Protection Measures using Geosynthetics along the Right and Left Bank of Jiabharali River in Assam

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Abstract: The River Jiabharali carries substantial quantity of silt along with discharge of 4429.73 cumec. Due to deposition of sediments, the sand chars forms in the river bed at random, creates spill channels making bank erosion more vulnerable. River Jiabharali has a natural gradient to shift its courses towards the western side and there is formation of offshoot channels after each flood, thereby widening its waterway and making the problem more intense. This paper describes the case study where Geosynthetics materials and Gabions are used in erosion and flood protection measures at Right and Left Bank of Jiabharali River in the Sonitpur District of Assam. Protection measures at Right Bank covers vulnerable reach from Ch: 9490 m (Dikoraijan) to 14397 m (Kurukani) and protection measures at Left Bank covers vulnerable reach from Chillanipam (Ch. 238 km) to Orangbasti (Ch. 245 km). The laboratory investigations undertaken for Geosynthetics materials and Gabions for the above project are presented in this paper along with advantages of using Geosynthetics materials.

Index Terms **- Protection, Erosion, Flood, Geosynthetics, Quality Control.**

1. INTRODUCTION

Jiabharali is one of the tributary of Brahmaputra which originates from Himalaya and after travelling through Arunachal Pradesh and Sonitpur District of Assam, it finally outfalls at mighty river Brahmaputra. Broadly Jiabharali River can be divided in to three main reaches i.e., upper (hilly), central reach and lower plain reach.

In the hilly region, rivers tend to erode their beds and banks resulting in deepening and widening of rivers. The bed of the basin is built up of rock boulders, gravels etc. When river enters the flood plains, it shows a tendency to braid and develop number of channels causing silting of the riverbed, change in course and bank erosion. In the lower plain reach, a river shows a meandering tendency with meander moving d/s causing erosion on the concave and deposition on the convex side as shown in Figure 1. Thus bank erosion and consequent loss of land has become a matter of concern due to its devastating impact on life and property

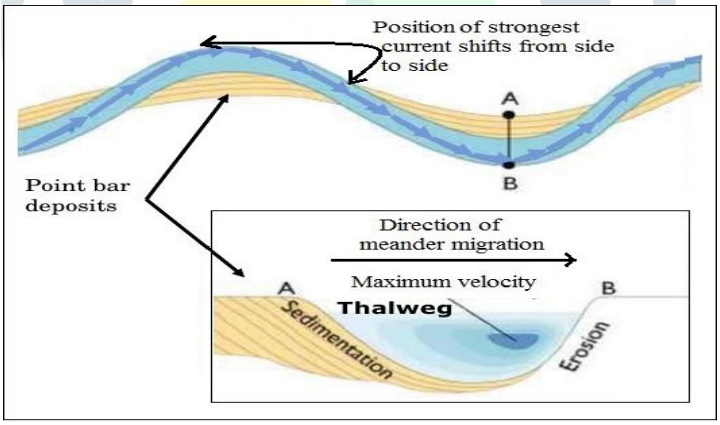

Fig. 1. Erosion and deposition in meandering stream

The behaviour of river Jiabharali in lower plain reach is found to be very critical due to its natural gradient towards western side and formation of offshoot channels after each flood, thereby widening its waterway. Within the last few years, river has migrated kilometres and shifted its channel running parallel to the extreme western side on its right bank. Also the soil forming the bank in this area vary from medium to fine sand and is very unstable and easily erodible by the flood water as shown in Figure 2.

Fig. 2. Eroded river bank at Jiabharali lower plain reach

2. BANK EROSION PROBLEM

2.1 Erosion at Right Bank

The river Mansiri, a sub tributary meet the river Jiabharali at Ch: 6000 m and boosts the erosion problem at Dikoraijan, Kuttamara and Kurukani area. Due to the combined discharge of both the rivers, there is severe bank erosion for a reach of about 4 km and the river has formed a sharp concave bend. In fact, the flood of 2010, 2012 & 2013 has devastated the entire area due to severe bank erosion. As a result of these, more than 3000 hectares of fertile and homestead land has already been eroded and in case the erosion problem continues, there is every possibility of collapse of the infrastructure of the entire locality including Tezpur University Campus.

2.2 Erosion at Left Bank

The U-shape configuration of bank from Chillanipam (Ch. 238 km) to Orangbasti (Ch. 245 km) is posing a constant threat to the large population residing nearby due to the flashy nature of the Jiabharali River. Moreover, the downstream portion of the reach from NH-52 Bridge is overtopped during normal flood wave due to absence of embankment. Erosion has been a continuous threat for the last many years though the problem has been acute since the year 2000. The average depth of erosion is about 12 metres every year. The river bed level is found elevated gradually due to heavy siltation. Already many families of this locality have been shifted to safer locations. Some of the major thickly revenue villages of Sonitpur district are near the area. Bordikorai, Nepaligaon, Mising village, Chillanipam are some of the villages on the left bank. Bank erosion has already engulfed a large area of homestead and cultivable land as shown in Figure 3. At present the erosion problem is posing threat to the whole area including the nearby railway line. When seen from bird view the river tends to avulse tending to form a more straighter path towards the river Brahmaputra and therefore protection of banks and construction of the embankment is of utmost necessity.

Fig. 3. Erosion of homestead and cultivable land

3. FLOOD MANAGEMENT SCHEME AND BENEFIT

The scheme is executed by Tezpur Water Resources Division, Assam under the Flood Management Programme to benefit thickly populated villages, other public and private properties and protect more than 15000 hectares of cultivated and homestead land. Geosynthetics materials and Gabions used in the above scheme were evaluated for their quality at CSMRS, New Delhi.

3.1 Flood Management Scheme on Right Bank

The flood management scheme on the right bank is to protect Tezpur University and its adjoining area against erosion of the River Jiabharali as shown in Figure 4.

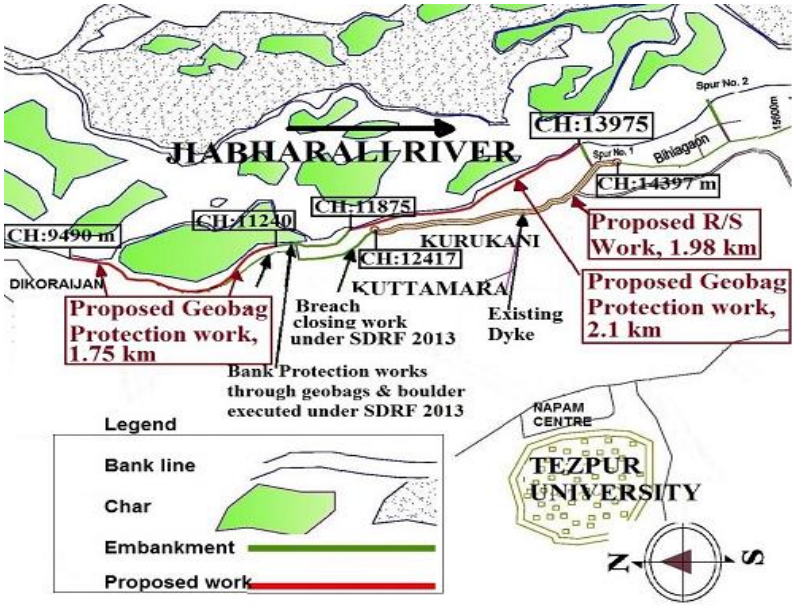

Fig. 4. Protection works at right bank

3.2 Flood Management Scheme on Left Bank

The flood management scheme on the left bank is to protect dyke from Chillanipam (Ch. 238 km) to Orangbasti (Ch. 245 km) against the erosion of River Jiabharali as shown in Figure 5.

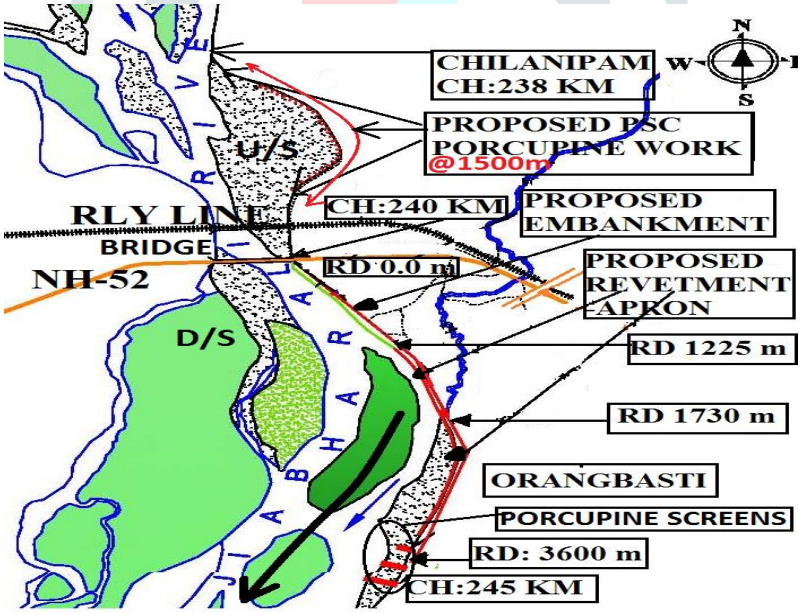

Fig. 5. Protection works at left bank

4. SOLUTION IMPLEMENTATION

In order to firmly arrest the erosion, prevent migration of the river and to provide protection to its adjoining areas, geosynthetics materials and gabions are adopted in construction of bank revetment with launching apron covering the most affected reach.

4.1 At Right Bank

4.1.1 Bank revetment with launching apron

Pitching of Geotextile bags and launching of apron is carried out for a total length of 3.85 km. Bank is dressed to the inclination of 1V: 2H and over this a layer of non-woven geotextile of 400 gsm is laid as filter media, anchored at the top and bottom of bank slope. After the placement of geotextile filter on the bank slope, sand filled geotextile bags of Type-A (size 1.03 x 0.70 m) made of non-woven geotextile are placed all along the length of the bank. Thickness of the pitching on bank slope is 0.45 m (3 layers) and top height of bank is maintained with respect to HFL of 71.82 m. Geotextile bags are filled with sand to the specified height to ensure that appropriate density is achieved and open ends of the bags is closed by stitching the bags with the help of hand stitching machines. Total quantity of filter material applied is 46489 m^2 and geotextile bags for the protection works is approximately 7,61,115 nos. Figure 6 shows the cross section of the launching apron and bank pitching work at right bank.

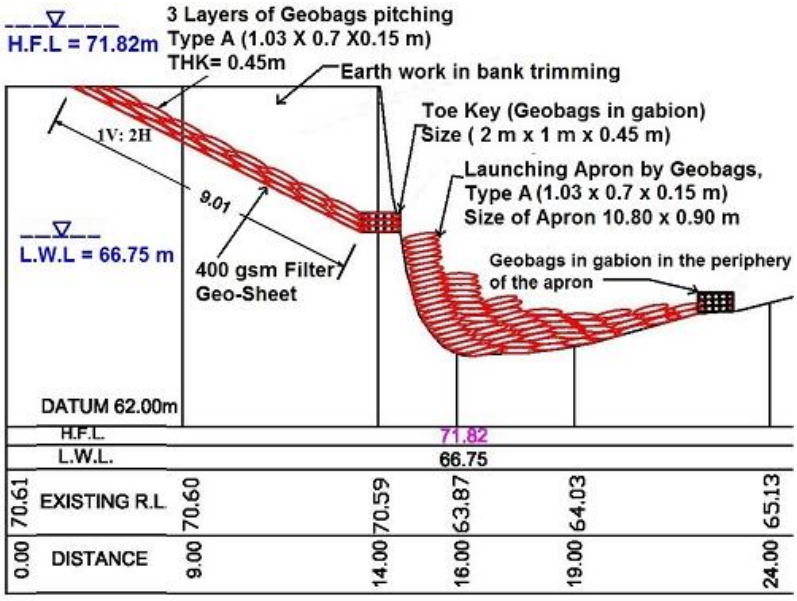

Fig. 6. Cross section of launching apron and bank pitching work at right bank

Launching of apron is carried out with multiple layers of geotextile bags (6 layers) having thickness of 0.90 m and width of 10.80 m. At the junction of the bank and apron, toe-key is formed from strips of zinc coated wire mesh gabion box (size 2 x 1 x 0.45 m) filled with three layers of sand filled geotextile bags of Type A (size 1.03 x 0.70 m) all along the length of apron. Intermediate key is placed at regular intervals of 50 m across the length of the apron and it is formed from two layers of strips of zinc coated gabion box (size 2 x 1 x 0.45 m) filled with three layers of sand filled geotextile bags each. Total quantity of Gabion boxes used in launching apron and toe-key is 16822 nos. Figure 7 shows installation of Geosynthetics materials and Gabions at right bank.

Fig. 7. Installation of Geosynthetics materials and Gabions at right bank

4.1.2 Raising and strengthening of embankment

Raising and strengthening of the embankment is carried out for the total length of 1.98 km. Crest width is kept 7.50 m and top height is maintained at RL 73.30 m with respect to HFL of 71.82 m with freeboard of 1.80 m. Filling of earthwork is done in uniform layers not exceeding 22.50 cm thick with profiling to achieve a slope of 1V:3H. Total quantity of earth work materials in use is 66029 m^3. Embankment slope is protected by turfing with grass sods of largest possible rectangles of 12 cm minimum thickness. The total quantity of turfing with grass sods is 23746 m^2.

4.2 At Left Bank

4.2.1 Bank revetment with launching apron

Bank revetment and launching of apron is carried out for a total length of 2075 m (from RD 1225 m to 3300 m) in the downstream side of the NH-52 bridge where the river bank is first dressed to the inclination of 1V: 2H and over this a layer of geotextile tubular mattress of 0.3 m fill height is to be laid and anchored at the top and toe of bank slope by bending the mat into key trench. Geotextile mattress is a double layered composite geotextile fabricated to form a three dimensional mattress after filling sand through pump at design slope of affected reach, the upper layer of the mattress is made from polypropylene woven geotextile needle-punched with a mixture of Ultraviolet (UV) stabilized green fibers and cut tape yarns and the lower layer of the mattress is also a UV stabilized polypropylene woven fabric. Total quantity of geo-mattresses under use is 19816.25 m^2. Fig. 8 shows the cross section of bank revetment and apron at left bank.

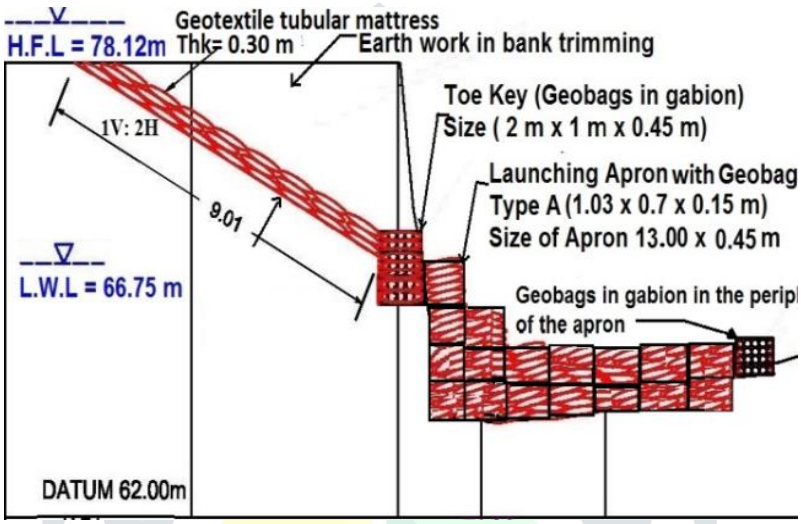

Fig. 8. Cross section of bank revetment and apron work at left bank

Launching of apron for a width of 13 m and thickness 0.45 m all along the bank is carried out with a sets of three layers of sand filled geotextile bags of Type A (size 1.03 × 0.70 m) in one layer of gabion box (size 2 × 1 × 0.45 m). At the junction of the bank and apron, toe-key is formed from two layers of strips of zinc coated wire mesh gabion box (size 2 × 1 × 0.45 m) filled with a sets of three layers of sand filled geotextile bags of Type A all along the length of apron. Intermediate key is placed at regular intervals across the length of the apron and it is formed from two layers of strips of zinc coated gabion box (size 2 × 1 × 0.45 m) filled with a sets of three layers of sand filled geotextile bags each. Total quantity of geotextile bags for the protection works is approximately 1,80,786 nos. and total quantity of gabion box under use is 8784 nos. Figure 9 shows installation of geotextile bags and gabions at left bank.

Fig. 9. Installation of geotextile bags and gabions at left bank

4.2.2 Raising of the embankment

Raising of the embankment is carried out for the total length of 3600 m (from RD 0.0 m to 3600 m). Crest width is kept 4.50 m and top height is maintained at Reduced Level (RL) 79.62 m with respect to High Flood Level (HFL) of 78.12 m with freeboard of 1.50 m. Filling of earthwork is done in uniform layers not exceeding 22.50 cm thick with profiling to achieve a slope

of 1V:2H. Total quantity of earth work materials in use is 124180 m3. Embankment slope is protected by turfing with grass sods of largest possible rectangles of 12 cm minimum thickness. The total quantity of turfing with grass sods is 11055 m2.

4.2.3 Porcupine works

Pre-stressed concrete (PSC) Porcupine works in the form of bars and screens are also carried out to provide additional protection to the banks by dampening the velocity of flow and inducing siltation in the vicinity of bank. At upstream of NH-52 bridge near Ch. 238 km, porcupine bars 15 m clear spacing with 5 rows in each bar are carried out all along the bank for a length of 1500 m. Erection of porcupine bars is done with six members pre-stressed cement concrete (M-40 grade reinforced with 4 nos. of 4 mm dia. high tensile steel wire cables at four corners) of size 0.10 × 0.10 × 3.0 m properly fitting/fixing with 12 mm dia. 25 cm long M.S. nuts and bolts. Total quantity of porcupine deployed is 11220 nos. In the downstream side of the embankment near Ch. 245 km three porcupine screens of length 78 m, 111m and 143 m respectively are proposed to induce siltation in the downstream area.

5. LABORATORY INVESTIGATION

The Geosynthetics materials and Gabions are tested for physical, mechanical, hydraulic and survivability properties in accordance with ASTM D (5261, 4595, 6241, 4751, and 4491) and IS codes (1608 and 16014). The tests results (CSMRS, 2015) are presented in the Table 1 to 3 for materials evaluated for right bank and Table 4 to 5 for materials evaluated for left bank..

Table 1 .Tests results of non-woven Geotextile bags for right bank

Properties	**Values**
Mass per unit area, g/m^2	401
Tensile Strength (MD), kN/m	21
Elongation (MD), %	72
Tensile Strength (CD), kN/m	20
Elongation (CD), %	79
CBR Puncture resistance, N	4010
Apparent Opening Size, mm	0.075
Permeability, m/sec	$>2 \times 10^{-3}$

Table 2 .Tests results of non-woven Geo-fabric filter media for right bank

Properties	**Values**
Mass per unit area, g/m^2	402
Tensile Strength (MD), kN/m	23
Elongation (MD), %	71
Tensile Strength (CD), kN/m	21
Elongation (CD), %	74
CBR Puncture resistance, N	4015
Apparent Opening Size, mm	0.075
Permeability, m/sec	$>2 \times 10^{-3}$

Table 3 .Tests results of Gabion wires for right bank

Properties	**Values**
Tensile Strength (Mesh wire), N/mm^2	481
Elongation (Mesh wire), %	17
Tensile Strength (Selvedge wire), N/mm^2	450
Elongation (Selvedge wire), %	15
Tensile Strength (Lacing wire), N/mm^2	470
Elongation (Lacing wire), %	17

Table 4 .Test results of non-woven geotextile bags for left bank

Properties	**Values**
Mass per unit area, g/m^2	404
Tensile Strength (MD), kN/m	24
Elongation (MD), %	73
Tensile Strength (CD), kN/m	22
Elongation (CD), %	79
CBR Puncture resistance, N	4090
Apparent Opening Size, mm	0.075
Permeability, m/sec	$>2 \times 10^{-3}$

Table 5 .Test results of gabion wires for left bank

Properties	**Values**
Tensile Strength (Mesh wire), N/mm^2	487
Elongation (Mesh wire), %	17
Tensile Strength (Selvedge wire), N/mm^2	445
Elongation (Selvedge wire), %	16
Tensile Strength (Lacing wire), N/mm^2	483
Elongation (Lacing wire), %	18

6. CONCLUSIONS

The paper presents the problems and the remedial works along the vulnerable reaches of Left and Right Bank of Jiabharali River. The flood protection and erosion control method adopted with Geosynthetics materials is a highly engineered solution. Such application replaces all other conventional methods (e.g. Boulders, RCC etc.) for immediate protection where flood is a regular phenomenon and construction is to be completed in a limited time period. The use of Geosynthetics materials permits to carry out the protection works at a faster rate. The use of the mechanically zinc coated wire mesh Gabion box ensured the stability of the geotextile bags by providing the peripheral confinement to the bank structures. Such an arrangement can be rapidly deployed to achieve maximum benefit to the community, typically through the use of on-site materials, innovative geosynthetics materials and construction techniques.

Protection work increase resistance of river banks to erosion and deflecting the current away. These generally shift the problem in the u/s or the d/s and necessitate further works to safeguard the land against erosion.

Considering the advantages of Geosynthetics materials, its use may rapidly increase in future and the importance of material evaluation should therefore be emphasized to ensure that the Geosynthetics materials and Gabions meet the qualifying criteria.

7. ACKNOWLEDGEMENT

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