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Channel Stabilization Using Bandalling

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Synopsis

Features of bank erosion and its countermeasures along the alluvial rivers in Bangladesh are presented. Performance of bandals to increase flow depth in the navigational channels is discussed. On the basis of empirically understood working principles of bandals, an idea is developed that bandals can be used as a method of bank protection/channel stabilization and presented in this paper. Outlines of the experimental methods on bandals are also highlighted briefly.

Keywords: bandals, navigational channels, channel stabilization, experimental methods

1. Introduction

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. Generally, groynes and revetments are applied as a method of bank protection (Rahman and Muramoto, 1999). 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 groynes 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 1/3rd of the regime depth which indicates the degree of instability of rivers in Bangladesh. Features of some protection work in the Jamuna where channel width is constricted significantly for the construction of the Jamuna bridge are discussed by Slaa (1995). The guide banks along both side of the bride are recommended to guide the approach flow towards the bridge opening. These guide banks are hard point type structures at the upstream and downstream reach of the bride site. Sarker (1995) reviewed the failure and success of riprap works in Bangladesh. Functioning of these works in field condition is explained. Anyway, if the bank protection structures such as groynes, 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 used to live in. 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 bandals for long-term channel stabilization is examined in the present study.

Bandals are one of the traditional river works that obstruct flow near the water surface and allow it to pass near the riverbed where major portion of the suspended sediment is concentrated. These are installed towards the downstream with an angle to the main flow. In alluvial floodplain countries, these are made of naturally available materials such as bamboos and woods and applied for the improvement of navigational channels during the dry season. Information available on bandals is from field experiences and details of flow and sediment transport around them are unknown. Moreover, the response of bandals during the monsoon season, when sediment and flow discharges are increased significantly, is not clear yet. The issues of river bank erosion and channel stabilization in the alluvial rivers in Bangladesh are discussed with special emphasis on gradual stabilization on long-term basis.

2. Features of Bank Erosion

2.1 River System

Bangladesh is a country of rivers over which three major Continental rivers: the Ganges, the Brahmaputra/Jamuna and the Meghna (Fig. 1) are flowing. The Ganges and the Meghna are generally considered as meandering, whereas, the Brahmaputra/Jamuna is treated as a multi-channel braided river. The combined flow of the Ganges and the Jamuna is named as the Padma. The Upper Meghna combins with the Padma and flows as the Lower Meghna. In addition to these, a number of tributaries and distributaries of the major rivers are also flowing over the country.

2.2 Bank erosion

In the alluvial rivers with erodible boundaries the bank erosion is drastic and channel width increases in an order of several hundred meters per year (Rahman et al., 2002). As a result, the major rivers in Bangladesh are shifting their courses every year creating problems at the local and national levels. Some of the key features of bank erosion along the Meghna river at the upstream of the Meghna bridge are shown in Fig. 2.

Fig. 1 River system in Bangladesh (location: bandals and bank erosion).

3. Bank Protective Measures

Usually, protective measures are applied against bank erosion for short-term basis. The local and temporal problems related to bank erosion and channel shifting is considered. Massive structures like groynes, revetment and hard points are expensive and often unfavorable to environment. On the other hand, relatively weak structures like vanes, permeable groynes, vegetations are not able to provide adequate protection against bank erosion.

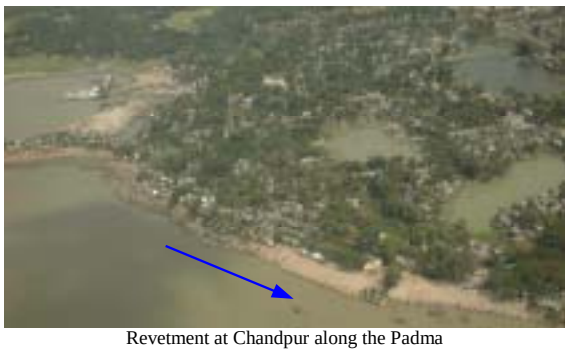
3.1 Partial and local methods

Partial and local methods are applied along the reach which are relatively less vulnerable to erosion and less important from socio-economic aspect. One of the partial bank protection method, the permeable groyne or pile dike that is tested in the Jamuna is shown in Fig. 4. Moreover, some methods along the Meghna and along the Mahananda river (small tributary to the Ganges) tried by the local people are also shown in Fig. 4.

Fig. 2 Features of bank erosion in the Meghna River
top: bank line survey by DGPS

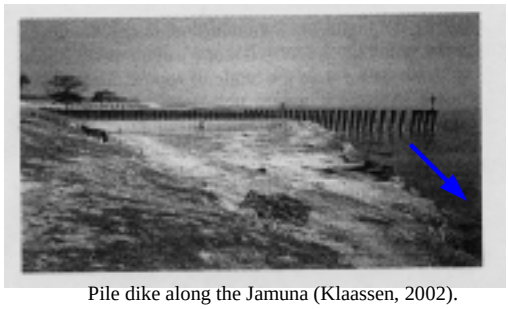
3.2 Conventional methods

Impermeable groynes, revetments and hard points are grouped here as conventional methods. These are applied for the bank protection in the reach that is important from socio-economic background. Some of the examples of groynes and revetments along the Ganges and the Padma, respectively, are shown in Fig. 3.



Revetment at Chandpur along the Padma

Fig. 3 Conventional bank protection methods
(top: Groyne along the Ganges at Rajshahi).



Pile dike along the Jamuna (Klaassen, 2002).

Bank protection by local people: the Mahananda

Fig.4 Partial and local methods of bank protection
(middle: by local people along the Meghna).

4. Channel Stabilization

The above-mentioned methods provide short-term bank protection in order to solve the local problem. Again, the response of large scale alluvial rivers against sudden changes created by these structures are not suitable for the overall stabilization of river courses. Also, the methods failed to develop river courses as regime flow. Therefore, it is important to have alternative long-term solution for river stabilization that will be friendly to the environment and create minimum disturbance to river courses. Bandals are chosen to serve for the above purposes and its basic working principles are explained below.

4.1 Basic principles of bandals

The sediment material of an alluvial river is transported both as bed load and suspended load. Even in the case of suspended load, most of the sediment is transported near the bed and very less sediment is carried near the water surface. This feature of sediment transport is the key to using bandals.

The working principles of bandals for the control of water and sediment flow are shown schematically in Fig. 5 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. The reverse is true for the water flow discharges.

Bandals or bandallings are commonly applied to improve or maintain the flow depths for navigation during low water periods in alluvial rivers of Indian sub-continent. Recently, theses are also used for closing off secondary channels in the large rivers like the Ganges to ensure stable single course. The essential 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. As a 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 bandal. The flow near the bed is directed perpendicular to the 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 bandals are 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.

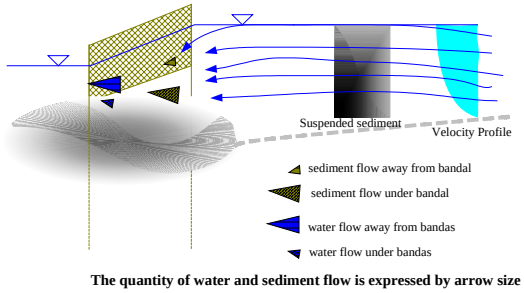


Fig. 5 Working principles of bandals.

4.2 Applications of bandals

Bandals are annual structures that are usually applied around Novermebr (end of monsoon) each year to maintain sufficient flow depth during the dry season for the navigational purposes.

(1) Navigation

The results of some of the field data in the Jamuna river and the Kushiyara river (see Fig. 1 for location) are shown in Fig. 6. It can be seen that the flow depth along the upper reach of the Jamuna and the Kushiyara increased significantly after the application of bandals, whereas, the effect at the lower Jamuna is not clear.

(2) Planform stabilization

Based on the working principle of bandals, an idea is developed so that it can be used to stabilize river courses for long-term basis in a step by step manner. River flow are suddenly disturbed by spur-dike-like structures (Rahman and Muramoto, 1999) and consequently their reponses are big against such interventions. Therefore, water courses can not be stabilize in the long-term basis. The gradual encroachment towards the lateral direction using bandals create less disturbance to the river and the river can get sufficient time for its adjustment and new bankline development. The river response against such small intervention will be comparatively less. The idea of stabilized channel development using bandals are shown in Fig. 7 schematically.

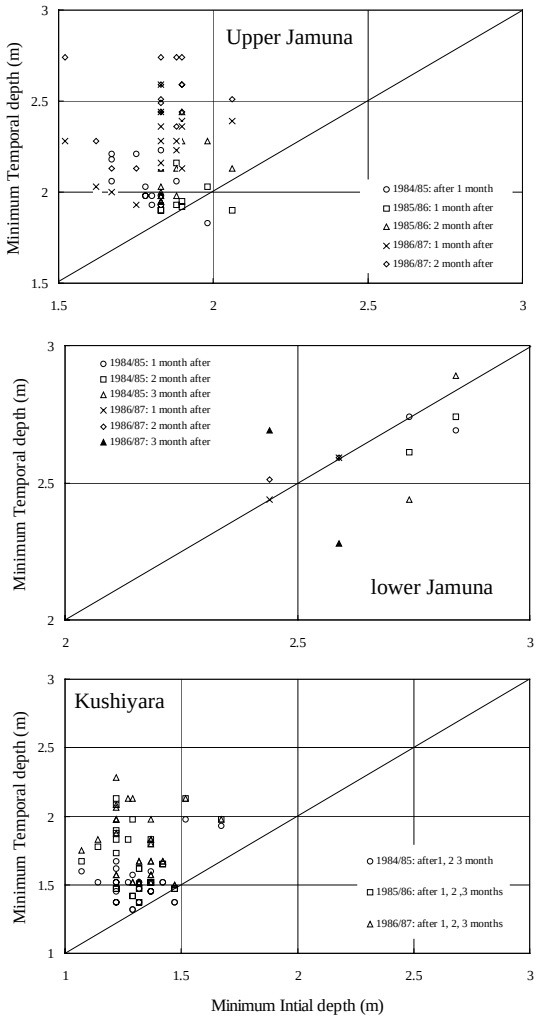


Fig. 6 Effect of bandals on navigational flow depth.

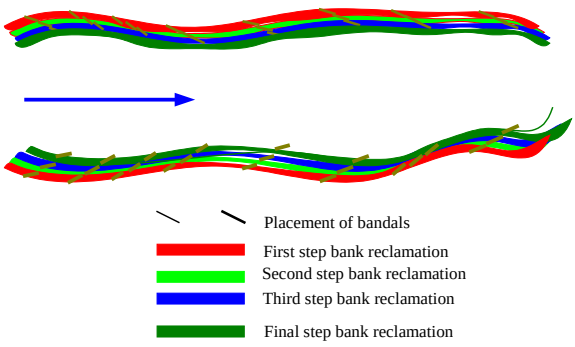


Fig. 7 Stabilization of river courses using bandals (schematic).

4.3 Experimental methods

Before, application of such idea as a pilot basis, it is important to clarify the flow and sediment control processes around bandals in order to develop optimal solution. As a first step of such a research project, systematic experimental studies are being carried out at the Ujigawa Open Laboratory of Disaster Prevention Research institute, Kyoto University. The experimental methods are explained briefly as below.

(1) Clear-water condition

Experiments in the clear-water condition are being executed in a 10 m long, 1 m wide and 0.3 m deep straight channel with discharge control system. The middle part of the channel having 1.8 m length is mobile with uniform fine sand having 0.23 mm diameter. Bed deformation and flow field will be measured using a Laser sensor and an electromagnetic velocity meter, respectively. Flow patterns will be observed using normal and submergible video cameras. From these experiments, the features of flow acceleration and deceleration around bandals will be explored which will be an essential input for the experiments under sediment transporting condition.

(2) Live-bed condition

The effect of a single and a series of bandals on the flow and sediment control are being executed in a 23 m long, 2 m wide and 0.15 m deep straight rectangular flume. The features of sediment control by bandals will be explored using the information on flow field achieved from the experiments under clear-water condition. Sediment laden flow will be used in this flume having the same sediment size that used in the experiments explained in (1). The same measuring facilities is used in this flume.

5. Conclusions

Bandals have positive impact for the increase of navigational flow depth in alluvial rivers. The output of the present research for the stabilization of river courses 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.

Acknowledgements

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バンダルを用いた河道安定工法について

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要旨

本研究は，バングラディシュの沖積河川における側岸侵食およびその対策法の特徴について検討することを目的としている。ここでは，航路維持を目的とした伝統的な工法であるバンダルを取り上げ，その経験的に得られた知見の河岸侵食防止法や河道の安定工法への適用に関する問題点を探った。本報告では，バンダルを用いて河道を安定させる基本的な概念を示し，その効果を検証するための実験方法の概要について述べている。

キーワード：バンダル，航路維持，安定河道，実験的検討