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ANTI-EROSION AND RIVER TRAINING WORKS ALONG THE BANKS OF RANGANADI RIVER, ASSAM

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***Abstract*— Flood and erosion are the two major problems of lower plain reach of Ranganadi River and hence become a matter of concern due to their devastating impact on life and property. With gradual rise in river bed over decades, discharge at the d/s reaches increases in monsoon period suddenly leading to flood-lift within a very short period and threatens both left and right bank embankment system of Ranganadi River. Every year flood-lift decreases the free board and causes overtopping. Now, for the safety, embankment system is to be raised and strengthened to overcome anticipated flood lift. This paper describes the case study of river training works at the most vulnerable reaches with launching of geotextile bags as the apron and geotextile mattress at the slope of embankment etc rather than the conventional type of boulder works since the boulder has become scarce. The project Ranganadi is located in the North Lakhimpur district of Assam. The laboratory investigations undertaken for geotextile materials and gabions for the Ranganadi project are presented in this paper along with advantages of using geosynthetics materials.**

***Keywords*—** Flood, Erosion, Geotextile, Ranganadi

I. INTRODUCTION

Ranganadi River is one of the tributary of Brahmaputra River which originates from Dafla hills of Arunachal Pradesh. Out of the total length of 150 km the river traverses a distance of 90 km in the hills of Arunachal Pradesh and about 60 km in the plains of Assam. The total catchment area of the river basin is about 2941 Sq km. Out of total 57.53 km of Ranganadi embankment 28.17 km is in L/Bank and 29.84 km is in the R/Bank. Figure 1 shows the location of Ranganadi River and Dam.

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 Fig. 2. Thus bank erosion and consequent loss of land and properties are normal phenomenon all along the course of the river and new areas get affected by erosion every year.

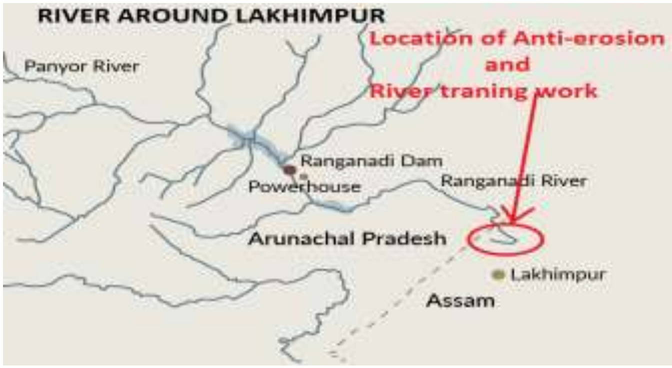

Fig. 1. Location of Ranganadi River and Dam

Anti-erosion works are normally taken up only where re-location is not possible on socio-techno-economic grounds, long lengths of embankment benefitting large areas and agriculture lands where cost-benefit ratio justifies such works [10]. Use of geotextiiles material has gained importance for immediate protection measures where flood is a regular phenomenon and construction is to be completed in a limited time period.

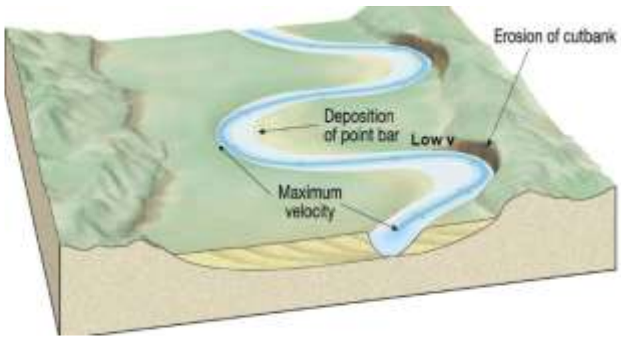

Fig. 2. Erosion deposition in meandering stream

II. FLOOD AND BANK EROSION PROBLEM

The River Ranganadi is an aggrading and meandering type of river by nature. Before entering the plains of Assam, numbers of big and small streams join to the River Ranganadi at the upper catchment area. Most of such streams carry large amount of silts/sand/tinny stone aggregates/boulders/gravel etc and deposit them at the bed of River Ranganadi. As a result, it creates sand chores in one bank and causing erosion at the other bank as shown in Fig. 3. Due to rapid growth of population and encroachment of forest land, the hills have become barren and landslide occurs very frequently during rainy season which in turn accelerates the deposition of silt load in these streams as well as in the bed of the River Ranganadi. This type of phenomenon has been continuously observed for the last two decades and is the main cause of rise of river bed. In addition to gradual rise of river bed, it is a matter of great concern that during every flood season, due to increase in the inflow of water from the upper catchment areas, the surplus/excess discharge have to be allowed to spill over the Ranganadi Dam of the NEEPCO hydel power project which ultimately increases the discharge at the downstream reaches. Figure 1 shows the location of Ranganadi Dam. Due to combined effect of increase in the river discharge along with gradual rise in the river bed, flood lift occurs in the River Ranganadi within a very short period and threatens both the banks embankment system. Every year the rise in flood lift decreases the free board and cause overtopping. Now, as per flood frequency analysis a DHFL has been calculated which has been found as 98.24 m at gauge site and it is 1.38 m above the observed HFL of 2008 (96.86 m). Now, for safety of the embankments against the anticipated flood lift, the embankment system at both the banks of River Ranganadi is required to be raised.

Fig. 3. Erosion of cultivable land

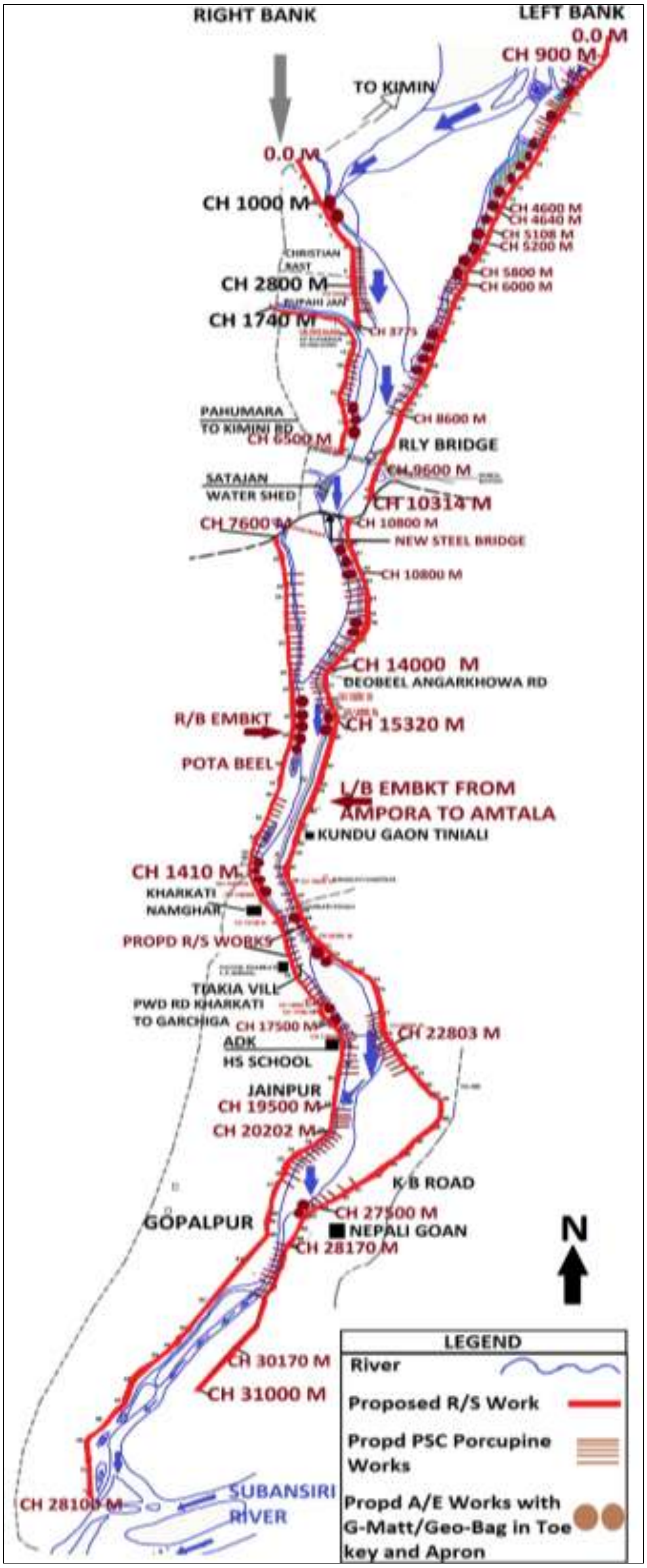

Fig. 4. Location of anti-erosion and river training work

III. FLOOD MANAGEMENT SCHEME AND BENEFIT

Flood management scheme mainly consists of anti-erosion and river training works on both the banks embankment of Ranganadi River in North Lakhimpur district of Assam. It consist of three main construction component i.e., raising & strengthening of embankment, bank revetment & launching apron and PSC Porcupine works as shown in Fig. 4. The estimated cost of the scheme is Rs. 361.42 cr. The scheme is executed by North Lakhimpur Water Resources Division, Assam under the flood management programme and will benefit an area of 18,850 hectares of land comprising of vast area of thickly populated homestead and fertile cultivable land in the North Lakhimpur district of Assam including North Lakhimpur Township and various Govt and private assets. Geotextile materials and gabions used in the above scheme were evaluated for their quality at CSMRS, New Delhi.

IV. SOLUTION IMPLEMENTATION

In order to firmly arrest the erosion, prevent migration of the river and to provide protection to its adjoining areas, geotextiles materials and gabions are adopted in construction of bank revetment with launching apron covering the most affected reach of left and right bank embankment of Ranganadi River for a total length of 7.20 km and raising & strengthening of the embankment in both the banks for a continuous length of 57.53 km as shown in Fig. 4. Such an arrangement can be rapidly deployed to achieve maximum benefit to the community, typically through the use of on-site materials, innovative geotextiles materials and construction techniques.

In the present cases, the following advantages of using geotextiles materials are outlined:-

- Filling, transportation and installing the geotextile bags and geotextile mattress is quick, simpler & economic when required in-filling sand material is abundantly available at site. Locally available unskilled labours for filling the bags can bring more economy to the project.
- It takes less time in the procurement of the geotextiles materials and gabions than the boulders and aggregates. Therefore huge cost for carriage of rock boulders would be saved.
- Conventionally used boulders for protection works have become scarce and their continuous use also disturbs the ecological balance. Use of sand filled geotextile bags and geotextile mattress in various forms, size, and shape is found perfect replacement for boulder and causes lesser environmental damage.
- Satisfying the filter and drainage criterion for conventional graded granular design is extremely expensive, difficult to obtain, time consuming to install and involves problem of segregation during placement. The conditions can easily and cheaply be achieved using a geotextile to perform filtration. Specially, a single layer of geotextile fabric can replace a graded filter comprising two or three layers.
- Restoration and maintenance work is easier than other conventional methods.
- Being light in weight, it is easy to handle and can be installed quickly. Also, working under water becomes much easier because the bags and filter system can be assembled above the water and lowered into position.
- They are made up of polypropylene materials, so they are durable and chemical resistant. Since they are factory manufactured products, high quality can be assured. Also, uniformity in material specification can be maintained throughout the project.

A. Bank revetment with launching apron –

Bank revetment and launching of apron is being carried out for left and right bank embankment of Ranganadi River at various vulnerable reaches for a total length of 7200 m where the river bank is dressed to the inclination of 1V: 2H and over this a layer of geotextile tubular mattress of 0.3 m fill height is laid and anchored at the top and toe of bank slope by bending the mat into key trench of size 1.0 m x 0.75 m. 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 1061939 m^2. Figure 5 shows installation of geotextile mattress at various stages.

Fig. 5. Installation of Geotextile mattress at various stages

Launching of apron of size 9 m width and thickness 0.9 m all along the left and right bank is carried out with six layers of sand filled non-woven geotextile bags which include two sets of three layers of sand filled geotextile bags of Type A (size 1.03 m × 0.70 m) in one layer of gabion box (size 2m × 1m × 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 m × 1 m × 0.45 m) filled with a sets of three layers of sand filled non-woven geotextile bags of Type A all along the length of apron. Here, the revetment is a part of bank protection work, while launching apron & toe-key are part of bed protection work. Bank protection followed by a suitable bed protection can be considered as the key success for any anti-erosion work. Strips of Gabion box placed along the length of the apron in toe-key impart further stability to the scour protection measure. IS code 14262 [13] provides guidelines for planning and design of bank revetment with launching apron. Non-woven 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 power driven double needle hand stitching machines. Total quantity of Non-woven geotextile bags for the protection works is approximately 20,45,583 nos. and total quantity of gabion box under use is 82700 nos. Fig. 6 shows cross section of bank revetment and apron.

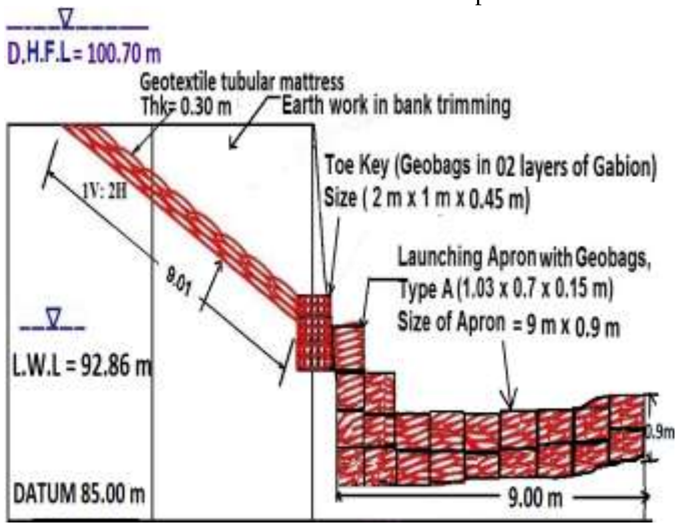

Fig. 6. Typical cross section of bank revetment and apron

B. Raising and strengthening of the embankment--

Raising and strengthening of the embankment is being carried out for left and right bank embankment of Ranganadi River for a continuous total length of 57.53 km. Crest width is kept 6.00 m and top height is maintained at Reduced Level (RL) 102.20 m with respect to High Flood Level (HFL) of 100.70 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 in use is 5563249 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 1043356 m^2.

C. Porcupine works--

Pre-stressed cement concrete (PSC) Porcupine works in the form of bars are also carried out at selected reach to provide additional protection to the banks by dampening the velocity of flow and inducing siltation in the vicinity of bank. Spacing of each porcupine bars are arranged 25 m clear distance with 3 rows of porcupine in each bar and 5 nos. of porcupines in each row all along the banks at required location. 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 and 4 mm high tensile stirrups at 250 mm c/c) of size 0.10 m × 0.10 m × 3.0 m properly fitting/fixing with 12 mm dia. 25 cm long M.S. nuts and bolts. Total quantity of porcupine deployed is 15372 nos. Figure 4 shows the location of PSC Porcupine bars in Left and right bank embankment at selected reach.

V. LABORATORY INVESTIGATION

Considering the advantages of geotextiles materials, its use may rapidly increase in future and the importance of material evaluation and their frequency should therefore be emphasized to ensure that the geosynthetics materials and gabions meet the qualifying criteria. The geotextiles materials and gabions are tested for physical, mechanical, hydraulic and survivability properties [1-8] in accordance with ASTM D (5261, 4595, 4632, 4533, 6241, 4751, 4491and 5199) and IS codes [11-12] (1608 and 16014). The test results [9] are presented in the Table 1, Table 2 and Table 3.

Table -1 Test results for non-woven geotextile bags

Properties	**Values**
Mass per unit area, g/m^2	**306**
Tensile Strength (MD), kN/m	**23.6**
Elongation (MD), %	**80**
Tensile Strength (CD), kN/m	**21.7**
Elongation (CD), %	**74**
Grab Tensile Strength, N	**1133**
Trapezoidal Tear, N	**470**
CBR Puncture resistance, N	**1947**
Apparent Opening Size, mm	**0.075**
Permeability, l/m^2/s	**15.5**
Thickness, mm	**2.06**

Table -2 Test results for geotextile mattress

Properties	**Values**
Mass per unit area (Upper layer), g/m^2	**669**
Mass per unit area (Lower layer), g/m^2	**411**
Tensile Strength (Upper Layer), kN/m	**49**
Tensile Strength (Lower Layer), kN/m	**81**
Apparent Opening Size (Upper layer), mm	**0.075**

Apparent Opening Size (Lower layer), mm	**0.250**

Table -3 Test results for gabion wires

Properties	**Values**
Tensile Strength (Mesh wire), N/mm^2	**475**
Elongation (Mesh wire), %	**>10**

VI. CONCLUSIONS

The paper presents the problems and the remedial works along the vulnerable reaches of River Ranganadi. The problem of flood and erosion in Assam is of high magnitude and to effectively deal with these issues, permanent solution will be essential in the near future. 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 geotextiles materials permits to carry out the protection works at a faster rate. The use of the mechanically twisted zinc coated wire mesh gabion box ensured the stability of the geotextile bags and provide confinement in toe-key. Figure 7 shows implementation of geotextile mattress and porcupine works.

Fig. 7. Implementation of geotextile mattress and porcupine works

Creating such type of protection work with greater area and uniformity in construction reduces damage to the base of structure and chance of sinking considerably. But the performance of restoration work is still to be observed in coming years as a long term measure and thereafter further decision can be taken for execution for similar vulnerable reaches.

Sometimes, conventional system for solution will not be sufficient for desired results. Use of a composite geosynthetics solution may prove effective and economically viable. To enable this system perform in the long run, it is necessary to prevent the erosion from bed and for that sand filled geotextile bags assembled in strips of zinc coated wire mesh gabion box, is an ideal option. While designing the protection works and choosing the products, due care has to be taken for proper design, structural integrity of the system, experienced designer and contractors who install the system.

Protection works 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.

VII. ACKNOWLEDGEMENT

The authors acknowledge the contributions of the North Lakhimpur Water Resources Division, Assam and CSMRS team by way of active cooperation at the time of laboratory investigation and testing.

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