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Study of River Bank Sedimentation Using Permeable Structural Measures

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Abstract

River bank erosion is a more or less common issue in our rivers in Bangladesh. On the other hand, the river bank erosion protection by the conventional methods such as the revetment, spur or groin is very costly. We need to find any low cost & cost effective approach. So a laboratory experimental study has taken to address this issue. A series of permeable structural measures i.e. structures prepared by bamboo sticks & chatai are constructed in laboratory flume. With the use of these structures, river bank sedimentation is developed. The velocity distribution at the upstream & downstream of the constructed permeable structural measures has an effect for the river bank sedimentation. The velocities in between the structures are less whereas the velocities away from the structures are relatively higher. It is important to note here in this paper so that the river bank sedimentation has a indication for the river bank erosion protection.

Keywords: laboratory experiment; permeable structural measures; river bank sedimentation; river bank erosion protection

1. Introduction

River bank erosion and channel shifting are recurrent problems in Bangladesh that usually occur during the monsoon (more specifically, during rising stage and recession stage) when huge sediment load is generated by means of bank erosion and bed changes. Conventionally, spurs, groins, revetments or combination of them are used in order to manage sediment load thus generated and mitigate river erosion and related problems. Spurs, groins or revetment-like structures are too expensive to adapt along the longer reaches of the large-scale alluvial rivers in Bangladesh. Therefore, it is important to develop alternative low cost approaches that can be adaptive within local socio-economic and environmental condition.

In Bangladesh, over the years, channel width is increasing and depth is decreasing because of unfavorable geographic location and discharge control by the countries in the upstream reaches that lead to unexpected erosion-siltation processes along the major rivers. It is very difficult and even impossible to maintain in-stream flow requirement that is very important for the maintenance of river ecology and aquatic habitat necessary for the healthy life cycle of plants and animals. Rivers are loosing their navigability and waterways are severely obstructed during the dry season. On the other hand, conveyance capacity of rivers is reducing and is insufficient for safe and expeditious passage of floodwater and sediment discharge during the monsoon. As a result, country had experienced severe flood disasters during the past such as in 1988 and 1998. However, the situation seems to get more severe gradually as compared with the past events.

Floodplains and riverbanks are developed from recent deposits consisting mostly silt and fine sand that are highly susceptible to erosion. As a result, the river channels often shifts within wide range of river belt. To prevent the river erosion groins, spurs, revetments, porcupines, sand bags, boulders etc are applied. Some of these methods (groins, revetments) are very expensive considering the large river dimensions and corresponding limited financial strength of Bangladesh. On the other hand, porcupines, sand bags, boulders are being used from experience of local people against river bank erosion and none of these methods have been proved to be effective for the protection of river erosion in long-term basis.

Bandals are one of the local structures developed in the Indian sub-continent that obstruct flow near the water surface and allow it to pass near the riverbed. These are made of naturally available materials such as bamboo, wood etc. and regarded as inexpensive method over conventional structures and mostly applied for the improvement of navigational channels during the low flow season. But application of Bandalling for riverbank protection is not yet practiced in Bangladesh. In recent past some field tests along the Jamuna was executed for the bank protection using Bandalling (FAP 21/22, 2001). At the laboratory scale, the preliminary idea on the possibility of use of Bandalling for sediment management (erosion and siltation) was discussed (Rahman et al., 2003, 2004).The main objective of the laboratory experimental study in order to investigate the sediment deposition and the flow field around bandals that are conducted under different scenarios.

2. Methodology

To achieve the objectives of the study, an experimental set are taken in re-circulated straight flume that is 22 m long, 2.2 m wide and 1.05 m deep. The flume setup was in live-bed condition. The effect of a series of bandals structures are examined in terms of the arrangement of spacing & with certain angle of the flow direction in the flume river channel. The laboratory experimental set-up with the circulated water supply system is shown in Fig.1 & Fig. 1a.

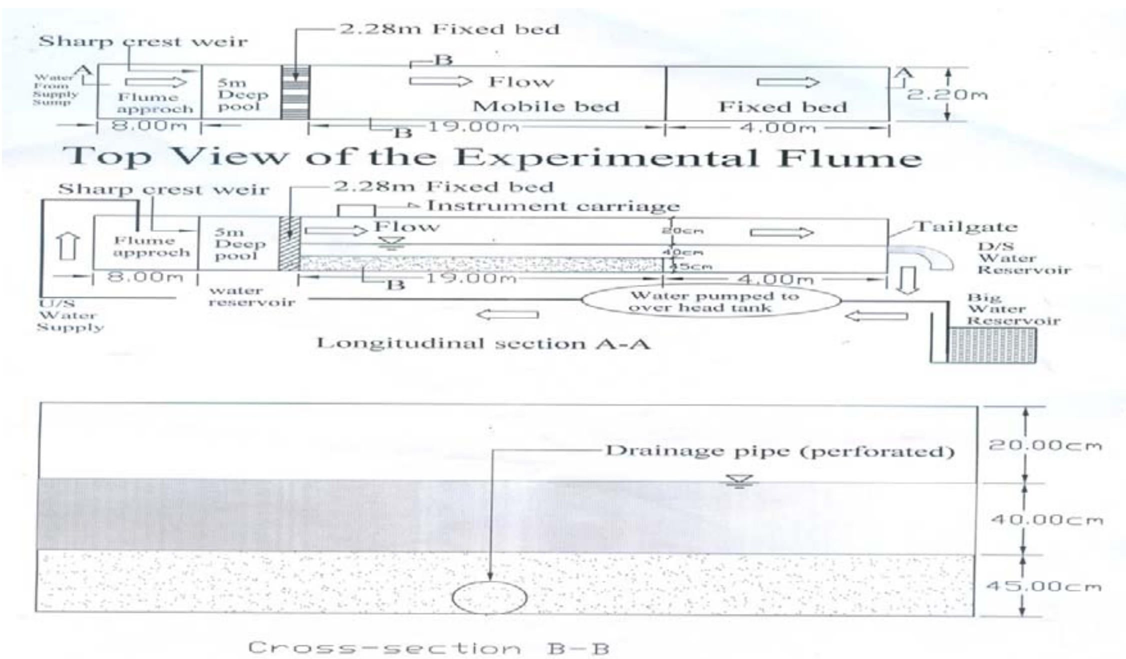


Fig.1 Laboratory experimental set-up with the circulated water supply system

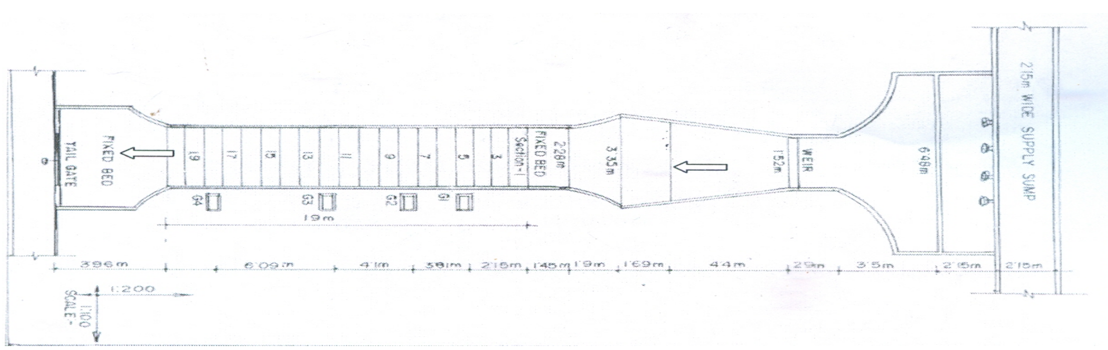


Fig. 1a The experimental test rig using for velocity measurement as wel as the bed level data collection

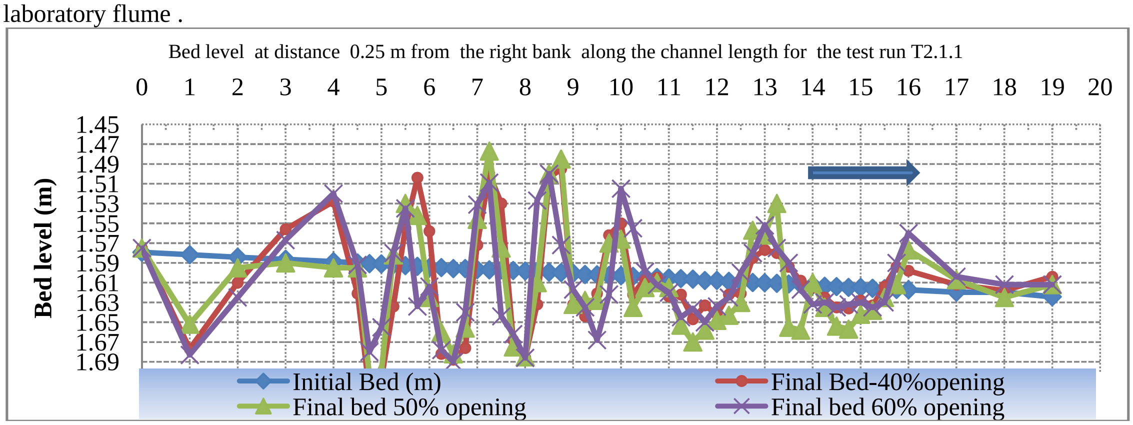
The laboratory channel/ flume width is 2.2 m which 30% i.e. 66 cm is blocked at the right bank by the bamboo bandalling structures. The test scenarios with the different channel parameters are seen in table-1.

Table -1: Matrix showing different experiment scenarios of the laboratory flume/channel

Channel/ Flume Contraction (C) in percentage	Angle with flow Direction in degrees (θ)	Length of the Bandal in centimeter (L)	Spacing between the bandals in centimeter (S)	Opening below the bamboo chatai in the percentage of water depth (36 cm) of the channel/flume in centimeter (O)	No. of bandals (Test name)
30	30	132	1.5*132=185	40	4 (T2.1.1)
			2.5*132=330	40	3(T2.3.1)

3. Result & discussion

As the channel is blocked by 30% at the right bank of the channel, the sedimentation is occurred near the right bank which is shown in Fig.2 whereas the channel bed is deepen away from the right bank. In the Fig. 2, the x-axis shows the channel length from upstream to downstream in metre along the main flow of the channel whereas the y-axis shows the channel bed level measured from a Temporary Bench Mark (TBM) from the different grid points at 25 cm intervals from the right bank. The plot line shows the initial bed level as well as the river bank sedimentation due to effect of the bamboo bandalling structures along the channel length of the laboratory flume .



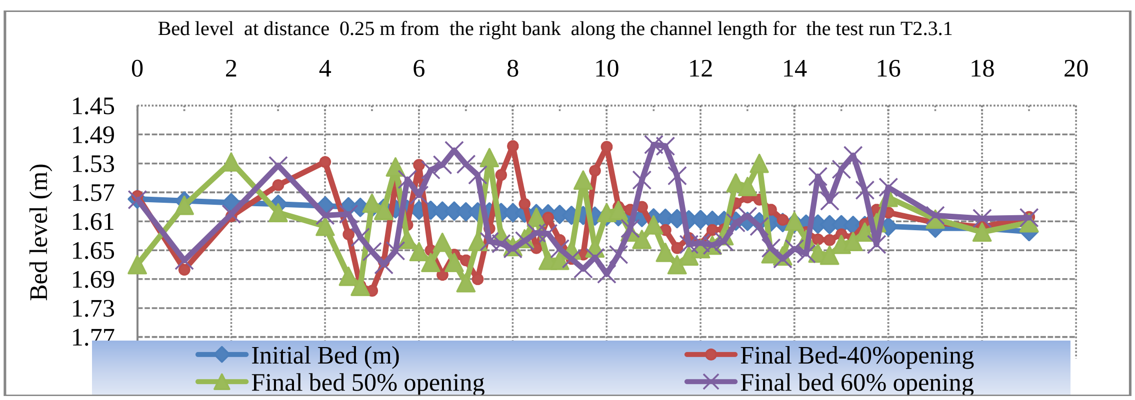


Fig.2 River bank sedimentation of the bamboo bandalling structures constructed in the laboratory flume .

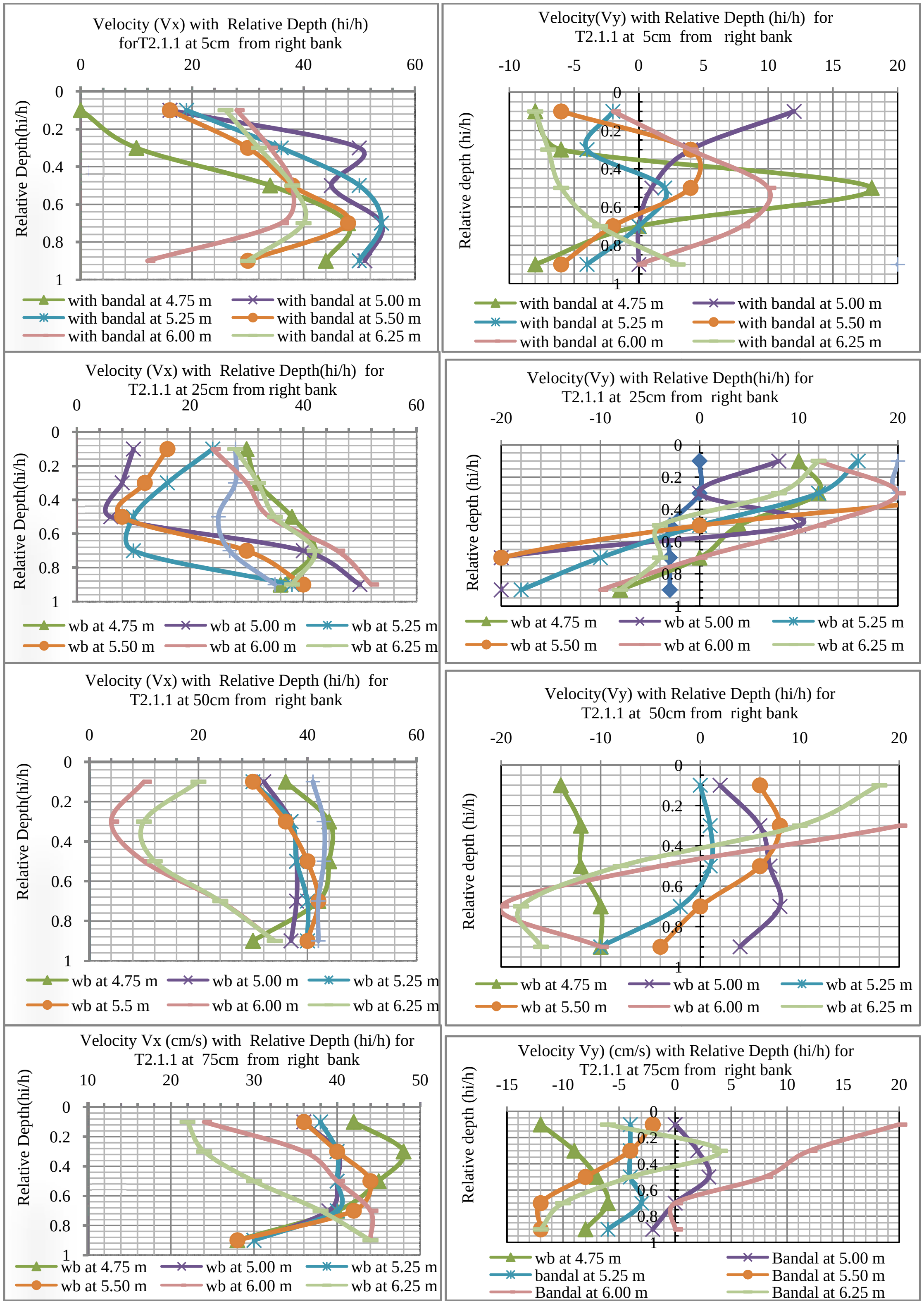


Fig.3 : Velocity distribution at different grid points at depth 0.1h,0.3h,0.5h,0.7h & 0.9h where h=36 cm

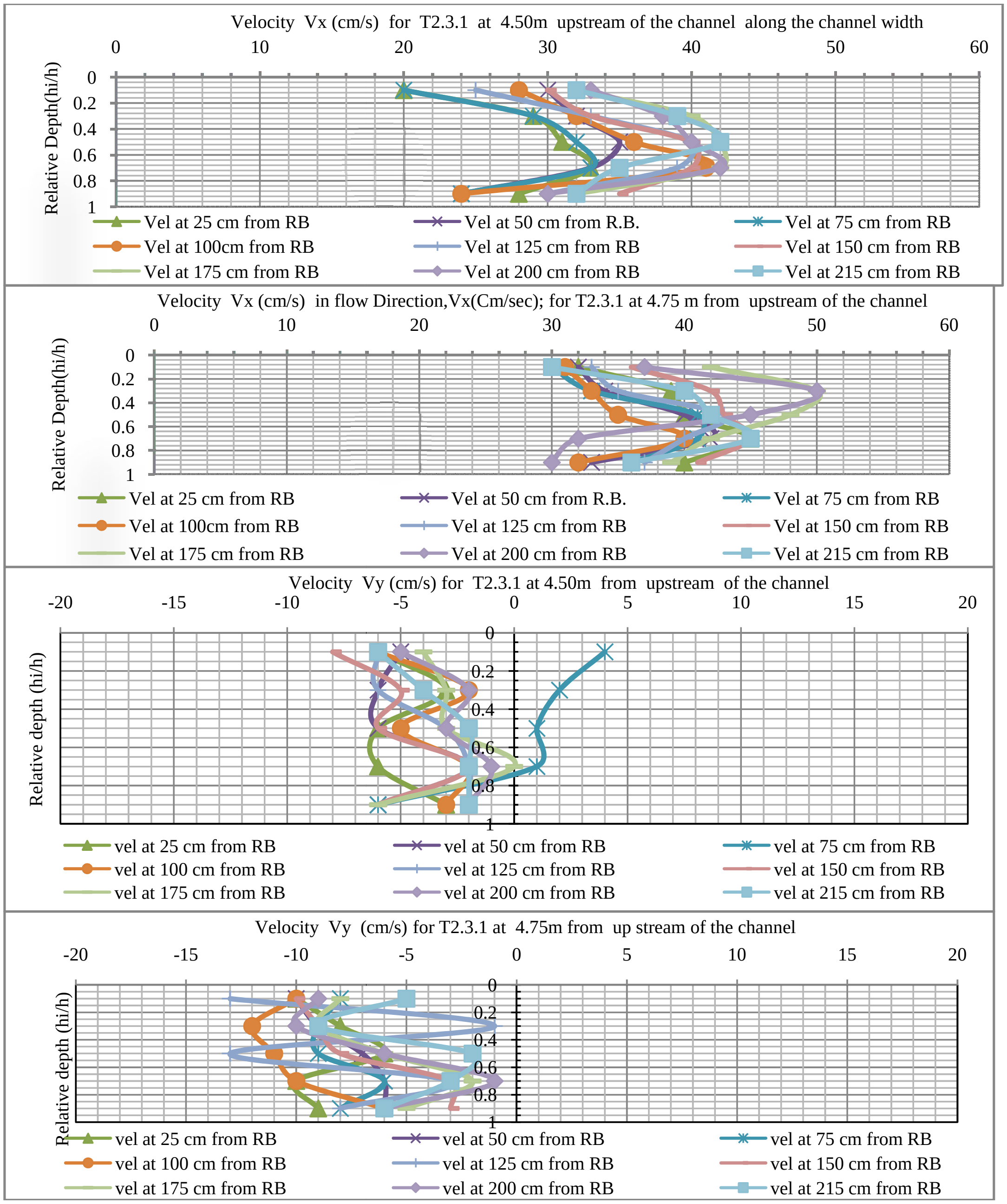


Fig.4 : Velocity distribution from right bank (RB) at depth 0.1h,0.3h,0.5h,0.7h &0.9h where h=36 cm

There are four bamboo bandalling structures are constructed near the right bank of the laboratory flume for test run T2.1.1 as in Fig.3 and that of 3 bandals are constructed as in Fig. 4 for the test run T2.3.1. Tthe velocities are measured at 25cm grids except the 1st one is measured at 5cm from the right bank. The grid points velocities are measured in each points at depths 0.1h, 0.3h, 0.5h, 0.7h & 0.9h from the water surface where h is the depth of water at initial bed condition which is 36.00 cm. As in Fig.3, distribution of velocities at distance 5cm from right bank at points 4.50m,4.75 m, 5.0 m, 5.25 m, 5.5 m, 6.0 m & 6.25m are measured and graphically presented for test run T2.2.1. If the velocities are taken at point (4.75m, 5cm), it is seen that at 0.1h water depth velocity is much less and that velocity increases in deeper water at points 0.3h, 0.5h & 0.7h. It appears to be realistic, because the points 0.1h, 0.3h are behind (downstream) bamboo chatai. Bamboo chatai blocked water current down to 18 cm (0.5h, 50% blockage in this test arrangement). As a result, the velocities are much less. But at 0.7h depth velocity is maximum at this grid location. It is obvious since this point is below the bamboo chatai. So the point is in the opening (water could flow freely below the chatai). Now the lowest point (at 0.9h depth) shows again relatively less velocity than that at 0.7h. Again it is realistic since it is near the bed & influenced by bed friction or other parameters.

Similarly if compared velocities at grid (4.5m, 5cm) with that at other grid points such as (5.0m,5cm),(5.25m,5cm),(5.5m,5cm),(6m,5cm), (6.25m,5cm) that shows higher velocities (but nature of vertical distribution is similar). It is realistic/ natural since the grids lies downstream and further away from the structure (Chatai), the chatai has less influence on this grid point. If velocities at grid points away further from 5cm such as 25cm, 50cm and 75cm is considered as in both 3 & Fig.4, it is seen that the velocities further away from 25 cm & 50cm and in more distance from the right bank are higher in magnitude. This is obvious, since they are away from the structure and the structure has less influence on them.

The velocity Vx distribution profiles as in Fig. 3 & Fig.4 represent the result as in Fig.2 in which there is sedimentation behind the bamboo bandals near the right bank of the flume. From Fig, 2, it is clear that the river channel bank is deposited where as Main River central channel is deepening to improve the navigational channel development. Although there is an idea from the Fig. 2 so that the river channel is deepen away from the right bank & at the same time the sedimentation near the river bank. Again from the Fig.3 & Fig.4, it is clear that the channel flow velocity is less behind the bandal as well as the velocity away from the influence of bamboo bandals i.e. from right bank is more or grater.

In case of velocities Vy perpendicular to the main flow velocities Vx is considered as in Fig. 3 & Fig.4, all the Vy velocity components moves towards the right bank & in these case the velocities are working as a sediment carrying agent. For the case of the velocity Vy perpendicular to the main flow velocity is always scattered and direction of these velocities are negative in magnitude that indicate the velocities are in towards the right bank that carry additional sediment near the right bank so that the river bank sedimentation occurred near the channel right bank.

5. Conclusion

In conclusion, we can say that bandals are capable for flow diversion towards the main channel leading to deep navigational channel formation. On the other hand, flow velocities are reduced near the bank lines that ensure sediment deposition. . If the bandal structure functions optimistically, the river can get sufficient time for its adjustment and new main channel and bankline development.

6. Recommendation

Pilot projects are recommended in the field are very important to execute before applying such method for the formation/ restoration of navigational channels in alluvial river. The output of the present research for the stabilization of river course can solve the problems of Bangladesh that is more or less inherent due to its complex geographical location at the lower riparian of the catchments

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