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Geotechnical Investigation of Reinforced Soil in Soil Slope Stability

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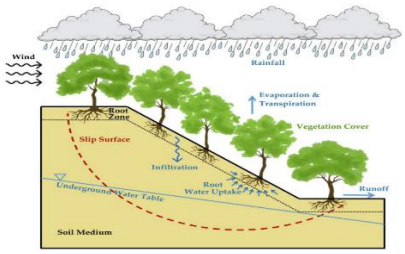
Abstract: Man has been disturbed with soil slope in order to increase the stability and improving its properties like soil holding capacity, prevent them from erosion and to make them better for construction of earth retaining building and road construction purposes. Vegetation can Increase not only the strength of stabilization of the soil but also improving the Geotechnical properties of soil. Hence Vetiver plant roots can be used to prevent erosion of slope failure and improve the stability of soil slope. Research was aimed to evaluate properties of soil and reinforced soil (plant roots used in mixed type of soil). This paper includes geotechnical physical properties of soil and vetiver plant root, and how the reinforced soil is improve the stability of the soil slope. Properties of Reinforced soil like specific gravity consistency, Permeability, OMC & MDD, mainly Tensile and Shear strength were performed by adding content of Root in some percentage like 0%, 2%, 4% and 6% is used in mixed type of soil. The results indicate that the vetiver roots have rapid growth in a year and that the shear strength of the root-reinforced soil was significantly increased by the roots.

Hence, Vetiver root is a low-cost i.e. Economic, Easily available material that can be effectively used for not only increases the stability of the soil slopes but also helps in various other parameters hence it's highly suggested that roots can also be used as soil reinforcing agents.

Index Terms **– Organic Soil, Vetiver Roots.**

I. INTRODUCTION

Plant roots uptake nutrients and water furthermore also give mechanical support against wind, snow and attractive forces exerted by the plant itself. Roots additionally aid in binding the soil it's contained inside, ups the steadiness of the slope and reducing eroding. The study of root systems and slope stability id difficult and comprehensive; thus empirical knowledge on this subject is troublesome to get analysis is restricted thanks to several method problems. Firstly, occupy giant amounts of space. This makes sampling tedious and extremely troublesome to assemble solid and correct knowledge. Secondly, trees and shrubs occupy a good vary of root dimensions and are in an elaborate way and extensively tangled. Thirdly, the advanced nature of the interactions between abiotic and organic phenomenon options, like rocks and different scrap additional complicate the matter.



An exploration of basic soil mechanics is important to know the forces and causes behind slope failures. The principle of effective stress, pore water pressure, oozing and slope stability analysis of soils are going to be explained so as to higher appreciate and perceive slope stability. Moreover, human and natural evoked activities are going to be concisely investigated to find the overall processes that cause slopes to fail.

The importance of soil to man can't be overemphasized. Most applied science construction works need the intensive use of soil. Soils conjointly function the planet foundation on that structural foundations of buildings, roads, dams, etc., are laid. Many buildings and roads are sited on and across earth slopes. However, many of them (with lives and properties) are lost to slope failure like landslide. Consequently, many means that are adopted or planned to boost the steadiness of such slope. Soil stabilization and soil reinforcement are a number of the common strategies of protective slopes. Plants are and ar still getting used to shield soils on slopes from being worn. Their roots ar best-known

to function reinforcement to the soil and thereby up their stability. Some researchers have investigated the action of root systems towards up the steadiness of slopes, however most approached their analysis works from the attitude of soil science. there's no analysis add open literature that has been reportedly dole out to gauge the geotechnical properties of soils strengthened with plant roots. This analysis work is thus geared toward work the results of the reinforcement of a landslide-affected soil mistreatment the roots of a locally-available plant (lemon grass) on the strength and porosity properties of the soil.

II. MOTIVATION

In India, a landslide occurred on 30th of July, 2014 in Malin village in Ambegaon Taluka of Pune district in Maharashtra State. The landslide, which hit early in the morning while residents were asleep, it was believed to have been caused by a burst of heavy rainfall, and killed at least 151 people. Cause of this landslide was the heavy rainfall which started the previous day that is on 29th of July, the village received 10.8cm (4 in) of rain which continued the following day. It was considered that there is more than one reason for the occurrence of this environmental disaster. The major cause behind this disaster was the inattention towards the geological facts of that zone. Deforestation was one of the major cause that resulted in causing of landslide. As root structure holds the soil together, therefore removing tress should stop. When Deforestation happens the absence of roots loosens the soil, and hence it was the primary reason for causing of landslide.

Vegetation helps in stabilizing the slopes in numerous ways. Hence, vegetation have very effective influence on soil slope stabilization.

III. PROBLEM STATEMENT

Improving the stability of soil slope (Landslide, dams, Retaining wall, etc.) by adding the easily available plant root (natural way) with some Percentage in Mixed type of soil (Organic Soil) to make reinforced soil.

IV. OBJECTIVES

I. To study the effect of plant root soil (Reinforced Soil) in Soil Slope Stabilization
II. To increase the stability of soil slopes by means of natural and economical way.
III. To understand the difference between natural soil and root soil by laboratory tests.

3.1 RESEARCH METHODOLOGY AND MATERIAL COLLECTION FOR TESTING

Soil is one of the most important Construction materials. It plays vital role in any type of Structure related to civil engineering. Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Every type of Civil engineering structure will be depend upon the Soil. Hence Soil should fulfil all the geotechnical properties like water content specific gravity permeability MDD & OMC, Shear Strength etc. Slope failure will not be due to a particular soil hence we are used organic soil (Fig : A) which should have shear strength parameter.

Vetiver, (Fig B) which is commonly available in Maharashtra and, is more popularly known as khus which contain fragrant essential Oil so as widely used to reduces the erosion.

Fig : A Organic Soil

Fig : B Vetiver Root (Khus)

To check the performance of Organic Soil by using percentage of Vetiver Plant root (0%, 2%, 4%, 6%) so we have to study the test like Water Content, Permeability MDD & OMC Specific gravity and Consistency of Soil, on Reinforced Soil.

3.3 Water Content by Oven dry method

It is the measurement of weight of water which already having a mass of soil. As per IS 2720 it should be a 15% for normally any type of soil. It is denoted by 'w' expressed in percentage. It one of the major property on which the growth of roots or plants will be depend. So it can be calculated by following expression.

$$\text{Water Content (w)} = \frac{Weight\ of\ water}{Weight\ of\ Soil\ Solid} \times 100$$

3.4 Specific Gravity by Pycnometer

Specific Gravity of soil is the ratio of density or weight of soil to the density or weight of water at a standard temperature of 27°C. Generally it is denoted by 'G'. It is one of the most important parameter on which all the factor like void ratio, degree of saturation, dry density, bulk density, etc. related to soil are to be determined. It can be calculated by following expression:

$$\text{Specific Gravity (G)} = \frac{Density\ or\ Weight\ of\ Soil\ mass}{Density\ or\ Weight\ of\ Water}$$

3.5 Consistency of Soil: Liquid Limit & Plastic Limit

Soil consistency is the capacity of **soil** materials are held together or the strength of **soils** to deformation and rupture. **Soil consistency** is find out for wet, moist and dry **soil** samples. Generally consistency of a soil can be divided into three major categories: Liquid limit Plastic limit Shrinkage limit. The liquid limit is the minimum water content at which soil changes its state from liquid to plastic. Liquid limit is find out graphically (Semi log graph) correspondence to 25 no. of blows. The minimum water content at which soil changes its state from plastic to semi solid state is called as Plastic Limit. In short plastic limit is that water content at which the soil will be crumble when it rolled into size of 3mm thread. For Liquid limit and plastic limit soil sample will be taken which is passed from 120 micron sieve. It denoted by W_L and W_P. All the Index Property like Plasticity Index Consistency Index liquidity Index are to be calculated by this test.

Fig : C Liquid Limit

Fig : D Plastic limit (Soil Rolled in 3mm thread)

3.6 MDD & OMC by Standard Proctor

This test is to be conducted for finding the maximum dry density at which the optimum moisture content. By this test we can easily find out Bulk density saturated density. Zero air void of particular Soil sample. It will be shown graphically also as shown in fig E

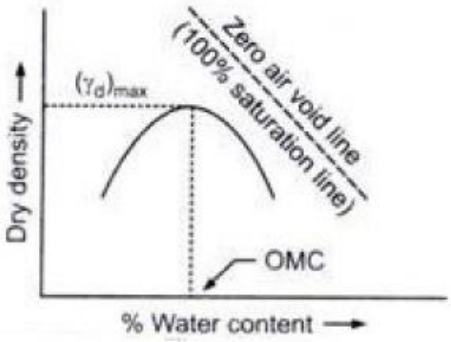


Fig : E Graph for MDD, OMC % 100% Saturation Line

3.7 Coefficient of Permeability by falling head permeameter

Permeability means movement of water and air through the soil. It obeys the Darcy's law It can be determined by two ways: For coarse grained soil - Constant head permeability and for fine grained soil - Falling head permeability. The permeability can be denoted by 'K' in cm/sec or mm/sec.

Constant Head Permeability - $\frac{QL}{ATH}$ & Falling Head Permeability - $2.303 \frac{aL}{At} \log_{10}\frac{H1}{H2}$

IV. RESULTS:

4.1 Water Content by Oven dry method (w)

Table 4.1: Water Content of Normal Soil & Reinforced Soil

Sr. No	*Wt. Of Empty Container* ***M1 (gm.)***	*Wt. of Empty Container + Soil Sample* ***M2(gm.)***	*Wt. Dry Soil after 24 hrs* ***M3(gm.)***	*Water Content*
Sample A (For 0 %)	18	55	50	15.26%
Sample B (For 2 %)	16	45	40	20.83%
Sample C (For 4 %)	17	40	36.5	17.94%
Sample D (For 6 %)	18	50	45	18.51%

Table 4.1 Show Water content Test Results for natural organic Soil and reinforced soil.

The normal water content for organic soil is 15% and when vetiver roots are added in soil to make reinforced soil, it will increased by 5 to 10%.

4.2 Specific Gravity Test (G)

Table 4.2: Specific Gravity Test Results

SR.NO	*ROOT CONTENT*	*SPECIFIC GRAVITY (G)*
1	0 %	2.52
2	2 %	2.66
3	4 %	2.7
4	6 %	2.72

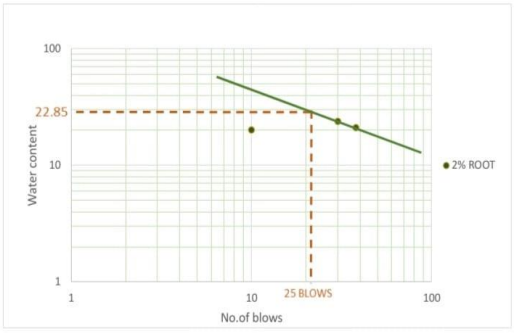
Range of Specific Gravity for organic Soil or reinforced soil is 2.6 to 2.7.

4.3 Liquid & Plastic limit (W_L & W_P)

% of Root	*Liquid Limit (W_L)*	*Plastic Limit (W_P)*	*Plasticity Index Ip*	*Consistency Index Ic*	*Liquidity Index I_L*
0 %	18.75	10.00	8.75	0.39	0.60
2 %	22.85	8.33	14.52	0.14	0.86
4 %	18.40	8.12	10.07	0.04	1.06
6 %	18.36	7.14	11.22	0.13	1.01

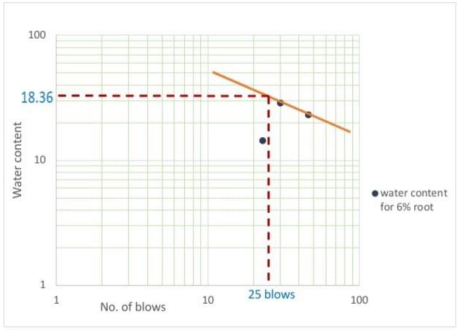
Table 4.3: Liquid limit and Plastic limit

Liquid Limit Graph 4.3.A For 0% Root



Liquid Limit Graph 4.3.A For 2% Root

Liquid Limit Graph 4.3.C For 4% Root



Liquid Limit Graph 4.3.D For 6% Root

4.4 Falling Head Permeability Test (K)

- Length of Stand Pipe and Soil specimen - 30cm and 10cm
- Diameter of Mould - 20cm

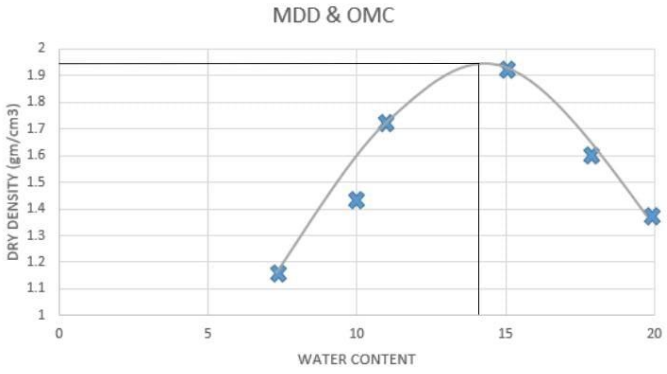
SR.NO	*PARTICULARS*	*SAMPLE NO*		
		1	*2*	*3*
1	*Initial head, h1 (cm)*	10	30	20
2	*Final head, h2 (cm)*	20	40	30
3	*Time Interval, t (sec)*	30	50	40
4	*Coeff. Of permeability, k (cm/sec)*	3.97	3.19	3.60
5	*Avg. Coeff. Of permeability*	3.59		

Table 4.5 Permeability Test Results

4.5 MDD & OMC Test

SR.NO	*MASS OF MOULD + SOIL (gm)*	*MASS OF SOIL (gm)*	*BULK DENSITY (gm/cm3)*	*WATER CONTENT in %*	*DRY DENSITY (gm/cm3)*
1	7837	1337	1.33	7	1.25
2	8106	1606	1.60	10	1.46
3	8460	1960	1.96	12	1.75
4	8705	2205	2.20	15	1.94
5	8444	1944	1.94	18	1.65
6	8237	1737	1.73	20	1.45

Table 4.5.1 Standard Procter Test Results



Graph 4.5.2 MDD = 1.92 gm. /cm^3 & OMC = 14.70%

V. DISCUSSION

Sr.No	Properties	Standard	Project
1	Water Content	10%	15.26%
2	Specific Gravity	2.6	2.6 – 2.7
3	Liquid Limit	23.37%	18.50%
4	Plastic Limit	10.00%	8%
5	Plasticity Index	30%	11%
6	Consistency Index	93.3%	80%
7	Bulk Density	2.12 gm/cm^3	2.20 gm/cm^3
8	Maximum Dry Density	1.93 gm/cm^3	1.92 gm/cm^3
9	Optimum Moisture Content	12.40 %	14.70%
10	Permeability	1.92 x 10^{-2} mm/sec	3.59 x 10^{-2} mm/sec

VI. CONCLUSION

[1] This research work investigated the effect of reinforcing a soil sample (with varying proportions of vetiver root) on its strength and permeability characteristics. The results obtained show that the strength properties of the soil samples were improved by the application of the root in to the soil.

[2] The permeability of the soil steadily found to be decreasing with the growth of root, reduction in permeability obviously ends up in more density and also in increased shearing Strength.

[3] Consequently, Vetiver root is a low-cost material that can be effectively used to improve the stability of soils by improving their shear strength and reducing their permeability. Plant roots can be used to reinforce or stabilize soils slopes to prevent slope failure.

[4] The use of Plant Root (Vetiver) can significantly enhance the engineering characteristics of soft soil. The maximum dry density from untreated soil increases with addition of 6% Vetiver Root.

[5] These Plant Roots can be used to find the strength characteristics of cohesive and Cohesion less soils for construction purposes like subgrade and to provide material for avoid erosion. By focusing more this research and efforts is taken for understanding the behaviour and strength of roots in slope stability.

[6] We can take advantage of utilizing trees and other vegetative options to stabilize slopes, as it is an inexpensive and environmentally friendly alternative to other methods.

VII. ACKNOWLEDGMENT

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