Protection of soil erosion and water management by using coir fibre as the geotextile coating

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Abstract — Soil erosion and water seepage is increasingly recognized as a problem which needs an effective and economic solution. Several slope protection methods are currently used to stabilize slopes thereby preventing the soil erosion and water management. A composite of geotextiles is required to keep erosion down to a tolerable level and also to maintain the water quantity against seepage. In this case we use geotextiles coating in soil slopes in order to prevent the soil erosion and also to maintain the water against seepage. Natural vegetation on slopes are able to self-maintain, brake and dilute the kinetic energy of the rain and also provide surface roughness which slows the runoff velocity. This may be proved as the effective and economic way to prevent the soil erosion. General reasons of embankment failure are soil erosion due to rain splash, wave action, overtopping of storm surge. Faulty design, poor maintenance and poor construction also cause failure. The use of cement concrete blocks, stone revetments, geo-bags, and plantation etc. are commonly used for protection of embankment in traditional practices. These materials are expensive and sometimes are not effective to protect the embankments and river bank for an expected design life. On the other hand, slope stability can be augmented by using bio-engineering techniques. Vetiver grass (Vetiveria zizanioides) is being used as an efficient bio-technology for slope protection in many countries, for its special attributes like longer life, strong and long finely structured root system and high tolerance of extreme climatic condition

Keywords — soil erosion; geotextiles; erosion control; erosion mats, vettiver grass.

I. INTRODUCTION

Soil erosion is the displacement of the upper layer of soil, one form of soil degradation. A low level of erosion of soil is a naturally occurring process on all land. Now-a-days soil erosion is consired as the major problem in all countries. Though there are many ways to prevent the soil erosion, there is always a need of most effective and economic way to prevent the soil erosion. In this paper, we enclosed a case study on geotextiles and vegetation coated soil layer which is design and planned to prevent the soil erosion. One common method is the use of geotextiles.

Geotextiles are permeable fabrics, synthetic or natural, that has the ability to reinforce slopes and control soil erosion. To effectively control soil erosion, geotextiles must be able to protect the soil from eroding elements like rainfall, runoff, and wind. It must also be able to trap suspended sediments in the water without hindering the water to pass through. The selection of geotextiles to be used is dependent not only on its effectiveness. According to Gray and Sotir (1996), the reasons for the widespread use of the geotextiles include availability, ease of installation, familiarity, advertising and promotion, existence of standards, and acceptance of specifies. Usual practice is to use the most suitable and economically-efficient materials.

II. OBJECTIVES

The main objectives of this project are to provide a effective and cost efficient solution to prevent the seepage of water from the water reservoir and also to prevent the soil erosion in slope by using the eco friendly and cheaply available materials,

III. MATERIALS

a. *Coir as geotextiles.*

Coir, a by-product from coconut husk, has shown distinct properties like high strength, stiffness, bulkiness, and resistance to soil moisture and microbes due to significant amount of lignin. We have adopted an innovative application of raw coconut fibre products in the field of geotextiles. The products, geotextile and geonet were developed and used for protection of a river bank.

b. *Effect of coir fibre as geotextile.*

In this case coco coir mat and coir materials are chosen as the geotextiles material. Natural materials can be as efficient as other synthetic materials, with less negative impacts on the environment.

Natural fibers are also biodegradable and a good moisture retainer and soil enhancer. Being so, the fibers can be applied in combination of plants with good soil-retaining capability, thereby, adding to slope stability and enhancing aesthetics. Coco fiber has the highest tensile strength among fibers and retains much of its tensile strength when wet. Because of its high tensile and wet strength, cocomat can be used in very high flow velocity conditions. Fibers also have high durability and slow biodegradation. So it is chosen the coco fibre as the geotextile.

IV. METHODOLOGY

Level the site

⇩

Make inclination as per need

⇩

Plant vetti root on the slope

⇩

Provide geo textile coating

⇩

Evaluate the process

V. MANUFACTURE OF GEOTEXTILE COATING

- Biodegradable geotextiles are usually made in three ways:
- from coir or jute woven manually or
- from staple fibers bonded mechanically by mechanical needling processes with metal needles.
- chemical assemblies with binders

These techniques have several drawbacks. The first is that they require the use of a large workforce, they are dependent on a geographic concentration of fibers used, and that the manufacture requires a high production cost. Risks machinery blocking mechanisms are forcing manufacturers to use as input short fibers in flake form (length less than ten centimeters), resulting in additional manufacturing step backward and a limited choice of fiber.

Coir geotextiles are of different types, the two main geo textiles made from coir:
- Woven geotextiles
- Non-woven geotextiles

Woven geotextiles

Three types of woven geotextiles are currently being manufactured. (a). Coir mesh mattings of two shaft view (b) Coir woven fabrics with loop construction. (c) Coir bags made with latex backed coir matting. Coir mesh mattings of different mesh sizes are most established coir textiles. Mesh mattings having different specifications are available under quality code numbers H2M1 to H2M10. These qualities represents coir textiles of different mesh sizes ranging from 1/8’’ to 1’’. The selection of geotextile for a particular slope depends upon the type of slope, soil condition and vegetation. If the slope is steep, the mesh size will be closer. The decorticated fibre/bristle fibre spun on machines can also be woven as geotextiles. Since colour of yarn is not a criteria for geotextile applications, the brown can be better utilized to produce coir geotextiles at a cheaper rate. This will pave way for manufacture of value added products from brown fibre

Non woven geo textiles :

Several types of non-woven geotextiles exist. Most non-woven mats are made from loose fibres, which are interlocked by needling or rubberizing. Non-woven mats are available in several dimension. They have a minimum thickness of two mm. The non-woven geo textiles are categorized into three groups. (a) Coco logs (b) Coir fibre beds (c) Coir needle felts.

VI. PROPERTIES OF GEOTEXTILES

- Separate: Placing a boundary between two things or areas
- Filter: Allowing a fluid to flow while removing or catching particulates
- Reinforce: Providing structural enhancement to an area
- Protect: Often in conjunction with separating, placing a boundary over soil or a foundation
- Drain: Removing fluid from an area or redirecting it to another area

Using a geotextile layer to separate the pavement from the ground helps maintain the structural integrity of the pavement over time. This is especially important in climates that undergo successive episodes of freezing and thawing. Geotextiles also help prevent the underlying soil from contamination, as well as the pavement from settling if the subgrade beneath the pavement sinks or shifts.

VII. ADVANTAGES OF GEOTEXTILES

- Faster binding of soil
- Excellent air and water permeability
- Holds the seeds and saplings vegetation
- Degrades owes a period of time
- Eco friendly and non- polluting
- Water course protection including stream ban protection
- Separation application in rural roads, railways, parking and storage areas.
- Agricultural and horticultural application like mulching, anti-weed, vegetable seeding etc
- Forestry vegetation
- Mine site reclamation
- Landscaping
- Agri. and Horti engineering industry
- Soil stabilization
- Ready to use lush green natural lawn can be made out of coir geotextiles and coir pith
- Geotextiles can regenerate the exposed rock patches.
- It is 100% natural
- It is biodegradable, still last minimum for 2 seasons
- It provides excellent micro climate for plant establishment and growth
- Easy to install
- Available in plenty
- Economical.

VIII. APPLICATIONS

- Reduce slope length
- Capture Inlet Sediment
- Prevent Construction Sedimentation
- Promote Re-vegetation
- Storm water on-off control

Geotextile coir

Geotextile coating with plantation

IX. CHARACTERISTICS OF VETTIVER

Vetiver grows to 150 centimetres (5 ft) high and form clumps as wide. Under favourable conditions, the erect culms can reach 3m in height. The stems are tall and the leaves are long, thin, and rather rigid.

The flowers are brownish-purple. Unlike most grasses, which form horizontally spreading, mat-like root systems, Vetiver's roots grow downward, 2 metres (7 ft) to 4 metres (13 ft) in depth. The Vetiver bunch grass has a gregarious habit and grows in tufts. Shoots growing from the underground crown make the plant frost and wildfire resistant, and allow it to survive heavy grazing pressure. The leaves can become up to 300 centimetres (10 ft) long and 8 millimetres (0.3 in) wide. The panicles are 15 centimetres (6 in) to 30 centimetres (12 in) long and have whorled, 25 millimetres (1 in) to 50 millimetres (2 in) long branches. The spikelet's are in pairs, and there are three stamens.

The plant stems are erect and stiff. They can survive deep water flow. Under clear water, the plant can survive up to two months. The root system of Vetiver is finely structured and very strong. It can grow 3 metres (10 ft) to 4 metres (13 ft) deep within the first year. Vetiver has neither stolons nor rhizomes. Because of all these characteristics, the Vetiver plant is highly drought-tolerant and can help to protect soil against sheet erosion. In case of sediment deposition, new roots can grow out of buried nodes

X. STABILITY OF VETTIVER ON THE SLOPE

Currently it is used in many countries in the world, vetiver grass (*Vetiveria zizanioides*) applications include soil and water conservation systems in agricultural environment, slope stabilization, mine rehabilitation, contaminated soil and saline land remediation, as well as wastewater treatment. The root system morphology of vettiver was investigated in a small plantation growing on abandoned marl terraces in southern Spain. Root distribution with depth, laterally from the plant, as well as root parameters such as root diameter and tensile strength were also investigated. The profile wall method combined with the block excavation showed that the Vetiver grass grows numerous positively gravitropic roots of more or less uniform diameter. These were generally distributed in the uppermost soil horizon closer to the Culm base. In situ shear test on blocks of soil permeated with vetiver roots were carried out and showed a greater shear strength resistance than the samples of non vegetated soil. The root reinforcement measured in situ was comparable to the one predicted by the perpendicular root reinforcement model. The stability of a modeled terraced slope planted with Vetiver was marginally greater than the one of a non-vegetated slope. A local instability on one terrace can have a detrimental effect on the overall stability of the terraced slope.

Vettiver grass

XI. TENSILE AND SHEAR STRENGTH OF VETTIVER ROOTS

Research conducted by Hengchaovanich and Nilaweera (1996) showed that the tensile strength of Vetiver roots increases with the reduction in root diameter. The tensile strength of Vetiver roots varies between 40-180 Mpa for the range of root diameter between 0.2-2.2 mm. The mean design tensile strength is about 75 Mpa (equivalent to approximately one sixth of mild steel) at 0.7-0.8 mm root diameter, which is the most common size for Vetiver roots. This indicates that Vetiver roots are as strong as, or even stronger than that of many hardwood species, which have been proven positive for root reinforcement in steep slopes. In a soil block shear test, the root penetration of a two year old Vetiver hedge with 15cm plant spacing can increase the shear strength of soil in adjacent 50 cm wide strip by 90% at 0.25 m depth. Vetiver can grow vertically on slopes steeper than 150%. It is faster growing and imparts more reinforcement, making it a better candidate for slope stabilization than other plants.

XII. APPLICATIONS OF VETTIVER SYSTEM

- Vetiver is very effective when planted closely in rows on the contour of slopes. Contour lines of vetiver can stabilize natural slopes, cut slopes and filled embankments.
- Its deep, rigorous root system helps stabilize the slopes structurally while its shoot disperse surface run-off, reduce erosion, and trap sediment to facilitate the growth of native species (Troung, et al., 2008)
- Edges of ponds, dams and reservoirs, road shoulders, gullies, hills, roadsides etc. are areas, where cultivation of vetiver should be carried out for conserving the environment and the infrastructures themselves.
- Vetiver is termed as “soil nail” or “living nail” for its effective conservation role of road and water infrastructures
- Presently Vetiver grass has been widely used for erosion and sediment control on steep slopes around the world including Africa, Asia, central and south America, southern Europe and Australia where it has been used successfully to stabilize steep batters of road and railway in north, central and south east Queensland.
- In China, the Vetiver System has been used for erosion and sediment control on more than 150,000 km of railway, highway and road batters in the last 5 years
- Using vetiver grass to stabilize river banks and canal walls is another recommended practice.
- The combination of the deep root system and thick growth of the vetiver hedges will protect the banks of river and stream under flood conditions.
- Its deep roots prevent it from being washed away while its thick top growth reduces flow velocity and its erosive power.
- In addition properly laid out hedges can be designed to direct water flow to appropriate area
- Vetiver plants will form a hedge which is very effective in slowing and spreading runoff water, reducing oil erosion, conserving soil moisture and trapping sediment and farm chemicals on site.

CONCLUSIONS

- Wastage of water is reduced by using geotextile coating.

- Water loss by seepage is reduced.
- Geo textiles are designed in association with various civil engineering purposes such as separation, reinforcement protection, etc.
- It helps to make environment good and sustainable.
- Vetiver grass, due to its extraordinary and unique morphological and physiological characteristics, is a very simple, practical, inexpensive, low maintenance and very effective means of soil and water conservation, sediment control, land stabilizations and rehabilitation, and phyto-remediation. When planted in single rows Vetiver plants will form a hedge which is very effective in slowing and spreading runoff water, reducing oil erosion, conserving soil moisture and trapping sediment and farm chemicals on site.

- The extremely deep and massively thick root system of Vetiver binds the soil and at the same time high velocity water flows. This very deep and fast growing root system also makes Vetiver very drought tolerant and highly suitable for steep slope stabilization

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