Local Scour Associated With Angle Spur Dike

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ABSTRACT

A numbers of experiments were carried out in a laboratory flume of National Institute of Technology Kurukshetra, Haryana, India in which the volume of the scour hole is related with model spur dikes, was measured . Spur dikes model were oriented at 90°, 75°, 60°, 45^0 and 30° to the downstream flume side wall. The main objectives of the experiment were to evaluate the effect of the five angles on the volume of scour hole and on minimizing scour adjacent to down stream banks. The experiments showed that of the five angles tested, the least erosion of the bed in the near bank region was associated with the spur dikes with 90° angles. While the greatest volume of scour hole was associated with the 45° spur dikes.

Keyword: Scour, Spur Dikes, Contraction Ratio, and Froude Number

1. INTRODUCTION AND LITERATURE REVIEW

A spur dike can be defined as an elongated structure having one end on the bank of stream and the other end projecting into the current Copeland, (1985), Kuhnle et al (1999). Spur dikes have been widely used to redirect the flow in channels and to protect eroding stream banks. They have also been used to enhance aquatic habitats by causing stable pools in unstable, distributed streams Klingeman, P.C. et al(1984).Like any hydraulic structure, when spur dikes crosses a water way the natural balance of the river is disturbed, in turn results in major disturbance of the flow pattern around the structure base. This disturbance leads to initiation of scour process. This scour is considered to be major cause of structure foundation failure. Therefore, the problem of scour around any obstruction placed in an alluvial channel is of great importance to hydraulic engineers, because an accurate estimation of local scour beside these structures is very important for safe and economic design of their foundations. There are many factor affect the scouring process. Researcher tried to study these factors separately, or made a combination between two or more factors. Garde et al (1961) found that in his experiment that when all other variable held constant, the maximum scour depth had the greatest value for spur dikes inclination of 90^0 . For all other inclination upstream or downstream, the scour depth was smaller. Tison(1962) disagreed with Garde et al idea and he proved his point of view by conducting experiments using three angles 72° 30’, 90° and 107° 30’ and held all the variable constant. He found that the greatest maximum scour depth was recorded for the upstream spur dike inclination. Melville (1997) found that the scour increase with an increase in angle, **θ** which is inclination with downstream bank**. R**audikivi agreed with his idea and stated that the scour depth was reduced for θ<90° and increased for θ>90°.

2. OBJECTIVES AND AIMS OF PRESENT STUDY

This study aims to investigate the local scour phenomena and the relation between the dimensions of the scour hole that takes place beside a single spur dike installed as a training structure on straight channel, and between flow parameters, contraction ratio and angle of inclination of the structure itself to the flow direction.

3. EXPERIMENTAL SETUP

The experiment work and plan was performed at the Hydraulic Laboratory, National Institute of Technology Kurukshetra, India (Haryana). A re-circulating flume of 12m long, 0.4m wide, and 0.6m deep was used. The erodible bed of 20cm depth was made of sediment (d_{50} = 0.18mm). The flume was provided with transparent glass for 8m length on both sides to view the flow conditions and flow mechanism inside the channel.

Fig:1 A Photographic View of the Flume

Scour depth measurement were taken at upstream side and downstream side along the line of symmetry and also at location where the scour depth could be maximum. Scour depth measurements were taken with the help of an improvised Z-shaped pointer gauge at time instants of 180 minute and this improvised Z-shaped pointer gauge could be moved over rails mounted on the vertical walls of the flumes. Tail control gate was used for the control of velocity and depth of flow. Discharge was measured with the help of a pitote tube and is cross checked by traditional formula used for sharp crested weir which is installed at tail of the flume.

To achieve the research objective, twenty spur-dike models were made in five different groups. The first group was aligned perpendicular to the flow, the second and the third group were aligned with angle 75° and 60° respectively and last two group aligned with 45° & 30°. For each group, there are four different lengths to achieve the proposed contraction ratios.

4. FLOW CONDITION

Experiments were carried out under uniform flow conditions. The waves generated at the inlet were suitably dampened by a smooth curved entry of flow in test section and by placing some floating planks of wood. Further, experiments were carried out at incipient velocity for clear water conditions. This was obtained by physical observation on regime of sediment bed. Experiments were also conducted under live bed conditions for velocities higher than the velocity of initiation of sediment motion. The initiation or threshold of movement of a particle due to action of fluid flow is defined incipient velocity of fluid particles.

Contraction Ratio: At different contraction ratio, b/B was used in this experimental study where b is length of spur dikes and B is width of channel.

Duration of test run: It has been referred to literature, there have been used time durations of 2, 3, 4, 6 hours. Three hour test runs were kept for the experimental study.

5. TEST PROCEDURE

The following procedure was followed to conduct each test:

1. The spur-dikes model was placed in the study reach and fixed well to prevent any movement.
2. The bed material was leveled to insure that all points of the bed had the same elevation.
3. A tail gate was kept temporarily closed until flume was filled up in a very low flow rate to avoid any disturbance for the bed elevation.
4. The required discharge was allowed to flow rate gradually until it reaches a constant value.
5. The tail gate was lifted up gradually until it reaches the required water depth, then starts time of run is recorded.

6 As soon as the run time was over, the flow discharge has been stopped then the water was drained slowly in order to prevent sediment movement. After the channel was dried, the measurement was recorded.

6. EXPERIMENTAL RESULT

From experimental study, it can be concluded that the hole geometry has the following characteristics:

- The scour hole side slope is steep at upstream of the spur, but the downstream portion of the scour hole is elongated in the downstream direction and has a milder slope. The difference in side slope is due to the higher flow energy and turbulence in the upstream than the downstream.
- The scour hole has the approximation form of inverted frustum cone with its vertex representing the point of maximum depth which always occur near spur.
- In most cases, the base of the scour hole with spur dikes having orientation angles of 90° 75° & 60° is nearly rectangular and orientation angle of 30°, the base of scour hole is circular with its center on extent of the spur longitudinal centerline.

Fig: 2 Elevation and top view of scour hole

Observation Table No.1

Ɵ	C.R (%)	B.L(m)	W.L(m)	Y(m)	V(m/s)	Fr	Q(m^3/s)	D_S(m)
90°	0.1	0.76	0.93	0.17	0.28	0.22	0.01904	0.072
	0.15	0.79	0.95	0.16	0.28	0.22	0.01792	0.065
	0.20	0.815	0.965	0.15	0.27	0.22	0.0162	0.09
	0.25	0.775	0.93	0.153	0.27	0.22	0.01485	0.109
75°	0.1	0.8	0.96	0.16	0.25	0.23	0.0192	0.095
	0.15	0.79	0.95	0.16	0.27	0.22	0.01728	0.045

	0.20	0.81	0.97	0.16	0.27	0.22	0.01728	0.09
	0.25	0.77	0.925	0.155	0.27	0.22	0.01674	0.118
60°	0.1	0.77	0.93	0.16	0.28	0.22	0.01792	0.065
	0.15	0.8	0.96	0.16	0.27	0.23	0.01728	0.07
	0.20	0.81	0.965	0.155	0.27	0.22	0.01674	0.077
	0.25	0.83	0.98	0.15	0.27	0.23	0.0162	0.10
45°	0.1	0.76	0.93	0.17	0.287	0.22	0.01952	0.005
	0.15	0.81	0.97	0.16	0.27	0.22	0.01728	0.054
	0.20	0.77	93	16	0.27	0.23	0.0172	0.400
	0.25	0.773	0.933	0.16	0.27	0.23	0.01728	0.68
30°	0.1	0.76	0.93	0.17	0.32	0.25	0.02176	0.005
	0.15	0.81	0.96	0.15	0.27	0.22	0.0162	0.042
	0.20	0.82	0.98	0.16	0.27	0.22	0.01728	0.059
	0.25	0.775	0.935	0.16	0.27	0.21	0.01728	0.035

From figure and table**,** the following conclusion can be drawn:

- The upstream length of the scour hole has an average value of 2b. And the downstream portion extents for about 3b to 4b.
- All the transverse sections passing by groin tip have identical lengths and side slope to the corresponding upstream sections.
- The upstream length of the scour hole is nearly twice the scour hole depth (D_s), and the downstream scour length has an average value $4D_s$.

7. ANALYSIS AND DISCUSSION

Effect of Contraction Ratio on Scour Hole

By changing the contraction ratio, this leads to a great change in a scour depth and length. In this study the effects of the contraction ratio on the scour hole, depth and length investigated for both the different flow conditions and angles of inclination, using four different contraction ratio, namely 25%, 20%, 15% and 10%. And, it's observed that the scour hole depth and length increase as the contraction ratio increases. Increasing the contraction ratio, i.e. decreasing the width available to water to pass by, result in including more flow pattern disturbance and higher velocities which in turn increases the down flow, horseshoe vortex that considered the main cause of scouring process, and increases other vortices strength with increase of obstruction length.

Effect of Spur Dike Alignment

Spur dikes may be positioned facing upstream (repelling dike), normal to flow (deflecting dike), or facing downstream (attracting dike). Each orientation to the flow affects the river current in a different way. The present study is limited on the case of deflecting and attracting dikes. The angle tested in this study was 90°, 75°, 60°, 45° and 30°. It can postulate, from comparison of data, that for all contraction ratio and flow conditions, the angle 45° and 30° has an obvious effect on reducing the scour depth, because spur –dike with angle 30° does not act as an obstacle for flow as that with angle 60°, or 90°, in another words it's effect on flow velocity is more gentler than greater value of **θ.** Further, angle 30° show the best performance in the bank protection especially upstream side wall was kept intact even for high flow conditions, used in this work. For angle 30°, the maximum scour depth occurred just downstream the dike tip, and the base of scour hole is circular.

8. CONCLUSION

A scour experiment were conducted to investigate the characteristic of the scour hole around single spur-dike installed in a straight flume, the result of these experimental test were analyzed and discussed and the following conclusion could be drawn from present study:

- The upstream side slopes are nearly equal to the wet angle of repose of the sediment bed, while the downstream average slope is about 50 to 60% of this angle.
- In most cases, the base of the scour hole with the spur dikes oriented at 90° and 60° is nearly rectangular and oriented at the upstream face of the spur. But with angle 45° and 30° the base of the scour hole is circular with its center located near the dyke tip on the extension for its center line.
- The upstream length of the scour has an average value of 2b, and 4b at the downstream side.
- All of the scour parameters increase with the increase of Froude number with a linear trend. On the other hand, Froude number has no effect on the general layout of the scour hole.
- The relative scour parameters increase of contraction ratio. But the effect of contraction ratio decrease with small value of Froude number, even for higher value of contraction ratio.
- For the same contraction ratio and flow conditions, angle 30° showed good performance in reducing scour depth and in bank protection.

9. NOTATION

The following symbols are used in this paper.

D_{50} = median size of sediment particle.

Fr = Froude no.

Θ = Orientation of Spur Dike with d/s bank

C.R = Contraction Ratio.=length of dyke/width of flume=b/B

B.L = Bed Level.

W.L = Water Level.

V = Velocity of flow.

Q = Discharge through Flume.

Ds = Maximum Depth of Scour Hole.

b = length of spur dike.

B = Width of flume.

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