Experimental setup and procedure

3.1 INTRODUCTION

Experimental setup and procedure for conducting the experiments for studying discharge characteristics of the labyrinth weirs using different crest shapes under free flow condition have been presented herein. Experiments were also performed to study the identification of parameters that affect the discharging ability of the labyrinth weirs. Jet interaction and its effect on labyrinth weir behavior at higher $H/P$ ratios and effect of weir height on the flow performance of various planform weirs have also been studied experimentally. The range of collected data is listed at the end of this chapter.

3.2 EXPERIMENTAL SET-UP

The experiments were conducted in a rectangular tilting flume of length 5.360 m; width ($B$) 0.245 m and depth 0.450 m in the hydraulics laboratory of Graphic Era University, Dehradun, India. For visual observation of flow pattern along the flume section both side of flume are provided with transparent Perspex sheet. The flume has the screw mechanical jack to give a tilt to the channel. Figure 3.1 shows the definition sketch of a sharp crested normal weir and Figure 3.2 shows the layout of the experimental set-up. Photographs showing different components of the set up are given in Figs. 3.3 and 3.4. Water was supplied to the flume using close circuit arrangement. The discharge in the flume was measured by means of an orifice meter (Fig. 3.5) provided in the inlet pipe and connected to the pressure gauges (Fig. 3.6). Water was guided to a sump provided at the end of the flume in the downstream of the weir to ensure free flow condition. Regulating gate (Fig. 3.7) and wave suppressors (Fig. 3.8) were provided at the upstream of the flume to control the discharge and to dissipate the surface disturbances; respectively. Sharp-crested labyrinth weirs were fabricated of mild steel plates and were located at 5.150 m downstream from the head of the flume. Head over the crest was measured using the point gauge of accuracy ± 0.1 mm. The flume is provided with pipe railing on full length for the movement of pointer gauge trolley. For every run, the head of water over the crest was measured at approximately 1.0 m upstream of the weir to avoid the curvature effect.
The experiments were performed on one hundred and two different planform weir models having crest lengths ($L$) 0.2450 m, 0.2506 m, 0.2620 m, 0.2794 m, 0.3050 m, 0.3422 m, 0.3976 m and 0.4840 m and for each lengths three weir heights ($P$) i.e. 0.08 m, 0.10 m and 0.12 m.

Figure 3.1 Definition sketch of sharp crested normal weir

Figure 3.2 Layout of the experimental set-up
Figure 3.3 Photograph showing pressure gauge, regulating gate and sump tank.

Figure 3.4 Photograph showing orifice meter, regulating valve and supply pipe.
Figure 3.5 Photograph of orifice meter

Figure 3.6 Photograph of pressure gauge
Figures 3.7, 3.8, 3.9, 3.11, 3.13, 3.15 and 3.17 illustrate the definition sketch of a sharp crested triangular, W, rectangular, curved and trapezoidal planform weirs respectively. Figures 3.10 (a-c), 3.12 (a-c), 3.14 (a-c) and 3.18 (a-c) shows triangular, W, rectangular and trapezoidal planform weir models having crest lengths ($L$) 0.2506 m, 0.2620 m, 0.2794 m, 0.3050 m, 0.3422 m, 0.3976 m and 0.4840 m and for each lengths three weir heights ($P$) i.e. 0.08 m, 0.10 m and 0.12 m while figures 3.16 (a-c) shows curved planform weirs of crest lengths ($L$) 0.2506 m, 0.2620 m, 0.2794 m, 0.3050 m and 0.3422 m only due to constraints in the geometry of the
channel and for three weir heights \((P)\) i.e. 0.08 m, 0.10 m and 0.12 m. Figures 3.10 (d), 3.12 (d, 3.14 (d), 3.16 (d) and 3.18 (d) demonstrates the flow patterns over triangular, W, rectangular, curved and trapezoidal planform weirs respectively.

![Fig. 3.9 Definition sketch of sharp crested triangular planform weir](image)

![Fig. 3.10 (a) Triangular planform weirs of height \((P) = 0.08\) m,](image)
Fig. 3.10 (b) Triangular planform weirs of height \((P) = 0.10\) m

Fig. 3.10 (c) Triangular planform weirs of height \((P) = 0.12\) m
Fig. 3.10 (d) Flow over the triangular planform weir

Fig. 3.11 Definition sketch of sharp crested W-planform weir
Fig. 3.12 (a) W-planform weirs of height \((P) = 0.08\) m,

Fig. 3.12 (b) W-planform weirs of height \((P) = 0.10\) m,
Fig. 3.1 (c) W-planform weirs of height \( P = 0.12 \) m.

Fig. 3.12 (d) Flow over the W-planform weir
Figure 3.13 Definition sketch of sharp crested rectangular planform weir

Fig. 3.14 (a) Rectangular planform weirs of height \( P = 0.08 \) m,
Fig. 3.14 (b) Rectangular planform weirs of height $(P) = 0.10$ m,

Fig. 3.14 (c) Rectangular planform weirs of height $(P) = 0.12$ m;
Fig. 3.14  (d) Flow over the rectangular planform weir

Figure 3.15  Definition sketch of sharp crested curved planform weir
Fig. 3.16 (a) Curved planform weirs of height \( P = 0.08 \) m;

Fig. 3.16 (b) Curved planform weirs of height \( P = 0.10 \) m;
Fig. 3.16 (c) Curved planform weirs of height ($P$) = 0.12 m;

Fig. 3.16 (d) Flow over the curved planform weir
Figure 3.17 Definition sketch of sharp crested trapezoidal planform weir

Fig. 3.18 (a) Trapezoidal planform weirs of height \( P = 0.08 \) m;
Fig. 3.18 (b) Trapezoidal planform weirs of height \( P = 0.10 \) m;

Fig. 3.18 (c) Trapezoidal planform weirs of height \( P = 0.12 \) m;
3.3 EXPERIMENTAL PROCEDURE

Procedures for conducting the experiments for various purposes are mentioned below:

(a) **Discharge equation in the flume:** A calibrated orificemeter is provided with the two pressure gauges which is used to measure the actual discharge. Using the equation of an orificemeter, the discharge through the supply pipe can be written as:

\[
Q_o = C_d \frac{a_p a_j \sqrt{2g \Delta h}}{\sqrt{a_p^2 - a_j^2}}
\]  

(3.1)

Where, \(Q_o\) is observed discharge, \(C_d\) is coefficient of discharge, \(a_p = \frac{\pi}{4} D^2\) (area of supply pipe), \(a_j = \frac{\pi}{4} d^2\) (area of the jet), \(\Delta h\) is difference of piezometric head, \(D\) is diameter of supply pipe and \(d\) is diameter of the jet through the orificemeter. For given setup \(D/d = 0.6\), \(D = 6.50\) cm, \(C_d = 0.55\), \(\Delta h = [1000(p_1 - p_2)]\) cm, \(p_1\) and \(p_2\) are pressure gauge readings in kg/cm².

Using above values in equation 3.1 the equation for observed discharge can be written as:

\[
Q_o = 311.76 \sqrt{\Delta h} \text{ cm}^3/\text{s}
\]

(3.2)
(b) **Discharge characteristics of labyrinth weirs:** The experiments were conducted to study the discharge characteristics of the labyrinth weirs for free flow condition. Experiments were performed for free flow condition for horizontal flume on different weir models having crest lengths \( L \) 0.2450 m, 0.2506 m, 0.2620 m, 0.2794 m, 0.3050 m, 0.3422 m, 0.3976 m and 0.4840 m and for each lengths three weir heights \( P \) i.e. 0.08 m, 0.10 m and 0.12 m and for each set of these parameters, different discharges.

For each run i.e., for single values of \( L \) and \( P \) water was allowed to flow in the main channel. Head over the crests of weir were measured and discharges in the approach channel were determined from the discharge equation i.e. Eq.3.2. When uniform flow condition was established, the depth of flow in the main channel at about 1.0 m upstream of the weir was measured in the middle of the channel using pointer gauge (Fig. 3.19) to calculate the head over the crest \( H \). Experiments were performed for free flow conditions for different discharges in the main channel.

![Figure 3.19](image)  Photograph showing depth measurement using pointer gauge for free flow condition over the weir

(c) **Visualization of flow over the weir:** For tracing the path lines of flow over the crest of the weir, an inert dye was injected by the use of hypodermic needle at upstream of the weir. The images of the path line of dye were captured by the high resolution camera from the front...
of the weir and from the same reference point. The captured images were superimposed to each other to trace flow lines at various sections.

Range of collected data are given in Table 3.1 and details of data are given in Annexure-I.

### Table 3.1 Range of collected data in the present study

<table>
<thead>
<tr>
<th>S.no</th>
<th>Planform</th>
<th>( L/B )</th>
<th>( P )  (m)</th>
<th>( H )  (m)</th>
<th>( Q )  (m(^3)/s)</th>
<th>No. of Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Triangular</td>
<td>1.000 – 1.976</td>
<td>0.08 – 0.12</td>
<td>0.0191 – 0.1038</td>
<td>0.0022 -0.0129</td>
<td>299</td>
</tr>
<tr>
<td>2</td>
<td>W</td>
<td>1.000 – 1.976</td>
<td>0.08 – 0.12</td>
<td>0.0253 – 0.1038</td>
<td>0.0022 -0.0129</td>
<td>310</td>
</tr>
<tr>
<td>3</td>
<td>Rectangular</td>
<td>1.000 – 1.976</td>
<td>0.08 – 0.12</td>
<td>0.0291 – 0.1038</td>
<td>0.0022 -0.0129</td>
<td>288</td>
</tr>
<tr>
<td>4</td>
<td>Curved</td>
<td>1.000 – 1.397</td>
<td>0.08 – 0.12</td>
<td>0.0312 – 0.1038</td>
<td>0.0022 -0.0129</td>
<td>230</td>
</tr>
<tr>
<td>5</td>
<td>Trapezoidal</td>
<td>1.000 – 1.976</td>
<td>0.08 – 0.12</td>
<td>0.0227 – 0.1038</td>
<td>0.0022 -0.0129</td>
<td>307</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total no. of runs</td>
<td>1434</td>
</tr>
</tbody>
</table>

#### 3.4 SUMMARY

The experimental set up and procedure for collection of data related to discharge characteristics of labyrinth weirs under free flow condition have been presented. Path lines of the fluid particles were also traced out by injecting the dye in the main channel upstream of the weirs. The validity of findings of the present study is limited to range of data given in Table 3.1. The collected data have been analyzed in the subsequent chapters.