ASSESSMENT OF COASTAL SCOUR OF SANDWIP CHANNEL FOR DESIGN OF A JETTY

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ABSTRACT

Hydrographic survey chart supplied by BIWTA has been utilized to assess the available navigable draft in the vicinity of a proposed jetty location. It has been seen that the jetty end at distance 360 m from the vicinity of existing shore line. According to the BIWTA hydrographic survey chart, the depth range at the shore line is about 3.4 m to 3.7 m. However at the Jetty end the available low water depth ranges from 4.7m to 5.25 m. The depths have been added to tidal range that found to vary between 3.0 m to 5.0 m. Assessment of scour has been done using Herbich et al. method. Local scour and total scour for various wave length and wave period have been computed. Variation of dimensionless scour depth (D_s/H) for various dimensionless wave heights (H_s/H) has been generated. It is seen that total scour depth (D_s) is much higher as compared to local scour for a given pile diameter and bottom velocity. For BIWTA Jetty at Sandwip local the scour at pile of diameter 1.5 m was found to be approximately5.22 m. Using the same method, the estimated total scour depth has been calculated as 12 m.

Keywords: Coastal scour; hydrographic chart; Sandwip channel; total scour; jetty pile

INTRODUCTION

The characteristics of the coastal morphology of the study area might be better understood if the morphological processes that govern the long-term natural and/or human induced changes at the coastal part are known. Due to scarcity of historical geological and morphological data at the vicinity of the project location, historical morphological changes have not always been analysed.

The subject of scour (and siltation) at coastal structures continues to receive much interest in the consulting and research fields. Coastal structures can be categorized as having four functions, either (1) to provide permanent protection against flooding (e.g. dykes and seawalls), (2) water level control during storm surges (e.g. barriers) or (3) benefits in coastal management such as preventing shoreline erosion (e.g. seawalls, breakwaters, groynes), or (4) for other industrial or economic functions such as harbour breakwaters and jetties, outfalls/intakes, and wind farms. As such, the topic of scour at coastal structures can be said to cover structures built on the shoreline as well as structures built in tens of metres of water, and waves and currents operate in varying combinations and relative magnitudes (Jiang, et al. 2004). In engineering projects scour needs to be considered in two phases, the installation/construction phase and the operational phase. The limiting case for design may require consideration of the erosion of seabed soils adjacent to the completed foundation. However, it is also important to evaluate what kind of scour might develop during installation as it might have a direct bearing on the stability of the structure that is being built, or on the construction methodology that is adopted. In most of the cases, the main issue for design relates to the target scour development that can be expected under design conditions, i.e. location, depth and extent, but knowing the time development is also important in some cases. A general approach for assessing the mobility of the sea bed soil at a structure was presented by Whitehouse (1998). This requires input data on waves, currents and water depth (chart depth plus water level variation). These inputs may be determined from modeling or analysis of field measurements made over a sufficiently long time, with analysis for relevant return period conditions. The input data are combined at a point A to produce a set of robust inputs and once combined with information on the soil characteristics obtained from the site investigation they are analysed to provide information on the bed shear stress and the critical value of bed shear stress for erosion of the soil. An experimental study on scour around a pile subject to combined wave and current is given by Sumer and Fredsøe, (2001). Irregular waves were used in the experiments carried out both for codirectional waves and for waves propagating perpendicular to the current. The measured scour depth is plotted as a function of $U_{cw} = U_c/(U_c + U_m)$ in which U_c is the undisturbed current velocity and U_m is the maximum value of the undisturbed orbital velocity at the sea bottom.

STUDY AREA AND ITS CHARACTERISTICS

Sandwip Island is surrounded by the tide-dominated East Hatiya Channel, the Sandwip Channel, and the channel linking Urirchar. Available data for the last 75 years (1913-1988) show that Sandwip was reduced to about 50% of its original size, with considerable erosion northwest and accretion southeast. Map comparisons show that erosion on the northwest coast of Sandwip accelerated after 1963. It was about 200m per year between 1913 and 1963 and about 350m per year between 1963 and 1984. Urirchar grew from 3 sq km in 1963 to 46 sq km by 1981.

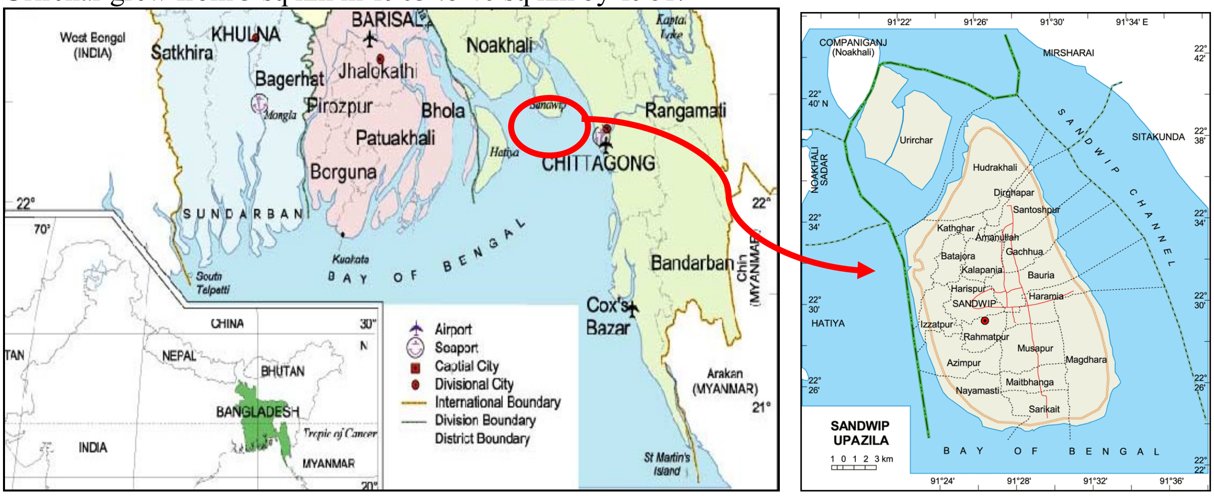

Fig. 1 Map of coastal zone of Bangladesh and blow-up map of Sandwip

Tidal Range and Depth Averaged Velocity at Sandwip Channel: Sandwip Tide Chart shows the largest known tidal range at Sandwip as 2.87m (August 2, 2015). Tide Times are BDT (UTC +6.0hrs). Last Spring High Tide at Sandwip was on Sun 02 Aug, 2015 (height: 2.60m). Next high Spring Tide at Sandwip will be on Sat 15 Aug (height:2.40m). However, Sandwip Tidal range Max.4.83 mMin. 0.79 was observed in 2008. Tide datum was Mean Lower Low Water (Satellite). Table 1 shows the depth average velocity of Sandwip channel.

Morphology of Sandwip Channel: Chittagong coastline remained relatively stable over the years. In the north, considerable accretion took place due to a closure damon the Feni river. The reason for its relative stability is perhaps the near-isolation of Sandwip Channel from the distributary network in recent times. Coastal plains are inundated every day by tides coming from sea. Sediments are generally consisting of clay with silty materials. It is worthwhile to mention that the present morphological features of the stream/creeks may alter due to any man-made activities as well as naturally induced hazards. At present, Sandwip Channel is tide-dominated, allowing a net import of fine sediments. Review of previous studies shows that the no significant changes in channel morphology have been observed. Reza (2010) analysed cross-sectional data of various years as shown in Figure 2. It is seen that maximum bed level changes to about 9 m at the thalweg.

Table 1 : Depth averaged velocity of Sandwip channel (Alam, et.al 2014)

Location	Measured depth Average Velocity, (m/s)	Maximum velocity for T=100year, (m/s)	Maximum velocity for 2011 flood, (m/s)
North Sandwip	1.13	1.3	1.08
North East Sandwip	1.79	1.8	1.59
South-east Sandwip	1.82	1.9	1.71

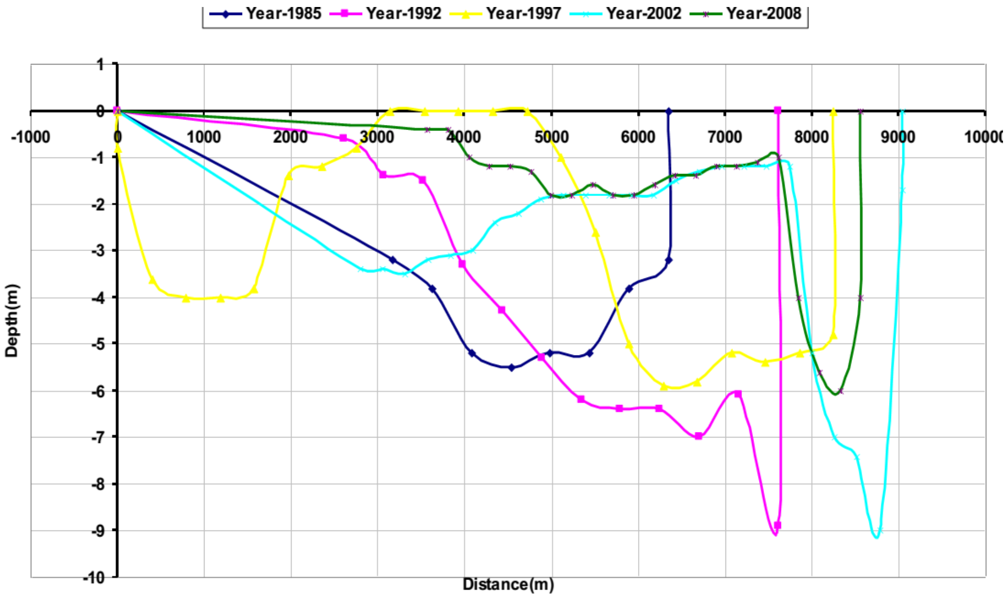

Fig. 2: Superimposed cross-sections of various years of Sandwip Channel
(source: Reza, 2010)

METHODOLOGY

Available formula for the computation of coastal scour has been analysed. As a thumb rule, local scour around a pile has been estimated as 2 to 3 times of pile diameter. However, some formula calculates the local scour due to current action and wave. Nearshore coastal piles are always vulnerable to both wave and current action. For a more complete description of scour prediction methods for scour at vertical piles can be found in Einstein and Weigel, (1970) and Herbich et al. (1984). Based on test results from a laboratory study, they made tests run to examine effects of waves, currents, and the combination of the two. Herbich et al. concluded that scour at the base of vertical piles caused by wave action alone is insignificant when the piles are in relatively deeper locations. They proposed a procedure consists of number of empirical (laboratory based) equationsto estimateboth local and total scours. The procedure has been adopted for present scour calculation. Hydraulic data used in this analysis were collected from secondary sources (Hydrographical data collected from BIWTA). Field visit has also been made in September 2014to observe the tidal and morphological characteristics at Sandip channel at the vicinity of proposed site whereBIWTA jetty would be constructed. BIWTA constructed a landing Jetty at Swandip channel in early year 2000 to facilitate inland passengers and cargoes and they cross the channel to Sandip headquarters from Kumira (Shitakunda). Unfortunately this jetty has not been operational in last 15 years due to considerable damage immediately after its construction. Reasons of such damage of jetty have not been explored, but it can be anticipated that proper design and constructional procedure might not been maintained. Some recent photographs (Photo:1 to Photo: 4) are shown to observe the condition of the old jetty at Sandwip side.

Photo:1 Damaged BIWTA Jetty at Sandwip side at high tide (September, 2014)

Photo: 2Ferry vessel of BIWTA has beenanchored away from jetty at Sandwip (Sept. 2014)

Photo:3 Damaged BIWTA jetty at Sandwip side low tide (September, 2014)

Photo:4 Damaged BIWTA jetty near shoreline at Sandwip (September, 2014)

RESULT AND DISCUSSIONS

Local scour and total scour for various wave length and wave period have been computed. As for typical results, Fig.3 to Fig.6 show the variation dimensionless scour depth (D_s/H) for various dimensionless wave heights (H_s/H) for various combinations of wave heights and periods. It is seen that total scour depth(D_s) is much higher compared to local scour for a given pile diameter and bottom velocity. The computed scour depths are very much sensitive to wave height (H_s) especially at shallower water depth (H).

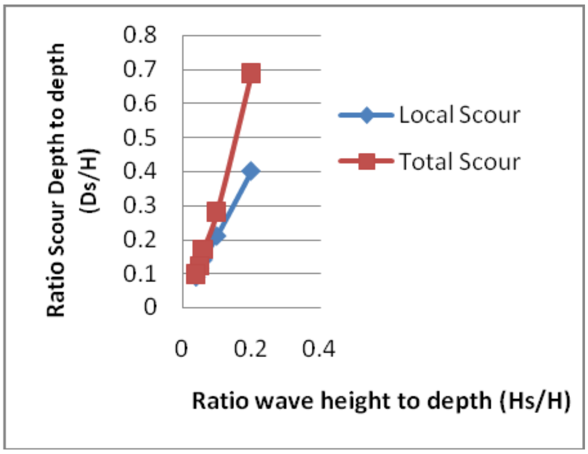

Fig. 3: Scour depths ratios (D_s/H) Vs. (H_s/H) for H_s=1m, T=1s

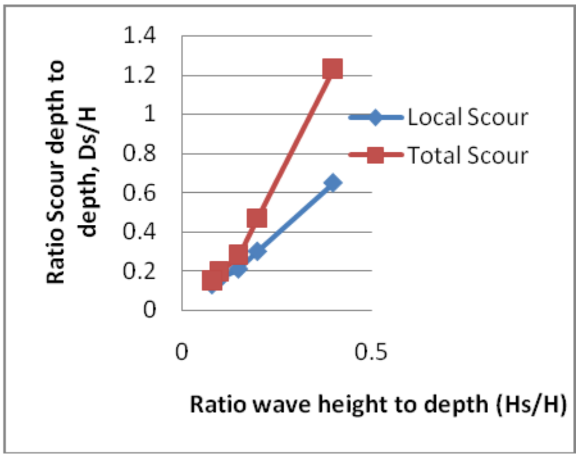

Fig. 4: Scour Depths ratios (D_s/H) Vs. (H_s/H for H_s=2m, T=2 s

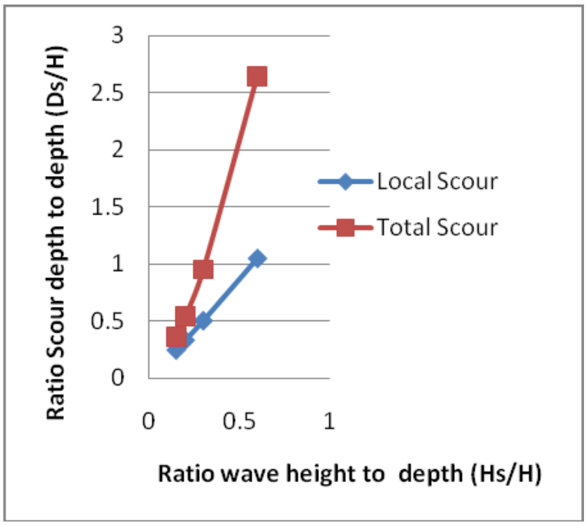

Fig. 5: Scour depths ratios (D_s/H) Vs. (H_s/H) for H_s=3 m, T=3s

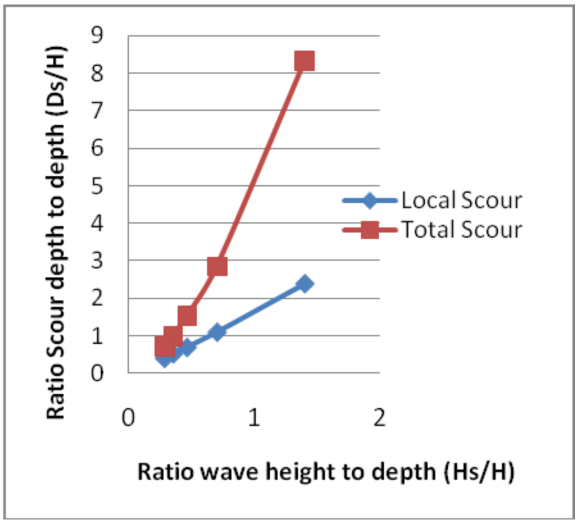

Fig. 6: Scour Depths ratios (D_s/H) Vs. (H_s/H for H_s=7m, T=3 s,

The hydraulic and bed material parameters provided in Table 2 have been used to estimate the bed scour. The local scour at pile of diameter D= 1.5 m was found to be about D_{sl}=5.22 m. Using the same method the estimated total scour depth has been calculated as D_{st}=12 m (BIWTA, 2016).

Table 2: Data used for scour calculation and scour values

Pile diameter (m)	D= 1.5
Wave height (m)	H_s= 2.0
Wave Period (s)	T= 4.5
Depth (m)	H= 8.0
Grain size (mm)	D_g= 0.15
Rel. Density	Δ = 1.65
K. Viscosity(m^2/s)	ν = 0.0000011
Bottom vel.(m/s)	v_b= 0.67

Design scour depth curves for various input values such as, velocity, depth, pile size and bed material size have also been generated for the users. In order to avoid any adverse effect in the vicinity of jetty piles, regular monitoring of river bank and bed condition in the vicinity of the bridge site and around the piers is recommended. A water level gauge should be installed with the jetty piles for regular monitoring of water level at the jetty site. Regular monitoring of scour at the vicinity of piles and at the piles is recommended so that any adverse scour can be monitored for emergency protective measures.

CONCLUSIONS

Proper understanding of the coastal morphology and thus assessment of local scour for any intervention of coastal line is vital importance. Design of coast line Jetty structures requires scour depth for adequate pile length and size. In such cases, morpho-dynamics of the site need to be assessed. It has been estimated that local scour in Sandwip channel for a near shore pile of 1.5 m diameter is about 5.22 m. Using the same method the estimated total scour depth has been estimated as12 m for the given pile size. Number of curves showing the scour depth for various input values can also be generated for design purposes. Post-construction suggestions have to be made so that countermeasure can be taken for any adverse impact on bed morphology.

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