Stability Analysis of Brahmaputra Riverbank at Neulgaon

N.Sarma[1], P.Dutta[2]

[1] P.G. Student, Department of Civil Engineering, Jorhat Engineering College, Jorhat, Assam, India
[2]Assistant Professor, Department of Civil Engineering, Jorhat Engineering College, Jorhat, Assam, India

Abstract— *River bank erosion is a recurrent problem in Jorhat district of Assam. Most of the rivers in Jorhat are shifting in nature and thus river bank erosion is common. Erosion has lead to the general widening of the river and instability of the river banks. River migration and land degradation displaces large number of people annually. This study intends to investigate the nature of river erosion and provision of adequate structural measures. Hydrological data and topographical sheet gathered from government departments have been used as a basis for this project. Software analysis and chronological survey techniques are used for the measurement of channel migration and thus eroded distances. Based on software viz. ARCGIS, channel migration of the river Brahmaputra in Neulgaon, Jorhat is found out. Secondary data were also collected from the local residents to explain the erosion status. The geotechnical properties of the eroded site are important parameters for construction of anti-erosion structures. The design of a structure mainly depends on the topography, hydrological data, and the materials of construction, the mode of construction, and various dynamic properties of the soil. Engineering tests (Field work & laboratory work) has been performed to find its suitability as construction materials. Embankments are the oldest known forms of flood protection works and have been used extensively for this purpose. It is designed in accordance with BIS code 12094:2000. Stability check is then carried out to determine the safety factors.*

Keywords— **ARCGIS, Embankment, Erosion, River migration, Topography.**

I. INTRODUCTION

Floods are recurrent phenomena from time immemorial. Hydraulically inter-reliant factors such as velocity, depth, channel width and slope mutually interact and self-adjust to lodge these changes in river geometry and discharge contributed by drainage basin. In case of a failure, gravitational forces exceed the forces holding the sediments together. Failures can take several forms depending on sediment type, sediment layering, and moisture content. Bank erosion is a key process in fluvial dynamics, affecting ample range of physical, ecological and socio-economic issues in the fluvial environment. Slope stability is an awfully important contemplation in the design and construction of earth dam, embankments and in cut slopes. The stability of natural slope is also important as the result of slope failure can often be catastrophic, involving considerable loss of life and property.

The river Brahmaputra River runs for 2906 km (approx) through China, India and Bangladesh. The river Brahmaputra is best known by its complex nature of flows. Brahmaputra, an alluvial river has problems of sediment erosion-deposition attach with it. The problems of flood, erosion and drainage congestion in the basin are gigantic. The river has braided channel in most of its course mainly in low flow condition showing islands and bars. During high flow conditions, islands and bars submerges completely. This practicability study is for construction of embankments and up gradation of riverbank protection works.

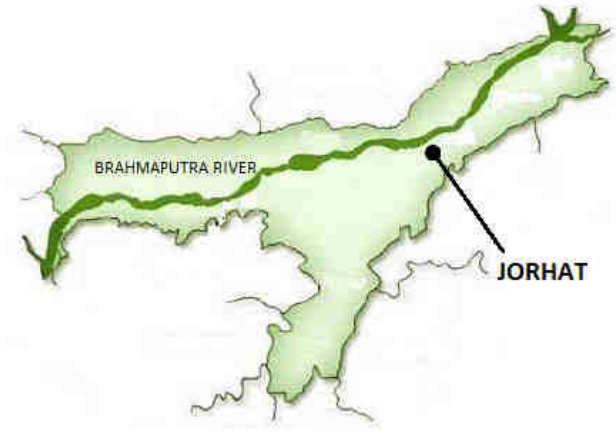

Fig.1: Jorhat district along the Brahmaputra River in Assam

II. STUDY AREA & RELATED PROBLEM

The study area includes Brahmaputra River in Neulgaon. The site is situated at North-West Jorhat, Assam. The area falls under Mising Autonomous Council. It is about 30kms from the centre of the Jorhat town. It is around 22km from Nimatighat via the road constructed adjacent the bank of the river. It takes around 1hr 45 minutes in private vehicle via Malow-ali which is attached to the

Jorhat by-pass 37# highway. In this area villagers suffer extensive damages to agricultural fields and properties every year due to erosion. Villagers reported that the Brahmaputra River wash away 40-50 meters of the bank every year in the area.

Fig.2: View of riverbank erosion at Neulgaon

2.1 Hydrological data

Hydrological data corresponding to the gauge site at Neematighat which is around 25 km from the actual site. It will be transferred to the actual site.

Year	Maximum HFL X(m)
1992	86.41
1993	86.60
1994	85.47
1995	86.25
1996	86.15
1997	86.82
1998	86.79
1999	85.66
2000	86.05
2001	85.70
2002	86.41
2003	86.60
2004	87.04
2005	86.15
2006	86.08
2007	86062
2008	86.09
2009	85.55
2010	86.38
2011	85.77
2012	87.25

III. METHODOLOGY

It consists of collection of hydrological data from the Upper Assam Investigation Division of Water Resources Department, Jorhat. Using these data, discharge, flow duration, flood frequency, high flood level is calculated for the project site. Software works consisted of delineation of Basin Area of Brahmaputra River over a particular area in Jorhat district. Appropriate GIS application is done to extract accurate bank line information. Collection of satellite-derived plan-form maps which have been developed for the year 1975.Here, ARCGIS is the software used for such application. Then follows, the collection of topographical sheet from Survey of India department. Toposheets (1975) viz. 83j1 and digital satellite images are used for the present study. In order to assess the rate of erosion, maps and imagery are registered and geo-referenced with respect to Survey of India toposheets using second order polynomial. Using ARCGIS imagine software; the satellite data have been geo-referenced with respect to 1:50,000 Survey of India toposheets. New database is then created to store the digitized information of the river Brahmaputra using Arc catalogue. From the database, the required digitization of the river is created over the toposheets. Then, the present (2016) Google map has been overlapped over that digitized portion which clearly depicts the change of course of the river over that area. Manual works consisted of field visit, collection of samples from the bed of the river and bank of the river, laboratory tests which consisted of engineering tests like Sieve Analysis test, Consistency test, test to determine specific gravity and dry densities, direct shear test. Experiments are conducted utilizing the instruments available at the soil Laboratory of the Civil Engineering Department, Jorhat Engineering College, Jorhat.

From the hydrological data and results of soil test embankment is designed in accordance with BIS code 12094:2000 and simultaneously slope stability analysis is carried out.

IV. RESULTS AND DISCUSSIONS

The processed version of imageries and maps developed in ARCGIS has been placed below.

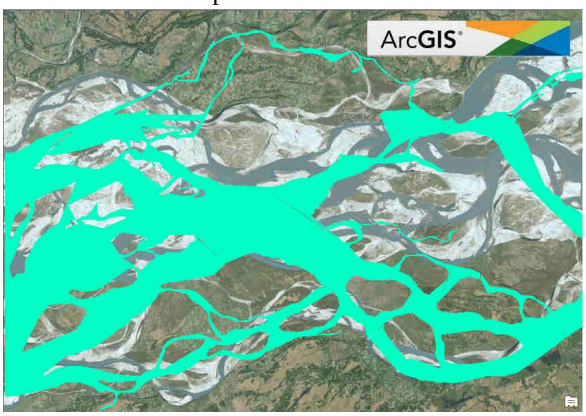

Fig.3: Comparison of Braiding of Brahmaputra River in Jorhat 2016 laid over Braiding of 1975

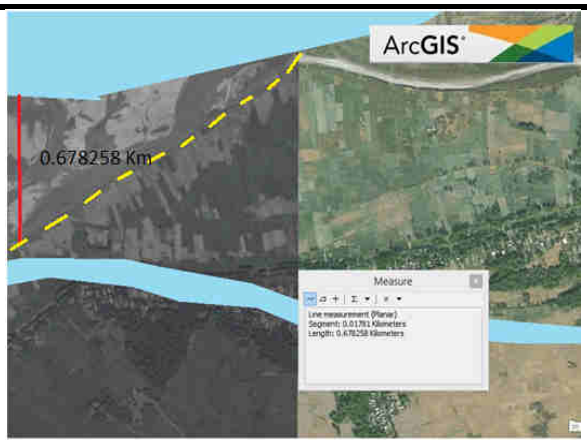

Fig.4: Superimposed braided channel layer showing an eroded distance of O.678258 km

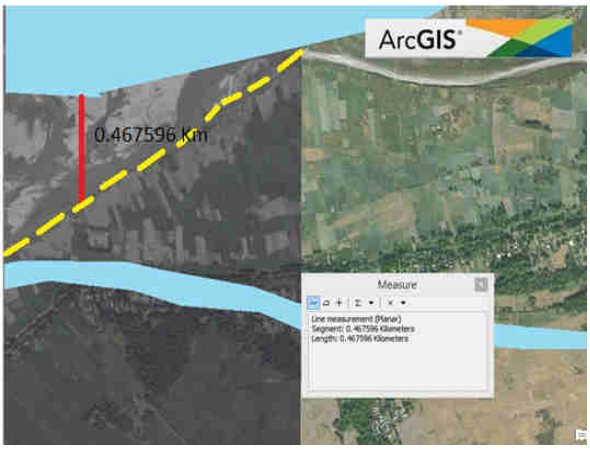

Fig.5: Superimposed braided channel layer at the site showing an eroded distance of O.467596 km

4.1 Results of flood frequency analysis

Flood Frequency Analysis is the statistical calculation of the probability of occurrence of flood of specific magnitude in a river, the specific period is called return period and the flow can be ranked as maximum possible flow. In Hydrology flow frequency analysis has occupied an important role and can be effectively used in any hydrology related project. A Flow frequency study is required to be carried out to evaluate the high flows for different return periods by using frequency analysis techniques. Different types of methods are used for flow frequency analysis.

· Gumble method

· Log Pearson type-III method

The calculation for hydraulic parameters viz design discharge, silt factor etc are done corresponding to the gauge site (i.e. Nimatighat, Jorhat). Hereafter, these are transferred to the actual site under study which will be used for design purposes of the embankment.

Design HFL by Gumble's method is 87.530m

Design HFL by log Pearson type3 method is 88.9194 m

Therefore, design HFL=87.530 (taking the value closer to maximum observed HFL i.e.; 87.25m)

4.1.1 Design HFL at Neulgaon site:-

Design HFL at Nimatighat, Jorhat=87.530m

Design HFL at Neulgaon, Jorhat= (Design HFL at Nimatighat)-(river gradient× distance to Neulgaon from Nimatighat)

=87.53-(25000/6450)

=83.654 m

4.2 Experimental Results

The results of the various laboratory tests performed on the sand sample of the river Brahmaputra, are as discussed in the following table.

Table 1: Results of the Soil Tests

Engineering properties	Test Result	
	Sample 1	Sample 2
Plastic limit	-	20.10%
Liquid limit	-	30.5%
Water content	19.57%	12.12%
Field density	2.35gm/cm^3	1.61gm/cm^3
Optimum Moisture Content	18.5%	11.51%
Cohesion	2.0kN/m^2	1.0kN/m^2
Friction angle	31 °	23 °

Sample 1: River Bed Sand

Sample 2: Bank soil

4.3 Embankment Design

It is designed in accordance with BIS code 12094:2000.

Height of the embankment= 15 m

Slope Angle = 33 °

Free Board = 1.5 m

Top Width = 5.0 m

4.4 Stability Check

For static slope stability analysis, Friction Circle Method and Bishop Method are employed. For any particular cross-section, the analysis involves trial and error, and many trials are required to locate the critical slip surface having the minimum factor of safety. Microsoft Excel is employed to find out the same. Friction Circle Method is based on total stress analysis and Bishop Method is based on effective stress approach.

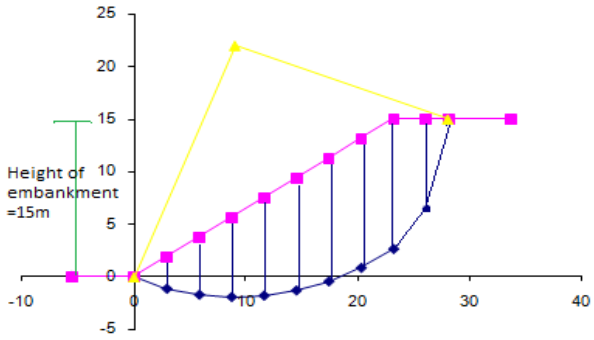

Fig.6: *Critical slip surface of embankment section*

Table 2: Slope safety for Embankment section

Method	Friction Circle Method	Bishop's Method	Fellenius method
Factor of Safety	1.3	1.11	1.2

Therefore, the slope is stable

V. CONCLUSION

With the advances in technology such as one in the field of GIS it has became ease to field out the present scenario in terms of its accurate results which is tiresome with the process of manual survey such as plane table, chain etc. With the use of ARCGIS we could easily find out the bank line map of the river where the erosion is maximum so that adequate measures can be used to predict the reason behind such happening and also propose suitable measures to prevent further erosion. Otherwise these sites would have remained unnoticed by the local engineering departments. From the above discussions, it is clear that the values obtained for the various engineering properties are well within the permissible limit for construction of anti erosion structures like embankment. The soil can be used for the construction of the embankment designed based on the IS code provision as the results obtained from mass stabilization calculation is safe and within the permissible limits. In the meantime efforts are going on for finding out the best suited method for the particular region with varied material and structural modification of the embankment.

REFERENCES

[1] Central Water Commission, Govt. of India (2012) "Handbook for anti-erosion, Flood protection"

[2] Clifton A. W. *et al. (*1980) "Riverbank instability and development control in Saskatoon".*National Research Council of Canada*

[3] Dapporto Stefano *et. al.* (2003) "Mechanisms of riverbank failure along the Arno River, Central Italy".*WileyInterScience(www.interscience.wiley.com). DOI: 10.1002/esp.550*

[4] Dutta M .K *et. al*. (2010) "A study of erosion-deposition processes around Majuli Island, Assam". *Earth science India Vol 3 (IV) Indian Institute of Remote Sensing, Dehradun*

[5] Fernando T. Leanne (2007) "The effect of flow induced erosion of riverbank stability along the Red River in Winnipeg". *The University of Manitoba*

[6] Goswami. R.K *et. al*. "Stability Analysis of Flood Protection Embankments and Riverbank Protection Works". (May 24, 2010). *International Conferences on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics.* Paper 34.

[7] Hossain Md. Bellal *et. al.* (2010) "River Embankment and Bank Failure in Bangladesh: A Study on Geotechnical.