MORPHOLOGICAL CHARACTERISTICS OF THE RIVER MEGHNA: A COLLABORATIVE STUDY

M. MOZZAMMEL HOQUE
M. MONSUR RAHMAN
M. ASAD HUSSAIN

Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Dhaka Bangladesh

Giving due importance on the control of natural disaster such as floods and river bank erosion in Bangladesh a morphological study was initiated through a cooperation between Bangladesh and Japan to evaluate the morphological process of the river and to recommend the possible preventive measure to control bank erosion. For this study a reach of the river Meghna at the close vicinity of a bridge popularly known as Japan Bangladesh Friendship Bridge is selected in such a way that the river reach represents the common morphological problems of the major river system of Bangladesh. For measuring river water level the staff and the automatic water level gauges are installed in the selected reach. For measuring bed level and scour around the piers and revetment of the bridge echo sounder coupled with DGPS and GPS have been used. Other measuring instruments used are recording current meter, sediment sampler and turbidity meter. In this collaborative study the flow characteristics, mode of sediment transport, extent of scour holes around the bridge piers and abutment, nature of migration of the sand bar upstream of the bridge, the extent and nature of bank erosion upstream and downstream of the bridge have been evaluated.

INTRODUCTION

In Bangladesh, natural hazards such as floods and river bank erosion cause many people land less and homeless. Enormous discharge of the main rivers systems, the Brahmaputra-Ganges-Meghna and their innumerable tributaries and distributaries make the rivers unstable, especially during the monsoon. Heavy rains associated with snow melts of the south and south-east slopes of the Himalayan Mountains cause devastating floods. One of the severe hazards associated with floods is the stream channel changes and bank erosion in the major rivers. The agricultural and industrial activities are greatly impaired by the failure of embankments, bridges and other river structures due to shifting of river courses and due to heavy on-rush of flood flows. To control the river channel changes and bank erosion the quantitative evaluation of the river channel process and the impact of the river improvement works on the morphological characteristics of the river are essential. The need of such study has become even stronger after Bangladesh experienced the consecutive devastating floods of 1987 and 1988 (UNDP, 1989; World Bank, 1989).

Giving due importance on the flood prevention and control in Bangladesh the Japan Government has agreed to cooperate with the Bangladesh Government and the joint study
Project was initiated in 1989 to conduct the study by Bangladesh University of Engineering and Technology of Bangladesh and the Kyoto University and the Tsukuba University of Japan with the major objectives of (a) transfer of technology, (b) development of research facility, and (c) perform research on the floods and related issues. The study of morphological behaviors of the river Meghna is one of the four topics of Japan Bangladesh Joint Study Project. The main and ultimate purpose of this topic is to understand the process of erosion and deposition and thus evaluate the morphological process of the rivers and to recommend the possible preventive measure of control the riverbank erosion.

STUDY AREA

Considering the size and ease of handling the data collection process, from the river system of Bangladesh, the upper Meghna River has been selected for the present study as shown in Figure 1.
The Meghna is one of the major rivers in Bangladesh having a total length of 820 km of which 420 km flows through Bangladesh. It is an alluvial meandering river. The study reach is situated in the vicinity of the Meghna Bridge (23°36.162’ N, 90°36.991’E) near Dhaka City, Bangladesh. In this river a reach about 1 km down stream of the Meghna Bridge and about 10 km upstream of the bridge has been selected. The location of the Bridge with the plan form of the selected river is shown in Figure 2.

Figure 2. Plan form of the study area with bridge location

The river reach selected represents possibly all the elements of morphological processes, such as erosion and accretion, sand bar formation, bifurcation, scouring along the bank and around the hydraulic structure, and tidal characteristics. Further, due to the construction of the Meghna Bridge, possibly some significant impacts of the bridge structures have occurred in the selected area. Therefore, the problem in the selected area is a representative one of the general morphological problem that a river system in Bangladesh may encounter.

RESULTS

In this Study Project, many field instruments were installed in the Upper Meghna River and many measuring equipments have been added to the laboratory of the Institute of Water and Flood Management of Bangladesh University Engineering and Technology (Sawai and Toda 2004). The relevant technology in using these equipments for filed data collection and in processing those collected data have been transferred successfully by the Japanese counterparts to the Project staff. Details of the technology transfer may be seen else where (sawai and Toda, 2004). By using the developed facilities of the project data in several areas such as bed form, bank erosion, scouring around the bridge piers, etc., data have been collected/measured.

The data collected from the river reach are analyzed in the form of general morphology of the area, scour along the bridge abutment, and scour around the bridge piers, river bank shifting, and the flow characteristics.
Morphology of the area
The general bed topography of the selected study reach is shown in Figure 3. The reach has deep scour hole on the left bank forming deeper channel along the outer bend and deposition on the right bank forming shallow deposited sand bar along the inner bend. A sand bar exists upstream of the bridge. This sand bar has taken the present form after construction of the bridge and possibly provides a positive flow deviation towards the left abutment and as a result deep scour holes are forming there. The details of the general morphology of the study reach are found elsewhere (Rhaman, et al., 2004a; Rhaman, et al, 2004b).

Figure 3. General morphology of the study river reach

Scour along the abutment
The bed contour near the left bank abutment in August 2000 is shown in Figure 4. It can be seen that the deep scour hole developed due to the abutment is approaching close to the scour hole developed by the piers.

Figure 4. Bed contour near the left abutment

Figure 5. Cross section along A-A’
It was estimated from the plan form at the bridge site that the lateral length of the abutment was approximately 90 m and the approach flow depth was 10 m. The initial bed level was at about -7 m and the maximum scoured level is -28.5 m, msl. Therefore, the maximum scour depth below the original bed level was 21.5 m. The water depth on the sand bar varies between 2-5 m. The detailed bed level along the section A-A' (Figure 3) from the left bank as measured in August 2000 is shown in Figure 5. The site was free from the influence of channel curvature, as the bridge was located at the cross over region of the meandering plan form. Therefore, the scour due to the effect of curvature is not significant. The details of the scour along the abutment of the bridge of the study reach are found elsewhere (Hinokidani and Kajikawa, Y., 2004; Rahman, et al., 2004c; Rahman, et al., 2004d).

**Scour around the piers**

The piers of the bridge are hexagonal in shape with length and width of each of the piers is 11 m and 3.2 m, respectively. Figure 6 shows the bed level along the cross section at the bridge before and after construction of the bridge. The post construction cross section was measured during August 2000. It is observed that the scour is formed on the left bank from pier 11 to pier 6 and deposition has taken place on the right bank from the pier 6 to pier 3. The deepest scour has taken place around piers 8, 9, and 10. The lateral profiles of the bridge section at the initial stage and on August 24, 2000 show that initially, 50 cm thick boulder pitching was constructed around piers for scour protection. It is clear that there is no boulder pitching around the pier, rather scour hole has been developed around them. There are piles up to about 40 m below the pile cap above which piers were constructed. Due to the deep scour hole, some portion of the piles below pier no.10, no.9 and no.8 have been exposed. The maximum scour depth below the original bed level was 14.5 m. On the other hand, deposition took place around the pier no.3, no.4, and no.5 towards the right bank of the river. The details of the scour around the bridge piers of the study reach are found elsewhere (Hinokidani, O.; Kajikawa, Y., 2004; Rahman, et al, 2004c; Rahman, et al., 2004d).

![Figure 6. River bed level at bridge section](image-url)
**River bank shifting**

To see the bank shifting of the selected river reach with time observations have been made several times using GPS along the bank line. But from the field observation, it is found that the inner bank line (right bank: X = 4000 to 5000 meter) is being eroded as shown in Figure 7. But, the measured velocity vectors show the opposite behavior. The details of bank shifting at the river reach studied are found elsewhere (Rahman et al, 2004e)

![Figure 7. River bank shifting](image)

**Flow characteristics**

At different sections of the study area velocity are measured using a 2-D electromagnetic current meter, and data are transferred to a note-pad computer through ACM210-D Data Processing software. The measurements are undertaken along the bridge section for 12 positions, along the abutment section, section between bridge and abutment, the other 4 main sections and 3 more sections between L2-R2 and L4-R4 (Figure 2) for 8/9 positions each. The velocity measurements for each longitudinal profile of the section are performed at 1 m vertical depth interval along the total depth. At each location velocity data are collected for 10 seconds which gives 10 sets of velocity data both magnitude and direction. These data are then processed and analyzed to observe the trends and pattern of bank erosion and also these results are used for the investigation of scouring, especially local scouring, formation of sand bar at upstream side of the bridge relation between depth and velocity, unit discharge and total discharge. A velocity vector model is being prepared to investigate the relation between the sediment material (suspended as well as bed material), size distribution and velocity distribution along the channel reach. Also through these observations, aggradation and degradation process are also investigated.
Velocity vectors in different horizontal planes have been presented in Figure 8. It can be seen that along the left bank from L4R4 to L2R2, the vectors are smaller as compared with vectors along the right bank. Then according to both the theoretical and empirical investigation, bank erosion should occur towards the left bank. But actually erosion is taking place towards the left bank of the concerned reach. The reason for the contradiction is not clear. However, other forces such as wave, wind etc. may play dominant role on the bank erosion instead of velocity. This is the remaining problem in the field and need to be solved in future. The details of flow characteristics of the study reach are found elsewhere (Rahman, et al, 2004a; Rahman, et al 2004b; Islam, et al, 2004).

CONCLUSIONS

Based on the result of the collaborative study the following general conclusion may be made:
1. The collaboration between Japan and Bangladesh has been found successful in technology transfer and research capability development in the area of river morphology of the Institute of Water and Flood Management of Bangladesh University of Engineering and Technology.
2. Implementation of the Meghna Bridge on the river Meghna has significant impact on the morphology at close vicinity of the bridge, especially at the upstream.
3. During post construction period a sand bar has been developed on the upstream of the bridge, heavy scour has been occurred on the left abutment and on the left side piers and deposition has been taken place on the right side of the piers.
4. The sand bar upstream of the Meghna Bridge is a non-migrating point bar and its height has already reached at almost equilibrium. The sand bar is the major
contributing agent for the outer bank erosion or bends development. The left bank close to the upstream termination of the guide bank will face severe erosion unless some protective measures are provided.

REFERENCES


