Water Acts as a Dredger to Protect River Side Industry using Bamboo Bandals

Dr. Engr. Md. Lutfor Rahman, PEng
Director, Hydraulic Research Directorate
River Research Institute, Faridpur-7800, Bangladesh
lutforntf@gmail.com

Abstract

River dredging is the intelligent arrangement for the river bank erosion protection. Most of the industries are situated near the river bank and those are facing river erosion. To avoid these river bank erosion, water can be used as dredger to combat river side industries situated near the river. To address such a national problems, a laboratory study is conducted at River Research Institute, Faridpur, Bangladesh. In the laboratory river channel banks, a series of bamboo bandals are placed to dredge the river to combat erosion. For this low cost approach, it is needed to know in details in the laboratory before going to the field. In laboratory, it is observed that water flow diverted towards the main river due to bandals placing near the river bank resulting comparatively high velocity appeared away from the erosion prone area of the industry where water acts as dredger deepening the channel. This has given an indication that water is act as a dredger to combat erosion near the river bank industries.

Keywords
Water, erosion, dredger, industry, bamboo bandals, river channel.

1. Introduction

In Bangladesh, over the years, river channel width is increasing and depth is decreasing because of unfavorable geographic location. 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 losing their navigability and water-ways and 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 flood water 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 river banks 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, the structures such as 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 the 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.

Bank erosion and channel shifting of the untrained alluvial rivers of Bangladesh are big problems to the socio-economic and environmental sector of the country (Klaassen 2002). During 1960's, a number of earthen embankments were constructed along the major rivers for the protection of rural people and agricultural lands from flooding. Since then the embankments were retired several times due to river bank erosion and bank protection are often required during the monsoon and post-monsoon season. Conventionally, groins and revetments are applied as a method of bank protection. Very recently the concept of hard points (strong revetment type structure) at the most vulnerable locations along the Jamuna river are considered, while in between hard points spurs or permeable groins are recommended (Klaassen 2002). In some reaches, channel widths along the major rivers are 2-3 times wider than the so called regime width while the water depth is around $1/3^{rd}$ of the regime depth which indicating the degree of instability of rivers in Bangladesh. If the bank protection structures such as groins, revetments or spurs are applied in such 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 (chars in local name) where a number of rural people are used to live in.

Figure 1. River System of Bangladesh

Therefore, 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. Alternative solutions that can be locally adaptive and friendly to environment, need to be developed for the long-term stabilization of river channels. The possibility of using bamboo bandals for long-term channel stabilization is examined using field data and laboratory investigation (Rahman et al., 2003).The responses of large scale alluvial rivers again.st sudden changes created by conventional structures are not suitable for the overall stabilization of river courses. Therefore, it is important to have alternative long-term solution for river stabilization that will create minimum disturbance to river courses as in Figure 1.

Bandals are one of the local low cost structures and there is an opening below bandal while obstruct flow near the water surface and allow it to pass near the riverbed. Bandals are positioned at an angle with the direction of flowing water. Naturally available materials such as bamboo and timber are used for bandals. The surface current is being forced from upstream side of the bandals and pushed it down near the bed towards bank at the down streamside. More sediment flow than water flowing towards the bank from the river side so that excess sediment deposited near the riverbank. There is a considerable pressure difference between the upstream and downstream side of the bandal.

Much sediment is supplied towards the countryside and relatively much water is transported to the riverside. Bank protection and river training works are therefore, one of the prime necessities for poverty alleviation and national growth. The issue is the safety of lives, land and sustainability of the infrastructure against the forces acting in the rivers. Bank erosion and channel shifting of the untrained alluvial rivers of Bangladesh are big problems to the socio-economic and environmental sector of the country. During 1960's, a number of earthen embankments were constructed along the major rivers for the protection of rural people and agricultural lands from flooding. Since then the embankments were retired several times due to river bank erosion and bank protection are often required during the monsoon and post-monsoon season. Conventionally, groynes and revetments are applied as a method of bank protection.

Alluvial rivers are characterized by the fact that the alluvia on which the rivers flow, are built by rivers themselves. The main characteristics of these river reaches is the zigzag fashion in which they flow, called meandering. They meander freely from one bank to other and carry sediment which is similar to bed material. Material gets eroded constantly from the concave bank (outer edge) of the bend and gets deposited either on the convex side (inner edge).

One would assume a large river flowing in alluvium would maintain a relatively uniform morphology because its dimension should follow the rules of hydraulic geometry, and its gradient and pattern should reflect the type of sediment load and valley characteristics. The significant stream power exerted by these formidable fluvial systems should ensure that long reaches of alluvial channels maintain a characteristic and relatively uniform morphology. But, in fact, the substantial energy of these mega river systems in many cases is inadequate to overcome accidents of geologic history and geologic controls. Large alluvial rivers appear to be sensitive to influences that can be relatively small. They frequently respond to factors that are not included in hydraulic models and sediment transport equations.

The performances of the bank protection structures and the recurrent measures, as well as the response of the river, have been monitored for several years, developing and applying new techniques of measuring & modeling. FAP 21 produced some progress in process based modeling of two mechanisms by which the mere presence of bank protection structures increases the loads on these structures: (i) the deeper bend scour due to stopping of bank migration [1]; and (ii) the attraction of channels and associated flow attack towards scour holes [2]. The stopping of bank erosion is assumed to produce deeper bend scour through: (i) prevention of bank sediment supply, (ii) channel narrowing due to retarded point bar growth, (iii) bend deformation due to local prevention of channel migration and (iv) vortices generated by flow impingement. A method was developed by Klaassen et al. [3], based on empirical laws derived from a large set of satellite images [4]. Jagers implemented the prediction method in a computer model and tested it against observations [5, 6]. He also constructed and tested an artificial neural network for the prediction of low-water plan form changes in the Brahmaputra-Jamuna

1. Working Principle Of Bandals

The working principles of bandals for the control of water and sediment flow are shown schematically in Figure-2, where sediments are transported as bed load and suspended load. 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. Bandals are commonly applied to improve or maintain the flow depths for navigation during low water periods in alluvial rivers of Indian sub-continent. The essential characteristics of bamboo 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. As an empirical rule the blockage of the flow section should be about 50% in order to maintain the flow acceleration. The surface current is being forced to the upstream face creating significant pressure difference between the upstream and downstream side of bamboo bandal. The flow near the bed is directed perpendicular to the bamboo bandal resulting near bed sediment transport along the same direction. Therefore, much sediment is supplied to the one side of channel and relatively much water is transported to the other side. The reduced flow passing through the opening of bamboo bandals is not sufficient to transport all the sediment coming towards this direction, resulting sedimentation over there. On the other side, more water flows with little sediment, resulting bed erosion of the channel on that side.

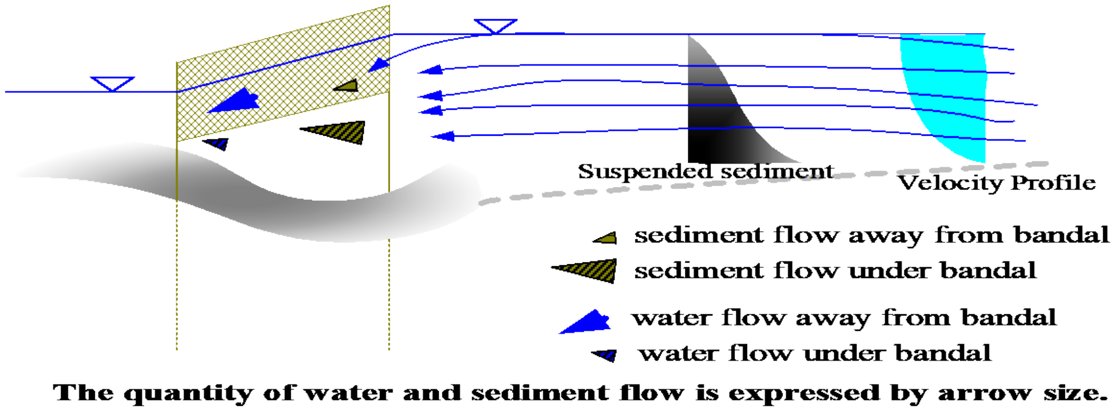

Figure 2. Working principle of the Bamboo Bandals

2. Data Collection & Analysis

There is a laboratory river channel at River Research Institute, Faridpur, Bangladesh from which required bathymetric & hydraulic data is collected. The dimensions of the laboratory river channel is in length, width and depth are respectively 22m, 2.2 m and 1.50 m as in Figure 3.

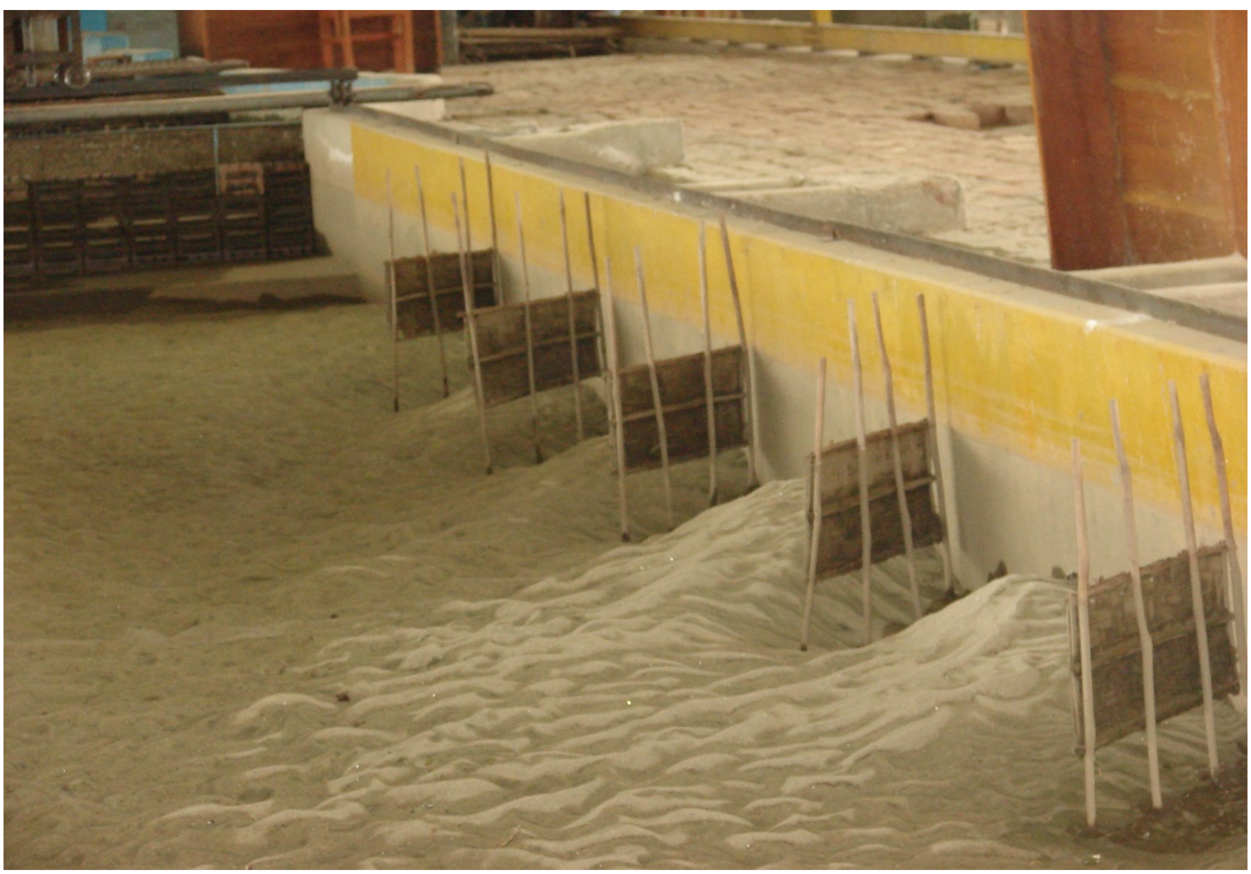

Figure 3. Laboratory River Channel where a series of bandals are placed near the river bank

3.1 Bed level contour map

The low cost bamboo bandalling structures are placed at one side in the laboratory river channel from upstream to downstream at 30 degree angles with the water flow direction. The bed level contour map for the 30 degree angle with the flow direction is shown below in Figures 4a and 4b.

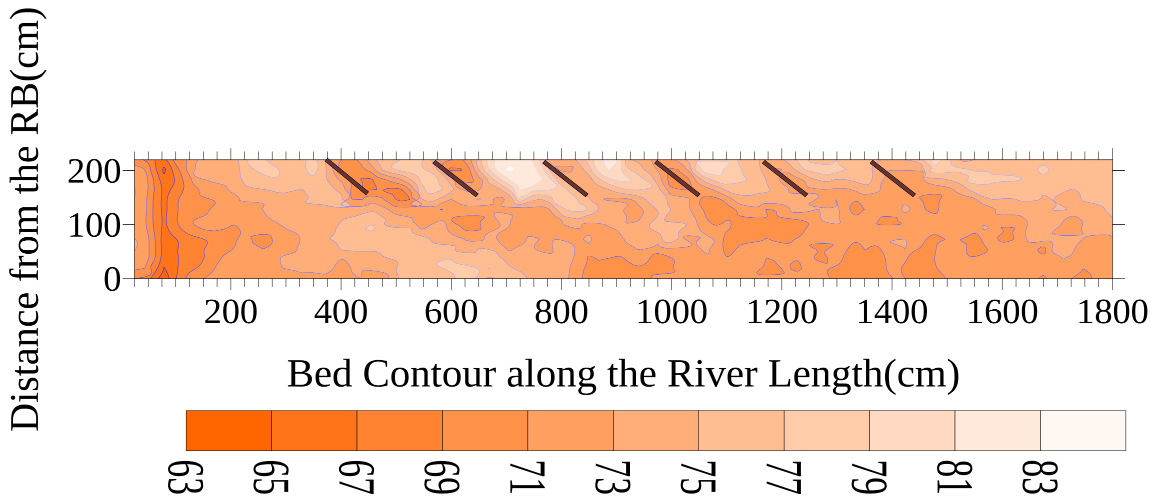

Figure 4a. Bed contour diagram of the river channel with lower slope

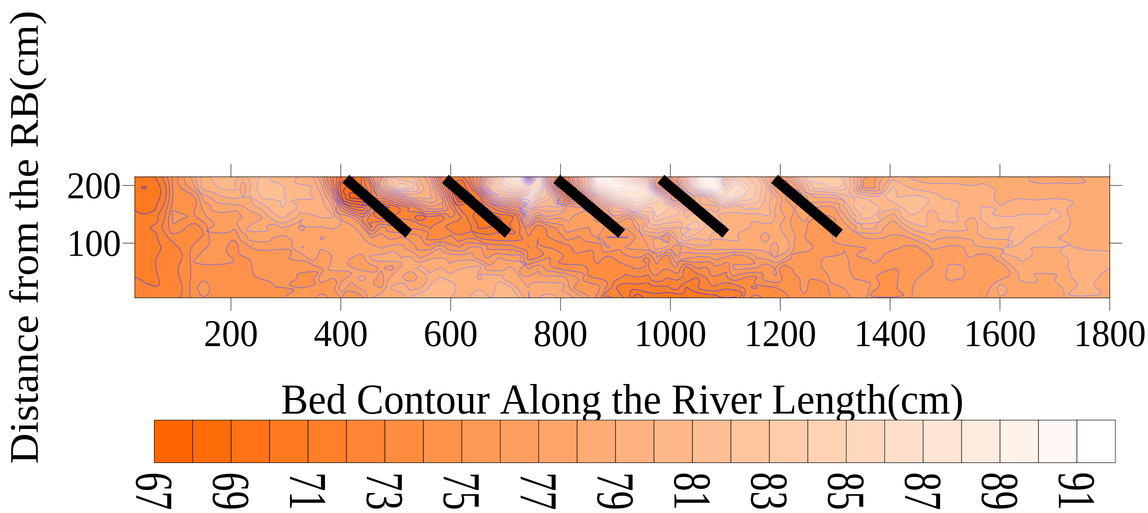

Figure 4b. Bed contour diagram of the river channel with higher slope

3.2 Velocity distributions

Velocity distribution with contour diagram as well as velocity vector diagram due to effect of bamboo bandals in the experimental river channel is given below in Figure 4. In this case, the velocity is measured with the two dimensional velocity meter with the automatic recorded computer. After collecting the velocity upstream and at & in between the bamboo bandals, the velocity vector diagram is plotted as in Figures 5a and 5b.

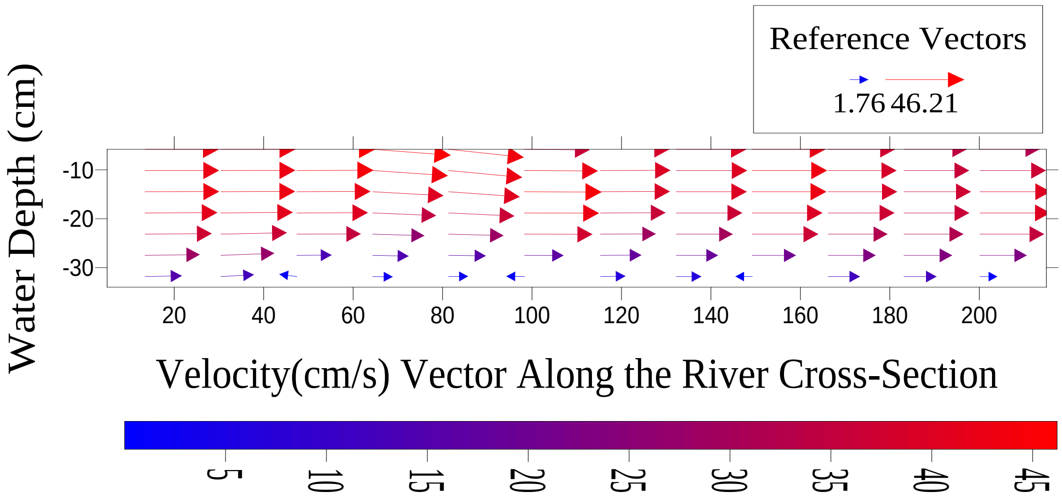

Figure 5a. Velocity vector diagram at the upstream of the bamboo bandals

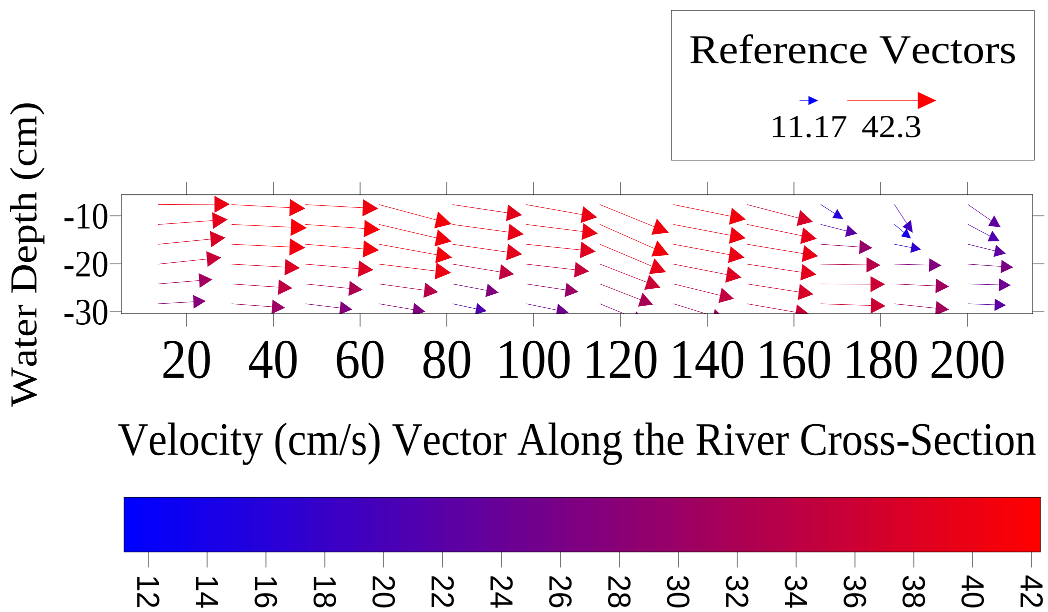

Figure 5b. Velocity Vector diagram at and in between the bamboo bandals

3.3 Bank Erosion Protection

Bed level reading is taken before the test run and that of after the test run. The test run conducted with the discharge 200 l/s & water surface slope was provided 8cm/ km. The bed level plot along the river channel cross-section is shown below in Figure 6a and 6b. The erosion protection pattern for the bamboo bandals spacing of 99 cm are found as in figure 6a. and that of the erosion protection pattern for the bamboo bandals spacing of 33cm is shown in Figure 6b.

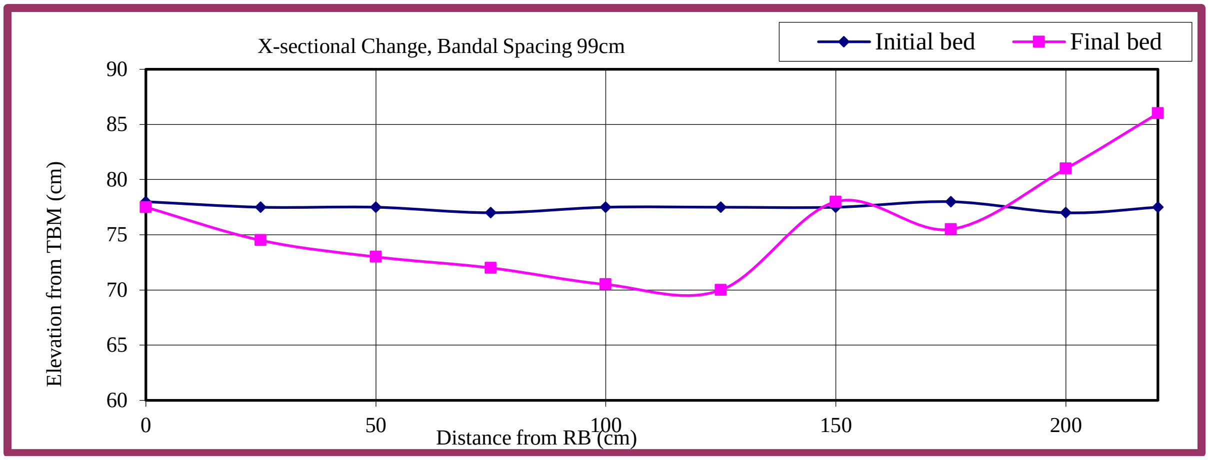

Figure 6a. Erosion-Deposition pattern along the cross-section

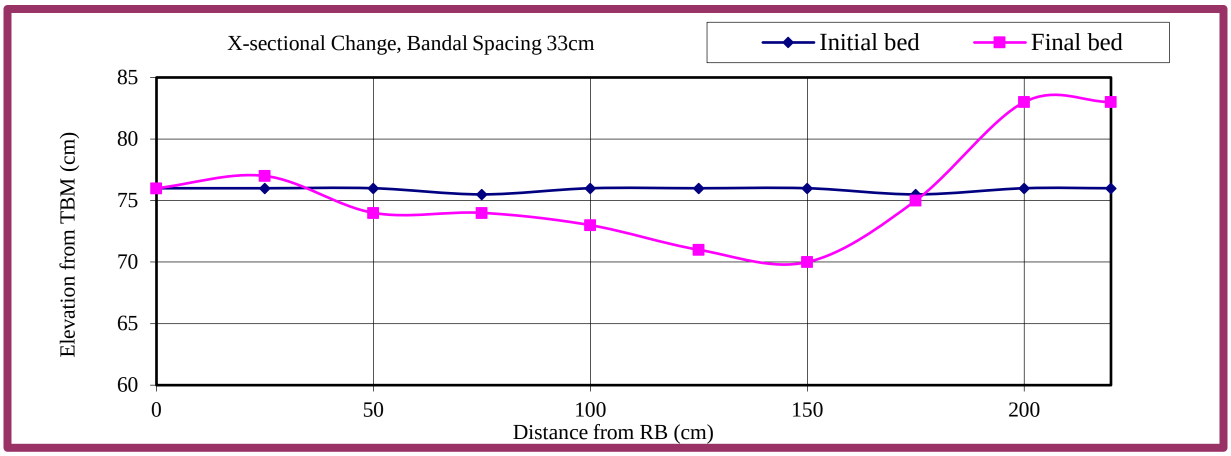

Figure 6b. Erosion-Deposition pattern along the cross-section

4. Results and Discussions

The experiment was conducted with the bamboo bandals are placed in series in the right bank of the river channel in the alignment of the downstream direction of the channel. There was a very beautiful erosion protection on and behind the bamboo bandals over the channel near the bank which is due to the low velocity near the bank as in Figure 3. It is appeared from the Figure 4a and Figure 4b so that the bed level between the bamboo bandals is higher whereas the bed level beyond the bamboo bandals are lower. It is seen from the Figure 5a and Figure 5b so that the magnitude of the velocity vector is low near the bank whereas the magnitude of the velocity vector is higher in the middle of the channel. This is may be the cause of the siltation of the river channel near the bank. So it is clear that from the Figure 5a and 5b so that the velocity near the river bank is low than that of higher toward the main channel. It can further be confirmed that in the river cross-sectional plot as in Figure 6a and Figure 6b so that there is sedimentation near the river channel. It is concluded from the result and discussions so that there is a siltation near the river bank where as there is deep pool away from the river bank. So it can be decided that the bamboo bandals are working as a river bank erosion protection structures.

5. Conclusion

It is concluded that bamboo bandals are capable for protecting river banks erosion by flow diversion towards the main channel leading to deep navigational channel formation in the main river. On the other hand, flow velocities are reduced near the bank lines that ensure bank protection by the deposition of sediment. If the bandal structure functions optimistically, the river can get sufficient time for its adjustment and new main channel and bank line development.

References

Mosselman, E., Shishikura, T. and Klaassen, G.J., 2000, Effect of bank stablization on bend scour in anabranches of braided rivers. Phys. Chem. Earth, Part B, 26(7-8), 699-704.

Mosselman,E. and Sloff, C.J., 2002, "Effect of local scour holes on macroscale river morphology", In: River Flow 2002: *Proceeding of the International Conference on Fluvial Hydraulics*, Vol. 2, Louvain la Neuve, Belgium, 4-6 September (EdsD.Bousmar and Y.Zech), pp. 767-772. Balkema, Lisse.

Klaassen, G.J. Mosselman, E. and brühl, H., 1993, "On the prediction of planform changes in braided sand bed rivers", In advances in Hydro Science and - Engineering (Ed. S.S.Y. Wang), pp.134-146. Publ. University of Mississippi, University, Mississippi.

Klassen, G.J. and Masselink, G.., 1992, "Planform changes of a braided river with fine sand as bed and bed and bank material", *Proceedings of the Fifth International symposium on river,* Sedimentation, 6-10 April Karlsruhe, pp. 459-471.

Jagers, H.R.A., 2001, "A Comparison of prediction methods for medium-term plan form changes in braided rivers", *Proceeding IAHR symposium on River Coastal and Estuarine Morph dynamics,* Genova,10-14 September, Obihiro, Japan, pp.713-722.

Jagers, H.R.A., 2003, "Modelling planform changes of braided rivers", Ph.D theses, University of Twente, ISBN 90-9016879-6.

Rahman, M.M., Nakagawa, H., Ishigaki, T. and Khaleduzzaman, ATM., 2003, "Channel stabilization using bandalling", *Annuals of Disaster Prevention Research Institute,* Kyoto University, No. 46 B, pp. 613-618.

Klassen, G.J., Douben, K.J. and Waal, M.V.D. (2002): Novel approaches in River Engineering, River Flow 2002, Bousmar and zech (eds.) ISBN 90 5809 5096, pp. 27-43.

Rahman, M.M., Nakagawa, H., Ishigaki, T. and Khaleduzzaman, A.T.M (2003): Channel Stabilization using bandalling, Annuals of Disaster Prevention Research Institute, Kyoto University, No.46, pp. 613-18

Biography

Dr. Engr. Md. Lutfor Rahman, PEng is a Director and X-Director General of River Research Institute, Faridpur, Bangladesh. He has completed his Ph.D. in the field of Civil Engineering major in water Resources Engineering in 2014 from Dhaka University of Engineering and Technology (DUET) Bangladesh. Dr. Rahman is doing his research from 2005 to till date to complete his research on the sediment management by using Bamboo Bandalling Structures. He has taken initiative to prepare a design manual for the interest of the common people in Bangladesh. He is the member (M-57095), International Association for Hydro-environment Engineering and Research (IAHR),World-wide Hydraulic & Environmental Research Institute, life member (LM#793), The Indian Society of Hydraulics (ISH), India, life fellow (LF # 4220), Institute of Engineers, Bangladesh (IEB); member (M# 570), Bangladesh Association for the Advancement of Science (BAAS);member (M # 620), Bangladesh Computer Society (BCS).life member, National Oceanographic and Maritime Institute (NOAMI) and life member (M#19868701812L), Association of BUET Alumni (ABUETA), Bangladesh . He has received letter of appreciation as Chief Scientific Officer (CSO) from the Secretary, Bridge Division, and Ministry of Communication for his excellent engineering work in the field of river bank erosion protection. He is also a recipient of the best award as an Engineer from Sheikh Hasina, Honorable Prime Minister, and Govt. of the People's Republic of Bangladesh for the recognition of the excellence performance in the professional activities in the 14th January 2012 at the 53rd IEB convention.