A M M Safiullah, M A Ali, B Ahmed, M A Noor and A F M Saiful Amin (eds): ISBN 984-32-2142-4
*Proceedings of the Third Annual Paper Meet and International Conference on Civil Engineering*

# Factors Influencing Failure of Bank Protection Embankment of Surma River

**M.T. Rahman, Md. Misbah Uddin, R. K. Chowdhury, M.J.H.Khan, S. Sultana**

Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh.

## Abstract

*This paper highlights the probable causes of failure of existing bank protection works of the River Surma for safety of Sylhet, the northeastern city of Bangladesh. In this study, eight places were selected where the concerned authority implemented bank protection works. Observation shows that the soil particle of the embankment carries significant amount of clay, fine silt and fine dust, indicating that the soil of such areas is subjected to be eroded, which poses a great risk to the safety of this city. Moreover, the grain size analysis of all the selected locations shows that the effective diameter ($d_{10}$) of the soil sample is much lower than the value used in the design calculation of the authority. In consequence of this the scour depth would be more than the calculated one. However, the study will give a better understanding of those factors causing deterioration to the protective structures.*

## INTRODUCTION

Sylhet is one of the six divisional cities of Bangladesh and it has prime importance for its tourism, religious places, shopping and trade centers. Around half a million people live in this city [5]. River Surma flows dividing the city into two parts and the city gets developed on both sides of this. For the importance of the city, existing river improvement works [2] was analyzed through this research work. This study is based on geotechnical aspects; hydraulic factors and other design considerations [1] and will provide suggestion and recommendations to the concerned authority (Bangladesh water Development Board) in selecting and designing safer type of structure [10] in future. Again, the responsible authority had chosen eight places for providing protection to the city, which are—Tukerbazar, Kanishail to Ghashitula, Khalopar, Kazirbazar to Mollapara, Technical College to Mistri Mosque, Jhalopar, Mendibagh and Kushighat to Burhanabad. Figure-1 shows the locations of the existing bank protection works of the River Surma.

## METHODOLOGY

For efficient design of any bank protection work, it is important to find out the actual soil characteristics, realistic hydrodynamic parameters and the hydrological features [6]. Considering these factors as basic parameters for designing bank protection work, the study was objected to determine all these parameters with the best care and depending upon the results the design was reviewed and a comparative study was made for the protected riverbank site, Kanishail to Ghashitula [5].

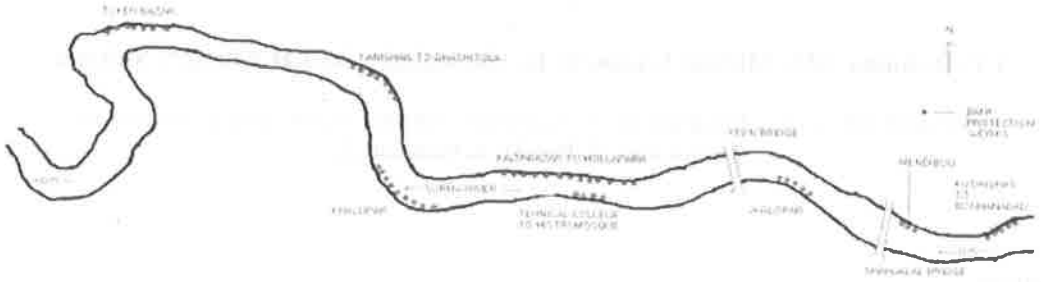

**Figure-1: Location of Bank Protection Works of Surma River**

Laboratory analysis was made to identify soil characteristics [4] such as grain size analysis for determining scour depth and design of geotextile [8]. To carry out the experiments, soil sample was collected very carefully and the characteristics of soil were identified in laboratory by particle size analysis in sedimentation method and gravimetric method [9]. Grain size and percentage of finer particles for the collected soil sample of different sites of Surma River, where concerned authority has taken protection works, were determined by these tests and the test results were used in reviewing the implemented design. For proper design of bank protection works, peak values of hydraulic factors such as water level, flow velocity, discharge etc. [3] should be considered. During this study of reviewing the design of bank protection work of the river Surma, highest values of 20 years' hydraulic parameters [3] were considered. With the reviewed design considering above factors, a comparative study was made for the site "Kanishail to Ghashitula".

## FINDINGS OF THE STUDY

Comparing the implemented [7] and proposed design [5] of a selected site named Kanishail, probable causes of failure of bank protection were identified. From the analysis of the available data and information, the dimensions and specifications of the structures were found out. Sample design calculation is shown for a particular site named Kanishail.

According to the suggested specification of the bank protection manual [1] detail design computation were performed. According to the computation and soil testing results for bank soil sample, the layout, the material specification of "Kanishail to Ghashitula" has-been shown in Figure-2 and Figure-3.

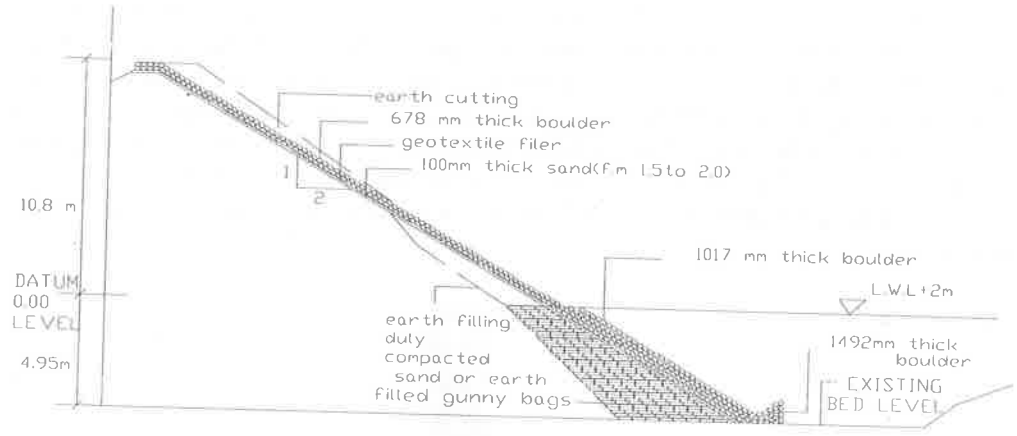


**Figure-2: Layout of bank protection works after calculation**

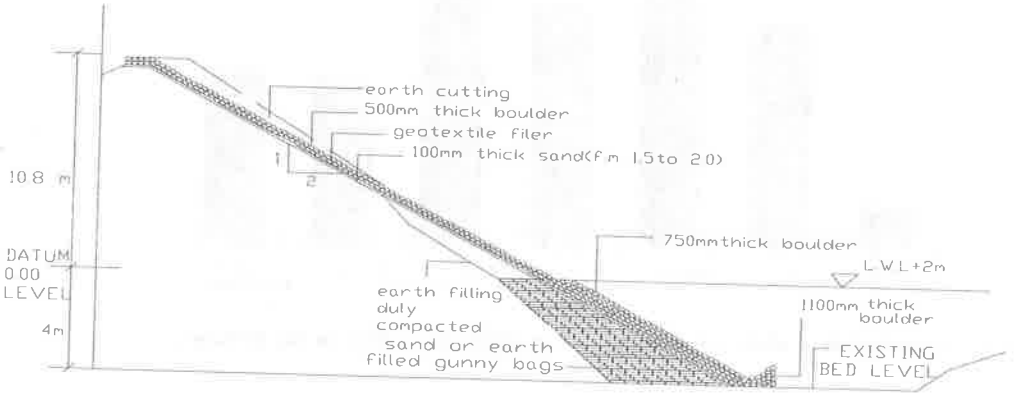


**Figure-3: Implemented design plan for "Kanishail to Ghashitula"**

## Comparison between Implemented Design and Required Design

**Table-1: Comparison between implemented and required design specifications**

| Design Parameter | Implemented values | Required values |
|---|---|---|
| The gradation of the Boulder | 250 mm to 300 mm 30%<br>300 mm to 350 mm 50%<br>350 mm to 400 mm 20% | 100 mm to 150 mm 30%<br>150 mm to 220 mm 50%<br>220 mm to300 mm 20% |
| The geotextile specification | Permeability is $7*10^{-5}$ m/s | Permeability is $6*10^{-4}$ m/s |
| Effective opening size | $O_{90}$ is 0.040mm | $O_{90} \leq 0.08$mm |
| Scour depth, d | 4 meter | 4.95 meter |
| Effective diameter $d_{10}$ | 0.14mm | 0.011mm |

The above comparison depicts that this design for the left bank of Kanishail to Ghashitula differs significantly from the estimated design of BWDB. As a consequence, the thickness of cover layer, grading size of stone, specifications of geotextile used in the bank protection works didn't satisfy the actual requirement. From the experimental results, it has been found that the soil carries significant amount of clay, fine silt and fine dust. This represents that the soil of such areas are subjected to be eroded, which poses a great risk to the safety of this city. In consequence of this the scour depth will more than the calculated one. The test results are shown in the Figure-4 and the Figure-5 represents photographic view of bank protection failure.

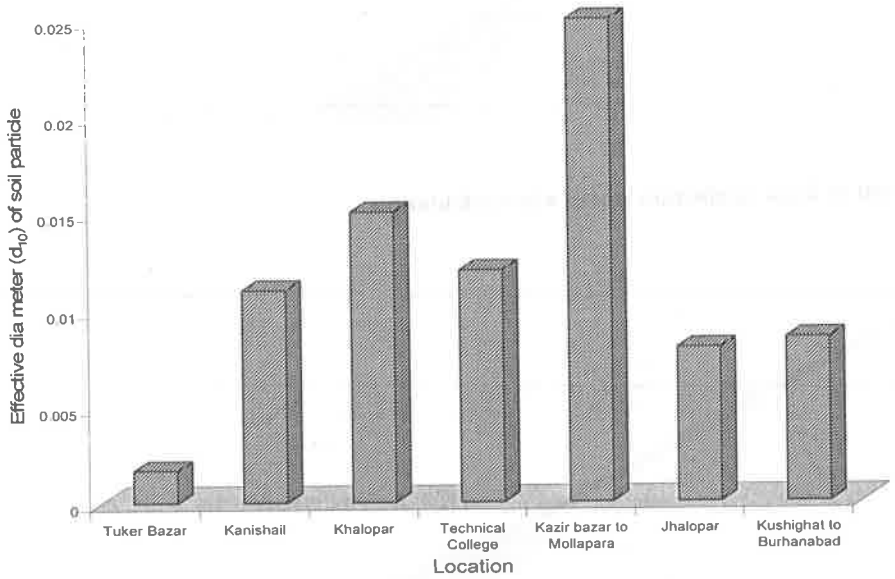


**Figure-4: Presentation of effective diameter of particle according to the location**

**Figure-5: Bank Protection Embankment, location Kanishail to Ghashitula**

## CONCLUSION AND RECOMMENDATION

Through this research work, the present condition of bank protection structures was evaluated and causes of vulnerability condition were pointed out. The average soil particle size were 0.011 mm and for this the calculated depth of scour should be 4.95 meter where as in the implemented design, depth of scour was estimated as 4.00 meter, considering the particle size 0.14 mm, which is not realistic. This might be the prime reason for the failure of bank protection works of River Surma. Other causes of failure were identified as follows:

- The thickness of cover layer, grading size of stone, specifications of geotextile used in the bank protection works didn't satisfy the actual requirement.
- The design plan of the bank protection works in each point in Sylhet city is similar; this represents the less assessment of soil parameter and other hydraulic factors in design calculation. In another words, the design of the embankments hadn't been updated timely according to the present data.
- Earth filling in the sloping surface of bank causes always less stability to the embankment because the compaction of soil hadn't been performed appropriately.
- Public structures made on the embankment, is a great risk for failure of the structure.

Visualizing the study, the following general recommendations are made for future works:

1. Extensive soil test should be done in both the banks of the river
2. Local station for measuring discharge, water level and velocity should be set up.
3. More research should be performed on the river Surma, and try to develop individual parameters. Physical and mathematical modeling can also be done to simulate flow pattern before designing the revetment works.
4. The main concern is to protect the Sylhet town, the revetment works in every section should be designed on its individual condition and consider factor of safety as it should be.
5. Open edge of boulders lead to more movement due to current action, it is better to use the cement concrete block which is regular, can be uniformly placed, and also economical.
6. Artificial water body i.e. pond, ditch in the vicinity of revetment will increase soil piping through the works leads to subsidence of the structure, it has to be filled before the works get started.
7. Community participation should be encouraged, to develop a sense among them about the structures overall objective.
8. Maintenance program should be improved to immediate recovery of partly damaged structure. Continuous monitoring may be more effective in the case of maintenance.

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