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Protective Measures For Faridpur Town From The Erosion Of Padma River

PROTECTIVE MEASURES FOR FARIDPUR TOWN FROM THE EROSION OF PADMA RIVER

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Abstract

A study was undertaken by the River Research Institute (RRI) to protect the Faridpur Town and its adjacent areas from the erosion of Padma river. The study area starts from Decreer Char Union under Faridpur Sadar Upazila to Zajirtek Union under Char Bhadrason Upazila in the District of Faridpur covering around 10 km long reach along the right bank of Padma river. Many permanent important installations such as High School, Primary School, Hat, Bazar, Post Office, Food Godown, Family Planning Centre, Ghat, Homesteads and Agricultural lands are affected due to the devastating bank erosion of Padma river. Every year the right bank of Padma river is shifting toward the right side at these areas. To save these areas and its agrarian economy from the devastating bank erosion of the Padma, this paper suggests retired embankment parallel to the existing banklines and also a series of spurs extending from the embankment upto this bankline. As an alternative to spur, river bank can also be protected by providing revetment.

Introduction

Faridpur Town and its adjacent areas such as Decreer Char Union under Faridpur Sadar Upazila and Gazirtek Union under Char Bhadrason Upazila in the District of Faridpur are located on the right bank of Padma river. The present right bankline of Padma river recently surveyed in February, 2001. The overall objectives of the present research project was to find out a viable solution from technical standpoint to protect Faridpur Town and its adjacent areas from the erosion of Padma river by constructing protective structures. However, in short, the objectives were: (i) to conduct a detailed literature review in the field of river bank erosion, river bank shifting and river bank protection. (ii) to determine the geometric as well as bank shifting characteristics of the river at the study area and (iii) to suggest possible bank protective structures to combat river bank erosion.

The Padma River

The combined flows of Jamuna and Ganges rivers constitute the flow of the present Padma river. Before the avulsion of Jamuna river, the flow was a continuation of Ganges river only, and Rennel's map shows that the river passed further south than the present course. The annual mean discharge is 28,000 m^3/s, and the bankfull discharge is about 75,000 m^3/s. The average size of the bed material is about 0.10 mm. Geomorphologically, the river is still young. A reach of about 90 km is almost straight and the planform of the river is a combination of the meandering and braiding type, indicating a wandering river. The variation of the total width of the river is quite high, ranging from 3.5 km to 15 km.The slope and the bed material sizes of the rivers vary within a range of 8.5 to 5 cm per km, and 0.20 to 0.10 mm, respectively. Bankfull discharges are within the range of 43,000 m^3/s to 75,000 m^3/s. With respect to planform, the Jamuna is distinctly a braided river, while the Ganges and Padma rivers fall in between braided and meandering rivers, i.e. wandering rivers. The bank erosion rates of the rivers are almost the same.

Methodology

Eight standard BWDB (Bangladesh Water Development Board) cross-sections (from downstream to upstream) were selected in the present study under the study region. These were CS P3, P3.1, P4, P4.1, P5, P5.1, P6 and P6.1. The spacing between successive cross-sections was 6.436 km. The cross-sectional map was produced for each of the cross-sections for 1992 and 2000.Area-elevation relationships were developed for selected BWDB cross-sections to determine the variation of cross-sectional area with elevation for the years 1992 and 2000.The thalweg level was determined as the deepest point from the cross-sectional map for each of the selected cross-sections for the years 1992 and 2000 to observe the variation of thalweg level along the river reach. The MBL at selected cross-sections was determined by subtracting average depth from average bank level of each cross-section and plotted for the years 1992 and 2000 to observe the variation of MBL at these cross-sections. Change in MBL was also determined at selected cross-sections during 1992 to 2000. Assuming linear variation of change in MBL, the amount of sediment deposited throughout the study reach was calculated for a period of eight years. The satellite imageries for the years 1973 and 1999 were traced and superimposed. These were then utilized to observe the lateral bankline movement i.e. to determine the bank erosion and deposition with respect to 1973. The bankline shifting at the study area (Decreer Char Union under Faridpur Sadar Upazila, Zajirtek Union under Char Bhadrason Upazila) was determined from 1999 to 2001 from the index map provided by BWDB. It was done in order to determine the trend and amount of bankline movement.

Results and Discussion

Variation of Cross-sectional Area

Each of the cross-sectional map was superimposed for the years 1992 and 2000 which clearly shows the shifting of thalweg, change of top width as well as the location of the deepest point. A typical plot is shown in Figure 1 (P5.1).

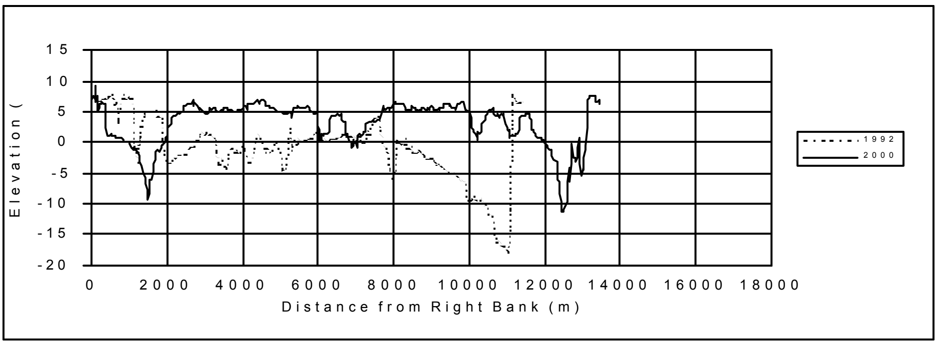

Figure 1 Superimposed cross-sectional maps for 1992 and 2000 (P5.1)

The variation of cross-sectional area, average depth, top width against the selected standard BWDB cross-section is also shown in graphical form in Figure 4 and 5. The cross-sectional area at cross-sections P3, P4 and P5.1 had a decreasing trend while there had an increasing trend at cross-sections P3.1, P4.1, P5, P6 and P6.1 during the period from 1992 to 2000. This indicates aggradation and degradation of these cross-sections respectively. The cross-sectional area at cross-section P5.1 in 1992 was reduced to 0.7 times the corresponding cross-sectional area in 2000. The cross-sectional area at cross-section P6.1 in 1992 was increased to 1.34 times the corresponding cross-sectional area in 2000. The cross-sectional areas calculated were 660387.0 m^2 and 676235.0 m^2 in 1992 and 2000 respectively and the increase in cross-sectional area was about 2.4%. The average depth in 2000 is less than 1992 while the average width increases.

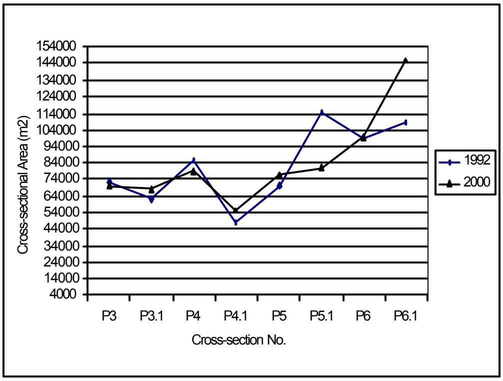

Figure 4 The variation of cross-sectional area

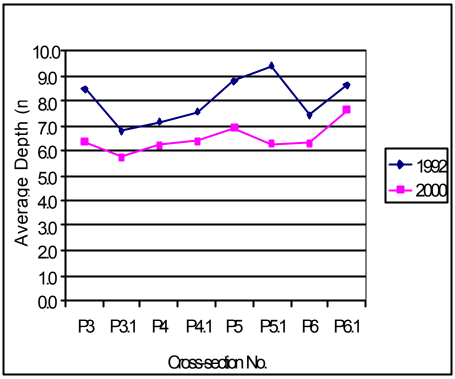

Figure 5 The variation of average depth

Variation of Thalweg Level

Table 1 shows the position of thalweg measured from left or right bank of river for the selected cross-sections over a period of eight years. The thalweg of cross-section P3, P4.1 and P6.1 shifted to the right and P3.1, P4, P5, P5.1 and P6 shifted to the left. The average thalweg level in 2000 was 1 m above relative to 1992. An exceptional deepest point was found in P5.1, which was 18 m below the PWD datum. The MBL in 2000 was higher relative to 1992 indicating channel bed had rising tendency. The maximum bed level rises at cross-section P5.1 that was about 3.4 m.

Table 1 Position of Thalweg Measured from Left or Right Bank for the Standard BWDB Selected Cross-sections

BWDB CS	1992 m	2000 m	Measured from	Shift m	Shifting Direction
P3	720	3030	LB	-2310	right
P3.1	9134	2590	LB	6544	left
P4	3850	11055	RB	-7205	left
P4.1	6725	4494	RB	2230	right
P5	9293	5053	LB	4240	left

P5.1	11024	12531	RB	-1506	left
P6	4390	15685	RB	-11295	left
P6.1	6294	3540	RB	2754	right

Calculation of Sediment Deposition from the Change in Variation of MBL

Assuming linear variation of change in MBL, the calculated net sediment deposition was found as 9.4×10^8 m^3 during 1992 to 2000. It corresponds to about 22.0cm sediment deposition each year throughout the study reach (P3 to P6.1) of Padma river during the period from 1992 to 2000.

The variation of annual maximum, minimum & average discharge for the Padma river at the same station shows in Table 2. From this table it can be seen that the annual average discharge had an increasing trend. As a result, cross-sectional area had increased and fall of water level had occurred at Baruria Transit Station.

Table 2 Variation of Annual Maximum, Minimum & Average Discharge for the Padma River at Baruria Transit Station

Year	Q_{max} (m^3/s)	Q_{min} (m^3/s)	Q_{avg} (m^3/s)
1966-67	81300	5600	24352
1967-68	63600	5350	22593
1968-69	80200	5090	24546
1969-70	72700	6000	24820
1970-71	84200	6080	28135
1972-73	76600	5910	24643
1974-75	113000	5660	33501
1980-81	109000	4490	31261
1981-82	88200	4250	26085
1982-83	89600	4760	27366
1983-84	101000	4440	29335
1984-85	107000	5010	31611
1985-86	90200	5430	31470
1986-87	81100	3040	27645
1987-88	113000	5120	30530
1988-89	132000	5200	33583
1989-90	79800	5300	29505
1990-91	83700	4570	31766
1991-92	100000	4610	31779
1992-93	72500	4750	23759
1993-94	84700	4120	31683

Table 3 Lateral Bankline Shifting along Grid Lines (along Eastings) of the Padma River from Satellite Imageries with respect t o 1973

Grid Line	m Easting	Right Bank (km)	Left Bank (km)
1	485000	+3.35	-0.55
2	490000	-1.45	-1.40
3	495000	-1.90	-4.50
4	500000	-2.75	-9.15
5	505000	-3.95	-1.55

NB: (+) means sedimentation and (-) means erosion.

Bankline Shifting from Index Map Supplied by BWDB

There was a pucca road between cross-section No. 43 and 15 from Lohertek regulator toward Faridpur Town which was already drowned under water within one year due to the devastating bank erosion. The embankment downstream of cross-section No. 8, 28 and 33 was also drowned under water. The embankment between cross-section No. 29 and 31 merged with the bankline. All these cause unmitigable losses of properties and unbearable sufferings to the people.

Table 4 Amount of Right Bankline Shifting of Padma River at the Study Area from Index Map

Cross-section No.	Shifting from 1999 to 2000 (m)	Shifting from 2000 to 2001(m)
12	240	315
13	225	420
14	262.5	450
15	315	495
16	360	465
17	397.5	480
18	412.5	525
19	405	577.5
20	592	330
21	420	585
22	450	517.5
23	450	525
24	450	525
25	450	495
26	450	495
27	450	495
28	420	510
29	405	510

30	390	510
31	360	480
32	337.5	427.5
33	322.5	375
34	285	360
35	285	397.5
36	300	420
37	315	360
38	322.5	298.5
39	330	255
40	300	217.5
41	285	172.5

Protection of Faridpur Town and its adjacent areas

A proposed embankment parallel to river bankline can be suggested as a temporary and low cost alternative to protect the affected areas from flood. If bank erosion continuously increases toward the countryside then a series of spur or revetment must be constructed. It can be seen in model that the existing retired embankment is very close to the present bankline. An this moment, another embankment parallel to the present bankline from cross-section No.1 to 52 can be proposed as shown in the above figure. In addition to this, a series of solid RCC/earthen spurs can be introduced from proposed embankment upto bankline for the protection of these areas. Due to this, the river bankline can not extend toward the countryside without disturbing the existing condition of river. As a result river is not affected naturally and no environmental impact has been occurred. The number, length and spacing of spur also depends on river reach to be protected and the distance between proposed embankment and bankline. As an alternative to spur, river bank can be protected by providing revetment. But it is too much expensive to protect such a long reach. The optimum number, length, spacing, orientation of spur and block size of revetment should be determined by physical model investigation.

Conclusions and Recommendations

Conclusions

The following conclusions can be drawn on the basis of the present research study:

- Over a period of eight years (2000-1992), the cross-sectional area varies randomly. The cross-sectional area at cross-section P3, P4 and P5.1 has a decreasing trend whereas CS P3.1, P4.1, P5, P6 and P6.1 has an increasing trend indicating aggradation and degradation of these cross-sections respectively during 1992 to 2000. The net increase in cross-sectional areas is about 2.4% in 2000 in comparison to situation in 1992. The study also reveals that the average depth in 2000 is less than that of 1992 while the average top width increases.

- The thalweg of the river moves from one bank to another in a random fashion. The thalweg of cross-section P3, P4.1 and P6.1 moves to the right whereas P3.1, P4, P5, P5.1 and P6 move to the left. The average thalweg level in 2000 is 1.0 m above than that of 1992.

- The MBL at all cross-sections rises in 2000 compared to 1992 situation which represents the channel bed has a deposition tendency during the period from 1992 to 2000. Assuming linear variation of change in MBL, the calculated sediment deposition was 9.4×10^8 m^3 over eight years period i.e. from 1992 t0 2000 which corresponds to about 22.0 cm sediment deposition each year throughout the study reach of Padma river.

- The general equation of rating curve obtained in the present study using data from 1966-94 is given by:
  WL = 2.2281Ln(Q) - 17.221 from which one can roughly estimate the water level with known discharge and vice versa for the study area.
- From the index map supplied by BWDB, the trend of right bankline shifting towards the countryside. The maximum amount of shifting at right bankline is around 1005 m near Romesh Bala Dangi under Char Bhadrason Upazila. During the period from 1999 to 2001 i.e. bankline is shifted towards the countryside at a rate of 502.5 m per year which is dangerous if appropriate protective measures have not yet been taken. If bank erosion is continues with this rate, the affected area with homesteads will be engulfed into the river within a very short period of time.
- From the superimposed satellite imagery supplied by EGIS, the river bankline has been extended both toward the left and right countryside in 1999 relative to 1973 situation at the study area.

Recommendations

The following recommendations can be made on the basis of the present research study:
- A series of spurs having tentative number, length, alignment and spacing from proposed embankment to bankline can be recommended to protect the study area. The optimum number, length, spacing, orientation of spur and block size of revetment should be selected by adopting physical model study.
- As an alternative to spur, continuously double layer revetment (by placing 2 layer RCC blocks) along the bankline for the study reach can be suggested. But for the long reach, it will not be economical in practice. For localized problematic reach, it can be constructed.
- All the suggested spurs to be constructed in one year so as a consequence of joint hydrodynamic effect to combat bank erosion.

- The research work was conducted on the basis of recent bathymetry of February, 2001. After this period bankline and morphology will be changed. For this reason, due care should be given to assess these changes before construction of any river training structure in the field.

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