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Impact of the 1998 Flood on the Morphology of Rivers around Bridges

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Abstract

The unprecedented flood of 1998 had severe impacts on bridge structures along with river channel processes. This paper presents an evaluation of flood impact on the morphological changes of the river Meghna, upstream and downstream of the Meghna Bridge and around Turag-Bhakurta Bridge on the river Turag. The Meghna river reach around Meghna Bridge has undergone significant changes in the river channel process during the 1998 flood. The morphological conditions around the Meghna Bridge were evaluated by comparing the results of detailed survey carried out in May (pre flood) and in October (post flood) in 1998. The bed level has changed at section from L10 to R1O showing about 20m depth near left bank while deposition has taken place at right bank. In the middle of the river near the section from R7 to L7 a sand bar existed before and significant erosion has taken place at the right side of the sand bar with a depth of about 20m. The erosion has extended up to 2 km. At some locations, no bed changes have occurred. Local scouring at right bank from R1O to R8 shows deposition of silt during flood time with scour depth varying from 2 to 22m, while at left bank from L4 to L3 shows a progressing scour depth of more than 20m and mostly 18m along the major part of the reach. Local scouring along left revetment at upstream and downstream of the bridge shows no significant changes and maximum scour at upstream is about 25m while at downstream it is about 22m. Maximum local scour depth around piers 7, 8 and 9 is about 20m. The Turag-Bhakurta Bridge on Turag-Bhakurta road was washed away by the 1998 flood.

INTRODUCTION

Flood is an annual event in Bangladesh. But unusual devastating floods like 1954, 1987, 1988 and 1998 are considered the worst ones on record, which caused widespread sufferings and loss of lives. The 1998 flood was unprecedented both in terms of magnitude and duration. The flood of 1998 being more serious in nature due to its longer duration than other past floods might have caused enormous impact on the major bridge structures of the country and morphological changes at the vicinity of the bridges. This has posed a threat to the sustainability of the bridges. Therefore, a study was undertaken to evaluate the impact of the 1998 flood on major bridges. A total of eleven bridges have been studied (Hoque et al., 1999), from which two bridges - the Meghna bridge over the river Meghna and the Turag bridge over the river Turag near Amin bazaar, Dhaka have been studied in detail. This paper presents the results of this detailed study. The location map of the bridges covered in this study is shown in Fig. 1.

METHODOLOGY

A detailed field survey around the Meghna Bridge has been carried out. Detailed cross-sectional survey and bed form measurement at 10km upstream and 2km downstream of the bridge have been made using the electronic distance meter (EDM) and echo sounder. The local scours at the piers, revetment and at another three locations, which are highly prone to erosion, have been evaluated by measurement and comparison with the previous records. The Turag-Bhakurta Bridge constructed by Local Government Engineering Department (LGED) on Turag-Bhakurta road over the Turag river has been studied in detail to compare the hydrological and morphological changes that had occurred during 1995 and 1998 floods. The relevant data were collected from LGED office, Dhaka. All these data have been graphically presented and a comparison has been made with the previous results to evaluate the impact of 1998 floods.

THE MEGHNA BRIDGE

The Megima Bridge is located on Dhaka-Chittagong Highway over the river Meghna about 25km south east of Dhaka. The location of the bridge is shown in Fig. 1. Dhaka-Chittagong Highway is the nation's 'lifeline' and construction of the bridge has added new dimension to this 'lifeline' eliminating the time killing ferry service at Meghna Ferryghat. The bridge is a pre stressed concrete structure and has 10 piers with eleven spans. The total length of the bridge is 930 m and its

construction was completed in 1991. Some parts of Dhaka-Chittagong Highway went under water during the 1998 flood. Discharge at Bhairab Bazaar in the Meghna river for 20 years return period is 19124 m^3/s. Water surface slope of the river at bridge site in respect to Bhairab Bazaar is about 0.0000158 (MPO, 1991).

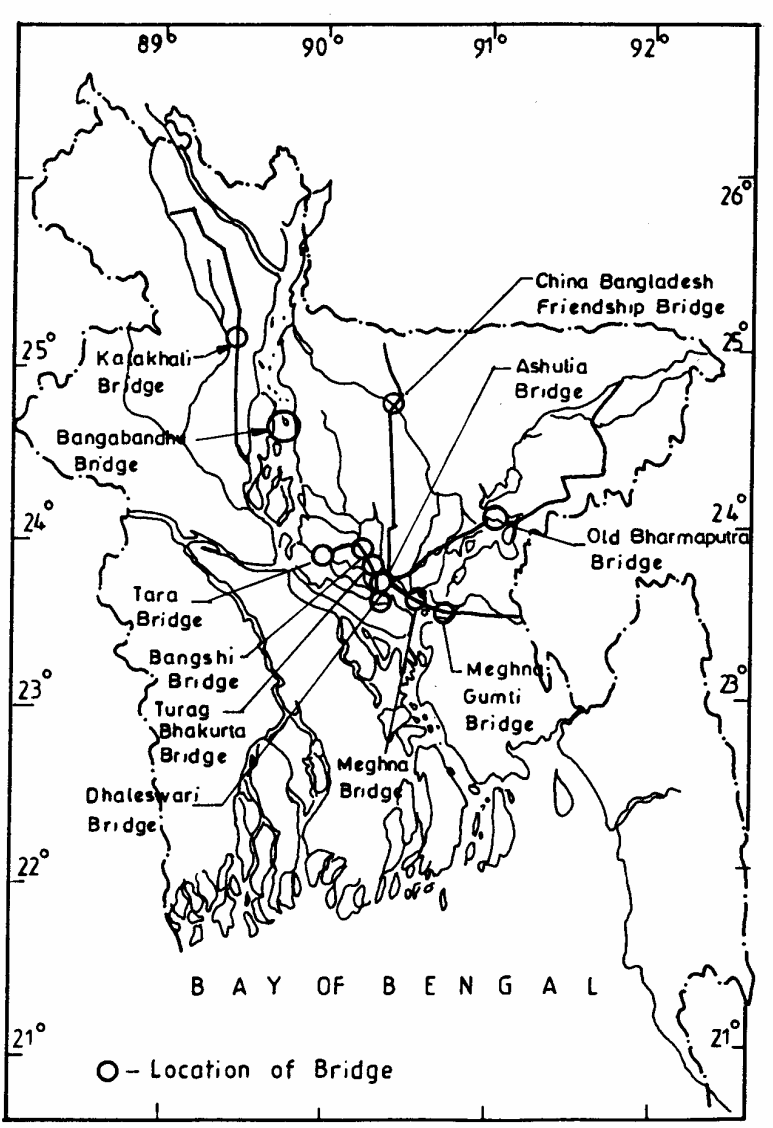

Figure 1: Location map of selected bridges

To evaluate the morphological changes at the vicinity of the bridge, a river reach of about 1km downstream of the bridge and 5km upstream has been considered. This reach has been studied by Japan Bangladesh Joint Study Project on Floods (Hoque et al., 1997). The selected river reach is shown in Fig. 2.

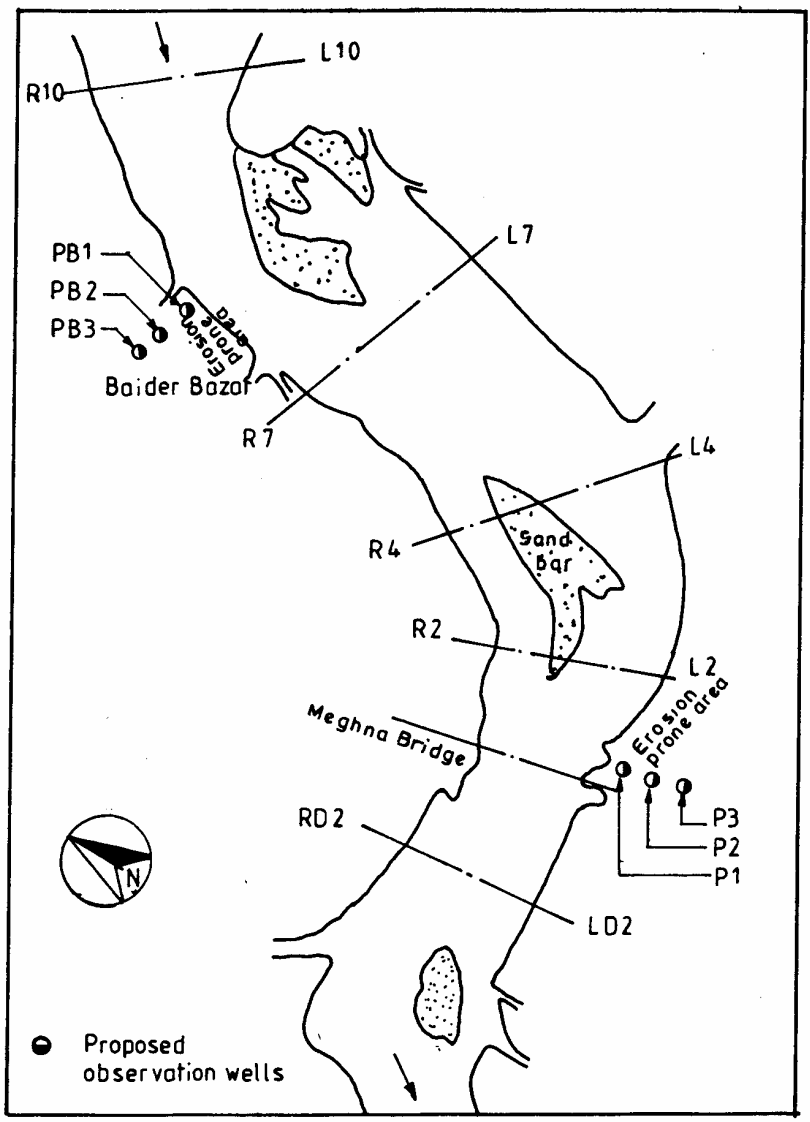

Figure 2: Location map of the study area

The 1998 pre-flood morphological conditions are available for this area from a previous study (Hoque and others, 1997) in terms of (1) bed topography, (2) local scouring along the bank and (3) local scouring around the bridge piers 7, 8 and 9 from Dhaka side. To evaluate the changes in the river channel processes that occurred due to the flood of 1998, a detail survey was conducted during October 1998 on the river cross-sections, bed levels, scour around the piers, scour along the left revetment at upstream and downstream of the bridge and scour along the bank. A comparison between situations in May (pre-flood) and in October (post flood) 1998 has been made to evaluate the impact of 1998 floods.

River Bed Changes

With riverbed cross-sectional data surveyed during May 1998 (pre-flood) and October 1998 (post flood) river, bed contour maps have been developed as presented in Fig. 3 and Fig. 4, respectively. From these figures significant differences have been observed in several places showing both erosion and deposition occurring during the 1998 flood.

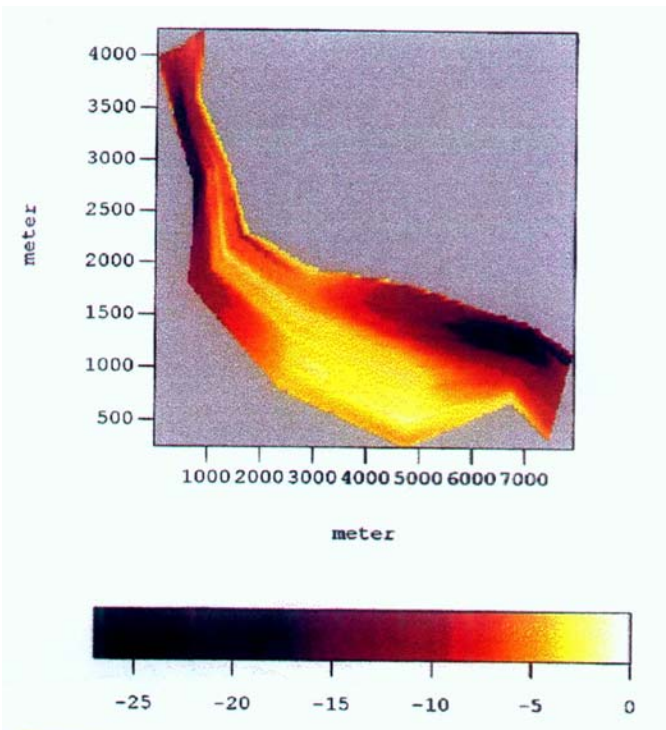

Figure 3: River bed during May 1998 (before the 1998 flood)

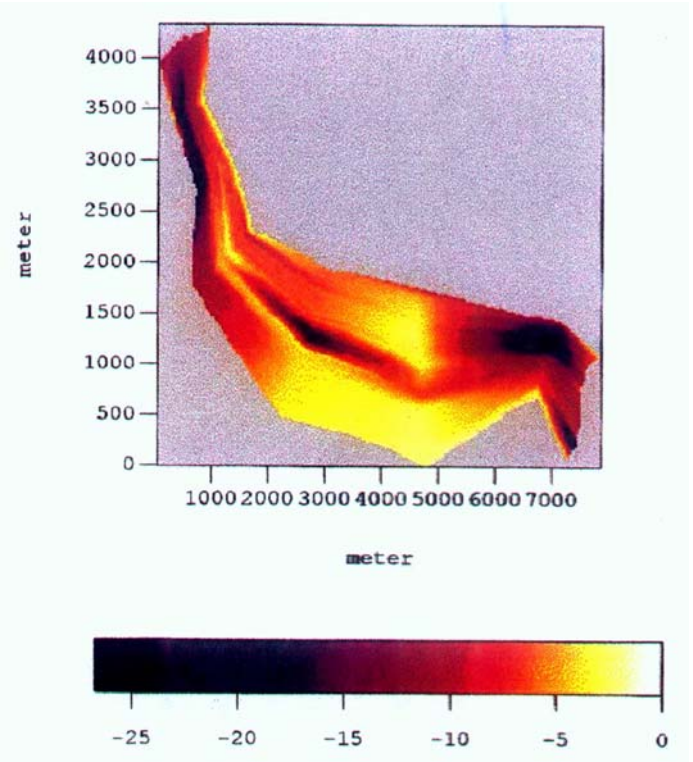

Figure 4: River bed during October 1998 (after the 1998 flood)

At section from L_{10} to R_{10}, significant erosions have taken place on the left side showing depth around 20m near the bank. A comparison of Fig. 3 and Fig. 4 reveals that at right bank some deposition has taken place during the 1998 floods. Downstream to this section on the right bank, the highest color shows further deposition where the depth is close to only Sm. However, further downstream to this section at the middle of the river where a sand bar existed before, significant erosion has taken place on the right side of the sand bar and the depth has reached to about 20m. This erosion has extended up to a reach of about 2km. On the left side of this section (left bank) further deposition has taken place. Further downstream up to the bridge and to the end of the reach, both sides show no change between the pre-flood and post-flood conditions. In general a significant change was found to have occurred in the bed level of the river Meghna upstream of the bridge during the flood of 1998.

Local Scour at Bank

Three locations in the reach in question have been identified with local scour at the bank and have been surveyed during October 1998. This survey has been made in addition to the general survey of cross-sections conducted for developing bed level contour as discussed above. This localized detail survey has been done between R_{10} and R_8 on the right bank, between L_4 and L_3 on the left bank and along the revetment, upstream and downstream of the bridge on the left side. The bank in this section is convex in nature and the comparison between the Fig. 3 and Fig. 4 shows that during pre-flood time (May 1998), the depth in this section was deeper than post-flood time (October 1998). River bed condition along the right bank between section R10-R8 (Hoque et al., 1999) shows that the depth at this section along the bank varies from 2 to 22m, which may be regarded as one of the deepest sections in the reach considered for the present study. The scour conditions along the left bank between L_4 and L_3 (Hoque et al., 1999) shows that the deeper part of this section is along the bank, which confirms the results in Fig. 3 and Fig. 4. So scouring is progressing at this section and the maximum depth of scour is more than 20m but mostly 1 8m along the major part of the section. The bank is also convex at this section, which increases the near-bank flow velocity causing transport of sediments. At the downstream of the Meghna Bridge, the maximum depth of scour is about 22 m, which is almost same as in February 1997 (Hoque et al., 1997). For upstream, this scour depth is about 25 m at several places which is about the same as in February 1997. This result also confirms that there is no significance difference in bed level between pre-flood and post-flood conditions. But in comparison with the results of February 1997, several scour holes have been observed in October 1998.

Local Scour Around the Piers

Detailed survey of bed level around the piers 7, 8 and 9 of the bridge was conducted during October 1998 to see the changes that occurred during the 1998 flood around these piers. Similar measurements were made during February 1997 and the results have been reported by Hoque et al. (1997). Conditions of the local scour in 1998 at piers 7, 8 and 9 are presented in Hoque et al. (1999). The maximum depth of scour holes observed is about 20m, which is less than the depth observed in February 1997 (Hoque et al., 1997). This may be due to the impact of the sand bar at upstream of the bridge, which has extended further down close to the bridge piers during the floods.

THE TURAG-BHAKURTA BRIDGE

Local Government Engineering Department (LGED) constructed the Turag-Bhakurta Bridge on Turag-Bhakurta road over the Turag river in 1994 at Savar,

Dhaka. The bridge connects a number of villages e.g., Bhakurta, Kamrangirchar, and Keranigonj with Dhaka. The construction of the bridge together with other structures on Turag-Bhakurta road has made communication easy towards capital Dhaka for the people of these areas especially during rainy season. The bridge consists of 5 spans with length 67m each and width 3.70m. After the construction of the bridge, about 1km portion of Turag-Bhakurta road was raised and upgraded. The raised portion of the road used to go under water every year during flood and floodwater flowed freely over it during flood season. Following the rise of road level, the bridge came under heavy water pressure during the 1995 and 1998 floods due to obstruction of free flow of floodwater. During 1995 flood, the first pier of the bridge from Dhaka-Aricha side settled down by about 1.61 m (as seen in Fig. 5). After recession of flood, the bridge was rehabilitated by providing additional piles with length of up to 30m at the affected pier. During the 1998 flood the bridge again came under flood attack and was washed away except for the pier rehabilitated after the 1995 flood (as seen in Fig. 6).

Figure 5: Settlement of Pier-1 of Turag-Bhakurta bridge on Turag-Bhakurta road near Amin Bazar close to Dhaka-Aricha road during the 1995 flood (Date: 25-02-95)

Figure 6: Washed away Turag-Bhakurta bridge on Turag-Bhakurta road near Amin Bazar close to Dhaka-Aricha road at Savar during the 1998 flood (Date: 27-10-98)

Morphological Changes

The cross-section along the central line of the bridge was measured after the 1995 flood by the local office of LGED at Savar. After the 1998 flood, cross-section was again measured along the central line of the bridge. These data were collected from LGED office, Dhaka to evaluate the morphological changes that had occurred due to floods of 1995 and 1998.

Information about water level, velocity etc. were also recorded during the cross section measurement in the year 1995 (September 24). Water level at the damaged bridge site was 6.50m during cross-section measurement and flood level was 7.88m during the 1995 flood. The surface velocity of water through the bridge section was about 2.OOm/s, which was measured by LGED. Measurements of cross sections at inflow and outflow points were carried out during survey work. Cross-section of outflow (damaged bridge) section is shown in Fig. 7. Figure 7 also shows the comparison of cross section before and after 1995 and 1998 floods at damaged bridge section. The water surface slope during the 1995 flood was quite high, as high land of Bhakurta village made spill water of the Dhaleswari river to make a substantial head at inflow section. Moreover, the catchment is a low-lying area bounded by highland and road network.

Discharge at damaged bridge section during the 1995 flood was about 1047 m^3/s while during the 1998 flood it was about 1370 m^3/s. For the passage of 1995 flood discharge through damaged bridge section, opening length should have been about 154m. But actual length of ridge was 67m. Hence, substantial morphological changes or scour had occurred at affected bridge section during the 1995 flood reaching a scour depth of (-) 6.60m as shown in Figure 7. For the passage of discharge through the bridge section during the 1998 flood, opening length should be about 176m. So significant morphological changes had occurred during the 1998 flood reaching a scour depth of (-) 13.40m as shown in Fig. 7. As a result, the bridge was washed away.

Causes of Failures of the Bridge During 1998 Flood

Design elevation of pile end at bed of the bridge was (-) 6.75m. It is evident from Fig. 7 that scour depth at pier-1 during the 1995 flood reached almost the pile length. Maximum scour was about (-) 6.60m below bed elevation. As a result, the pier got settled down from the effect of load of deck slab and girder. But during the 1998 flood, scour depth reached the extent of about two times the pile length of the bridge. Maximum scour is about (-) 13 .40m below bed elevation (Fig. 7). Hence, total bridge had been washed away except for the portion of the bridge rehabilitated after the 1995 flood. The pile length provided for the rehabilitated pier is about 30m. During the 1995 flood the outflow discharge at the damaged bridge section was about 1047 m3/s. During the 1998 flood the outflow discharge at bridge section was about 1370 m3/s. As a result, enormous pressure was exerted on the structure. For the passage of the discharge of the 1995 and the 1998 floods through the bridge section, the adequate opening length should have been 154m and 176m, respectively. But the bridge length is only 67m. Hence, due to enormous thrust of floodwater heavy morphological change occurred during flood period. The failure of the bridge is mainly due to a severe morphological change. Flood level in 1998 was 9.70m and the bridge was partially submerged. So, enormous hydraulic pressure was exerted on the bridge during the flood of 1998. As a result, the bridge was washed away.

CONCLUSIONS

The major floods, like the one of 1998, have significant impact on the river morphology at the vicinity of the bridges. The impact on a smaller bridge is more severe than that on a larger bridge. Significant changes took place in the river channel process due to the 1998 floods at the vicinity of the Meghna Bridge. Heavy scouring occurred under the Turag-Bhakurtia bridge during 1998 flood.

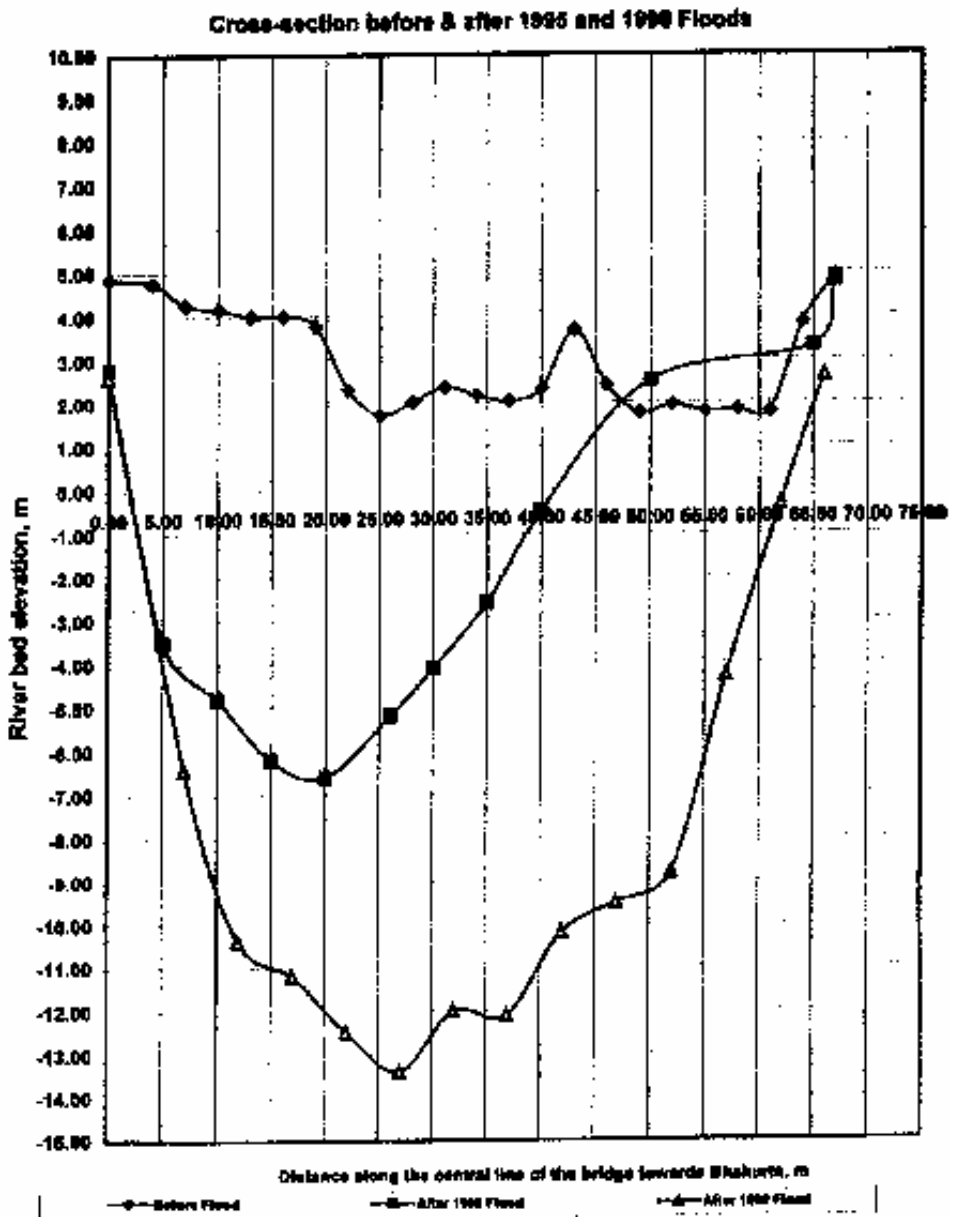

Figure 7: Cross-section at damaged bridge section before and after the 1995 and 1998 floods

REFERENCES

MPO (1991), Surface Water Hydrology Report, MPO, Dhaka.

Hoque M.M. et al. (1997), Study of Morphological Behaviours of the river Meghna, Final Report of Japan Bangladesh Joint Study Project, Topic 3, IFCDR, BUET.

Hoque, M. M., Bala, S. K., Ahmed, S. M. U., Haque, A. and Al-Mamun, S. (1999), Impact of 1998 Floods on the Morphology of the Rivers Around Bridges, BUET.