CHAPTER 6

LABORATORY SIMULATION OF DIKE BREACH FLOOD

6.1 INTRODUCTION:

The flood havoc created due to failure of river dike is of such magnitude that, obtaining real data of flood propagation for this situation appears to be almost an impossible task. But data of flood movement is essential for calibration and verification of the developed mathematical model. Therefore, fabrication of a laboratory set-up for simulating dike breach flood has been considered essential. Physical observation of the flow phenomenon also enables one to get insight into the actual problem, which in turn helps in the refinement of the mathematical model.

The river with embankment is a typical example of two stage compound channel. The flood channel facility (FCF), constructed at H.R. Wallingford in 1985-86, provides experimental facilities for investigating flow in such situation. Some experimental works on meandering channel, with over bank flow, were earlier carried out at Water Way Experimental Station, Vicksburg, Mississippi (1956). Significant contributions towards experimental investigation on over bank flow were made by Sellin (1964, 1995)\textsuperscript{66,82}, Zheleznyakov (1965)\textsuperscript{95}, Toebes and Sooky (1967)\textsuperscript{86},
Rajaratnam and Ahmadi (1983)\textsuperscript{64} and Elliot and Sellin (1990)\textsuperscript{23}. However, nothing has been reported in the literature, till now, regarding existence of experimental facility where movement of flood on downstream of river dike due to any opening in it can be studied. Therefore, an experimental set-up for investigation of the said problem has been developed in the hydraulic laboratory of Assam Engineering College with partial financial support from Assam Science Technology and Environment Council. This chapter basically deals with the development of experimental set-up for simulating flood movement on the downstream of the river dike due to its instantaneous failure.

Detail description about the experimental set-up has been presented at the beginning of this chapter.

The procedure for conducting the experiment has then been given.

The technique used for studying the effect of different bed resistance has been discussed in this chapter.

The experimental results have been presented towards the end.

A critical analysis on the experimental observations has then been attempted.

Finally some concluding comments, specially on the possibilities of improving the developed model, have been drawn.
6.2 EXPERIMENTAL SET-UP:

The experimental set-up consists of a 9.2 m long two stage tilting compound channel attached with a side platform of 2.5 m in length and of 2 m width (Fig 6.1). The lower stage of the channel is trapezoidal in shape, having a side slope of 1: 2 and the upper stage is rectangular. Bottom width of the main channel is 0.2 m and width of the over-bank portion is 0.15 m on both sides. The depth of the main channel is 0.15 m and that of the upper stage is 0.1 m. The compound channel represents a river with side embankments and the side platform resembles the dry valley, lying downstream of the river dike.

Although truly straight river channels are rare in nature, the compound channel in the laboratory set-up has been kept straight. This is justified by the fact that most of the embankments are generally constructed straight. However, straight embankments some times lead to skewness of the main channel. Even then straight channel has been considered satisfactory as the prime objective of this study is to investigate the propagation of flood in the flood plain, lying downstream of the embankment, and not in the main channel.

The side platform has been fabricated by using steel sheet. The platform, which is basically an undular one, has been converted to a level surface by using cement mortar over sand bed. A dumpy level with a levelling staff of least count 0.005 m
has been used for the purpose. The platform stands on some adjustable stands, placed on the four corners and midway on each side. The slope of the platform in both longitudinal and transverse directions can be adjusted to any desired value within a reasonable range.

A side gate has been provided between the side platform and the upper stage of the compound channel. Instantaneous breach of river dike or opening of flood gate is simulated by sudden opening of this side gate. Re-circulating arrangement of flow has been made in the experimental set-up so that the experiment can be conducted for any desired period of time, with limited quantity of water. The flow enters the channel through a stilling tank followed by a transition reach (Fig. 6.22). Water is supplied to the inlet from a sump by means of three centrifugal pump connected in parallel. Water passing either through the main channel or through the side gate ultimately falls in a conveyance channel which carries the water back to the storage reservoir, connected to the sump. The steady state discharge through the main channel is measured by the method of direct volume measurement with utmost care. The steady state discharge through the side gate, after complete submergence of the platform is also measured by direct volume measurement. Flow depth either in the main channel or over the side platform is measured by a pointer gauge, placed on a supporting rail, arranged for the purpose. The ratio of longitudinal and transverse velocity in the gate position is measured by using a Pitot tube.
FIG. 6.1: PLAN VIEW OF EXPERIMENTAL SET-UP

- STORAGE TANK
- COMPOUND CHANNEL
- SIDE PLATFORM
- GATE
- PUMP 1
- PUMP 2
- PUMP 3
- CHANNEL AT FLOOR LEVEL
- 2.5 m
- 9.2 m
6.3 EXPERIMENTAL PROCEDURE:

During the experiment flood water from the main channel is released through the side gate, which flows over the side platform and gets released through another opening, on the downstream of the platform. After being suddenly released through the side gate, the flood water moves over the platform with a tremendous speed. Therefore, direct measurement of flood movement is not possible. Thus recourse has been made to video recording, for obtaining data of flood movement. The following procedure has been adopted to perform the experiment systematically.

To facilitate measurement of flood propagation, square grid of 200mm x 200 mm is first drawn on the side platform by using non-washable paint. The thickness of the grid lines is made such that they become visible in the video recording even in submerged condition.

The channel and the platform is then adjusted by adjustable screw to obtain the required slopes.

Water is then supplied to the main channel, keeping the side gate closed, so that water cannot move to the side platform. The depth of flow in the gate position of the main channel is then measured by using the pointer gauge, placed over the rail. To obtain sufficient depth of water over the flood plain of the compound channel, the slope of the main channel is further adjusted by adjusting the adjustable supporting stand of the main
channel. All the supporting stands must be adjusted carefully so that uniform slope can be maintained throughout the channel reach.

After obtaining the required depth, steady state discharge through the channel is measured by direct volume measurement at the downstream end. For this purpose a detachable channel portion, kept at the downstream end of the main channel, is suddenly removed and water is collected in a tank of known dimension, already placed in the position for the purpose (Fig.6.23). The time required for filling up of the tank is recorded by a stopwatch. Thus main channel discharge is calculated as

\[ Q_{\text{main}} = \frac{V}{t} \]

Where \( V \) = Volume of the measuring tank
\( t \) = time required for filling up the tank.

Flood is then allowed to move from the main channel to the side platform by sudden opening of the side gate. This simulates instantaneous failure of river dike.

The ratio of flow velocity in the longitudinal and transverse direction in the gate position is measured after opening of the gate by using a Pitot tube.

Video recording of the flood movement, on the side platform, is continuously done from opening of the gate till complete submergence.
The steady state discharge through the outlet, at the downstream end of the platform, is then measured by the method of direct volume measurement.

The main channel discharge is then again measured to ensure no major fluctuation of supply discharge during the experiment.

A white paper containing identical grid pattern, in scale, as that of the platform, is then used to draw the position of wave tips at different times. A V.C.R., having step advancing facility, has been used for this purpose. The wave tip position at any instant of time is obtained by advancing the film step by step to reach the required time. The position of wave tips at different times are then drawn on the specified paper, from the T.V. screen, with reference to the grid lines mentioned above.

6.4 SPECIAL CONSIDERATION FOR BED RESISTANCE:

Unlike channel flow, the flow depth in this case is very less and as a result, the bed resistance influences the flood propagation to a great extent. Therefore to investigate the influence of bed resistance experiments have been conducted for different bed resistance by using P.C.C, jute fabric and stone chips as the bed material (Fig. 6.19, 6.20 and 6.21). Before conducting the experiments, reference square grid has been drawn on each roughness. Because of small flow depth, one can distinguish the dry and submerged portion, in the video recording, only from the
difference in colour between the dry and wet bed. For the beds with cement finishing i.e., in case of P.C.C and stone chips beds, the colour difference is prominent. But to obtain a distinct colour contrast between dry and wet zones in case of bed with jute fabric, chalk powder has uniformly been sprayed over the jute bed before releasing the water. In the submerged portion the colour of chalk powder becomes dark, as it absorbs water.

6.5 EXPERIMENTAL RESULTS:

The prime objective of this experimental work was to generate data of flood propagation, which is essential to test validity of the developed mathematical model. However, a few sets of experiments have been conducted just to acquire a better idea regarding the influence of some of the flow parameters on flood propagation.

To investigate the problem a total of ten sets of experiments have been carried out. The video recording of flood movement, translated to pictorial form, for all these experiments have been presented in the Fig. 6.2 to 6.11. The first eight experiments have been conducted either over a horizontal bed or over a regularly sloping bed. For all these experiments the longitudinal slope, in the direction of main channel flow, has been kept horizontal and the transverse slope of the platform has been adjusted to have the desired transverse slope for different experiments.
Experiment No. 1, 2, and 3 have been conducted over Plain Cement Concrete bed by adjusting the transverse slope as horizontal, 1 : 200 (adverse) and 1 : 100 (adverse) respectively. The main channel discharge of these experiments have been kept as 0.03 cumec. The depth of flow in the gate position, over the upper stage of the main channel has been measured as 0.061m. The results of flood movement obtained from these experiments have been presented in Fig. 6.2, 6.3 and 6.4 respectively. It has been observed that the influence of bed slope on flood propagation does not become prominent in case of transverse slope of 1 : 200. Therefore, experiment in this slope has been omitted while conducting experiment for other bed roughness.

Experiment No. 4 and 5 have been conducted over a P.C.C. bed covered by jute fabric. A horizontal bed has been used for experiment No. 4 and an adverse slope of 1 : 100, in the direction normal to the main channel flow, has been used for the experiment No. 5. The main channel discharge has been kept as 0.03 cumec and the depth in the gate position has been kept as 0.061 m, for these two experiments also. Fig. 6.5 and 6.6 show the flood propagation of experiment No. 4 and 5 respectively.

Experiment No. 6 and 7 have been conducted over stone chips bed with transverse bed slope as horizontal and adverse (1:100) respectively. Discharge and depth in the main channel have been kept same as those of the earlier experiments. Fig.6.7 and 6.8 show the flood movement of these two experiments respectively.
Experiment No. 8 has been conducted to acquire an idea regarding influence of main channel discharge on the propagation of flood wave in the valley, lying downstream of the river dike. For this purpose a horizontal jute bed has been used, and the discharge in the main channel has been reduced to 0.02 cumec. However, the depth of flow in the main channel, near the gate, has been kept same as that of the experiment No. 4 by raising the water surface artificially. This has been achieved by suitably positioning a barrier at the downstream end of the channel. Fig. 6.9 shows the flood movement for the experiment No 8. It has been observed that as the depth near the gate position is same for both experiment No. 8 and experiment No. 4, initially the wave propagates almost in same speed in both the experiments. But after elapse of few seconds the outflow discharge through the gate attains a steady state and the propagation speed of experiment No. 8 reduces considerably as compared to flood propagation of experiment No. 4.

Experiment No. 9 has been conducted for a ground having gentle and regular undulation. For this purpose, a Plain Cement Concrete bed has been used. Bed slope transverse to the main channel flow, has been kept horizontal and a gentle upward slope of 1: 200 has been given up to a distance of 1m on both sides of the normal axis passing through the side gate. Fig. 6.10 Shows the plot of this experiment.
FIG 6.2: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER HORIZONTAL P.C.C. BED FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC

GRID SIZE 200mm x 200 mm
BOUNDARY WALL — ■ ■
WAVE TIP ---------- -
GATE
FIG. 6.3: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER RCC BED HAVING ADVERSE SLOPE OF 1:200 IN 
THE TRANSVERSE DIRECTION FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC
FIG. 8.4: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER P.C.C. BED HAVING ADVERSE SLOPE OF 1:100 IN THE TRANSVERSE DIRECTION FOR A MAIN CHANNEL DISCHARGE OF .03 CUMEC
FIG. 6.5: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER HORIZONTAL JUTE BED FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC
FIG. 6.6: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER JUTE BED HAVING ADVERSE SLOPE OF 1:100 IN 
THE TRANSVERSE DIRECTION FOR A MAIN CHANNEL DISCHARGE OF .03 CUMEC
FIG. 6.7: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER HORIZONTAL STONE CHIPS BED FOR A MAIN
GRID SIZE 200mm x 200 mm
BOUNDARY WALL
WAVE TIP
CHANNEL DISCHARGE OF .03 CUMEC

1 7 7 1 3 1 2 1 1 1 0
GATE
1 3 1 2 1 1 1 0
1 2 1 3
9 8 7 6 5 4 3 2 1 0
1 2 1 3

CHANNEL DISCHARGE OF .03 CUMEC
FIG. 6.8: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER STONE CHIPS BED HAVING ADVERSE SLOPE OF 1:100 IN THE TRANSVERSE DIRECTION FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC.
FIG. 8.9: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER HORIZONTAL JUTE BED FOR A MAIN CHANNEL DISCHARGE OF .02 CUMEC
FIG. 8.10: FLOOD PROPAGATION IN THE LABORATORY MODEL OVER A P.C.C. BED HAVING GENTLE UNDULATION FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC
FIG. 6.11(a): CONTOUR LINES SHOWING STRONG AND IRREGULAR UNDULATION OF FLOOD PLAIN IN THE LABORATORY MODEL.
FIG. 8.11(b): FLOOD PROPAGATION IN THE LABORATORY MODEL OVER A BED HAVING STRONG AND IRREGULAR UNDULATION FOR A MAIN CHANNEL DISCHARGE OF 0.03 CUMEC
Although a ground having strong and irregular undulation is rarely found in an alluvial flood plain, one set of experiment (Exp. No-11) has been conducted to acquire a qualitative idea of flood movement over such ground. For this purpose a side platform, made of steel sheet, having irregular and strong undulation, has been used. Contour lines showing undulation of the side platform have been shown in the Fig. 6.11(a). Contouring has been done by using a dumpy level and a staff having least count of 0.001 m. The flood propagation on this surface has been shown in the Fig 6.11(b). It has been observed that the movement of flood in such situation is governed primarily by the ground undulation; and the effect of other influencing factors become insignificant. However, result of this experiment has not been taken for detail analysis, as possibility of obtaining such irregular undulation in alluvial plain is almost non existent.

6.6 ANALYSIS OF EXPERIMENTAL RESULT:

For analysis of the experimental results, a quantitative comparison among different experiments is essential. For this purpose tip velocity has been used as an index for comparison. This has been calculated from the known wave tip position at different instants of time. The tip velocity, midway between any two successive wave tips has been calculated as;

\[ (V_t)_r = \frac{r_2 - r_1}{t_2 - t_1} \]
Where

\[(V_t)_r = \text{the tip velocity at a radial distance 'r' from the gate}\]
\[r_1 = \text{Radial distance from the gate up to the preceding wave tip}\]
\[r_2 = \text{Radial distance from the gate up to the succeeding wave tip.}\]
\[r = (r_1 + r_2)/2\]
\[t_1 = \text{Propagation time of preceding wave tip.}\]
\[t_2 = \text{Propagation time of succeeding wave tip.}\]

6.6.1 Calculation of Tip Velocity:

Tip velocity has been calculated from the graphical plots of flood propagation on different beds. For the purpose of analysis, tip velocity in the direction normal to the gate has been calculated. Calculation of tip velocity for different cases have been presented in tabular form in the table 6.1 - 6.4.

6.6.2 Plot of Tip Velocity Vs Distance:

To acquire a better perception regarding variation of tip velocity with distance, graphical plot of tip velocity Vs distance has been made. A total of six plots (Fig. 6.12 to Fig. 6.17) have been made for comparative study of flood movement in different situations.

Curves showing variation of tip velocity with distance, over different bed roughness have been presented in the Fig 6.12 and
TABLE 6.1 : TIP VELOCITY OVER PLAIN CEMENT CONCRETE BED IN

THE DIRECTION NORMAL TO THE GATE

<table>
<thead>
<tr>
<th>Bed Slope : Horizontal</th>
<th>Bed Slope : 1:100 (Adverse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_1$ (m)</td>
<td>$r_2$ (m)</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>0</td>
<td>0.517</td>
</tr>
<tr>
<td>0.517</td>
<td>0.77</td>
</tr>
<tr>
<td>0.77</td>
<td>1.23</td>
</tr>
<tr>
<td>1.023</td>
<td>1.133</td>
</tr>
<tr>
<td>1.133</td>
<td>1.166</td>
</tr>
<tr>
<td>1.001</td>
<td>1.232</td>
</tr>
</tbody>
</table>
### TABLE 6.2: TIP VELOCITY OVER STONE CHIPS BED

**IN THE DIRECTION NORMAL TO THE GATE**

<table>
<thead>
<tr>
<th>Bed Slope : Horizontal</th>
<th>Bed Slope : 1:100 (Adverse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_1 ) (m)</td>
<td>( r_2 ) (m)</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>0.0</td>
<td>0.44</td>
</tr>
<tr>
<td>0.44</td>
<td>0.605</td>
</tr>
<tr>
<td>0.605</td>
<td>0.726</td>
</tr>
<tr>
<td>0.726</td>
<td>0.814</td>
</tr>
<tr>
<td>0.814</td>
<td>0.891</td>
</tr>
<tr>
<td>0.891</td>
<td>0.957</td>
</tr>
<tr>
<td>0.957</td>
<td>1.034</td>
</tr>
</tbody>
</table>

- \( V \): Velocity
- \( t_1 \) and \( t_2 \): Time intervals
- \( r_1 \) and \( r_2 \): Radii of the stones
- \( t_1 \) and \( t_2 \): Time intervals
- \( r_1 + r_2 \): Sum of the radii of the stones
- \( V_1 \): Tip velocity

- Adverse: Bed slope is against the flow direction
- Horizontal: Bed slope is parallel to the flow direction
<table>
<thead>
<tr>
<th>Bed Slope : Horizontal</th>
<th>Bed Slope : 1:100 (Adverse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_1$ (m)</td>
<td>$r_2$ (m)</td>
</tr>
<tr>
<td>0</td>
<td>0.407</td>
</tr>
<tr>
<td>0.407</td>
<td>0.616</td>
</tr>
<tr>
<td>0.616</td>
<td>0.836</td>
</tr>
<tr>
<td>0.836</td>
<td>1.0</td>
</tr>
<tr>
<td>1.0</td>
<td>1.298</td>
</tr>
<tr>
<td>1.298</td>
<td>1.397</td>
</tr>
</tbody>
</table>
### Table 6.4: Tip Velocity over Horizontal Jute Bed in the Direction Normal to the Gate for Different Discharges in the Main Channel

<table>
<thead>
<tr>
<th>Discharge = 0.2 cum</th>
<th>Discharge = 0.3 cum</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_1 )</td>
<td>( r_2 )</td>
</tr>
<tr>
<td>0</td>
<td>0.407</td>
</tr>
<tr>
<td>0.407</td>
<td>0.816</td>
</tr>
<tr>
<td>0.407</td>
<td>0.836</td>
</tr>
<tr>
<td>0.407</td>
<td>0.836</td>
</tr>
<tr>
<td>0.836</td>
<td>1.0</td>
</tr>
<tr>
<td>0.836</td>
<td>1.0</td>
</tr>
<tr>
<td>1.0</td>
<td>1.298</td>
</tr>
<tr>
<td>1.0</td>
<td>1.298</td>
</tr>
<tr>
<td>1.298</td>
<td>1.397</td>
</tr>
<tr>
<td>1.298</td>
<td>1.397</td>
</tr>
<tr>
<td>1.045</td>
<td>1.33</td>
</tr>
</tbody>
</table>
FIG. 6.12: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A HORIZONTAL BED FOR THREE DIFFERENT ROUGHNESS
FIG 6.13: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A BED HAVING ADVERSE SLOPE OF 1:100 IN THE TRANSVERS DIRECTION FOR THREE DIFFERENT ROUGHNESS
FIG. 6.14: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A P.C.C. BED FOR DIFFERENT BED SLOPES.
FIG. 6.15: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A JUTE BED FOR DIFFERENT BED SLOPES.
FIG. 6.16: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A STONE CHIPS BED FOR DIFFERENT BED SLOPES.
FIG. 6.17: VARIATION OF TIP VELOCITY WITH DISTANCE OVER A JUTE BED FOR TWO DIFFERENT DISCHARGES.
Fig. 6.13. Fig. 6.12 shows the variation in case of a horizontal bed while the Fig. 6.13 shows the same variation in a bed having adverse slope (1:100) in the transverse direction from the main channel.

Curves of Fig. 6.14 show the effect of bed slope on the tip velocity over a Plain Cement Concrete bed. Fig 6.15 and Fig. 6.16 show the similar effect in case of a jute fabric bed and stone chips bed respectively.

Curves of Fig. 6.17 show the influence of main channel discharge on the tip velocity of wave propagation.

6.6.3 Critical Analysis of The Experimental Result:

From the plot of tip-velocity Vs distance, it has been observed that, irrespective of bed roughness and bed slope, tip velocity drops from a very high initial value to a comparatively low value within a short distance. However, the distance required for this sudden drop of propagation speed, depends on both bed roughness and bed slope. Fig. 6.12 shows that in case of horizontal P.C. C bed tip velocity drops from 1m/sec to 0.35 m/s, in a distance of nearly 1.15m. Whereas in case of jute bed, the tip velocity drops from 0.82m/sec to 0.088m/sec at a distance of about 1.0m. Again over stone chips bed the tip velocity drops from 0.88m/sec to 0.08m/sec within a distance of 0.8m. Fig. 6.13 reveals that in case of adverse slope, the distance required for this major drop of
tip velocity is less as compared to the horizontal bed. Of course, the trend of wave propagation over different roughness is same for both horizontal and adverse slope. It has also been observed that tip velocity continues to decrease up to a certain distance only. This distance varies from 0.7m to 1.0m, depending on the type of bed roughness and bed slope. Beyond this, tip velocity suddenly increases and then keeps on fluctuating around an average value. The increase in tip velocity after a certain distance is due to the fact that, at this distance, the wave reflected from the side wall (towards right side of the gate) meets the wave propagating directly from the gate. The fluctuation of tip velocity is also due to successive interactions of these two waves. The wave propagating towards the side wall impinges on the wall obliquely and therefore, after reflection also the wave moves in the forward direction, making an angle with the side wall. Thus this reflected wave contains a positive component in the direction normal to the gate. Therefore, tip velocity in the direction normal to the gate suddenly increases due to interaction of this reflected wave with the direct wave coming from the gate. After this instant, tip velocity may again decrease until another wave interaction occurs. Influence of surface tension can be regarded as another cause for this fluctuation in tip velocity. Due to wave interaction flow depth increases, thus effect of surface tension decreases and the flow advances with a higher velocity. Again with increase of velocity flow depth decreases and resistance due to surface tension
becomes significant. This process continues in the laboratory model till the flow reaches the downstream boundary.

Curves of Fig. 6.14, 6.15, and Fig.6.16 have revealed the fact that, whatever may be the bed roughness, tip velocity is always less in case of adverse slope than horizontal bed.

Although it is an well established fact that the value of roughness coefficient depends on the depth of flow, the degree of dependency has been observed to vary with the nature of the surface. Fig. 6.13 shows that up to a distance of 0.72m the bed covered by jute fabric behaves like a smoother surface than that of the stone chips bed. But beyond this, resistance offered by jute fabric exceeds the resistance of stone chips bed. Therefore, total submergence time is considerably more in case of jute fabric bed (45 sec) as compared to stone chips bed (29sec). This is due to the fact that, height of roughness in case of jute fabric bed is less as compared to stone chips bed. But so far as gap between individual roughness element is concerned, it is more in case of stone chips bed than jute fabric bed. In jute fabric bed the roughness elements are so closely packed that it behaves like a quasi smooth surface when the depth of flow is considerably more. On the other hand when the depth of flow becomes small, in jute fabric bed the form loss increases sufficiently and thus the total bed resistance also increases significantly. Because of this, initially, up to a certain distance the jute fabric bed behaves like a quasi smooth surface as flow depth to that point remains
comparatively more. Beyond this, resistance offered by jute fabric bed exceeds that of the stone chips bed.

Again, the Fig. 6.5 has indicated that in the experiment No.4, i.e., over horizontal jute fabric bed, flood wave moves with a much higher speed in the direction normal to the gate as compared to the flow towards left of the gate. As the side wall on the right side is at a near distance from the gate, the reflected waves, combining with the direct waves, increase the flow depth around the normal axis passing through the gate. This in turn reduces the bed friction of the jute bed and hence increases the propagation speed significantly in that region. Considering the above facts it is felt that use of an average value for resistance parameter may not be justified for all types of bed resistance. Therefore, a conditional resistance coefficient value, defined as a function of depth, can be used for the purpose of modelling two dimensional flow over vegetal roughness, which resembles, to some extent, the jute fabric bed.

Fig. 6.17 shows that although discharges are different in experiment No. 4 and 8, the propagation speed is almost same for initial few seconds for both the experiments. This is because depth of flow has been kept same near the gate position for both the experiments. But after few seconds, the out flow discharge through the gate attains a steady state. This steady state out flow discharge is obviously less in case of experiments No. 8, where main channel discharge is less (0.02 cumec) than that of the experiment No 4.
Fig. 6.18 : A COMPLETE VIEW OF EXPERIMENTAL SET-UP

Fig. 6.19 : PHOTOGRAPH SHOWING EXPERIMENTAL SET-UP WITH JUTE BED
Fig. 6.20: PHOTOGRAPH SHOWING EXPERIMENTAL SET-UP WITH STONE CHIPS BED

Fig. 6.21: CLOSE VIEW OF STONE CHIPS BED
Fig. 6.22 : PHOTOGRAPH SHOWING TRANSITION PORTION THROUGH WHICH FLOW ENTERS THE MAIN CHANNEL

Fig. 6.23 : DETACHABLE CHANNEL PORTION AT DOWNSTREAM END OVER THE MEASURING TANK
Fig. 6.24: VIDEO RECORDING OF EXPERIMENTAL WORK

Fig. 6.25: AUTHOR VERIFYING THE VIDEO RECORDING
(0.03 cumec). Therefore, after a few seconds propagation speed of experiment No. 8 becomes considerably less than propagation speed of experiment No. 4. This has indicated that if breach of river dike occurs due to afflux of bridge, the depth of flow in the breach position should not be considered as the observed depth for the purpose of modelling flood propagation. In such situation, the uniform flow depth computed on the basis of main channel discharge should be used as the final depth in the gate position.

6.7 CONCLUSION:

The constructed laboratory set-up can be regarded as a satisfactory physical model for investigating flood movement propagating from an opening in the river dike. The developed model provides the facility of investigating influence of ground slope and ground roughness on the flood movement. Flood movement over an undular ground can also be studied in this model. Although, discharge regulating facility has not been incorporated in the model, experiment can be carried out for three different discharges. This is possible by operating required number of pumps as desired (maximum three pumps in the existing system). Minor variation of discharge during the experiment may occur due to fluctuation in the supply voltage. In the conducted experiment maximum variation in the supply discharge has been observed to be less than five percent. Thus such minor variation does not bear any significant impact on the experiment as a whole.
However, this minor drawback can be eliminated by incorporating one regulating value and one venturimeter or orificemeter with each of the supply pump and keeping continuous observation upon them. The platform and the main channel of this developed set-up can be adjusted to any desired slope within a reasonable range. Of course it requires lot of time, care and efforts for fixing the model to prefect adjustment.

From the experiment conducted in the developed set-up, following conclusions regarding effect of different parameters on flood movement can be drawn;

1) Speed of propagation reduces with the increase in the bed roughness, both in horizontal and adverse slope.

2) Flood propagates quickly in horizontal bed than adverse bed.

3) More the main channel discharge more is the propagation speed of flood wave on the d/s of river dike.

4) Reflection boundary plays an important role in the direction of propagation of flood wave.

5) Resistance parameter is very much sensitive to the flow depth in case of jute fabric bed of the experimental model.

6) Ground undulation influences the flood movement significantly.