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Sedimentation processes at the navigation channel of Mongla port on the Pussur-Sibsa river system in Bangladesh

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Abstract:

Mongla port is situated in the south western hydrological zone of Bangladesh at the confluence of Pussur River and Mongla Nullah approximately 132km u/s of the Bay of Bengal and 45 km south of Khulna city. This is the second sea-port of the country which faces problem of navigable depth. The study finds out the present navigational depth scarcity from sea mouth to port jetty due to siltation of the River Pussur, Mongla and Sibsa River System by using HECRAS-4.0 mathematical model. Sensitivity by a method of river width contraction is to see the erosion deposition pattern in the channel and response of the system hence then analyzed.

Key words: navigation, port, morphology, width contraction, sedimentation etc.

Introduction

Southwestern regions of Bangladesh are bounded by the Ganges and the Lower Meghna in the east and by the Indian Border in the west and by the Bay of Bengal in the south. The coastal region of Bangladesh and the rivers in this region shows a continuing process of siltation progressing generally from northwest to southeast. The significant source of upstream freshwater at Mongla Port is flow through Ganges to Pussur.

Mongla port consists of shore based facilities and a sheltered anchorage in the Pussur river. The banks of the river have continuous belt of mangrove forest of Sundarbans with small creeks at places throughout the passage from 5.75miles south of Hiron Point up to the Mongla Harbor area. The weather in the port area is tropical with minimum temperature is 8^0c and humidity of 50%. During summer maximum temperature rises to 40^0c and humidity is 95%. Southwesterly monsoon from June to August causes rainfall of average 200cm.Tropical storm is formed in the Bay of Bengal during April to May and September to October. The intensity of storm is lost on reaching the port after crossing the coast and the Sundarban. Thunderstorms of very short duration usually occur with squally winds up to 21m/s. (Rahman et. al 2000). Maximum length of vessel that can enter in the anchorage is 225m and for mooring buoy it is 185m. Vessel of 8.5m, 8m and 7m maximum draught can take berth in the anchorage, mooring buoys and jetties respectively. Entrance to the Pussur River is about 6miles wide at the mouth and has a bar over about 5miles where depth is 6.2m. Ships having draft up to 7.5m can cross the bar in all seasons. (Malek & Ashraf 2004, MPA 2007, Womera 2006)

As per investigation by IWM (2004), the dominant bed material can be classified as fine sand. There is no distinct variation in the bottom sediment over the area. (min D50=.098 mm max D50 =.126mm mean D50=.11mm), although it is strongly suspected that coarser material would be encountered over the shoals, due to sorting action of the waves that will break in these areas. The variance of the bottom grading is surprisingly small (typical D85/D15=2.6) which implies very little cohesive material is settling out of suspension in the main channel on over the outer bar. The absence of cohesive material on the bed cannot be explained by the by the local wave conditions, as the wave climate was generally very mild during the field campaign (typically Hs<1m). Consequently, the tidal currents along must be sufficient to maintain the cohesive material in suspension and transport it out of the Pussur entrance and over the outer bar, where it will be deposited in deeper water.

The dominant suspended material can be classified as medium silt, D_{50}=.015mm. There is little discernible difference in the grading of the surface and near bed samples, although, in general the surface samples have a slightly finer grading. The proportion of non-cohesive material is less than 10% for the samples taken 1m below the surface. This implies that suspended sand is confined to the area very close to the bed. The majority of the suspended load is therefore classified as wash load which will have a little effect on the morphology and the sedimentation characteristics of the area.

The key observations from the sample analysis are:

a) The bed material along the main flow areas of the bigger rivers is fine sand. Closer to the banks it is often mainly silt.

b) The suspended solid fine materials does not contribute significantly to erosion/sedimentation processes in the main flow regions of the bigger rivers including the navigation channel of Mongla port.

c) The transport of bed materials is significantly smaller than the transport of fines. It contributes to the total transport of sediment by to approximately one-third.

Problem aspects of navigational system near Mongla port

Mongla Port is facing navigational problem mainly in the following areas (areas illustrated in figure 1):

a) In front of the Jetties
b) At the inner bar reach
c) At the outer bar reach

In 1964 the left bank of Pussur River was selected for 8.5m draught vessels, the sites for the berth in Mongla Port. But the river suffered gradually deterioration in subsequent years including the harbor areas due to Siltation. The reduction of U/S flow after commissioning of Farakka barrage further resulted in a decrease in navigational depth. Since 1970, the depths in the area had been reduced significantly and presently 6m draught vessels can take berth at the jetties. The severe flood of 1988 carrying large sediment loads caused further shoaling particularly at the confluence and the southern anchorage. Since last two decades from Maidara to Sabur Beacon the required 6m draught for continuous navigational channel are not available. The dredging works done each year from 1979 to 1997 in front of the jetties weren't sustainable. The scarcity of navigable depth has worsened after the flood of 1988 and 2000. The inner bar is located 10km D/s from Mongla and lies between Danger khal and southern anchorage. Significant morphological changes have occurred from Mongla Port Jetty and to Joymonirgal due to inner bar. The outer bar is located about 45km seaward from Hiron Point. Since the beginning of the port outer bar is a problem for marine vessels over 8m. The main problem is frequent shifting of bar position on the left right direction. The gradual loss in depth is also happening day by day. (DRP Farleigh 1981, 1984)

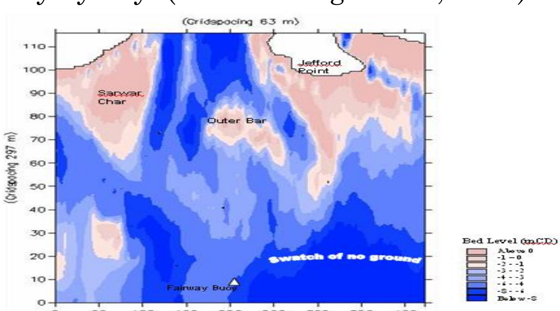

Figure 1 Bed level change near Mongla port (IWM, 2004)

Data and methodology for the problem analysis

Data has been collected from different secondary source(s). Bathymetry data were collected from Hydrographic survey carried out by Mongla Port Authority (2002-03). Discharge data at Mongla Nala (near the confluence of Mongla Nala and Pussur River) and Sibsa River near the confluence of Sibsa and Pussur are used for analysis. Data is available for April 2003 & August 2003 which covers both dry and Monsoon season end spring and neap tide cycle (Womera 2006). Other data used in the report were collected from statistical year book of Bangladesh, Banglapedia and different websites. Suspended samples has been collected during discharge measurements at 8 cross-sections. The samplings were done simultaneously during the flow measurement. The suspended sediment samples were collected in each vertical at Surface, 0.2, 0.4, 0.6, 0.8 and Bottom (1m above the bed) of the total depth. Determination of total suspended sediment concentration and separation of fine and coarse sediment in suspended was done by filtration method. The filtration method was somewhat faster for samples of small concentrations. Usually Millipore filter papers are used in case of water samples with rather low content of sediments. This is due to the fact that the pores of the filters are of the dimension 0.45 μm. The concentration samples are separated by an elutriator into grain size fractions above and below 0.05 mm.

Hydrologic and morphological modelling set up is done by HECRAS 4.0. It can simulate both steady and unsteady flows and includes elaborate treatment for complex channel cross-sections and structures like bridges, culverts and dams. The HECRAS 4.0 has added some new functions to simulate sediment transport within the SIAM module. SIAM is based on dividing the sediment load in a geomorphic reach into wash load and bed material load components and then accounting for the supply, movement and storage of each component on a reach by reach basis throughout the fluvial system. It is assumed that transport of wash load is supply-limited and that wash load sediment will pass through a stream reach, without interacting with the bed and being deposited to drive aggradations. The movement of bed material load is assumed to be transport-limited so that scour or fill will occur if the local transport capacity is either greater than or less than the supply from upstream (HEC RAS 4.0 user manual 2009).

HECRAS uses St.Venant Equations (#ref) in the form of continuity to describe flow movement and equilibrium equations for sediment transport modeling. The flow is also solved using the Preissmann four-point scheme, with elaborate considerations of complex cross-sectional geometry and numerous types of hydraulic structures. For the morphological model set up, Exner equation, inbuilt in HECRAS sediment routing routines, is the sediment continuity equation for the analysis. The whole approach towards the modelling is shown in the figure below.

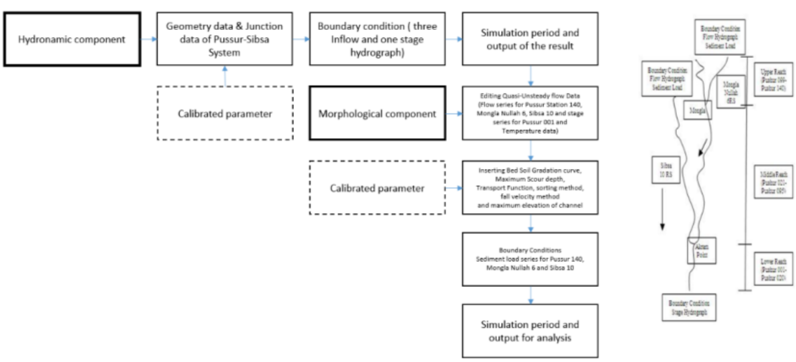

Figure 2 Approach and methodology

Results and discussions

Figure 3 represents the depths along the Pussur River from west point (Sea Mouth) to U/S of Mongla Port. Figure 6.1 also represents the depth along the Pussur reach. It is seen from the figure that the navigable depth is maximum (35m below CD, ISLWL) near Tinkona dwip and minimum (4m below CD, ISLWL) near Mongla where the port is presently located as marked by circle.

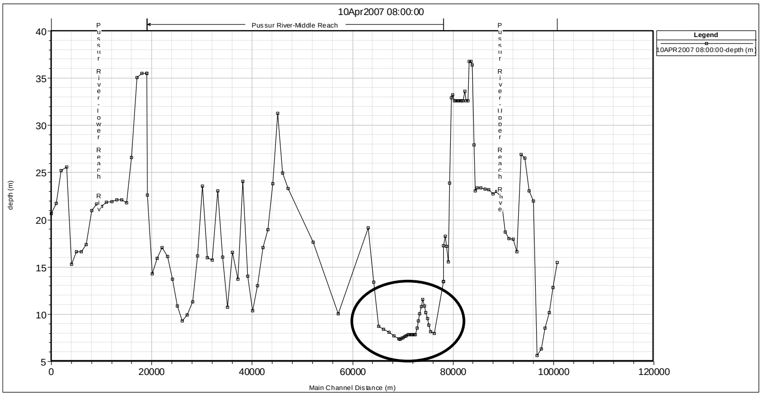

Figure 3 Depth orientation in the Pussur system (Depth in chart datum, CD, ISLWL)

Navigational width is also a problem for the Mongla port. The following observation is made from the navigation width. These facts are illustrated in the figure 4 below.

- For 6m draught vessels 250 width along the channel from Jafford point (RS 2) about 66km is available but from RS 85 to RS 95 near Mongla 250m width is hardly available.
- For 8m draught vessel the channel has adequate width from Jafford Point (RS 2) to Joymonirgoal (RS 65 about 62km). At the upstream of Joymonirgoal the width is less than 250m.
- For 10m draught vessel the channel is continuously navigable from Jafford point to 34km upstream along the channel. Except this reach, there are several places where 250m width is not available.

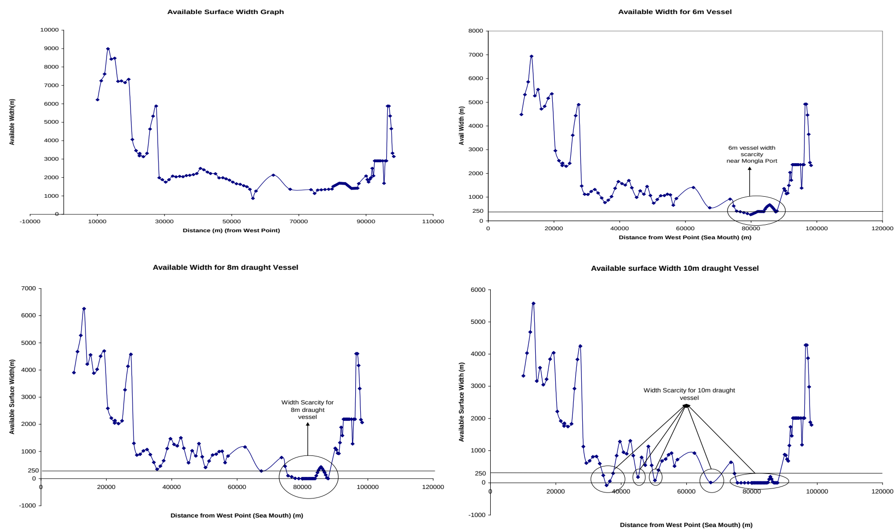

Figure 4 Width orientation in the Pussur system (top-left), with scarcity for 6m vessel (top-right), 8m vessel (bottom-left) and 10m vessel (bottom-right)

Two types of velocity are observed here. These are ebb velocity and flood velocity. The calculated velocity along the channel is shown in Figure 5. The average ebb velocity is 0.28m/s and it ranges from 0.09m/s to 0.5m/s and the average flood velocity is 0.68m/s and it ranges from 0.9m/s to 3m/s. The highest velocity is found at the upper reach station Pussur -140 where the channel is narrow. Maximum discharge at Middle reach is 7382 m3/s (Ebb) (RS 20) and 8145m3/s(flood). Maximum discharge at upper reach is 8145.77 m3/s (flood).

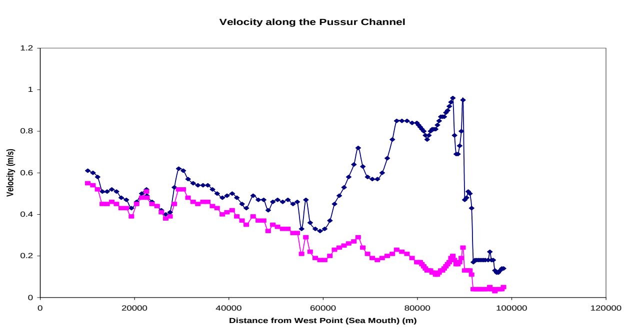

Figure 5 Flood and ebb velocity in the channel

The average sedimentation rate is 0.57m3/day. The maximum sedimentation rate is found 4.89 m3/day at the point where Mongla port is located. The sedimentation rate varies from 0m3/day to 4.89m3/day. It could be noted from the Figure 5 and Figure 6 that the water velocity near the Mongla port region is so low which ultimately leads to sedimentation and increase the bed level. The increase of bed level also causing navigational problem in the particular area.

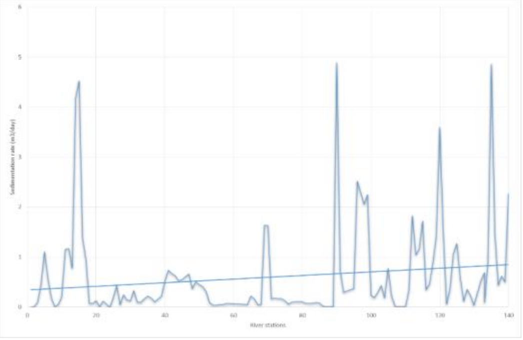

Figure 6 Sedimentation pattern in the channel

To learn the behavior of sedimentation response, a further modeling study is conducted. The right bank side near the Mongla port region is selected for width contraction. The main focus is to learn to find the sensitivity in the sedimentation pattern. For the particular study, the modeling a simple obstruction of 10% of existing width is used for the effect of contraction. 10% contraction of the width produces an increase in velocity from 12% to 22%. In the downstream of the contracted reach the effect of contraction is negligible and except at reaches from 27 to 38 and 44 to 46. The velocity more than 1m/s (RS 85 to RS 90) may cause bank erosion. An increase in discharge between 14% to 21% is found in the Mongla port area. The change in the sedimentation pattern is shown in the figure 7 below.

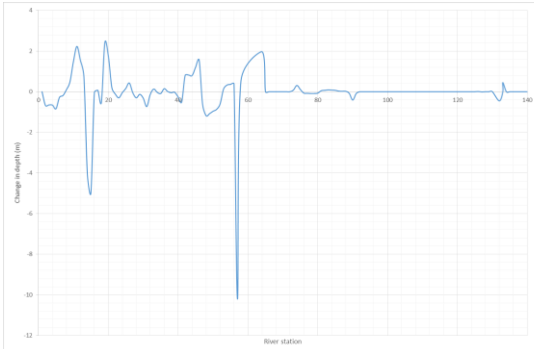

Figure 7 Sedimentation pattern fluctuation in the channel by contraction near channel of Mongla port

It could be seen from the figure that the contraction shows the erosion-deposition pattern. The contraction in near the Mongla port (RS 75 to RS 90) leads to erosion the place port jetty to Joymonirgal in downstream which helps the increase of navigational depth. Moreover, the some pattern also find a scope to know where the measure required to be taken for the improvement of navigational depth.

Conclusion

Mongla port is suffering significant deterioration in depth. The maximum draft of vessels that can enter presently the port varies between 6.0 m and 8.0 m, depending on the tide and weather conditions. From Maidara to Joymonirgoal the required minimum depth for 10m draught vessel, continuous navigation channel does not exist. The river from Joymonirgoal to Hiron Point maintains a good navigable channel which is sufficient for even 10m draught vessel. The channel from Hiron Point to Fairway Buoy also lack of required navigable depth. For modern age the port, navigable depth more than 12m, are useful for modern cargo handling which is the lack of Mongla Port.

It can be stated that the present study is more qualitative than quantitative due to lack of field data. If proper field data is available for calibration and validation of the model HECRAS SIAM model can also be satisfactorily used for morphological changes of Pussur-Sibsa river system hence Mongla Port. Width contraction and dredging can be used for improving the channel navigable depth. In this study it is seen that, contraction of river width for Mongla cannot be very useful in improving of navigation condition. A combination of contraction and dredging may prove useful.

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