DEPARTMENT OF CIVIL ENGINEERING

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

CE 362 Open channel flow sessional

Experiment No. 4

FLOW THROUGH A PARSHALL FLUME

4.1 General

The problem of Venturi flume is that there is relatively small head difference between upstream section and critical section, especially in low Froude number. This problem can be alleviated by designing a flume which has a constructed throat section in which critical flow occurs followed by a short length of flume in which supercritical flow occurs. A flume of this type was designed by R.L. Parshall and widely known as the Parshall flume. Practically this type of flume is used in small irrigation canals for flow measurement purpose. It is better than all other devices discussed before as it is more accurate, can withstand a relatively high degree of submergence over a wide range of backwater condition downstream from the structure, and it acts as a self-cleaning device due to the fact that high velocity washed out the debris and sediments present in the flow. However, when a heavy burden of erosion debris is present in the stream, the Parshall flume becomes invalid like weir, because deposition of debris will produce undesirable result. Another problem arises with this flume is that the fabrication is tough and also fabrication should be done as per requirement. This experiment deals with the measurement of discharge using Parshall flume.

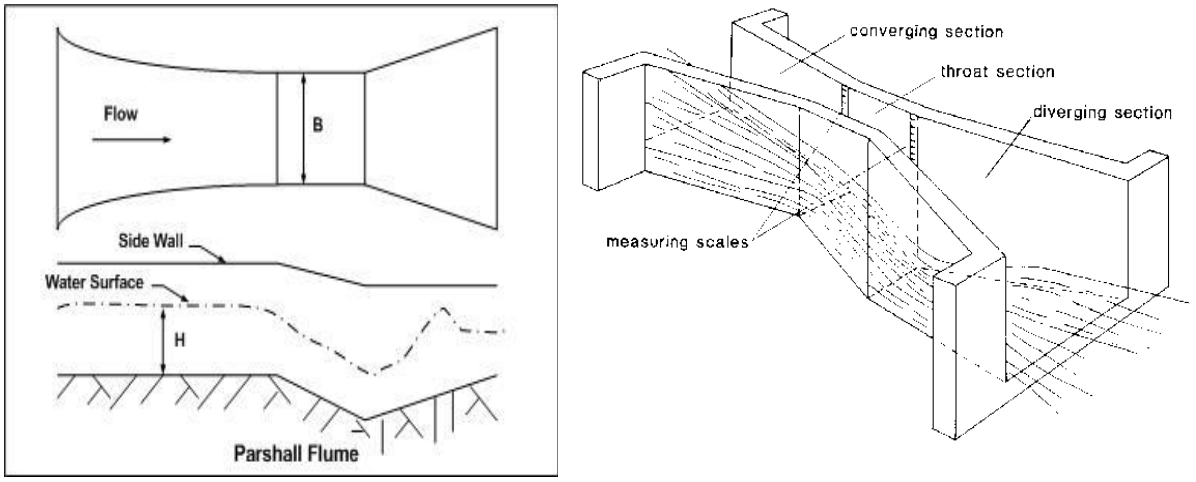


Fig: Parshall flume

4.2 Practical Application:

1. Parshall flume particularly suitable for flow measurement in irrigation canals, certain natural channels, and sewers.

2. Use as a self-cleaning device due to the fact that high velocity washed out the debris and sediments present in the flow.

3 Parshall flumes are in extensive use in many western irrigation projects, they are no longer generally recommended.

	
Parshall flume measures the flow of a mountain stream into a reservoir.	Fiberglass Parshall flumes are the standard for measuring influent and effluent flows at wastewater treatment plants (WWTPs) in North America
	
Parshall flume at Henderson, Kentucky, USA	Parshall Flumes in Nashik, Maharashtra, India

4.3 Theory

Description of the flume

Parshall flume consists of a broad flat converging section, a narrow downward sloping section and an upward sloping diverging section. The reason of downward sloping throat section is to increase the head difference between upstream section and critical section. The upward slope is given in diverging section to procedure a high tail water depth which reduces the length of the supercritical flow region.

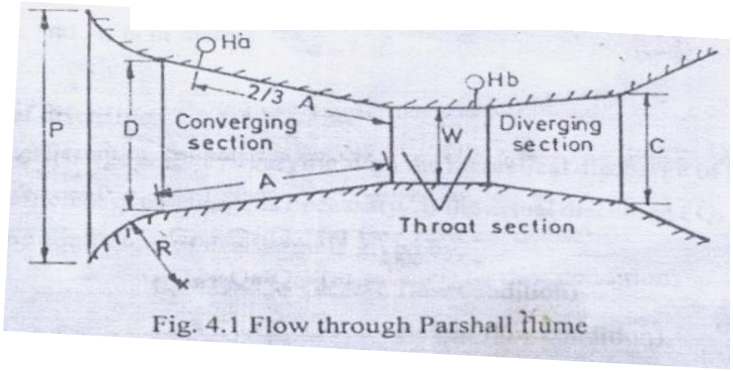


Fig. 4.1 Flow through Parshall flume

Theoretical discharge:

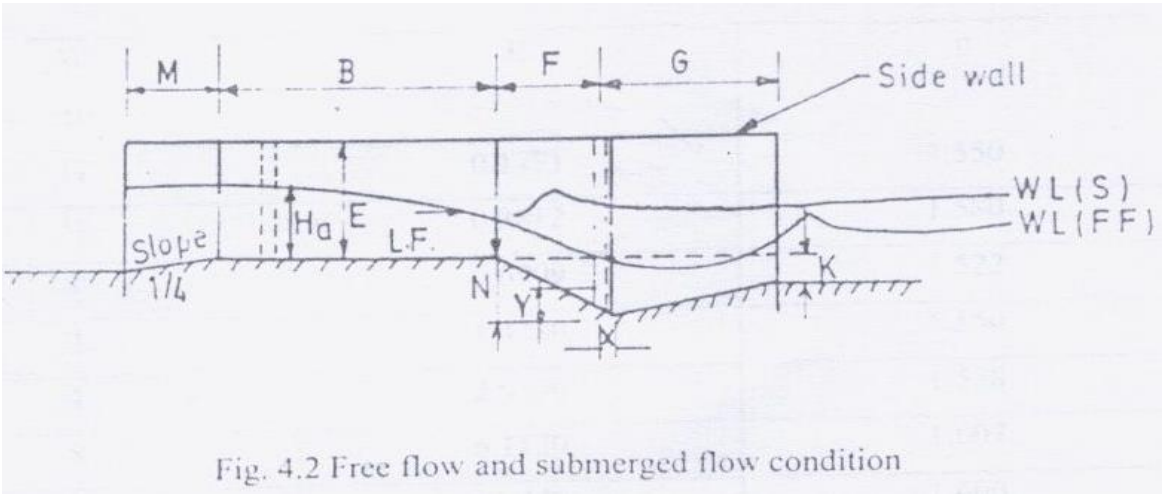


Fig. 4.2 Free flow and submerged flow condition

The Parshall flume is a calibrated device i.e. a definite depth discharge relationship for the flume exists there. So, analytical determination of theoretical discharge is not required for the flume. The discharge through a Parshall flume is given by

$Q_t = KH_a^n$.....**(4.1)**

Where, K = a constant which depends on the system of units used

n = exponent

H_a = upstream depth measured at the location shown fig 4.1

The values of K and n are depend on the throat width and given in table 4.1. According to this table for free flow condition, the depth discharge relationship of a Parshall flume of 6" throat width which is normally used in the laboratory, as calibrated empirically, is given by,

$Q_{tf} = 0.3812\ H_a^{1.58}$ ..... **(4.2)**

Where Q_{tf} is in m^3/s and H_a is in meters.

Coefficient of discharge:

The actual discharge is always varying with the theoretical discharge of the flume. So an introduction of coefficient of discharge is necessary. If the actual discharge Q_a is measured by the water, the coefficient of discharge is given by,

$C_{df} = \frac{Q_a}{Q_{tf}}$ (at free flow condition) ..... **(4.3)**

$C_{ds} = \frac{Q_a}{Q_{ts}}$ (at submerged flow condition) .....**(4.4)**

Table 4.1

Values of K, n for different Throat width (b),

b(ft)	K	n
1/4	0.1771	1.550
1/2	0.3812	1.580
1	0.6909	1.522
2	1.4280	1.550
4	2.9530	1.578
8	6.1120	1.607
20	14.450	1.600
50	35.410	1.600

Percentage submergence:

The percentage of submergence for the Parshall flume is given by $\frac{H_b}{H_a} \times 100$, Where H_b is the downstream depth from the invert datum. When the percentage of submergence exceeds 0.6 the flume discharge is reduced. The discharge of Parshall flume then equals

$Q_{ts} = Q_{tf} - Q_E$ .....**(4.5)**

Where,

Q_{ts} = Corrected discharge due to submergence

Q_{tf} = Theoretical free flow discharge

Q_E = Correction of discharge as found from the attached figure.

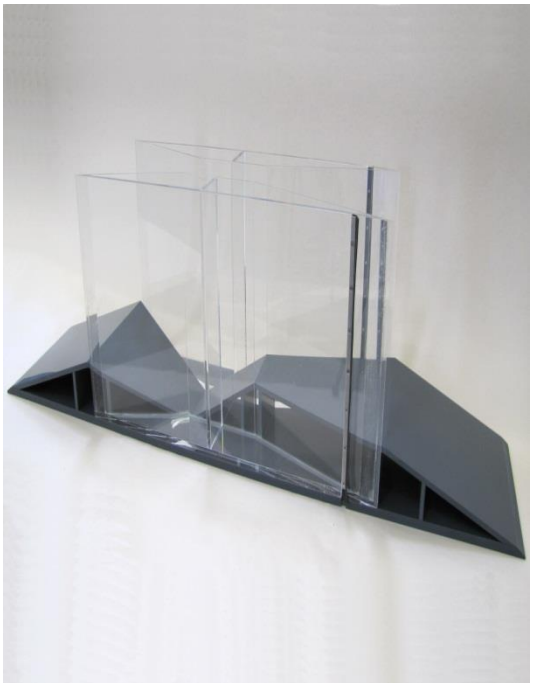
The correction of discharge for a 6 inch Parshall flume is given in Fig 4.3

4.4Objectives

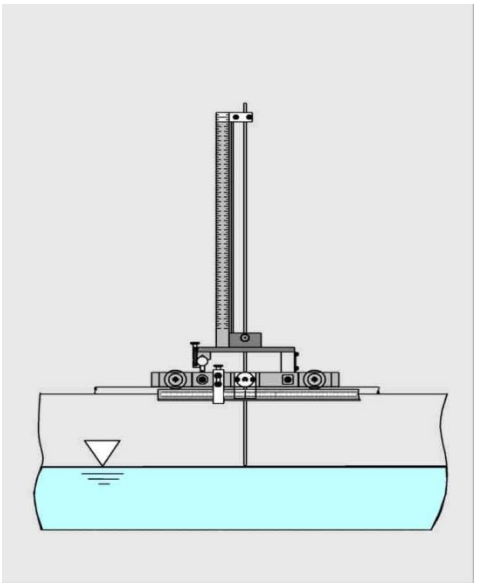
1 To determine the theoretical discharge at free flow condition.
2 To determine the theoretical discharge at submerged flow condition.
3 To determine the value of coefficient of discharge C_d for both conditions.
4 To verify the value of K and n.

4.5 Apparatus

Parshall Flume, Instrument carriage, Flow channel



Parshall Flume



instrument carriage



Flow channel

4.6 Procedure

Determination of theoretical discharge at free flow condition:

i. Measure the head H_a
ii. Compute Q_{tf} using Eq. 4.2

Determination of theoretical discharge at submerged flow condition:

i. Measure the heads Ha and H_b
ii. Compute Q_{tf} using Eq. 4.2
iii. find % of submergence $100*H_b/H_a$
iv. If % submergence exceed 60% then find correction Q_E using Fig 4.3
v. Find Q_{ts} using Eq 4.5

Determination of coefficient of discharge:

Measure actual discharge from water meter and calculate C_{df} and C_{ds} using Eq 4.3 and 4.4

Verification of the value of K and n:

i. Plot different Q_a and H_a in log log paper
ii. Slope of the line gives the value of n
iii. Using this n for any set of value of Q_a and H_a find K using Eq 4.1

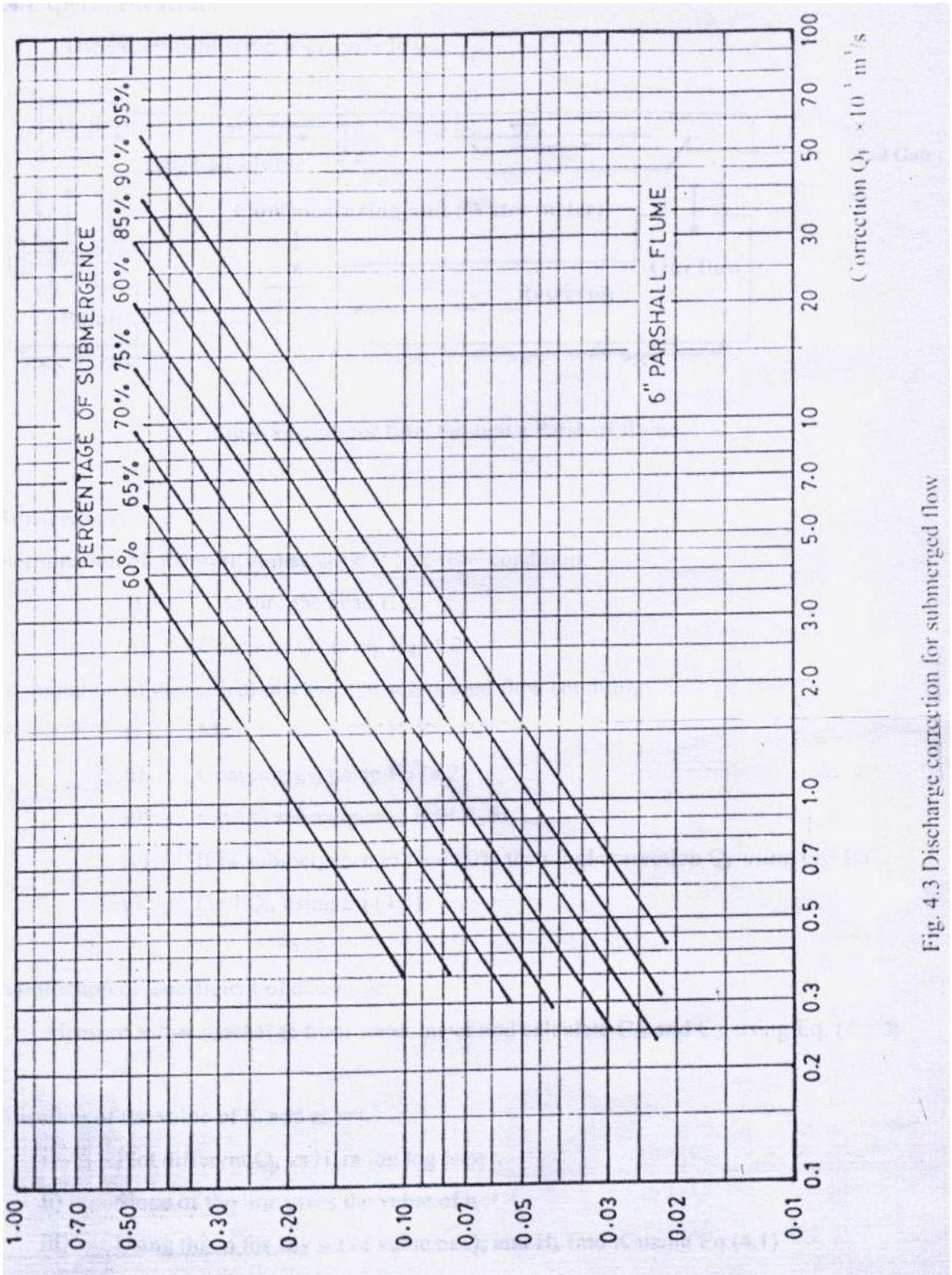
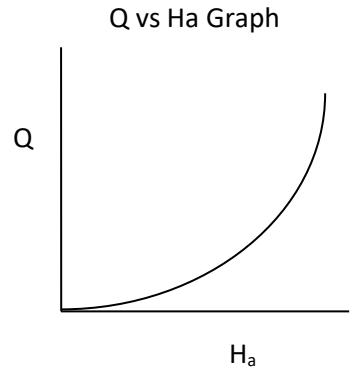
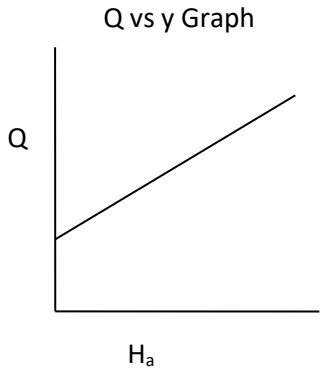


Fig. 4.3 Discharge correction for submerged flow

4.7 Typical shape of the graph

Q vs. Ha graph: As generally, $Q = K H_a^n$ so, in log log paper it will be a straight line as log $Q = n \log H_a + \log K$ which is a equation of straight line ($y = mx + c$)





4.8 **DATA SHEET**

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Throat width, b = Channel Width, B =

Group No		**Free flow condition**			**Submerged flow condition**						
	Q_a (m^3/s)	H_a (m)	Q_{tf} (m^3/s)	C_{df}	H_a (m)	H_b (m)	%Submergence $= \frac{H_b}{H_a} \times 100$	Q_{tf} (m^3/s)	Q_E (m^3/s)	Q_{ts} (m^3/s)	C_{ts}
1											
2											
3											
4											
5											

Level / Term : **Dept. :**
Reg No. : **Section:**
Group No. : **Date :**

Signature of the Teacher

4.9 Calculation

Verification of K and n:

Actual discharge, Qa (m^3 / s)	Ha (m)

Calculation from graph:

4.10 Assignment

1. What are the advantage, disadvantages and uses of Parshall flume?
2. Why a downward narrow section and upward diverging section is provided in Parshall flume?

4.11 Discussion