Geosynthetics in maritime and hydraulics structures - Case histories in India

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Keywords: Polymer rope Gabion, Metal Gabion, geotextile tube, geotextile bag, river and coastal protection

ABSTRACT: Construction of hydraulic structures, especially for river training and coastal protection works, with conventional structures made of masonry or concrete have numerous limitations like prohibitive costs, high rigidity, impermeable nature, difficulties in construction etc. In recent times geosynthetics structures have come as handy to overcome all those limitations. Geosynthetic structures are flexible in nature to withstand minor ground movements if any; they form porous structures that enable quick dissipation of pore pressures. Moreover these structures use predominantly the locally available earth materials which otherwise would lead to fast depletion of natural quarry resources. Most common forms of geosynthetic structural elements often used in hydraulic environments are gabions, geotextile containers (soil filled in suitable form of containers made of geotextiles) such as geotextile bags, geotextile tubes, geomattresses etc. India is country blessed with vast coast line of around 5,700 km enclosing the peninsular part and around 14,000 km length of rivers running across all the provinces. There is a big challenge to protect the adjoining habitants and structures from the detrimental effects of aggressive flow of water during monsoon or high tides etc and hence there is a huge potential for geosynthetic structures to be used in these works. This paper narrates some of the successful implementation of geosynthetic structures (involving gabions, geotextile containers such as geotextile bags, geotextile tubes) in India for the river training and coastal protection works.

1 INTRODUCTION

In the coastal areas it is always a challenge to the Civil Engineers to prevent the erosion of the shore line. In India there is vast coast line of around 5700 km covering the entire peninsular part of the country. The habitants and other monumental structures near the shore are to be protected from the erosion of the shore line by suitable structures which will impede the aggressive actions of the sea waves. On the other hand India has about 14,000 km length of river flowing in various provinces. Especially during monsoons, there is always threat to the adjoining areas of the river course because of the meandering, breaches in river bunds etc. And the banks of the river also get progressively eroded. The river course should be properly channelised with suitable bank protection works and revetments in order to sustain the detrimental effects of the excess flow in the river. The major role of any hydraulic structures in River training work or coastal protection shall be put under two heads viz. (i) to control and regulate the water flow (ii) to impede the erosive effects of water waves.

Over the last two decades, as the importance of preserving natural coastal resources were realised on a global scale, efforts have been made to migrate from the conventional approach of hard engineering to soft engineering and eco-engineering especially in environmentally sensitive areas. Compared to the conventional structures with masonry or concrete, structures with Geosynthetics can be technically and economically superior. The advantages of geosynthetic structures over the traditional techniques are (i) Higher flexibility and durability of the structure, (ii) Geosynthetic structures use only local soil materials rather than imported quarry products, there by preserving the natural quarry resources (iii) Faster construction is possible, and (iv) They are cost effective. Figure 1 shows the common forms of geosynthetic structural elements (photographs of which are self explanatory) used in water bound environments.

Geotextile bags

Polymer Rope Gabions

Geomattress

Geotextile tubes

Steel Gabion boxes

Steel Gabion as revetment

Figure 1. Various forms of Geosynthetic structural elements for Coastal and River training works

2 COASTAL PROTECTION STRUCTURES

Use of geosynthetics for coastal structures started in 1980s as evidenced from Bogossian et al. (1982) and Harris (1987). Geosynthetic structures in hydraulic applications can be broadly grouped under two heads. One is metal or polymer gabions (sausages) filled with boulders and secondly Geotextile containers which are nothing but containers of various forms and sizes made of suitable geotextile, which are filled with locally dredged granular soil. The structures constructed using Geotextile containers and gabions in coastal works act as good energy dissipaters in minimizing the erosion potential of the water currents. In some cases they are placed underwater off the shore to minimize silting. These geosynthetic structural elements being highly porous in nature there is almost no development of pore pressure behind the structures and within the system.

The design of coastal structures is based on all the possible modes of failure such as Wave over topping, Sea erosion, Slip circle failure, Liquefaction, piping, ship collision etc. as given by Pilarcyzk (2000). In general 2-dimensional limit equilibrium method is used to check the stability of the system against expected failures for the calculated wave forces. Other than above mentioned design criteria, factors such as boat access, navigation, bathymetric characteristics, waves and currents, aquatic and terrestrial habitat, deeper water access, aesthetics, project expansion, ease of repair, durability, inspection requirements, erosion control, safety, vandalism, ease of construction, and economy in construction are also considered in the designs. In the following sections few case histories on the coastal protection works executed in India incorporating geosynthetics are illustrated.

2.1 *Protection against wave erosion near Swaminarayan Temple in Gujarat, India*

The Swaminarayan temple in Tithal, in Gujarat is situated at a distance of around 200-250 m from seashore. The shore suffered extensive erosion due to strong wave action and the formation of eddies from the adjacent river and high velocity winds. The problem of erosion is so tremendous that roughly 6 - 7 m of the shore was lost per year. This was threatening the very existence of the temple structure in the long run. The severity of the erosion can be seen from Figure 2a.

A shore protection structure using polymer rope gabions with boulder fill was constructed as shown in Figure 2b. A layer of Geotextile was laid as a filter media below the gabion at the eroded portion of the beach profile. The polymer rope gabion is made of 10 mm diameter rope with aperture size 150 × 150 mm. The total volume of the work carried out with polymer rope gabion was 6070 m^3. This structure was constructed during May 2001 to October

2001. The structure is functioning well till date without any major complaints.

Figure 2a. Eroded shoreline before construction of Gabion wall (Tithal, Gujarat)

Figure 2b. Sea wall with polymer rope gabion protecting sea-shore (Tithal, Gujarat)

2.2 *Shore protection with geotextile tubes at Uppada in the state of Andhra Pradesh*

The coast line in Uppada in the state of Andhra Pradesh was experiencing continuous erosion by the sea waves. The erosion has resulted in development of vertical cliffs in the beach profile for a height of about 2 to 4 m. Initially a sea wall with geotextile tube was planned for stretch of around 2 km. The geotextile tube as a core and an armour layer of polymer rope gabions was proposed abutting the cliffs as shown schematically in Figure 3.

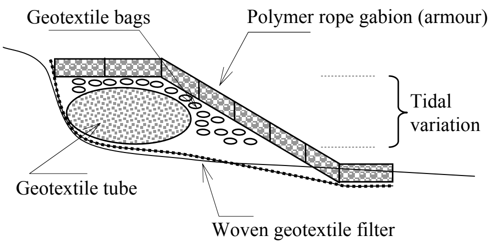

Figure 3. Schematic of the section of sea wall with geotextile tube.

The tube structure was covered with one layer of 1 m thick gabions. The gabions were made of polymer rope nets and filled with boulders of size varying from 150 mm to 300 mm. Geotextile bags filled with locally dredged sand was placed around the tube and on the toe portion of the tube to act as a cushion. The Polymer rope gabions act as armour layer in preventing any damage to the geotextile tube due to sudden impact of any sharp article. The individual geotextile tubes were made of woven geotextile to a diameter of 3 m and length 20 m. The tubes were laid on the locations and hydraulically filled in-situ with sand slurry dredged off the shore. The water in the slurry easily comes out of the tube and the tube gets consolidated. The following photograph (Figure 4) shows the finished work geotextile tube wall.

Figure 4. Geotextile tube covered with armour layer of polymer rope gabion.

2.3 *Shore protection by Geotextile Tube at Shankarpur to Halda, West Bengal, India*

Figure 5. Geotextile tube at Shankarpur, West Bengal, India.

Coastal line of Bay of Bengal between Shankarpur to Halda in West Bengal had experienced severe erosion due to tidal currents. At some locations vertical cuts of 4m were observed. It was expected to cause severe damage to shoreline scenic views and public property along the coastal line. It was proposed to have environmental friendly solution to this and it to be efficient in prevention of scouring due to waves. Considering these points an effective solution was adopted by providing geotextile tubes in two plus one configuration with Scouring apron and geotextile-Filter Media. The project involved the installation of 150 numbers Geotextile tubes of 20 m length and 3 m diameter. Completed portion is shown in the Figure 5. Since the installation it is functioning well in preventing the sea erosion.

3 RIVER TRAINING WORKS

In river training works metal gabions are used to have comparatively rigid structures. These gabions are made of double twisted hexagonal galvanised wire mesh with or without PVC coating. The gabion boxes (cages filled with boulders) are properly wired and laced together to form flexible, monolithic, confined building blocks. They are used to build soil retaining structures (especially in water bound environments) slope stabilization structures, erosion controlling systems, aprons and revetment construction etc. The pervious nature of the gabions allows immediate dissipation of hydrostatic pressure that may otherwise cause destabilizing effects. These structures are flexible enough to withstand any undue stresses caused by differential settlement or earthquake forces. As Gabions promotes growth of natural vegetation, it offers natural aesthetics with decorative landscaping besides maintaining the natural Environment

3.1 *Flood Control Work at Mula river for Pimpri-Chinchwad Municipal Corpn, Pune.*

Figure 6. Construction of river bank with Gabions for the Mula river in Pune, India.

A Gabion wall was constructed along the Mula river in Pune for a stretch of approximately 240 m. The Gabion retaining wall protects the Madhuban society catchment from flooding during rainy season. As the foundation soil had very less bearing capacity, gabion mattress were used for foundation improvement and walls of 5m and 8m height were constructed along the river as shown in Figure 6. Apron of required length were provided using steel gabions. For better durability, the Gabion wires were coated with Zinc and PVC.

3.2 *Flood Control Work on Narmadha river at Madhi for Surat Municipal Corporation, Gujarat*

Polymer rope Gabion revetment was constructed along the river Narmadha for a length of about 1 km.

Figure 7. Revetment by Polymer rope gabions in Narmadha river at Madhi, Gujarath.

4 CONCLUSIONS

From the case histories illustrated in this paper it could be concluded that Geosynthetic elements such as Geotextile containers and boulder filled gabions can be successfully employed in coastal and river training structures. Design and construction of these structures require consideration of site-specific conditions and geosynthetic techniques. With high flexibility and pervious nature these geosynthetic structures can provide technically and economically efficient solutions besides being eco-friendly.

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