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River bank erosion protection using bamboo bandalling structure: a case study

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Abstract

Bandalling is a locally bamboo made structure used in the river bank erosion prone area for the river course stabilization. Due to locally available low cost materials, the construction cost of the bandalling is also low. The bamboo bandalling structures are placed at the river bank erosion prone area of the river Jamuna near the Shaheed Salahuddin Cantonment at the upstream of the Bangabandhu Bridge East Guide Bund, Bhuapur, Tangail, Bangladesh. Due to the effect of the constructed bamboo bandalling structures in the river bending reach, there is huge sedimentation behind the bamboo bandalling structures and at the same time river course matches with upstream and downstream reach. This matching gives an indication of channel stabilization by stopping the river bank erosion in the bend of river reach as well as destroying the secondary which is responsible for accelerating the river bank erosion. It is observed that water flow is diverted towards the main channel and low flow velocity near the river bank. Due to low flow velocity near the river bank, sedimentation occurs near the river bank between the constructed bandals indicating that bandalling can be used successfully as river bank erosion protection structures as like as the conventional groin/spur like structures.

Keywords: Bamboo Bandalling structures, river bank erosion, sedimentation, groin

1. Introduction

The alluvial rivers of Bangladesh have its bank erosion. Due to this river bank erosion, the socio-economic conditions of the country are being affected. By this time of 1960's Bangladesh Water Development Board (BWDB) has constructed a number of earthen embankments along the major rivers such as the Brahmaputra-Jamuna, Ganges-Padma to protect the rural people and agricultural lands from the damage in flooding. Since then the constructed embankments were retired several times due to river bank erosion during flood period in Bangladesh. Due to this river bank erosion, the bank protection are often required also during the monsoon flood season and post-monsoon.

The structures spur/groins and revetments are used as a method of bank protection conventionally. The characteristics of the alluvial rivers are such that its river courses are shifting within the limited regime width by changing its depth of the flood plains rivers. Some cases the length and width of the river is more than the regime length and width of the river. It gives us an indication of the degree of instability of rivers in Bangladesh.

If the bank protection structures such as groynes, revetments or spurs are applied in the alluvial rivers the utmost success may be achieved protecting river bank locally. But these structures will create problem somewhere else resulting far away bank erosion and additional instability to the sand bars where a number of rural people may be lived in the sand bars or chars. So, applying these conventional methods of countermeasure, the river bank erosion at the short term basis can be obtained, whereas, the long term stable channel or regime channel can never be developed. The possibility of using bandals for long-term channel stabilization is examined using field data and laboratory investigation (Rahman *et al.*, 2003).

It is obvious from the flood hazards so that the river bank erosion is one of the natural disaster in Bangladesh. The global climate is changing which has an effect in Bangladesh for the river bank erosion. So it is needed to protect river bank erosion. It is mentioned here that every year the river bank is being eroded and the intensity of erosion is increasing day by day.

A pilot test basis project was taken with the application of the low cost bandalling structures in the Jamuna River at the upstream East Guide Bund of the Banghabandhu Bridge near the Shaheed Salahuddin Cantonment area to protect the river bank erosion. The low cost Bandalling structures are placed at the river bank at an angles with water flow direction with the spacing 2 times of the Bandals length.

It was observed that water flow diverted towards the main river due to Bandals resulting maximum velocity accumulated towards the main river whereas comparatively less velocity appeared near then river bank where Bandals were placed resulting sediment deposition. This near bank sedimentation of the river gives us an indication for the river bank erosion protection which is very low cost. From Bangladesh Water Development Bord (BWDB) practiced different river bank erosion structures, we can get the comparative costing from literature as shown as in the table1.

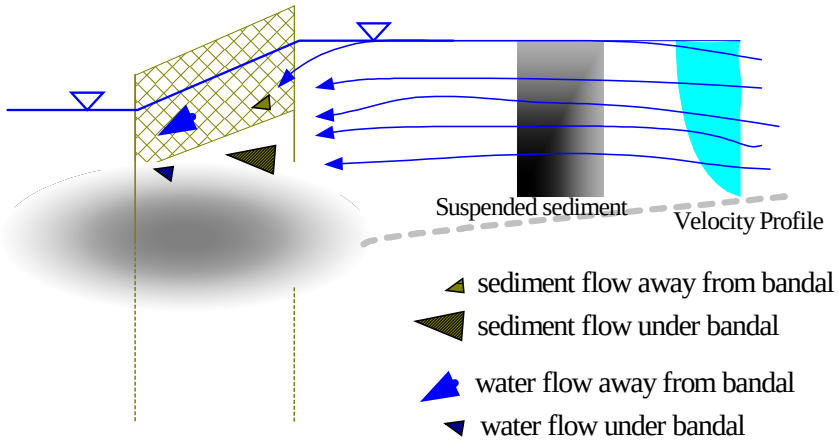
As because of the bamboo bandalling structures are constructed with the locally available bamboo as raw materials and local labor oriented workers and so this is the low cost method for the river bank erosion protection structures (Rahman, *at el.*, 2009).

Table 1
Comparison among implementation cost of different bank protection structures

Type of structure	Name of the Rivers	Implementing Agency	Cost in USD
Guide Bund	Jamuna (Bridge)	Foreign	33,000.00
Hard point	Jamuna in Sirajgonj	Foreign	21,000.00
Solid spur	Jamuna in kalitola	Foreign	12,500.00
Revetment (Geobags)	Jamuna	Foreign	2000-3000
Revetment	Jamuna	BWDB	3800-4000
RCC spur	Jamuna / Ganges	BWDB	950.00
RCC spur	Teesta	BWDB	350.00
Bamboo Bandalling	Jamuna (Branch Channel)	RRI	70.00

2. Working principle of bandals

The working principles of bandals for the control of water and sediment flow are shown schematically in Figure-1, where sediments are transported as bed load and suspended load (Rahman, *et al.*, 2007). The above working principle was the beginning of the bamboo bandalling work and using here as a reference so that within the lower half of the flow depth, major portion of the sediment flow is concentrated, whereas, within the upper half water discharges are more. It is also mentioned that in the Indian sub-continent bandals are commonly applied to improve or maintain the flow depths for navigation during low water periods in alluvial rivers. The characteristics of bandals are that they are positioned at an angle with main current and there is an opening below it while the upper portion is blocked.It is mentioned that as an empirical rule the blockage of the flow section should be about 50% in order to maintain the flow acceleration (Rahman *et al.*, 2003), but in this paper it mentioned that the flow depth is blocked by bamboo chatai for about 60% and the result is very good with huge sedimentation behind the bandals.



The quantity of water and sediment flow is expressed by arrow size.

Fig. 1. Working principles of bandals (Rahman, *et al.* 2007)

There is a pressure difference at the upstream site and downstream of the constructed bandals. The higher pressure is in the upstream of bandals than that of the bandals in the downstream site. Due this pressure difference, water flow is forced along with the sediment below the opening of the bandals and the surface current is being forced towards the main river channel. So, much sediment is supplied from the upstream site to the river bank. There is reduced flow velocity behind the bandals near the river bank resulting sedimentation over there.

3. Bamboo bandals construction for river bank erosion protection

The bamboo bandalling structures are constructed from the left bank of the Jamuna branch channel and protruded towards the main river channel near the Shaheed Salahuddin Cantonment, Bhuapur, Tangail as in figure. 2 and before the bandal construction the eroding river bank is looked like as in figure-3 (IEB, 2010) shown below. The condition of the river bank before taking the erosion protection by the bamboo bandalling structures, it was very steep slope. The channel near the river bank was very deep. In this situation bamboo bandalling was constructed. The initial river bank conditions were seen as in figure 3 in above. This low cost Bandalling structures were placed on the left side in the Jamuna river branch channel from up stream to downstream at 45 degree angles with the water flow direction i.e. the bank line is shown in figure 4.

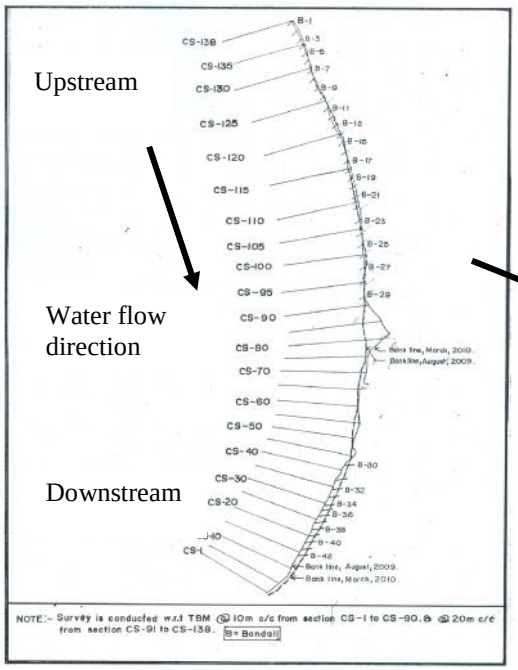


Fig. 2. location of bandal construction

Fig. 3. Eroding river bank before bandals construction

Fig. 4. Bamboo Bandals constructed in the Jamuna River (Rahman *et al.*, Hydro conference 2009)

Fig. 5. Photographs showing bandals in 2009 flood and that of after flood

As in figure 5(a), the officers of the Bangladesh Bridge Authority (BBA), River Research Institute, Faridpur as well as the Bangabandhu Bridge Special Orginization (BBSO) are visiting the bandalling construction site during 2009 flood. There is huge sedimentation

behind the bandals seen as in the figure 5(b) after 2009 flood. The sedimentation behind the bamboo bandalling structures is responsible for the flow field behind the bandal like structures. There is an idea gathered by the flume study set up as in figure- so that at the upstream of the bamboo bandalling structure no disturbance in the velocity vector field as in figure- , where as the velocity vector field at the bandal location as well as behind the bandal location, the velocity profiles near the river bank in the bandals construction zones is disturbed. This effect of bamboo bandalling structures constructed in the laboratory study on river flow & morphology is published by the same author (s) in the 6th Symposium on River, Coastal and Estuarine Morphdynamics 2009 (Rahman *et al.*, 2009) mentioned here as a reference given below.

Fig. 6. Bandalling experimental set-up at laboratory

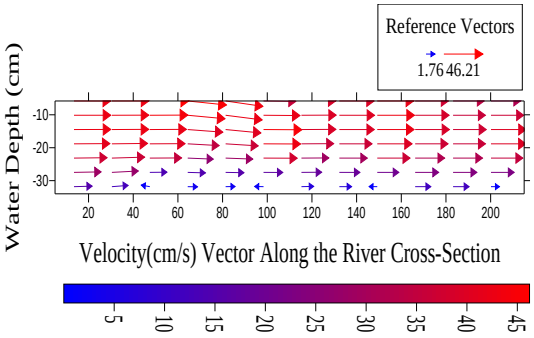


Fig. 7. Velocity vector at u/s of the bandalling

So it can say that bandals are capable for protecting river banks by flow diversion towards the main channel leading to deep navigational channel formation in the main river. On the other hand, flow velocities are higher at the main channel increased the depth of the navigational channel that ensure the navigational channel development. If the bandal structure functions optimistically, the river can get sufficient time for its adjustment and new main channel and bank line development

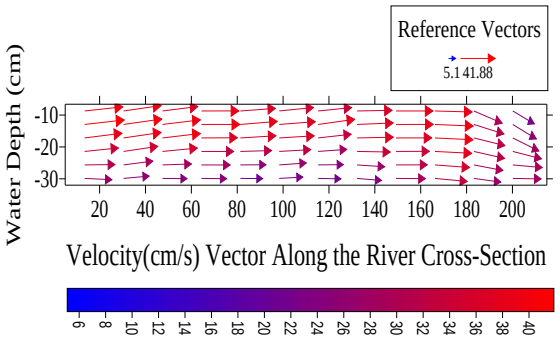


Figure 8. Velocity at bandal construction location

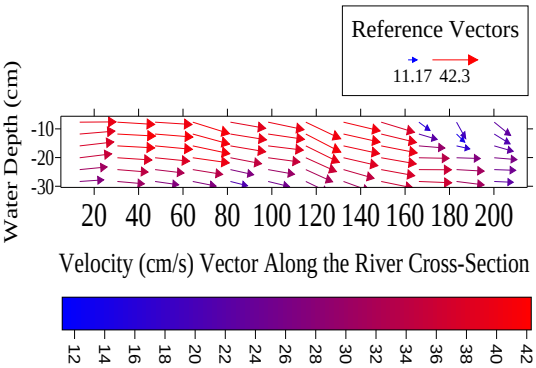


Figure 9. Velocity vector at d/s of the bandalling

4. Data Collection and Analysis

The river bathymetry data is collected from the cross- section 1 through cross- sections 138 over a length of river reach 1.5 km. For the better analysis, this 1.5 km river reach is divided into three reaches as in figure-2. The three reaches such as the 0.50 km downstream reach, 0.70 km middle and 0.3 km upstream reach. There is taken one cross-section no. 6 as in the figure-3 from the downstream 0.50 km reach, two cross-sections no.86 & 88 are taken from the middle 0.70 km reach and that of one cross-section no. 106 is considered as in figure-3,

4(a) & 4(b) and 5 respectively. The bed level, water level data are collected in this problem area with reference to a Temporary Bench Mark (TBM) near the Bangabandhu Bridge East Guide Bund.

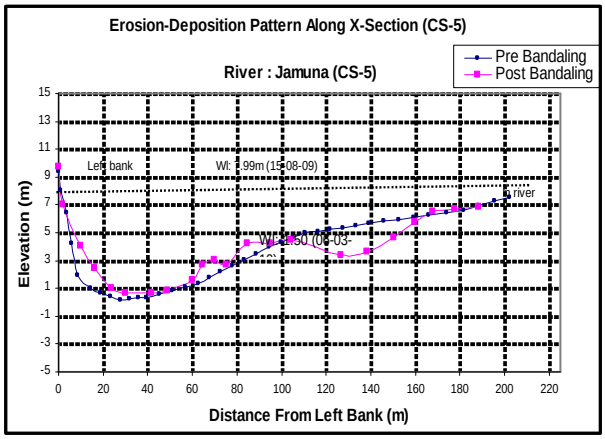


Fig. 10. X-section within 0.5 km d/s reach of 1.5 km

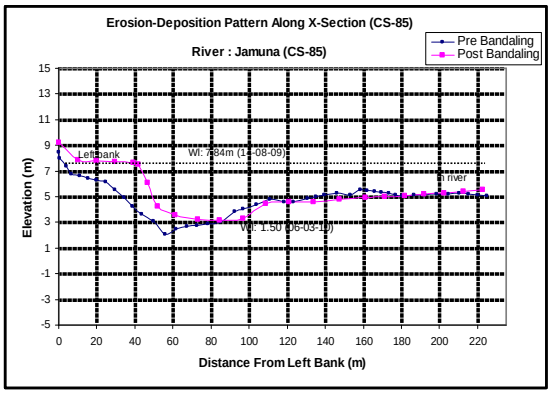


Fig. 11(a). X-section within 0.7 km middle reach of 1.5 km

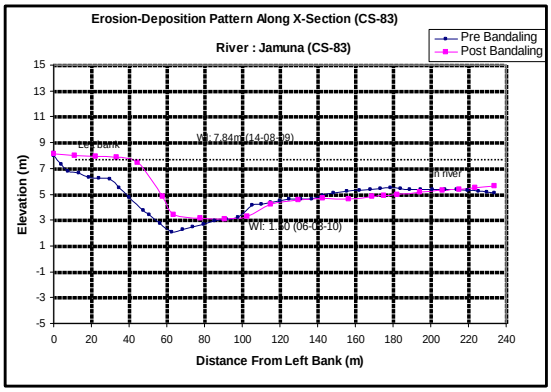


Fig. 11(b). X-section within 0.7 km middle reach of 1.5 km

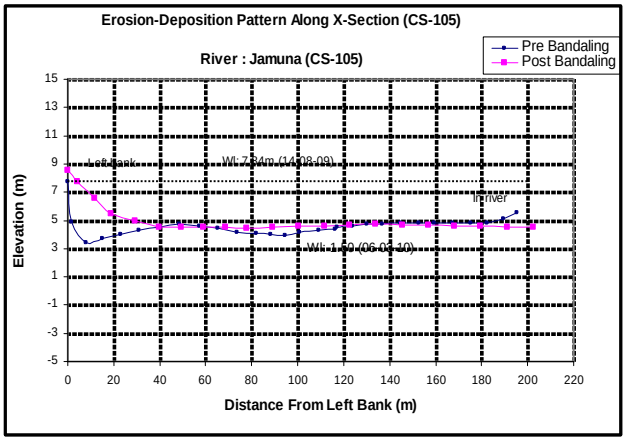


Fig. 12. X-section within 0.3 km u/s reach of 1.5 km

5. Results and Discussion

The constructed bandals near the Bangabandhu Bridge functioned well to river bank erosion protection through near bank sedimentation. It is evident from the above figures as in 11(a) and 11(b) so that there is about more than 30 m sedimentation towards the horizontal

direction and about more than 3 m sedimentation in the vertical direction near the river bank from at the middle 0.70 km reach. At the upstream 0.30 km river reach as in figure-8, there is less sedimentation due begining thrust of flowing water pressure, but there is river bank erosion protection. This position will be improved if bamboo bandalling structures are constructed in further upstream of this reach. At the remaining downstream 0.50 km river reach as in figure-6, there is also less sedimentation due to direct impact of the flowing water trust, but river bank erosion protection. It is also mentioned that even in some area of this reach, there is little bit bank erosion due to some unavoidable reason such as (i) there are so many sand businessmen & they are plying the sand loaded water vehicles as like as the cargo vessels or heavy barges or trailers that remove the deposited sediment soil from the river bank, (ii) within this reach, there is bend effect so that flowing water hit directly in the flood period, (iii) there is some public dredger parties conduct dredging operation to fill the some ditches or to collect sand for further away, (iv) there is dredging operation to fill low laying area of the Shaheed Salahuddin Cantonment for about 2(two) months during the 2010 flood season, and (v) due to this dredging operation, the morphology of this downstream area is seriously changed by forming nearby char just immediately upstream of this reach and (vi) bank erosion in this reach is accelerated although char erosion steps are on going to divert some portion of water flow from the upstream of this reach. To protect this downstream 0.50 km reach, a series of bamboo bandalling should be constructed over the char land from the upstream river bank to divert some portion water flow from the thalweg line of the river bank. From now to this coming 2011 flood is the appropriate time to work with bandals construction. If the bandals are constructed to erode the char to divert flow over the char, there will sedimentation at the 0.50 km reach area.

6. Conclusions

From the above result and discussions, it can be concluded that use of bamboo bandalling structures will be very much effective for the river bank erosion protection. It can also be concluded that the bandals are working as a river bank erosion protection structures. In addition to this main conclusion, the flowing points should be taken in consider for better achievements for this special case studies:

- any type of sediment soil near the river bank should not be removed
- no further dredging operation near the river bank of the problem area
- the activities of sand businessman should be restricted
- constructed bamboo bandalling structures should be maintenance properly
- in the bandals constructed area, the sand loaded water vessels movement should be restricted

Previously constructed bamboo bandals are to be repaired before the up coming 2011 flood and during the flood.

7. Recommendations

The following recommendations should be considered for further study.

- Some places of the whole 1.5 km reach, some more or less 10(ten) new bamboo bandals approximately 25 m each are to be constructed.
- To avoid the erosion near the tip of the Bangabandhu Bridge East Guide Bund, there will be needed to complete the selected 2.5 km river reach to construct bandals for making sedimentation near the east guide bund in lieu of erosion.
- Some hydraulics and morphological data should be collected from this 2.5 km river reach to get comprehensive result for this bamboo bandalling application.

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