International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Ecofriendly and Versatile Coir Geo-Textile for Reinforced Critical Slope Surface

Avi Bhadiyadra[1], Maulik Rafaliya[2], Harsh Gujarati[3], Ravi Karkar[4], Meet Viradia[5]

[1, 2, 3, 4, 5]Department of Civil Engineering, Sarvajanik College of Engineering and Technology, R.K Desai Marg, Surat, Gujarat, India

Abstract: ***In this project coir geotextile placed at particular depth of soil improves Erosion Control and Slope Stability as well as Soil bearing capacity and its Performance. The natural products like coir geotextiles make the construction cost effective and eco-friendly. This has added a new dimension to the development of coir products in the field of geotextiles as coir possesses high strength and biodegradability to add to its advantages over other natural and synthetic Fibers. Coir geotextile can be effectively used as stabilizer and reinforcement in paved and unpaved roads. It improves the mechanical characteristics of roads, yielding to significant increase in road life span and reduction in maintenance cost***

Keywords: Coir Geo-textile, Eco-friendly, Slope stability, Erosion control, Critical Slope surface

1. Introduction

A slope surface is said to be critical slope surface when a combination of slope and soil factors make a high potential for slope stability failure and subsequent erosion. Over-steepened disturbed (graded) slopes are considered to be critical when resistance against surface erosion and shear strength resistance are low. For some situation, soil movements are affected by various parameters including angle of repose, soil structure, incline length and erodibility. Advancements in sediment control and erosion innovation have produced better than ever products, which have encouraged innovative techniques for critical slope face stabilization. Slope stabilization techniques are can be utilized for critical slope surfaces identified with roadway development. Geosynthetic Stabilized Embankments (GSE) are usually utilized for over steepened slope when a site presents restricted right of way and construction limitations. GSE embankments have steep slope face surfaces that present difficulties in the outline of practical and successful slope stabilization measures. By utilizing well established Biotechnical Slope Protection standards related to enhanced erosion control products, erosion control and slope surface stability can be fundamentally improved.

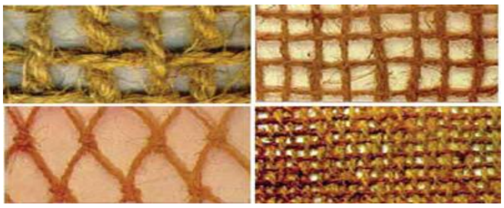


Figure 1: Type of coir

2. Materials

2.1 Coir Geo-Textile

Coir is a biodegradable organic natural fibre material which is coarse, inflexible, and solid and further more environmental friendly material is practically irreplaceable by any of the modern polymeric substitutes. The constituents of coir have been observed to be for the most part cellulose and lignin. Coir fibre is climate safe and impervious to fungal and bacterial disintegration Because of the high lignin content in the fibre, the rate of disintegration of coir is substantially less than some other regular fiber.

Geotextile comes from two words "Geo" and "Textiles", so it means fabric used in relation to "soil/earth ". The term geo Textiles or geographic fabrics represent woven / non-woven fabrics, Knitted (composite / natural blankets) or Artificial origin is used as a permeable fabric Inside geotechnical engineering to prevent soil Migrates while the water flows (earth Eat). Geo fabrics come in the thickness range from 0.2 mm to 10 mm with gradient lengths of up to 100 meters and width up to 10 meters with permeability comparatively differ from coarse/raw gravel to fine sand. The role of this material is to secure and advance vegetation cover amid its developmental period then after it will degrades over a long period of time and blends with the current soil proving for important nutrients;

- Made from natural fibre
- Durable natural fibre
- Biodegradable (degrades over a long time about 4-6 years)
- Having High tensile strength and modulus
- Good dimensional stability
- Anti-slip in nature

2.1.1 Environmental Application of Coir Geo textiles

- Stabilization of shoreline and sand dunes
- Tree and plant protection systems
- High altitude vegetation
- Protection and re vegetation of waste dumps
- For reinforced soil retaining structures
- Protection of Road / Railway / River embankments
- Protection of Dams
- To strengthen cuttings and hill slide slope
- For irrigation works
- Protection from wind erosion also
- Stabilization of soil

2.2.2 Furnishing of Coir Geo-textile (The major application area vs. percentage)

Table 1: Furnishing of Coir Geo-textile

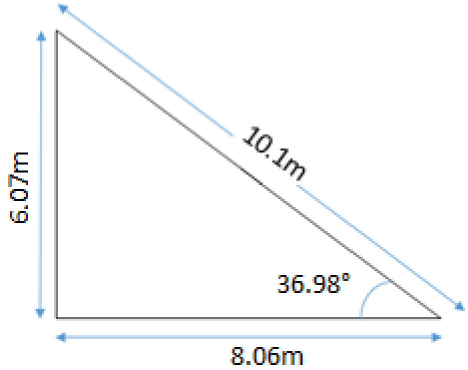
Application area	*Percentage (%)*
1. Reinforcement	4
2. Silt fences	6
3. Erosion control	7
4. Linings	8
5. Drainage	16
6. Asphalt overlay	17
7. Separation /stabilization	42

3. Study Area Selection

We selected the study area that completely covered our objectives. Our site is situated on the National Highway-48, Kadodara, Surat. Basically it is the road side embankment with the efficient slope. It is the gradually increasing slope with length and we selected the flatty longest slope as a study area for our project work. This slope is situated at 12k.m. from the kamrej intersection. On that slope, due to steep surface the problem of erosion and sedimentation down below were largely seen. Kadodara has tropical climate. In winter, there is much less rainfall than in summer. The average temperature in Kadodara is 32°C. About 1223mm of precipitation falls annually. Most Precipitation falls in July, with an average of 483mm.

Figure 2: Site Location


Figure 3: Measurement of actual site



4. Procedure of installation of Coir Fibre

Firstly the area cleared of from all the vegetation, rocks, slumps from slope on which placing of the Coir Geo-textile material sheet is done and also then levelling & temping is done to get desire shape and well prepared slope area.


Figure 4: Preparation of site

After preparing the slope area the sheet of Coir Geo-textile material is being placed to the slope surface and it fixed by J pin & U pin and upper side the trench is formed to fix the sheet to prevent against sliding to its own weight.


Figure 5: Laying of coir Geo-textile material

After placing of Coir Geo-textile the process of hydro seeding is done for faster vegetation growth and some plants & manures are added with it.


Figure 6: Process of Hydro seeding

Now the process of watering is done for vegetation growth around 15 days and it found that vegetation growth is around 60% to 70%.

Figure 7: Watering and Vegetation growth

Now onwards the erosion test is conducted on selected slope surface area. Firstly the bucket is put on the lower part of slope surface to collect the eroded soil mass. Then checking of erosion is done on two control slope surface area by applying artificial rainfall of water. Then the eroded soil is collected through slope surface is weighted and compared and after that it is found that the slope surface with coir geotextile is lesser then existing slope surface condition.

Figure 8: Eroded soil mass collection

5. Experiments and Result of Soil

Following Tests which performed in the laboratory for the analysis of the collected soil sample from the existing site,

1) Sieve analysis
2) Liquid Limit
3) Plastic Limit
4) Standard Compaction Test
5) Direct shear Test

5.1.1 Sieve Analysis

The grain size analysis is broadly utilized in order of soils. The information got from grain size distribution curves is utilized in the design of channels for earth dams and to decide appropriateness of soil for road development, runway and so on. Data acquired from grain size analysis can be utilized to predict soil water movement although permeability tests are more generally used. The type of soil present at project site is SW (Well Graded Sand) that we found from Sieve Analysis.

Table 2: Observation table of sieve analysis test

1	2	3	4	5	6	7
Sieve size (mm)	Mass of each sieve (mm)	Mass of each sieve + retained soil	Mass of soil retained-Wn (g) Col3-Col2	Percentage on each sieve Rn Col4/Wt. *100	Cumulative percent retained S R n	% finer, 100-S Rn
4.75	427.69	431.365	3.675	1.8375	1.8375	98.1625
2.00	400	412.015	12.015	6.0075	7.845	92.155
0.6	354.8	372.785	17.985	8.9925	16.8375	83.1625
0.212	346.8	371.615	24.815	12.4075	29.245	70.755
0.075	324.8	359.985	35.185	17.5925	46.8375	53.1625
L.P.	484.4	590.725	106.325	53.1625	99.9975	0
			$S=W_1=$ 200			

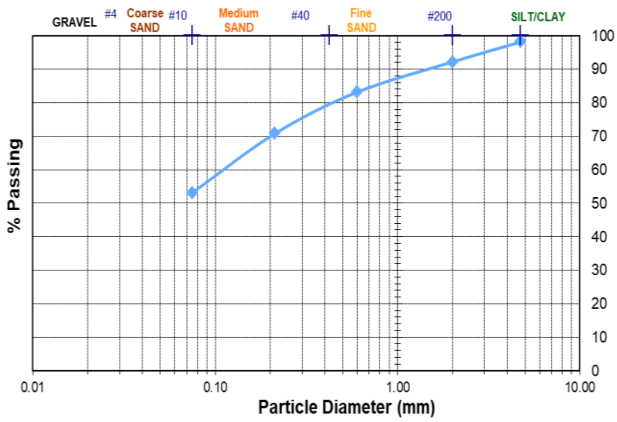


Figure 9: Sieve analysis curve

Uniformity coefficient (Cu)

$$Cu=\frac{d_{60}}{d_{10}}=\frac{0.112}{0.031}=3.61$$

Coefficient of curvature (Cc)

$$Cc=\frac{d_{30}{}^2}{d_{60}\times d_{10}}=\frac{0.074^2}{(0.112)(0.031)}=1.577$$

The soil presented at the study area is the type of Lean Clay (Low Plasticity Clay).

5.1.2 liquid Limit

This test is essential to determine the liquid limit of soil using Casagrande apparatus. Moreover, we took "IS: 2720(Part 5)-1985- Methods of test for soils: Determination of liquid and plastic limit." as a reference.

Table 3: Observation table of liquid limit test

Sr No	Test	1	2	3	4
1	N Blows	22	31	18	29
2	Moisture Dish No	10	8	6	9
3	Weight of Empty dish(M1) g	21.5	22.7	32	22.2
4	Dish+Wet soil(M2) g	85.2	62.5	57.2	64.5
5	Dish+dry Soil(M3) g	71.5	55.2	51.3	56.2
6	Water content	27.39	22.45	30.5	24.4

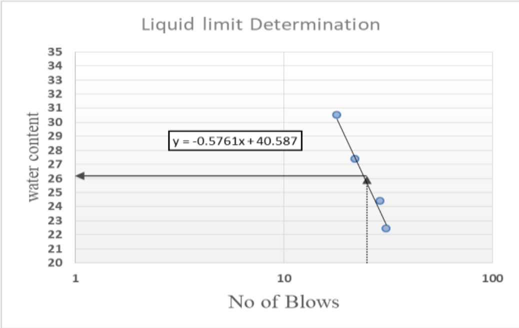


Figure 10: Graph of liquid limit

Liquid Limit of Soil specimen (From Graph) = **26.1845**

5.1.3 Plastic Limit

A percentage of the weight of the oven-dry soil at the boundary between semisolid state and plastic state of consistency expressed by Plastic Limit which is the moisture content of soil at which a soil will begin to crumble when rolled into a thread ⅛' (3mm)in diameter on glass plate.

Figure 11: Thread of soil sample for plastic limit test

Table 4: Observation Table for Plastic Limit

Sr No	Dish No.	Weight of Dish	Weight of Dish + Wet Soil	Weight of Dish + Dry Soil	Plastic Limit = Moisture Content
		W_1 (gm)	W_2 (gm)	W_3 (gm)	W_p (%)
1	7	26.7	37.8	36.8	9.900
2	1	22.4	39.6	38.4	7.500
				Average	8.700

Plastic Limit (W_p) = 8.700 %

Plasticity Index = $W_L - W_P$
= 26.1845 – 8.700
= 17.4845 %

5.1.4 Standard Compaction test

The equipment and technique are basically the equivalent as that utilized for the Standard Test aside from that the soil is compacted in 5 layers, each layer additionally getting 25 blows. A similar shape mould is utilized. To give the increased compactive effort, a heavier rammer of 4.9 kg and a more noteworthy drop height of 450 mm are utilized.

Table 5: Observation table of compaction test

Determination Number	1	2	3	4	5
Wt. of mould + Compacted Soil W(gm)	14896	15200	15500	15500	15050
Wt. of mould Wm(gm)	10450	10450	10750	10750	10450
Wt. of compacted Soil (gm)	4446	4750	4750	4750	4600
Water Added (%)	14%	16%	18%	20%	22%
Wet Density Y_m (Wd)	2.0127	2.1504	2.1504	2.1504	2.0824
Moisture Content					
Crucible Dish No.	7	1	8	5	4
Wt. of Empty Crucible W1(g)	23.86	30.8	33.8	31.0	26.2
Wt. of crucible + Wt. of soil W2 (g)	60.52	96.8	72.2	71.0	75.4
Wt. of crucible + Wt. of Dry Soil W3(g)	56.49	88.6	66.8	64.2	66.2
Moisture Content W%	12.35	14.187	16.36	20.48	23.0
Dry Density ɣ(g/cc)	1.792	1.8828	1.8477	1.7845	1.6911

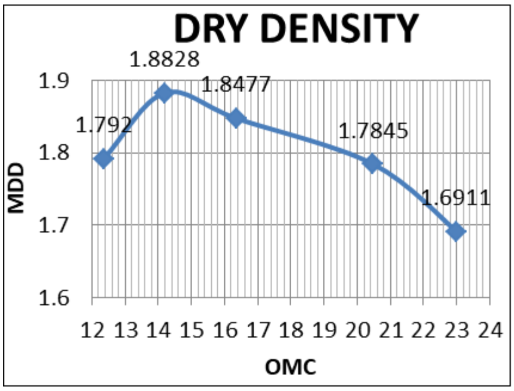


Figure 12: Compaction curve

OMC (%)	14.187
MDD (gm/cc)	1.8828

5.1.5 Direct Shear Test

- Rate of Strain: 1.25mm/min
- Specimen Measurements:
- Sample Dimension: 6×6×2.5*cm*
- Thickness: 50*cm*

Table 6: Observation tables of direct shear test

Date and Time	Displacement Dial Reading	Displacement (δ)	Corrected Area (cm^2)	Stress dial reading	Shear Force	Shear stress (Kg/cm^2)
17-09-2019	35	0.035	35.58	80	17.6	0.4946
	34	0.034	35.59	106	23.32	0.655
	30	0.030	35.64	151	33.22	0.932

Sr No.	Dial Gauge Reading	Proving Dial Readings		
		0.5 (Kg/cm^2)	1.0 (Kg/cm^2)	1.5 (Kg/cm^2)
1	0.3	10	33	62
2	1.0	22	50	101
3	1.3	32	62	117
4	2.0	52	67	127
5	2.3	61	72	132
6	3.0	69	78	135
7	3.3	74	84	142
8	4.0	77	89	144
9	4.3	80	94	146
10	5.0	79	99	148
11	5.3	80	102	151
12	6.0	76	106	141
13			104	138

Table 7: Observation tables of direct shear test

Sr. No	Normal Stress (Kg/cm^2)	Shear Stress at Failure (Kg/cm^2)	Shear Displacement at failure	Initial Water content
1	0.5	0.4946	0.035	20.57
2	1.0	0.655	0.034	18.81
3	1.5	0.932	0.030	19.86

Remarks: Shear Parameters: C = 0.26 Kg/cm^2
$\emptyset = 24°$

6. Results for the properties of coir geo-textiles

Chemical Properties (Composition) of Coir Fiber which are collected by the supplier of our Coir Geo-Textile material PV Exports, Alappuzha, Kerala.

Table 8: Properties of Coir Geo-Textiles

Water soluble	5.25%
Pectin & related compounds	3.30%
Hemi-Cellulose	0.25%
Cellulose	43.44%
Lignin	45.84%
Ash	2.22%

6.1 Result For moisture regain of coir geo-textile

According to the literature, Fibres, which are more crystalline in nature, show high strength. That means more crystalline Coir Geo-Textile must be strong.er

Textile material	Moisture Regain (%)
Coir Geo-Textile	10.25%

6.2 Result of Swedish slip circle method for Slope stability analysis

For the stability analysis of slope from this method, first of all determine all the normal and tangential load components. Determine the length of the arc and finally got the factor of safety regarding to our Slope Surface.

Table 9: Observation table of Swedish slip circle method

Slice no.	Mid Ordinate (meter)	Width (meter)	Volume (m^3)	Weight (KN)	Angle (α)	N =Wcosα (KN)	T =Wsinα (KN)
1	1.0	2.0	2.0	37.6	9°	37.1371	-5.8819
2	2.6	2.0	5.2	97.76	2.5°	97.6669	4.2642
3	3.8	2.0	7.6	142.88	13°	139.2179	32.1410
4	4.6	2.0	9.2	172.96	26°	155.4554	75.8207
5	4.1	2.0	8.2	154.16	39.5°	118.9536	98.0578
6	1.9	2.0	3.8	71.44	55.5°	40.4641	58.8756
					$\sum$ =	588.895	263.2774

$$\text{Length of Arc} = \frac{2\pi r\delta}{360} = \frac{2 \times \pi \times 10.1 \times 83.5}{360} = 14.7192\text{m}$$

$$\text{Factor of Safety} = \frac{(C\times L) + \tan\emptyset \sum N}{\sum T} =$$

$$\frac{(25.497)(14.7192) + \tan(36.94°)\,588.895}{263.2774} = \frac{818.0934}{263.2774} = 3.1073$$

Table 10: Observation and Result data for Erosion of slope surface

Control Plot Area	$(10\times1)m^2$
No. of Control Plots	2 (1-Non protected,1-Protected with Coir)
Test Period	15 minutes
Artificial Rainfall	9.2 cm
Soil erosion of non-protected slope	4.376 kg/m^2
Soil erosion of protected slope with coir	1.161 kg/m^2
Percentage Reduction (%)	73.46 (%)

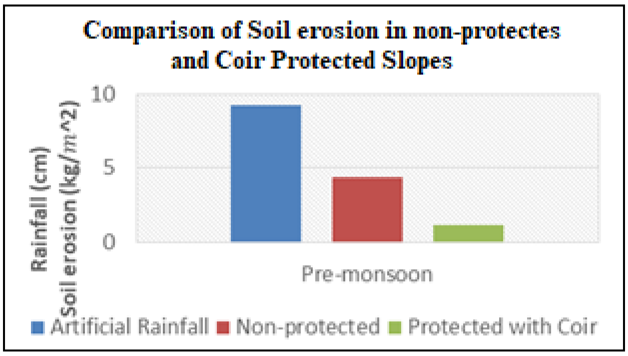


Figure 13: Comparison and Analysis of Soil Erosion test

The Percentage reduction in Erosion is 73.46 (%).

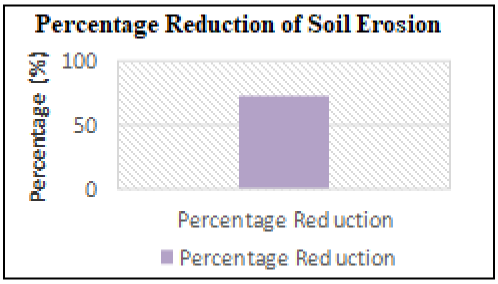


Figure 14: %Reduction on Erosion

7. Conclusion

The Concluding remarks from the analysis of untreated side slope road embankment are as follow:

- From the Sieve Analysis Test, the soil situated at the study area is Lean Clay (Low Plasticity Clay).
- The Liquid Limit of the Untreated Soil is 26.1845 %.
- The Plastic Limit of the Untreated Soil is 8.7 %.
- The Plasticity index of the Untreated Soil is 17.4845%. So the soil has Medium Plasticity.
- The Untreated Soil Sample has OMC is 14.187 % and MDD is 1.8828 gm/cc.
- The Shear Parameters derived from the Direct Shear Test are as Cohesion(C) 0.26 kg/cm^2 and Co-efficient of friction ($\emptyset$) 24°.
- With the help of Swedish Slip Circle Method, We derived the Factor of Safety (F.O.S.) of the existing side slope of the Road embankment.
- The Moisture Regain (%) capacity of coir geo-textile material is 10.25%.
- The Percentage reduction in Erosion is 73.46 (%).

- After concluding it is shown that by using such kind of coir geo-textile material to improve the stability of slope one can increase the slope angle and ultimately one can minimize the filling material for slope surface and also it gives better protection against erosion of soil mass.

References

[1] Ankita I K, Devika G, Lakshmi Priya K, Remya R, Jayamohan J. (2016, February). Applications of Geosynthetics in Embankments- A Review. *International Advanced Research Journal in Science, Engineering and Technology (IARJSET), 5*(1), 11.

[2] Baruah, U.K,Saikia, B.D.,Bora, P.K. (2010). Road Construction in Assam by Using Coir Mat. *Indian Geotechnical Conference* (p. 4). Mumbai: IIT Bombay.

[3] Bhavesh Joshi, Dr. R.P.Arora. (2015, November). PAVEMENT DESIGN BY USING GEOTEXTILE. *International Journal of Civil Engineering and Technology (IJCIET), 6*(11), 6.

[4] Chetan R Bhole, V Sunitha, Samson Mathew. (2015, December 11th - 13th). EFFECT OF COIR

[5] GEOTEXTILE AS REINFORCEMENT ON THE LOAD SETTLEMENT CHARACHTERISTICS OF WEAK SUBGRADE. *6th International Conference on Structural Engineering and Construction Management 2015*, 8.

[6] David W.Yam. (2006). *Slope face stabilization for critical slope surfaces.* Department of Transportation. Oakland: David W.Yam.

[7] Dean & Prof. T. Subramani. (2012). Application of Eco-Friendly Geotextiles for Landslide Mitigation in a Part of Oaty Hills,Tamilnadu. *International Journal of Modern Engineering Reserch (IJMER)*, 16.

[8] G. L. Sivakumar Babu, A. K. Vasudevan. (2008, September). Strength and Stiffness Response of Coir Fiber-Reinforced Tropical Soil. *Journal of Materials in Civil Engineering, 20*(9), 20.

[9] G.L.Shivakumar Babu, A.K.Vasudevan, M.K.Sayida. (2008). Use of Coir Fibers for Improving the Engineering Properties of Expansive Soils. *Journal of Natural Fibers, 5*(1), 61-75.

[10] Jesus Alvarez-Mozos, Eguzki Abad, Rafael Gimenez, Miguel A.Campo, Mikel Goni, Maider Arive, Javier Casali, Javier Diez, Ignacio Diego. (2014, July). Evaluation of erosion control geotextiles on steep slopes. Part 1: Effects on runoff and soil loss. *CATENA, 118*, 168-178.

[11] Jesús Álvarez-Mozos, Eguzki Abad, Rafael Giménez, Miguel A.Campo, Mikel Goñi, Maider Arive, Javier Casalí, Javier Díez, Ignacio Diego. (2014, July). Evaluation of erosion control geotextiles on steep slopes. Part 1: Effects on runoff and soil loss. *CATENA, 118*, 168-178.

[12] K. R. Lekha. (2003). *Field instumentation and monitoring of soil erosion in coir geotextile stabilized slopes-A case study.* Centre for Water Resources Developement and Management . Kunnamangalam: K. R. Lekha.

Author Profile

Avi Bhadiyadra completed the D. E (Diploma Engineering) and B.E. course in Civil Engineering from S.T.B. S College of Diploma Engineering and Sarvajanik College of Engineering and Technology, Surat in 2016 and 2019 respectively.

Maulik Rafaliya completed the B.E. course in Civil Engineering from Sarvajanik College of Engineering and Technology, Surat in 2019.

Harsh Gujarati completed the B.E. course in Civil Engineering from Sarvajanik College of Engineering and Technology, Surat in 2019

Ravi Karkar completed the D. E (Diploma Engineering) and B.E. course in Civil Engineering from S.T.B. S College of Diploma Engineering and Sarvajanik College of Engineering and Technology, Surat in 2016 and 2019 respectively.

Meet Viradia completed the B.E. course in Civil Engineering from Sarvajanik College of Engineering and Technology, Surat in 2019