Experimental Assessment of Effectiveness of VetiverGrass Root for Landslide Protection in Laterite Soil

Rinitha P
Dept. Of Civil Engineering
(A P J Abdul Kalam Technological University)
College Of Engineering Thalassery (APJ Abdul Kalam Technological University)
Kannur, India

***Abstract*—Landslides are one of the most important and major natural hazards and that mankind is facing all over the world. Landslides are more widespread than any other geological hazards. A study comprising experimental work was undertaken to evaluate the effects of plant roots, especially vetiver roots on strengthening and stabilizing the ground slope. Vetiver species are selected because it is widely available in country and its root morphology is most effective for slope protection. The biological measures by means of vetiver plantation for the rehabilitation of landslides and reduction of landslips incidence in high rainfall region is discussed in the paper. The study includes shear strength parameter changes that happen to the soil by the addition of vetiver grass and other geotechnical properties**

Index Terms— Vetiver, rehabilitation, geotechnical properties.

I. INTRODUCTION

A. Need of the study

In order to meet the needs of a growing population and the emergence of new cities, new roads need to be built to travel and move from place to place and to transfer goods for both private and commercial enterprises. In the new roads the embankment needs to be stabilized and strengthened to ensure safe passage. Stabilizing the slope in an economical and environmental way is a major problem in this situation. The monsoon seasons that appear with heavy rain and flooding usually causes the failure of slopes. August 2018 led to the worst flooding in Kerala in nearly a century impacting almost 5.4 million people - one-sixth of the State's population. Several districts were inundated for more than two weeks due to heavy rains induced floods. The torrential rains triggered several landslides and forced the release of excess water from 37 dams across the State, adding to the impact of floods. Nearly 341 major landslides were reported from 10 districts. Idukki district was ravaged by 143 landslides. 1,260 out of 1,664 villages spread across its 14 districts were affected. Seven districts were worst hit: Alappuzha, Ernakulam, Idukki, Kottayam, Pathanamthitha, Thrissur and Wayanad (Fig 1.) where the whole district was notified as flood affected. The devastating incident delivered a total of 435 casualties, with 6,85,000 familiesbeing affected with loss of assets and property forcing them to temporarily move to relief camps during the peak of the disaster. Thus, there is an urgent need of stabilization of slopes to lessen theimpacts of these landslides. But the national budget is not enough to adopt conventional methods. Hence, Biological methods are adopted. In this method, strength of soil is increase by growing grass, pteridophytes, plants, trees especially in the slope. Thus, the Bioengineering tool we adopt is Vetiver grass, this is becauseof its wide availability.

Figure 1. Landslide in Kurichyar Mala, Wayanad and Landslide in Kottiyoor forest area

II. METHODOLOGY

Firstly, we selected the topic which we needed to study. We went through various journals and made an outline of what we need to do. Test was conducted on the soil sample collected from the region of Thalassery. Vetiver plants were collected and cultivated. Then laboratory test of the soil sample which is collected is conducted. After the maturity of growth after 39 day we collect the mature roots of vetiver and the bare soil is reconstituted according to the optimum moisture content. Then we performed shear test over the reconstituted soil at MIT Laboratory. Result of various studies have been enabled and comparing of shear and temperature parameters have been done. Tests such as direct shear test, compaction test, water absorption test, grain size test are needed to be done We compared the strength of bare and rooted soil. The effectiveness of biological remediation by means of vetiver grass has been studied successfully.

III. INDEX PROPERTIES

A. Grain size analysis

TABLE I GRAIN SIZE DISTRIBUTION OF SOIL

Sieve Size (mm)	Weight Retained(g)	Percentage Weight Retained(g)	Cumulative Percentage	Percentage Finer (%)
4.75	279	27.9	27.90	72.1
2.36	128	12.8	40.70	59.3
1.18	117	11.7	52.4	47.6
0.6	112	11.2	63.6	36.4
0.425	73	7.3	70.9	29.1
0.3	83	8.3	79.2	20.8
0.15	139	13.9	93.1	6.9
0.075	65	6.5	99.6	0.4
Residue	4	0.4	100	0

D60=2 D30=0.4 D10=0.15

Uniformity Coefficient (C_u)=D60/D10=13.3

Coefficient of Curvature (C_c) =(D30)2/(D60) *(D10) =0.53 From the above table graph was plotted and its grain sizedistribution curve is as shown (Fig 2.)

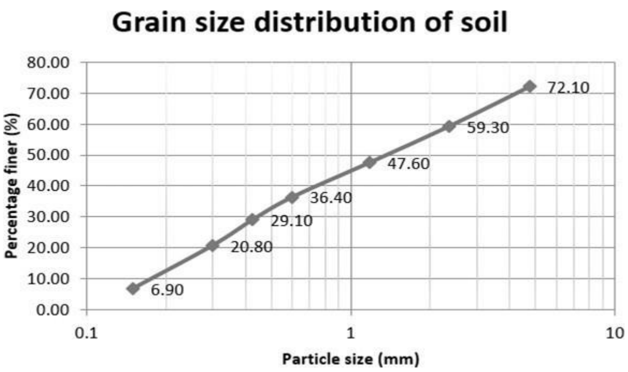

Figure 2. Grain size distribution curve

B. Specific Gravity

Weight of dry soil = Weight of pycnometer with dry soil(W2)-Weight of pycnometer(W1) = 400g.

TABLE II SPECIFIC GRAVITY OF SOIL NEAR THE VETIVER

	1	2	3
Weight of pycnometer(W1) (g)	550	550	550
Weight of pycnometerwith dry soil(W2) (g)	950	950	950
Weight of pycnometer with soil and water filledup to top (Ws)(g)	1635	1637	1640
Weight of pycnometerfull of water	1454	1454	1454

Specific gravity, G = (W2-W1)/(W2-W1) -(W3-W4)W1=550g, W2=950g, W3=1635g, W4=1454gG=(W2-W1)/(W2-W1) -(W3-W4)

G = (950-550)/ (950-550) -(1635-1454)G =1.84%

C. Water Content

TABLE III WATER CONTENT

	1	2	3	4	5
Weight of the container with lid(g)W	19	19	19	19	19
Weight of container with wet soil and lid (W_{wt})	92	78	56	44	36
Weight of the container with dry soil and lid (W_d)	90	74	52	38	32
Weight of water	2	4	6	6	4
Weight of dry soil	71	55	33	19	13
Water content (W_w*100/W_d)	2.81	7.27	18.18	31.58	30.77

Mean Water Content =18.122

D. Compaction Test

Weight of soil taken = 3kg

Weight of mould =4.138kg

Volume of container =$\Pi r^2 h=\Pi *(10)^2*12/4$ =942.47cc

TABLE IV. COMPACTION TEST

Determination number	1	2	3	4	5
Weight of the mould + compacted soil(kg)	5.738	5.775	5.924	5.919	5.868
Weight of compacted soil(kg)	1.6	1.64	1.79	1.78	1.73
Wet density(g/cc) (γ)	1.66	1.74	1.90	1.89	1.84
Dry Density(g/cc) $\gamma_d = \gamma/(1+w)$	1.52	1.58	1.65	1.57	1.47

Maximum dry density = 1.65g/cc
Optimum Moisture Content = 12.8%
From the above values graph of density vs water content was plotted which is as shown (Fig.3)

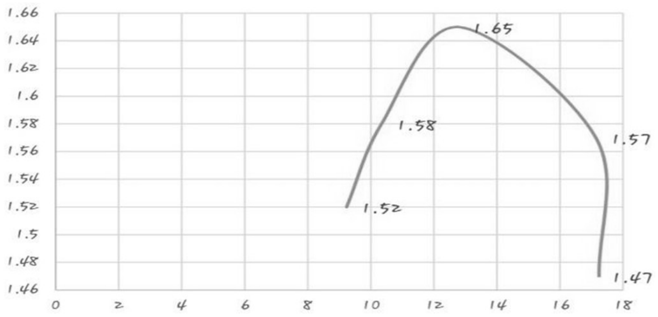

Figure 3. Density VS Water content

E. Direct Shear Test

At first, the collected soil samples were air dried and then crushed into powder form by a wooden hammer. After that water was added in the dry soil to bring it into the natural moisture content (12.8%) condition. Chopped vetiver roots of 30 mm long (arbitrarily chosen) were randomly mixed with the wet soil. Percentage of root content 3% of the dry weight of the soil sample. The prepared samples were kept in a desiccator to keep the moisture content unchanged. Direct shear test was conducted on those prepared specimens according to ASTM standards.

TABLE V BARE SOIL-0.7 KG/CM²

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Load=Proving Ring Reading*0.3001	Shear Stress=LOAD /AREA (kg/cm²)
20	9	0.2	2.7009	0.0625
40	10	0.4	3.001	0.0694
60	11.4	0.6	3.42114	0.0791
80	12	0.8	3.6012	0.0833
100	12.4	1	3.72124	0.0861
120	13	1.2	3.9013	0.0903
140	13.4	1.4	4.02134	0.0930
160	13.8	1.6	4.14138	0.0958
180	14.4	1.8	4.32144	0.1000
200	14.6	2	4.38146	0.1014
220	15	2.2	4.5015	0.1042
260	15.4	2.6	4.62154	0.1069
280	15.8	2.8	4.74158	0.1097
300	16.2	3	4.86162	0.1125
320	16.4	3.2	4.92164	0.1139
340	16.6	3.4	4.98166	0.1153
360	16.8	3.6	5.04168	0.1167
380	17	3.8	5.1017	0.1180
400	17.4	4	5.22174	0.1208
440	17.8	4.4	5.34178	0.1236
480	18	4.8	5.4018	0.1250
500	18.4	5	5.52184	0.1278
520	18.8	5.2	5.64188	0.1305
560	19	5.6	5.7019	0.1319
580	19.2	5.8	5.76192	0.1333
640	19.8	6.4	5.94198	0.1375
680	20	6.8	6.002	0.1389
820	20	8.2	6.002	0.1389
860	20.4	8.6	6.12204	0.1417
880	20.8	8.8	6.24208	0.1444
960	40	9.6	12.004	0.2778
975	51.2	9.75	15.36512	0.3556
990	66	9.9	19.8066	0.4584
1000	70	10	21.007	0.4862
1020	85.4	10.2	25.62854	0.5932
1040	100	10.4	30.01	0.6946

From the Table IV. for the normal load 0.7 kg/cm²
shear strength is 0.6946 kg/cm²
displacement graph was plotted which is shown in the Figure 4.

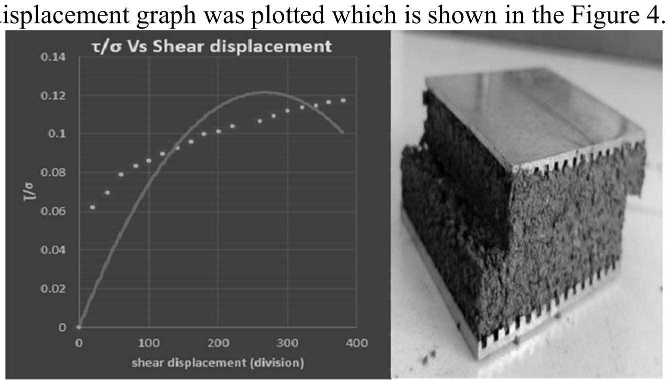

Figure 4. τ/σ VS Shear displacement graph (Bare soil 0.7 kg/cm2)

a) *Preparation of reconstituted soil samples-* At first, the collected soil samples were air dried and then crushed into powder form by a wooden hammer. After that water was added in the dry soil to bring it into the natural moisture content (12.8%) condition. Chopped vetiver roots of 30 mm long (arbitrarily chosen) were randomly mixed with the wet soil. Percentage of root content 3%of the dry weight of the soil sample. The prepared samples were kept in a desiccator to keep the moisture content unchanged. Direct shear test was conducted on those prepared specimens according to ASTM standards.

TABLE VI. NORMAL STRESS VS MAXIMUM SHEAR TEST VALUES

Normal stress	Max shear stress	Rooted soil
0.70	0.69	0.8679
1.20	0.83	0.9807
1.70	0.92	1.0837

With the values given in the 2-table graph was plotted as shown (Fig 5.)

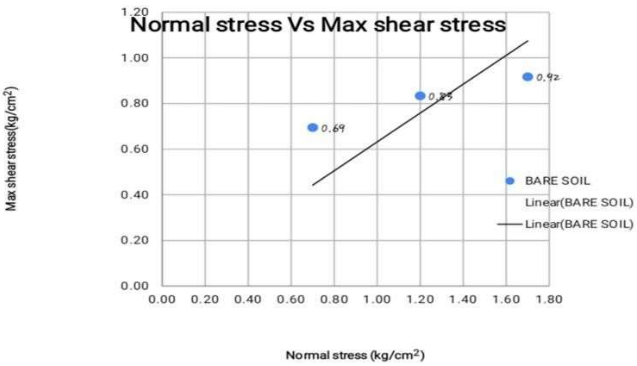

Figure 5. Normal shear stress vs maximum shear graph for bare soil.

IV. RESULT AND DISCUSSIONS

The soil was collected from near the vetiver plant by pickaxe. Specific gravity of the soil was 1.83. Grain size distribution curve is shown in Figure 2. Grain size distribution curve. From the graph, it has been found that the soil is well graded having coefficient of uniformity Cu=13.3 and coefficient of curvature Cc=0.53 Figures shows some pictures of vetiver root matrixes. The root network of the vetiver grown in soil is found to be massive. The percentage of roots in the soil mix has a significant effect on the shear strength of soil.

TABLE VII.PROPERTIES OF SOIL

Sl No.	Properties	Result
1	Uniformity coefficient (Cu)	13.3
2	Coefficient of Curvature (Cc)	0.53
3	Water Content (%)	18.122
4	Specific Gravity	1.83
5	Dry Density(g/cc)	1.65g/cc
6	Optimum Moisture content (%)	12.8%
7	Bare Soil	
	c(kg/cm^2)	0.02
	Φ (in degrees)	37°
8	Rooted Soil	
	c(kg/cm^2)	0.01

V. CONCLUSIONS

Bio-engineering technology using vetiver system is effective in protecting earth slope. Protection of embankments by bioengineering process is being secured efficiently in many countries. From our investigation it is found that addition of 3% provided 2% improvement of shear strength of the soil. The vetiver grass was selected due to its strength, longer life, and long finely divided root system and high tolerance in extreme climate change. An attempt has been made to determine the root morphology of vetiver grass in laterite soil. Presence of vetiver root also increases the shear strength of laterite soil. So this long and bushy vetiver root network will be able to retain the soil from erosion and thus vetiver system can be effective in protecting earth slopes constructed with laterite soil. Soil fails mostly due to shear failure and thus its mandatory to initiate the shear strength, in this test its found that there is considerable increase of shear strength is obtained with the increase of root mass in the soil. Shearing resistance grows steadily with the increase of root content in the soil the root creates a fiber matrix and with the increase in matrix density and the variation of fiber the strength value steadily increases. As per the test results vetiver root soil have higher strength compared to without root soil. From the test results it can be concluded that the vetiver plantation might be an efficient to protect the slopes against flood, landslide etc.

REFERENCES

[1] G.P.Ganapathy,S.P.Saravanan,V.Vijayan,S.Muthukumar,M. Muthuseenivasan,(2015)"Experimental Studies on SoilStabilization Using Vetiver Root as Reinforcement'' International Journal of Applied Engineering Research, ISSN0973-4562 Vol. 10, No.53.

[2] [2]M.S.Islam, Arifuzzaman & S. Nasrin (2010), "In-situ Shear Strength of Vetiver Grass Rooted Soil", Bangladesh Geotechnical Conference 2010: Natural Hazards and Countermeasures in Geotechnical Engineering.

[3] Joice K Joseph1, Amrutha Haridasan, Karunakaran Akhildev and Pradeep Kumar AP (2017) ''Applications of Vetiver Grass (Chrysopogon zizanioides) in Eco System Based Disaster Risk Reduction - Studies from Kerala State of India'', J Geogr Nat Disast, an open access journal, Volume 7, Issue 1, 1000192, ISSN: 2167-0587.

[4] Edgard Gnansounou, Catarina M. Alves, Jegannathan Enthori Raman (2017) "Multiple Applications of VetViver Grass-a review", International Journal of Environmental Science, ISSN: 2367-8941, Volume 2.

[5] Donal Nixon D'Souza, A. K. Choudhary, P. Basak and S. K. Shukla "Assessment of Vetiver Grass Root Reinforcement in Strengthening the Soil".

[6] Paul Truong, Tran Tan Van and Elise Pinners Vetiver System Applications, CreateSpace, (10 April 2008).