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Investigation Effect of Groin Length on Scouring Depth at 90 Degree Positions of Rivers Having 180 Degree Bend

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Abstract: Groin is used as one of the most common methods of organizing and controlling erosion in the side wall at the river bends. Groin is designed to direct flow towards the axis of the river and by so doing protecting the coast and the infrastructures in that vicinity. The new flow pattern in turn could lead to scouring around the groin. Variation in the groin length can cause degradation on the groin nose. The aim of the paper is to investigate the effect of groin length on the scouring pattern using an experimental flume having a 180 degree bend, R/B= 4.7 and made from Plaxy glass. For the purpose of this paper a groin with 90 degree position having lengths of 8, 10 and 12 cm, flow discharge of 28 liters/second and a depth fixed at 13 cm with pore water was modeled in the laboratory . For the materials of the flume bed, aggregation of natural sand with a uniform coefficient of 1.7 and D_{50}= 2 mm was used. Results showed that the increase in the groin length will result in a corresponding increase in the depth degradation around the flume. Results further indicated that an increase in the length of groin causes a corresponding increase in the scouring hole around it. There was also an observed increase in the length of Sediment Island as well as an increase in the dimensions of scouring hole downstream of the groin by increasing in flow discharge.

Key words: Groin · Degradation · River bend · Length of groin

INTRODUCTION

Groins are designed and constructed to organize the river course in the bend and straight direction. One of the major challenges posed by the river bend is the secondary flows accompanied by the erosion of the river banks and walls where the construction of groin is considered as a remedial intervention [1]. These structures are extended from the river banks into the main flow stream causing regional flow contraction [2]. These structures which are sometime designed individually and in certain cases are constructed in series, divert the flow thus protecting the walls from destruction. By generating the recirculation flow downstream will cause gradual sedimentation around the main banks that in the long term will protects and preserves the natural river wall [3,4]. One of the reasons for building the groins is the scouring effects around these structures which necessitate the study of the important parameters which could protect the banks from the destruction. Various studies have been conducted on scouring phenomenon around the groin in straight rivers [5,6].

The river bend and its associated complexity of flow pattern around the groin, leads to more complex flow pattern around the groins. Although Engelund et.al and Prezedwojski et.al have been conducted on groin behavior in bend, a little reference is available in the literature to help determine the depth of scour in waterways [7,8]. This calls for a rigorous experimental investigation to investigate the flow behavior around these hydraulic structures. This paper aims to use an experimental model to investigate the complex hydraulic behavior around the groins and assess the ways in which the findings would help design an optimum system to cope with the challenges. The paper experimented with a single groin with various lengths at 90 degree angle in an experimentally-designed flume having a 180 degree and a constant depth. Using the topography of the river bed with various discharges a relation between the groin lengths and the scouring dimension was determined.

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MATERIALS AND METHODS

Research shows that the scouring phenamenon around the groin structure can be influenced by five major factors such as the waterway or channel geometry, groin characteristics, sedimentation flow and hydraulic characteristics. This study assumes the channel geometry, flow depth, characteristics river bed load materials as constant whereas the flow discharge and groin length were variables.

Given the above considerations, the flowing relation to investigate the influence by which the stabled scouring around the groins within the bend could have on scouring is provided as follows:

$$\frac{dz_{maz}}{L} = f(\theta, Q) \qquad (1)$$

Where:

θ = Angle position at the breakwater placement

Q = Discharge

dz_{maz} = Maximum scour depth at equilibrium

L = Groin length

The experiments were carried out in a curvature glass flume with 180 degree angle and the radius of $B = 0.6m$ 2 and a width of $R = 2.8m$. The bend was of a mild type with a relative curvature of the bend amounting to $R/B = 4.7$ The straight inlet channel was designed with a 9.1 m length to converge into a channel with 180 degree curvature . The later was then joined by another straight channel of 5.5 m length leading to a flow depth control gate and from there to a outflow reservoir (Figure 1).

Donnat recommends the maximum groin length of between 10-20% of the channel width[9]. This was used as a model to b ase the experimentation on using a three-layers wooden surfaced sheet with a 3mm thickness and at three varied lengths of 8,10,12 cm were selected for this purpose. The expansion percentage were taken 33,13, 16.66 and 20 respectively. The water depth was recommended to exceed 20 mm in order to prevent the roughness effects. This was considered at 13 cm which was constant during experimentation. The average flow velocity was less than the critical velocity. The discharges of 20,24 and 28 lit/sec were considered which were measured by a 60 degree triangular gate.

An experiment were designed and conducted for 10 hours period a nd maximum discharge of 28 lit/sec at a 90 degree angle and the groin length of 12 cm to reach at a e quilibrium time. The scouring depth was measured with 1 mm of accuracy. The measurements were taken at 10 minutes intervals for the first 60 minutes which was followed at 20 minutes intervals followed by 30 minutes intervals. According to figure 2, 86% of the final scouring took place within the first 120 minutes. For this reason a two-hours period was allocated for the experiment.

The experimentation followed the sequence which started with the installation of the groin. The bed load sediments were scattered uniformly in the longitudinal and lateral directions. Prior to the operation of the pump the end gate was closed and clear water was allowed to enter the canal gradually. After ensuring that the moisture was distributed evenly in the sediments the pump was operated with a low discharge rate. This was gradually increased to reach an appropriate level. By simultaneous regulation of the flow tap and downstream gate, the appropriate discharge was reached at a flow depth of 13 cm. Two hours later the pump was switched off and the water trapped in the system was gradually drained in order to prevent any effects on the topography of the channel bed. The topography of the bed around the cylindrical pillars were then taken at various discharge and positions with an accuracy of 0.01 mm. The distance of the measured points were 2 cm in the longitudinal directions.

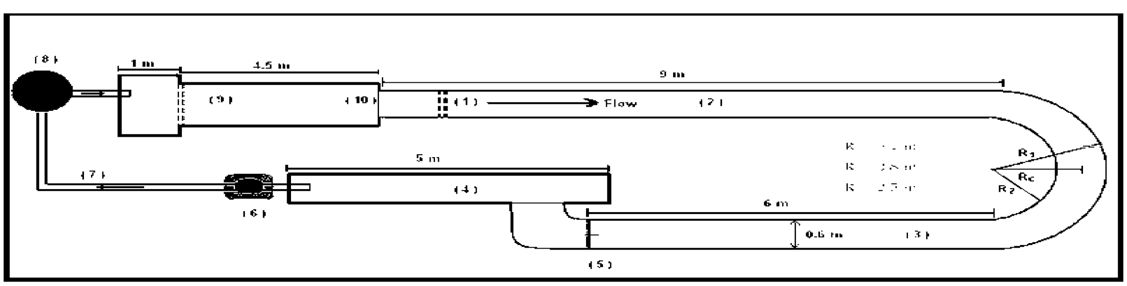

Fig. 1: The laboratory features of the experimental flume

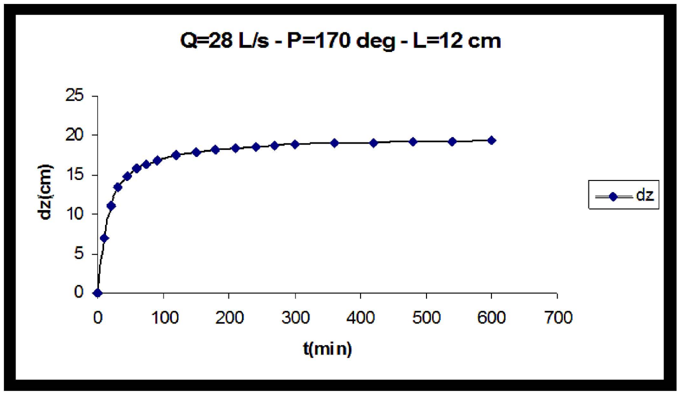

Fig. 2: Chart balance time for the groin 12 cm, in position $\theta = 170^0$, with 28 liters per second discharge

In all experiments, after adjust the flow discharge and flow depth, immediately vortex formed around the groin and scour began with high speed. With the formation of scour holes, deposits arose from the hole were moved downstream. In effect of diversion of flow by the groin, Prolapse occure around groin, this Prolapse in all the experiments were observed.

RESULTS AND DISCUSSIONS

Results showed that by installing the groin across the river, the cross-section decreases markedly. it can be deducted from the results that with an increase in the length of groin there will be an increase in scouring at groin nose. The underlying reason for that is the increased in flow velocity and as such the Froude Number given the constant flow-depth at the nose of the groin. These in turn increase the shear stress on the bed materials which leads to scouring phenamenon.

Results also showed that by increasing the flow discharge (assuming a constant flow depth and the canal cross-section) the flow velocity will have an increasing trend which in turn will increase the shear stress on the river bed. It can be deducted from the results that increase in shear stress increases the strength of vortex on the groin nose. This in turn causes erosion of the groin nose and the scouring hole at that point with a consequence of increased in the dimensions of erosion holes.

Fig. 3: Prolapse and sedimentation in the upstream and downstream of groin with lengths of 8 and 10 cm, in 170-degree position

For 20 Liter/sec Flow Discharge: IV.It was also found that by increasing a 25% in the groin length (from 8 to 10 cm) there will be a 123.22% increase in the scouring rate at the nose of the groin. Results further showed that by a 20% increase in the length (from 10 to 12 cm) there will be an I ncrease of 43.98% in the groin nose erosion. This was also repeated when the length was increased of 50%, from 8 to 12 cm with a subsequent increase o f 221.42 % in the groin nose erosion. All of these suggest a direct relation between the groin length and erosion phenamenon at the groin nose.

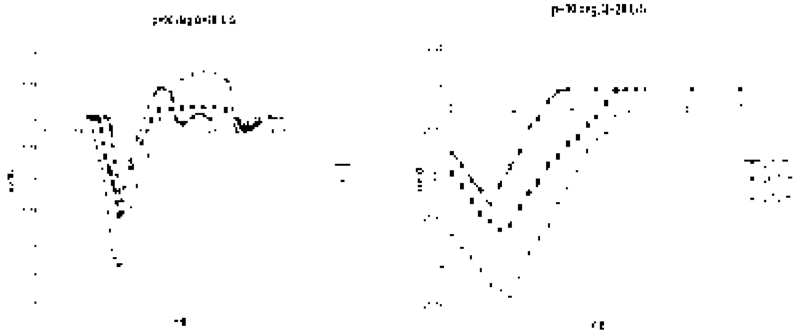

Fig. 4: Transverse and longitudinal maximum scour profiles, with different lengths, in 28 liters per second discharge

Fig. 5: Transverse and longitudinal maximum scour profiles, with different lengths, in 24 liters per second discharge

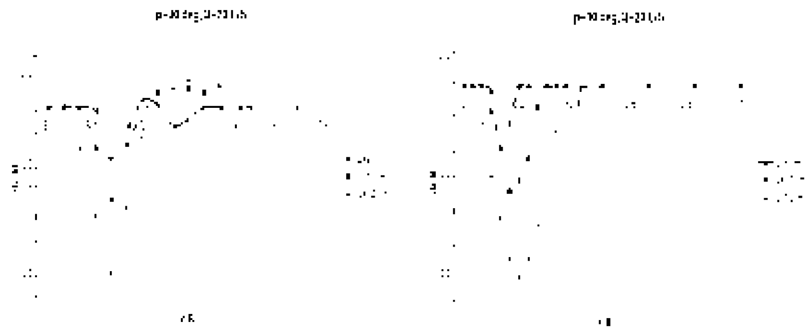

Fig. 6: Transverse and longitudinal maximum scour profiles, with different lengths, in 20 liters per second discharge

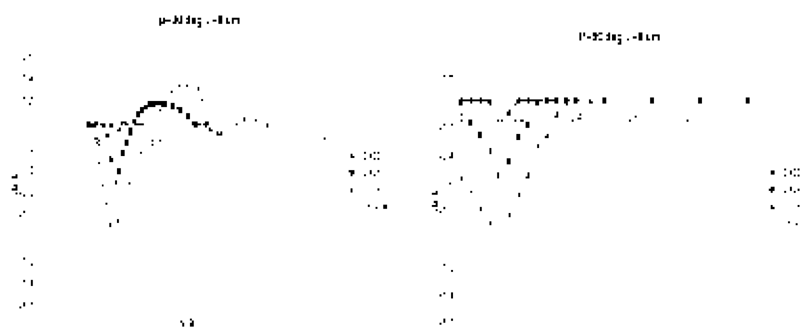

Fig. 7: The longitudinal and latitudinal profiles of the maximum scouring depth with an 8 cm in various discharges

For Discharge of 24 Liters per Second: It was also found that by increasing a 25% in the groin length (from 8 to 10 cm) there will be a 73.52% increase in the scouring rate at the nose of the groin. Results further showed that by a 20% increase in the length (from 10 to 12 cm) there will be an increase of 11.52% in the groin nose erosion. This was also repeated when the length was increased of 50%, from 8 to 12 cm with a subsequent increase of 93.52 % in

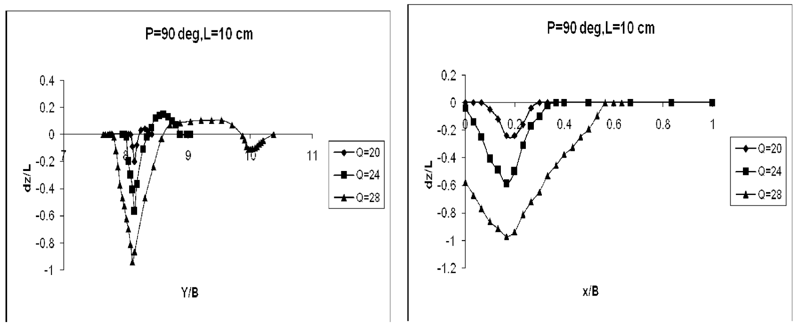

Fig. 8: The longitudinal and latitudinal profiles of the maximum scouring depth with an 10 cm in various discharges

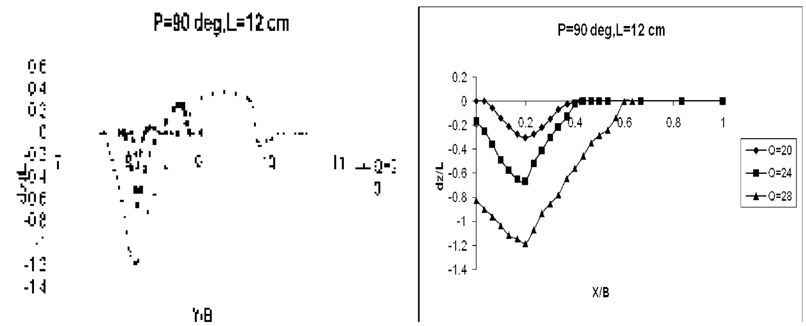

Fig. 9: The longitudinal and latitudinal profiles of the maximum scouring depth with an 12 cm in various discharges

the groin nose erosion. All of these suggest a direct relation between the groin length and erosion phenamenon at the groin nose.

For Discharge of 28 Liters per Second: It was also found that by increasing a 25% in the groin length (from 8 to 10 cm) there will be a 15.29% increase in the scouring rate at the nose of the groin. Results further showed that by a 20% increase in the length (from 10 to 12 cm) there will be an increase of 20.40% in the groin nose erosion. This was also repeated when the length was increased of 50% from 8 to 12 cm with a subsequent increase of 38.82 % in the groin nose erosion. All of these suggest a direct relation between the groin length and erosion phenomenon at the groin nose.

CONCLUSION

According to Objective Testing and Observation During Testing and Review the Obtained Curves, Obtained the Following Results:

Groin a 8 Cm Length: It was also found that by increasing a 20% in the flow discharge (from 20 to 24) there will be a 264% increase in the scouring rate at the nose of the groin. Results further showed that by a 16.66% increase in the discharge (from 24 to 28) there will be an increase of 150% in the groin nose erosion. This was also repeated when the flow discharge was increased of 40% from 20 to 28 with a subsequent increase of 810.69% in the groin nose erosion.

Groin a 10 cm Length: It was also found that by increasing a 20% in the flow discharge (from 20 to 24) there will be a 183% increase in the scouring rate at the nose of the groin. Results further showed that by a 16.66% increase in the discharge (from 24 to 28) there will be an increase of 66.1% in the groin nose erosion. This was also repeated when the flow discharge was increased of 40% from 20 to 28 with a subsequent increase of 370 % in the groin nose erosion.

Groin a 12 Cm Length: It was also found that by increasing a 20% in the flow discharge (from 20 to 24) there will be a 120% increase in the scouring rate at the nose of the groin. Results further showed that by a 16.66% increase in the discharge (from 24 to 28) there will be an increase of 49.33% in the groin nose erosion. This was also repeated when the flow discharge was increased of 40% from 20 to 28 with a subsequent increase of 294 % in the groin nose erosion.

As was observed with a 40% increase in discharge, the maximum scour occurs.

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