^2y^2} C_m\sqrt{2g} \qquad (4)$$

$$Q = by\sqrt{2g(y-w)} \qquad (5)$$

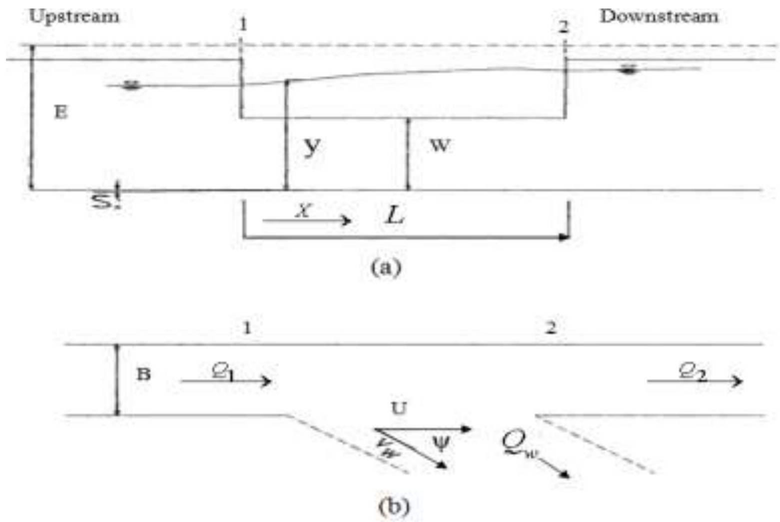


Figure 1. Scheme of a Side Weir (a) Lateral (b) Plan View

Combination of equation (4) and (5) produces equation (6)

$$(2E - 3y)\frac{dy}{dx} + y\frac{dE}{dx} = \frac{4}{3b} C_m\sqrt{(E-y)}(y-w)^{1.5} \qquad (6)$$

DeMarchi (3), solved the flow over side weir analytically by made some assumptions. Assuming constant specific energy and friction is ignoring along lateral weir are the main assumption made by him. According to this assumption, by solving analytically [6; 18] he presented the equation (1). Along the side weir, he supposed constant specific energy(dE/dx=0), so DeMarchi eliminated the second term of the left side of the equation (6) and that led to his famous equation shown as equation(7), In which upstream and downstream condition is indicated by subscripts 1,2 respectively.

$$\frac{2C_mL}{3b} = \frac{2E-3W}{E-W}\left\{\left[\frac{E-y_2}{y_2-W}\right]^{0.5} - \left[\frac{E-y_1}{y_1-W}\right]^{0.5}\right\} - 3\left\{\sin^{-1}\left[\frac{E-y_2}{y_2-W}\right]^{0.5} - \sin^{-1}\left[\frac{E-y_2}{y_2-W}\right]^{0.5}\right\} \qquad (7)$$

Where L is the length of side weir.

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