COMPARISONS OF VELOCITY DISTRIBUTIONS DUE TO PERMEABLE AND IMPERMEABLE SPUR-DIKE IN A RECTANGULAR CHANNEL

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Abstract - *This paper presents a series of experiments conducted for permeable and impermeable spur-dike in a rectangular channel. The coconut coir carpets have been used as a bed resistance. The analysis of variations of flow parameter such as velocity and Froude's number associated with these model spur dike have been computed and analysed. The main goals of the experiments are to study and analyse the effect of the flow i.e, the velocity analysis around the permeable and impermeable spur dikes placed in three different angles, i.e, 30 degree (attracting), 90 degree (defecting) and 120 degree(repelling) at 1m away from 6m channel of the upstream of the tilting flume channel. The experiments are conducted in a straight tilting flume under non-submerged flow condition. Based on the study results, flow parameters at different angles of spur dykes are characterized. This is of great reference for the design and assessment of spur dykes*

Key Words: Local flow, permeable spur-dike, impermeable spur-dike, angle of installation, resistance

1. INTRODUCTION

Spur-dikes are straight perpendicular structures that project from the bank of a stream at some angle to the main flow direction. They are mainly used for river training and for protection of the river bank from erosion, river-based navigation. The spur dikes with respect to erosion control can be used to deflect the high velocity flow away from erodible bank and thereby protect the bank from erosion. Depending on the river discharge and height of the structure, spur-dikes may operate in either a submerged or a non-submerged mode.

However, failures of spur dikes frequently occur in the world. For example, the Betil and Enayetpur spurs on Brahmaputra-Jamuna River for embankment protection in the Sirajganj District of Bangladesh have experienced damages and rehabilitations after their completion on 2002 which is now under repair. Another case is in Japan un which the spur-dikes constructed for river restoration purpose on the Kizu River in Kyoto Prefecture were washed away in a flash flood soon after their completion in 2004.

2. LABORATORY EXPERIMENTS

Experiments were conducted in a glass sided tilting flume channel at Water Resource Laboratory in Assam Down Town University. The flume is 6m long, 0.3m wide and 0.45m deep. The slope of the flume was adjusted to 1:150 in the experiments. Two kinds of spur-dikes have been used: impermeable and permeable. These are made out of wooden block with dimensions (5x10x5) cm. For permeable spur, the space has been made on the upper portion of the block to allow the water to pass through it. The spur has been placed 1m away from the upstream of the channel without resistance and the depth of water and velocity has been measured using measuring scale and pitot tube. The spur dikes have been installed at three different angles, 60°, 90° and 120° respectively.

Fig-1: Wooden block used as impermeable and permeable spur

Fig-2 Pitot tube and coconut coir carpet

Fig-5: Flow in permeable spur placed at 60 degree

Fig-6: Flow in permeable spur placed at 90 degree

Fig-7: Flow in permeable spur placed at 120 degree

Fig-8: Flow in impermeable spur placed at 60 degree

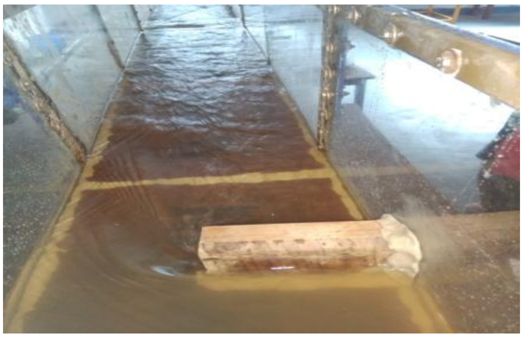

Fig-9: Flow in impermeable spur placed at 90 degree

Fig-10: Flow in impermeable spur placed at 120 degree

3. ANALYSIS OF EXPERIMENTAL RESULT

The effect of velocity is very important as a hydraulic parameter represents the main function of depositions actions in open channel. From the experiment data obtained, the velocity of the flow in the channel is found out by using the formulae:

$$V = \sqrt{2gh}$$

Where, V = velocity of the flow
g = specific gravity
h = depth of water in pitot tube

Froude's number can be found out from the velocity calculated by using the formulae:

$$Fr = \frac{V}{\sqrt{gy}}$$

Where, Fr = Froude's Number
y = depth of flow in channel

The decrease in velocity percentage have been computed by:

$$\frac{Vo - v}{V\,o} \text{x}100$$

Where, V_o =original velocity without the placement of spur
v= velocity after the placement of spur

The following cases have been considered for the analysis:

No. of cases	Angle of spur-dikes	Types of spur	Conditions
Cases-1	(a) 60° (b) 90° (c) 120°	Permeable and impermeable	Comparison of decrease in velocity percentage between permeable and impermeable spur for three different angles.
Cases-2	(a) 60° (b) 90° (c) 120	Permeable and impermeable	Comparison of velocity change between the original velocity (without the placement of spur) and permeable and impermeable spur for different angles.

Cases-3	(a) 60° (b) 90° (c) 120	Permeable and impermeable	Comparison of Froude's number between permeable and impermeable spur for three different angles.

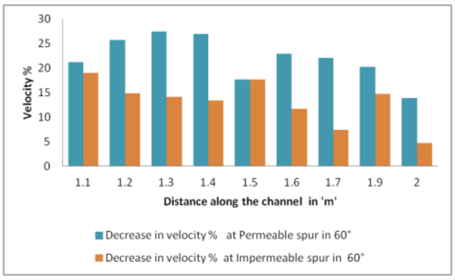

Fig-11: Bar graph showing the decrease in velocity % for permeable and impermeable spur placed at 60 degree

Fig-11 shows that the last measuring point for velocity in the channel (at 2m), the effect on the channel by permeable spur is 13.93% whereas for impermeable spur it is below 5%. From the graph, we can observe that the permeable spur have greater effect on the channel when placed at 60 degree.

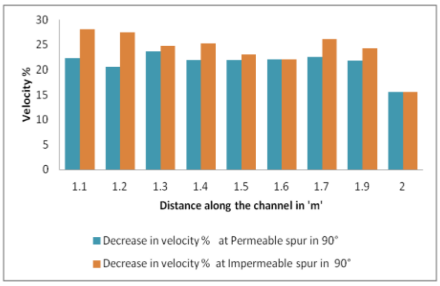

Fig-12: Bar graph showing the decrease in velocity % for permeable and impermeable spur placed at 90 degree

Fig-12 shows that the maximum velocity is decrease by 28.08 % by impermeable whereas for permeable it is decreased by 22.54%. Comparing both the spurs placed at 90 degree, the impermeable spur have a greater effect on the channel than the permeable spur.

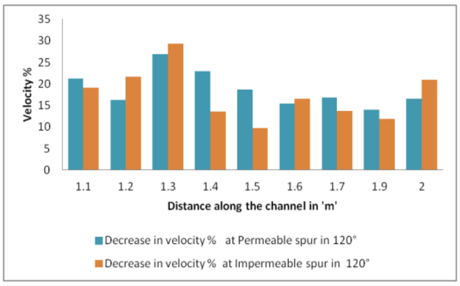

Fig-13: Bar graph showing the decrease in velocity % for permeable and impermeable spur placed at 120 degree

Fig-13 shows that the impermeable spur have irregular velocity decrease along the channel where it is observed that the maximum change occurs at 1.3m.

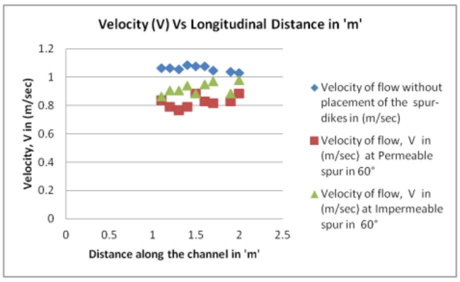

Fig-14: Plot showing the decrease in velocity change before and after the placement of spurs at 60 degree.

Fig-14 shows that the sudden rise in velocity at 1.5m for permeable spur maybe due to hydraulic jump in the channel. The impermeable spur has a greater effect on the channel as compared to permeable spur.

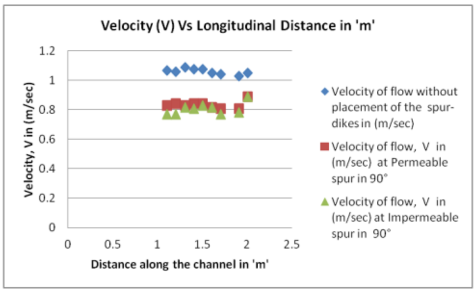

Fig-15: Plot showing the decrease in velocity change before and after the placement of spurs at 90 degree.

Fig-15 shows that both spur have a great effect on the channel for reducing the velocity. Comparing both the types of spurs, the impermeable spur has a greater effect than the permeable spur.

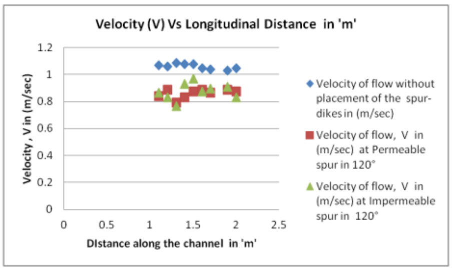

Fig-16: Plot showing the decrease in velocity change before and after the placement of spurs at 120 degree.

Fig-16 shows that both spur did not show much effect on the channel. Comparing both the types of spurs, the permeable spur shows a decent velocity reduction as compared to impermeable spur.

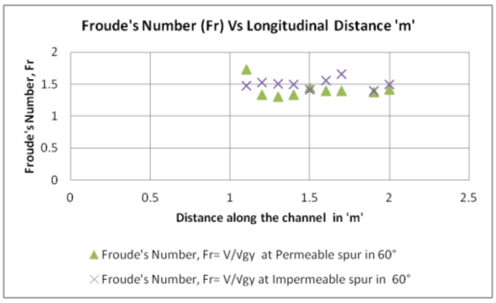

Fig 17: Plots showing the Froude's number between permeable and impermeable spurs placed at 60 degree

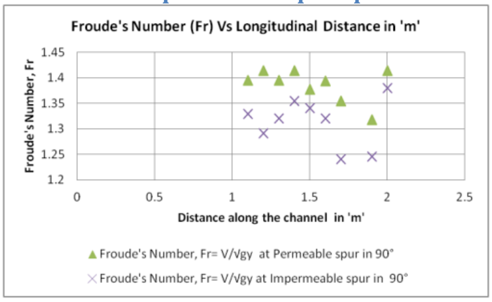

Fig 18: Plots showing the Froude's number between permeable and impermeable spurs placed at 90 degree

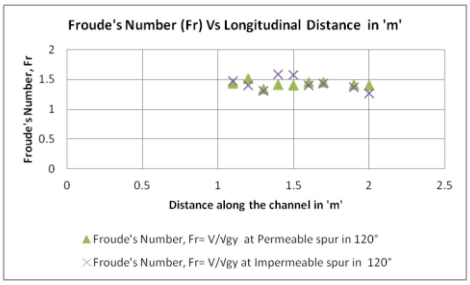

Fig 19: Plots showing the Froude's number between permeable and impermeable spurs placed at 120 degree

Fig-17, 18 and 19 shows that for all the types of spur placed at three different angles, the Froude's number computed is more than 1 which is super-critical.

4. OBSERVATIONS AND DISCUSSION

For case-1, from the Fig- 11, 12 and 13, it has been observed that the two types of spurs placed at three different angles, the impermeable spur placed at 90 degree have a great effect on the channel as compared to the rest of the spurs.

For case-2, from the Fig-14, 15 and 16, it has been observed that the spurs placed at 90 degree reduces the velocity effectively more than the spurs placed at 60 and 120 degree as compared to the original velocity, i.e, without the placement of the spur.

For case-3, from the Fig-17, 18 and 19, for permeable and impermeable placed at three different angles, the flow is super-critical as the Froude's number computed is more than 1.

5. CONCLUSION

From the analysis done for the three cases, it can be concluded that for the channel bed with resistance (coconut coir) the impermeable spur placed as 90 degree have a great effect as compared to the other spurs placed at different angles. However, since the construction of impermeable spurs are expensive, permeable spur placed at 90 degree can also be used since the construction cost of permeable spurs are less expensive as compared to impermeable spur-dikes.

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