AN OVERVIEW OF CASE AND MODEL STUDIES WITH COIR GEOTEXTILES

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ABSTRACT

Geotextiles with natural fibres like coir, jute, sisal, hemp etc are used in Civil Engineering applications. Mainly they are used for erosion control applications. The main advantage of geotextiles with natural fibres is that they are ecofriendly and biodegradable. They can be successfully used in limited life applications of geotechnical engineering. This paper deals with an overview of various case studies and model studies conducted by the author on the various uses of coir geotextiles. It also gives an overview on the potential uses of coir geotextiles in various civil engineering applications.

Keywords: Coir Geotextiles, natural fibres, coir, erosion control

INTRODUCTION

International Geosynthetic Society defined Geosynthetic as a plannar, polymeric (synthetic or natural) material used in contact with soil/rock and/or any other geotechnical material in civil engineering applications. The term Geosynthetic is a generic name and it covers a variety of materials such as Geotextiles, Geogrids, Geonet, Geomembrane, Geocells and Geocomposite etc. Most of these products are manufactured with polymeric materials like Polyester, Polypropylene, HDPE etc, as they have long life and has resistance to the possible chemical contents in the soil.

Natural fibres such as coir and jute are widely used for the manufacturing of geotextiles, which are mainly used in limited life applications in geotechnical engineering, considering its biodegradability nature. One of the main areas of application of geotextiles with natural fibres is erosion control. The major advantage of geotextiles with natural fibres is its ecofriendliness. Natural fibre geotextiles may be used where the design life of the fabric structure is relatively short or where strength or integrity requirements decrease with time.

HISTORICAL BACKGROUND

Use of natural fibres in construction can be traced back at least to the fifth and fourth millennia BC when dwellings were formed from mud-clay bricks reinforced with reeds or straw. Two of the earliest surviving examples of material strengthening by natural fibres are the ziggurat in the ancient city of Dur-Kurigatzu and the Great Wall of China (Jones, 1996). The Babylonians constructed the ziggurat some 3000 years ago using reeds in the forms of woven mats, laid in horizontal beds of sand or gravel at vertical spacings of between 0.5 and 2.0 m and plaited ropes, 100 mm in diameter, as reinforcement. It is believed that it was originally over 80 m high; even today it is 45 m tall. The Great Wall of China, completed during 200 BC, utilized tamarisk branches to reinforce mixtures of clay and gravel.

In 1926, the Highway Department in South Carolina undertook a series of tests, using woven cotton fabrics as a simple type of geotextile or geomembrane, to reduce cracking and ravelling failure of roads was the first documented engineering use of natural fibres in Civil Engineering (Sarsby 2007). The application was similar to that of pavement fabric now a days used to prevent alligator cracking, i.e., to perform as a geomembrane than a geotextile. The high extensibility of the cotton fabric and its poor durability negated the slight improvement in road performance that the fabric produced.

Jute, coir and straw continue to be used extensively in erosion control products in the form of nets, meshes, blankets and reinforcement mats which are laid directly on the ground surface (Mandal 1989; Rickson 1994; Balan1995, 2004; Balan and Rao, 1996; Balan et al, 2011a,b, 2012a,b, c; Balan and Sibi, 2011).

CASE STUDIES

Stabilization of Slope above Retaining Wall

A high altitude cricket stadium was planned by the District Cricket Association of Wayanad District in Kerala. The land proposed consists of highly undulating ground surface with hillocks and deep valleys. The required ground area has been developed by cutting the hillocks in the northern area and filling the valley in southern side. To achieve a level ground, a gravity retaining wall of 9 m height was constructed with rubble masonry. Above the retaining wall, a further filling of 5 m is needed. The exposed slope of the filled soil has to be protected against erosion, and at the same time it should not hamper the aesthetic appearance of the stadium, since the exposed surface of the fill is facing one of the main entrances to the stadium. Slope protection against surface runoff and rainwater splash is done with Erosion Control Blanket made of coir fiber in conjunction with Bermuda grass (Balan and Sibi 2011)

The southern side of the proposed stadium has a retaining wall to retain the filled up soil. The height of the retaining wall is 9 m.Above the retaining wall; a further filling of 5 m is needed. The problem was referred to the Authors at this stage. Further filling was made with the locally available soil of silty sand with clay. The slope of the filled embankment was 1:1.2. In the natural condition, the soil at the site is very intact, but the excavated soil will become more slushy as the water content increases. Hence, proper drainage of the surface of the ground is required.

The finished surface of the stadium will have a marginal slope to all the sides from the centre potion, so that rain water will not be stagnated in the stadium. Concrete edge drain to collect the rain water from the surface of the play area is constructed all around the stadium. The slope of the drain has been made in such a way that the storm water is disposed off safely, on either side of high retaining wall, without coming on the top of the sloping face of the filled up soil. Edge drains are to be constructed at about 2 m away from the top edge of the filled up slope. Protective nettings will be provided at about 1.50 m from the top edge of the slope, i.e., 0.50 m away from the outer edge of the drain.

Ground filling above the retaining wall was made with proper quality control. The edge of the filled up soil was trimmed off, removing the uncompacted portion along the slope. A schematic diagram of the proposed slope protection is shown in Fig. 1. Construction of the slope above the retaining wall is shown in Fig. 2.

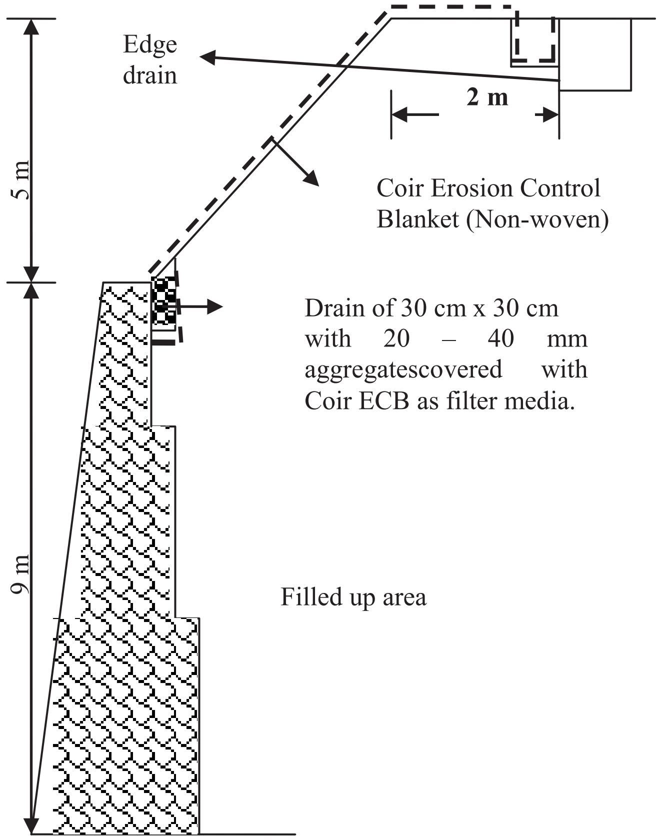


Fig.1 Schematic diagram of the proposed slope protection measures

Since the slope is to be protected against the rain water splash erosion, conventional woven or mesh coir mattings are not effective and hence it has been decided to use CCM Coir Blankets (non-woven) of 450 gram per square meter. The same blanket has been used as a filter media along the trench at the base of the slope, i.e., at the top of the retaining wall.

The sequence of construction of the slope, protection of the slope against rain splash erosion using erosion control blanket and the vegetation growth over the ECB are shown in Figs. 2 to 5.

Coir Reinforced Gabion Retaining Wall

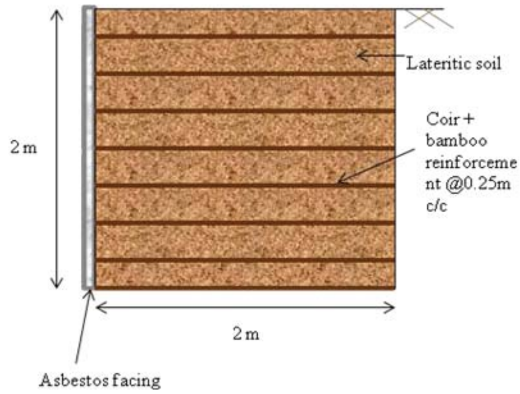
A coir reinforced retaining wall 10m long x 2m wide x 2m high was constructed using gabion as the facing. A similar retaining wall with thin panel (asbestos) as the facing was also constructed adjacent to the gabion facing retaining wall. The cross-sectional views of both the walls are presented in Fig. 6 (Balan et al. 2011)

Fig. 2 Construction of fill over the retaining wall is in progress

Fig. 3 Prepared slope surface above retaining wall.

Fig. 4 Laying and fixing of the coir erosion control blanket

Fig. 5 Vegetation is in full along the slope after 5 months



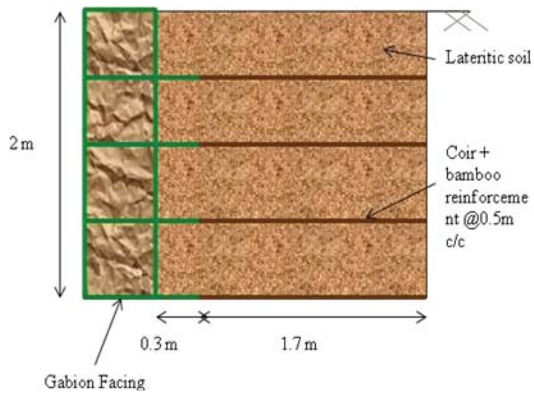


Fig. 6 Cross-sectional view of the coir reinforced wall with thin panel facing (asbestos) and gabion facing.

Woven coir geotextile in combination with bamboo was used as the reinforcement in the retaining wall. The construction procedure adopted for both the walls were similar. The spacing and width of the reinforcement was decided based on standarddesign. The spacing of reinforcement for stability was obtained as 0.5m and 0.25m for gabion and thin panel wall respectively as per the design. Locally available lateritic soil at the site of construction was used as the backfill for the reinforced retaining walls. The optimum moisture content was 21% and maximum dry density 17 kN/m^3. Gabion boxes of size 1m x 0.5m x 0.5m with diaphragm at the middle and with an extension of 0.3m at the base was used for the field study. The boxes were prepared by joining mesh panels of plan size 1.8m x 1m and 2m x 0.5m. The mesh panels were joined with the help of GI lacing wires. Sequence of construction of the gabion faced coir reinforced retaining wall is shown in Figs 7 to 10.

Fig. 7 Placing of gabion boxes and Laying of bamboo reapers for the second layer of retaining wall

Fig. 8 Laying of woven coir geotextile as reinforcement and non-woven coir geotextile as filter

Fig. 9 Compaction of the backfill

Fig. 10 Front view of the completed gabion facing retaining wall

Both the wall, having gabion as facing and asbestos as facing were constructed side by side and their horizontal and vertical deformations were observed. The walls were constructed during May 2011 and it has been subjected to two monsoon season.

The gabions used for the construction of the retaining wall were locally available galvanized wire meshes. Even after 16 months, the locally available galvanized wire meshes gabions are standing intact even though retting has been started here and there. The asbestos faced retaining wall overturned at the centre 1.5 m length out of the 10 m length of the wall after 12 months owing to inadequate bonding between the reinforcement and the facing.

Hydroseeding with Woven and Nonwoven CCM Geotextiles at LAVSA, Pune.

A new hill city project based on the principles of New Urbanism, near Pune was taken up by Lavasa, the real estate division of Hindustan Construction Company, Bombay. An ecofriendly town planning is proposed in this project. The city is spread over 100 sq.km almost one fourth size of Mumbai. The city was set amidst seven hills of Sahyadri Mountains with 60 Km lake front along Warasgaon Lake.

The principle for sustainable growth at Lavasa adopted a two-pronged strategy; viz, protecting the existing natural habitat as it is and further enhancing the habitat through hydro-seeding, mass plantations and beautification of ravines. No effort has been spared to ensure that Lavasa maintains natures ability to replenish and renew its resources.

Hydroseeding over CCM woven coir geotextiles and a comparative performance evaluation of hydroseeding over woven and non-woven CCM coir geotextiles are shown in Figs. 11 and 12. It has been shown that hydro-seeding over coir geotextiles are more effective for speedy vegetation growth compared to that of seeding above geotextiles. Among woven and non-woven, the performance of non-woven coir geotextiles is found to be more effective than woven. More displacement and concentrated patching of hydroseed were found in woven geotextiles, whereas a uniform distribution of hydroseed could be observed in non-woven coir geotextiles after 2 weeks of application of hydroseeding. A comparative evaluation of vegetation growth on CCM geotextiles alone and CCM geotextiles with hydro seeding is shown in Fig. 13 (Balan, 2010).

Fig. 11 Hydro seeding over CCM mesh mattings.

Fig. 12 A comparative performance evaluation of hydroseeding over woven and nonwoven CCM geotextiles

(a)

(b)

Fig. 13 Comparison of vegetation growth after hydro seeding on bare ground(a) and using CCM woven geotextiles (b)

MODEL STUDIES

Model Studies on Coco Log as Wave Attenuator

In this study the reflection and transmission characteristics of coco log when it is placed normal, parallel and inclined to the wave direction, in a wave flume at different depth of submergence are conducted. Studies were also conducted for different bed conditions such as impervious horizontal bed and impervious sloping bed and pervious moving bed. The efficacy of coco log in wave attenuation under the above conditions was determined. It was observed that the maximum wave attenuation and maximum energy dissipation were obtained for zero submergence condition when coco log is placed normal to the wave direction. From the bed conditions tested the maximum wave attenuation is obtained for pervious moving bed condition. The coco log used in the study and the wave flume arrangement for various cases are shown in Figs. 14 to 16 (Balan et al. 2011).

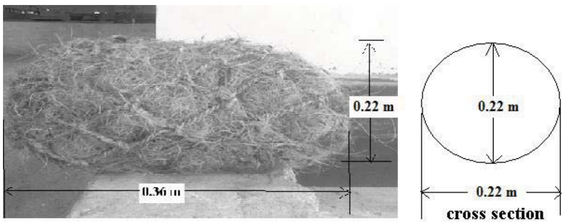


Fig. 14 Coco logs used in the wave flume

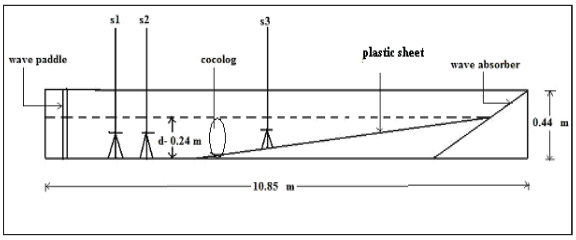


Fig. 15 Set up for impervious horizontal bed

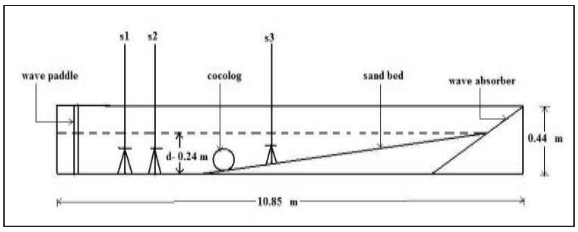


Fig. 16 Set up for sloping pervious moving bed

The percentage energy dissipation was maximum for zero submerged coco log placed normal to the wave direction and least in the case of submerged coco log when placed parallel to the length of the flume.

Wave reflection due to coco logs is practically nil hence toe erosion can be prevented to a great extent in coastal protection structures.

Zero submergence coco logs do not break the aesthetic beauty of the shore in addition to providing a calm area. Hence, zero submerged coco log placed normal to wave direction is the best for wave attenuation

Coir Geotextile Tube Breakwaters

Conventional beach protection structures such as groins and sub-arial breakwaters are becoming increasingly unpopular, mostly due to their adverse impact on beach amenity and aesthetic considerations. They are also very expensive to build and maintain. Geosystems have gained popularity nowadays because of their simplicity in placement, cost effectiveness and environmental aspects. Geotextile tube technology is one of such alternative for coastal protection. In this model study, a comparative evaluation of tube breakwaters made of synthetic geotextiles and specially treated woven coir geotextiles with latex are made. Experiments were conducted for different cross-sections of Geotextile tube breakwaters – Single, Double-lined and Three-lined tube breakwaters, in two conditions of submergence – Submerged and Zero-submerged condition, for different wave heights. The reflection and transmission characteristics as well as the wave dissipation and wave energy attenuation by the Geotextile tube breakwater were studied using data acquisition system to identify the best cross-section and the best condition of submergence of geotextile tube breakwater. The cross sections of tube breakwater used in the study are shown in Figs.17 to 19. The physical properties of the material used to fill the tube breakwaters are given in Table 1 (Balan et al. 2012).

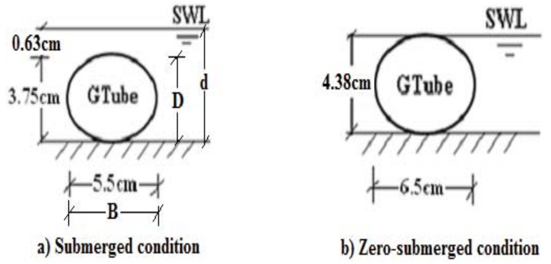


Fig. 17 Model cross-section of Single tube breakwater

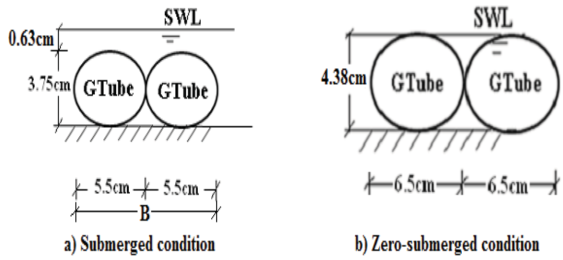


Fig. 18 Model cross-section of Double tube breakwater

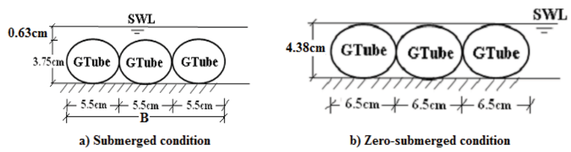


Fig. 19 Model cross-section of three tube breakwater

Table 1 Physical properties of filling material

Item	Quantity
Effective size	0.23 mm
Uniformity coefficient, C_u	1.739
Coefficient of curvature, C_c	1.184
% clay	0
% silt	0.05
% sand	99.5
D_{85}	0.48 mm
Coefficient of permeability, K cm/s	0.0089

Experiments were conducted in a two dimensional wave flume in the Coastal Engineering Laboratory. The wave flume was 11.00 m long, 0.45 m high and 0.46 m wide and was equipped with a wave paddle at one end and a wave absorber at the other end (Fig. 20).

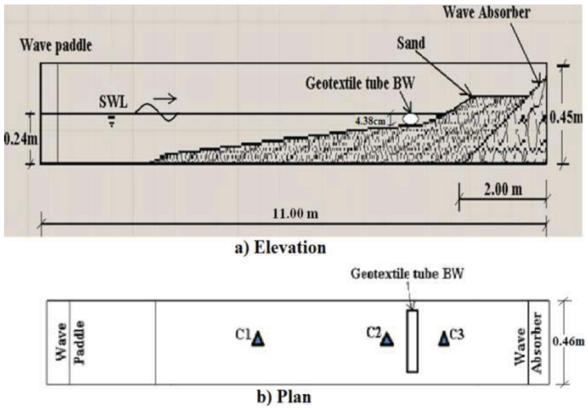


Fig. 20 Schematic representation of Wave Flume setup

Physical model studies were conducted on single tube, double tube and three tube breakwaters, for both submerged and zero-submerged conditions, for three wave heights representing the wave heights along Kerala coast, in India and the following conclusions were arrived at.

- With increase in submergence, reflection coefficient decreases and transmission coefficient increases for a particular wave height.
- Wave height attenuation and energy dissipation were greater for zero-submerged case than for submerged case and decreased with increase in wave height.
- The percentage energy dissipation increased with increase in B/D ratio for both submerged and zero-submerged condition for all the three types of breakwaters tested.
- Greater energy dissipation occurred in zero-submerged condition than in submerged condition for single tube, double tube and three tube breakwaters.
- Double tube in submerged condition and single tube in zero-submerged condition produce more or less same energy dissipation.

- A double tube geotextile tube breakwater in zero-submerged condition will be ideal case for Kerala coast.

CONCLUSIONS

The real case studies reported above and also the models studies conducted, the versatile use of coir geotextile in various civil engineering applications are clearly established. The model studies reported in this paper are to be established beyond doubt with actual field trials and efforts are on the way in this direction.

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