CHAPTER-12

A STUDY ON RESTORING SOIL STRENGTH ON LANDSLIDE-AFFECTED SLOPES BY USING VETIVER ROOT AS A SOIL BIOENGINEERING TOOL

[1]MUKUL SHARMA

[1]Assistant Professor, Department of Botany, HLM College Ghaziabad

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ABSTRACT

Slope stabilization designs that include soil bio-engineering methods are gaining traction. As a result, researchers have started paying more attention to how plants affect soil strength, specifically how they affect root reinforcement. It has been shown that rural mountain regions in the wet tropics and subtropics are at great danger of erosion, which in turn causes frequent landslides. The use of plant resources to improve slope stability was shown to be more practical than technical alternatives. In many cases, bioengineering technology is employed all over the world since it is an inexpensive method of preventing surface erosion. We conducted experiments to uncover the true potential of these plants for improving slope stability and decreasing soil erosion. Researchers examined the pull-out resistance of the roots and the soil reinforcing potential of the plant roots by growing plants in pot culture and collecting soil samples from the root zone of mature plants. Both direct and indirect measures, including those using image processing, were used to determine the Root Area Ratio (RAR). The collected information was used to examine the effectiveness of root reinforcement and the stability of an artificial slope (a landfill). Finite Element modelling using data from field and lab investigations revealed that having roots on a slope increased the factor of safety by approximately 100%.

Keywords: *Restoring, Soil Strength, Landslide, Affected Slopes, Soil Bioengineering Techniques.*

INTRODUCTION

This study investigates the effect of soil reinforcement using plants roots on the shear strength, and compressive strength of soil. The tests that carried out are classified into two categories: First; tests on soil without reinforcement and second tests on soil with reinforcement. The loading test was conducted on small scale model using different layers of reinforcement. The results showed that the shear strength parameters could be improved by using plants roots reinforcement. Moreover, the shear strength, and compressive strength of soil are increased by using plants roots [1]. The vegetation materials may reduce soil erosion and runoff, create space for breeding and habitat and they are commonly used in river ecological engineering. Therefore, it is important to select the soil bioengineering plant by taking its growth characteristics and the soil solidity of its root system as the major considerations. Many studies on vegetation-reinforced soil have been carried out including laboratory shear tests on soils with plant roots. Several indirect methods are available to estimate the increased strength of the soil due to the presence of plants, including the pull-out test. The uprooting resistance force provides valuable information on the role of root hairs in anchorage. The lateral pulling test was used to simulate a certain bamboo failure during a landslide and also was used to ascertain the resistance the vetiver grass root system can provide when torrential runoffs and sediments are trying to uproot the plant [2]. In particular, the aims of the study were 1) to investigate the plant's bio-mechanical aspects and 2) to verify whether root reinforcement and the field rooting ability of stem cuttings enhance its potential for use in slope stabilization and soil bio-engineering techniques, particularly in the Mediterranean areas. Single root specimens were sampled and tested for tensile strength, obtaining classic tensile strengthdiameter relationships. Analysis was performed on the root systems in order to assess root density distribution. The Root Area Ratio (RAR) was analyzed by taking both direct and indirect measurements, the latter relying on image processing. The data obtained were used to analyze the stability of an artificial slope (landfill) and the root reinforcement. Soils covered by vegetation run less risk of erosion from both water and land movement. The role roots play in slope stabilization has been recognized for many years whereas interest in biomechanical tests on roots (of Mediterranean species in particular) has arisen only in more recent years showed how some typical Mediterranean plants increase topsoil resistance to erosion and shallow landslides from runoff and superficial flow [3].

MATERIALS AND METHODS

The present study focused on this typical Mediterranean species and studied the following features on an experimental basis by distinguishing transplanted and spontaneous Spanish Broom specimens: its bio-mechanical characteristics, the spatial distribution of its roots and the statistical variability of RAR at each depth. Root tensile strength tests were carried out using devices that were custom-built in our Faculty laboratories. The plants had grown in a local nursery and had been transplanted with their root balls, when the slope was being restored [3]. The study sites are located in nine different regions of the nilgris. Each region represents a different set of environmental conditions. Nine tree species were chosen for study [4].

Plant root collection

To facilitate the study and to ascertain the results accurately the native plants that are available in the Nilgris district is used throughout this study, some of the plant species that are selected for the root reinforcement studies are

1. Lemon grass
2. Love grass
3. Vetiver

Plant Root Collection

Plant collection is done by removal of the sub soil using soil removal tools without affecting the soil surrounding the roots of the plants, the plants are then covered in plastic sheets and transported to the laboratory carefully without affecting the root-soil mass. The roots are then separated only in the required quantity; the remaining portion is watered to keep the plants alive until the testing is completed. This method allowed the roots to continue growing during the portion of the experimentation.

RESULTS AND DISCUSSION

Tests were conducted after proper maturation period using Indian standard test procedure, the shear strength test is conducted with shear controlled undrained pattern, Unconfined test is conducted in the stress controlled, undrained pattern. Permeability and hydraulic characteristics were obtained using falling head permeameter. Plant roots in single aspect ratio is used throughout the study, the length and the diameter of the root is measured using digital Vernier caliper (Mitutoyo), the roots are washed and immersed in water for at least 3-4 hours before addition of fibers in the soil. The soil- root matrix is prepared by using hand mixing to enable through mixing of the roots across the soil matrix. The soil is kept is specially designed soil mould which enabled undisturbed soil testing. The results obtained were given in table 1 which shows the variation of strength and hydraulic parameters with and without addition of roots.

Image Showing the Sample Preparation for Strength Tests

Table 1: Properties of Soil Sample

S.No	Properties		Result
1.	Uniformity coefficient (Cu)		4.848
2.	Coefficient of curvature (Cc)		1.065
3.	Liquid limit		23.37%
4.	Plastic limit		10%
6.	Plasticity index		30%
7.	Liquidity index		6.667%
8.	Consistency index		93.3%
9.	Bulk density		2.12 g/cm^3
10.	Dry density		1.93 g/cm^3
11.	OMC		10%
12.	Permeability test- Falling head (kg/m^3)	1200	0.067 mm/sec
		1450	0.050 mm/sec
		1600	0.0192mm/sec
13.	Cohesion		5 kN/m^2
14.	T		33°
15.	Φ		28°
16.	Total stress		9.03 N/cm^2
17.	Shear strength		13.53 N/cm^2
18.	Unconfined Compressive Strength		3.42 N/cm^2
19.	Specific gravity		2.6
20.	Saturation ratio		49 %

Table 2: Strength Variations after Addition of Roots

Sl.No	Test Of Red Soil	Percentage of Vetiver Root						
		0	0.5%	0.75%	1%	2%	3%	4%
1	OMC %	10.00	9.53	9.30	9.43	9.38	10.90	11.00
2	UCC (1200kg/m³) kg/cm²	3.42	4.99	5.09	5.52	5.65	6.72	7.20
3	Direct shear test (1200 kg/m³) N/cm²	3.53	3.20	3.34	3.78	3.94	4.59	4.89
4	Permeability							
5	(1200 kg/m³) mm/s	0.067	0.015	0.014	0.012	0.014	0.014	0.016
6	(1450 kg/m³) mm/s	0.050	0.011	0.010	0.010	0.013	0.014	0.015
7	(1600 kg/m³) mm/s	0.019	0.006	0.006	0.008	0.0079	0.008	0.009

B. Effect on optimum moisture content

Optimum moisture content of the soil gets affected by the addition of roots, this is an important parameters concerned with the consolidation and compaction characteristics of soil, it is found that the addition of 2-4 % of roots by weight in the soil affects the OMC value and increase it to 10% from 11%. This is a considerable increase in terms of water quantity required to compact the soil, this is mainly attributed to the larger surface area of the roots which absorbs more water during the mixing and maturation. This also increases the weight of root mass and hence provides more stability and strength to the soil- matrix.

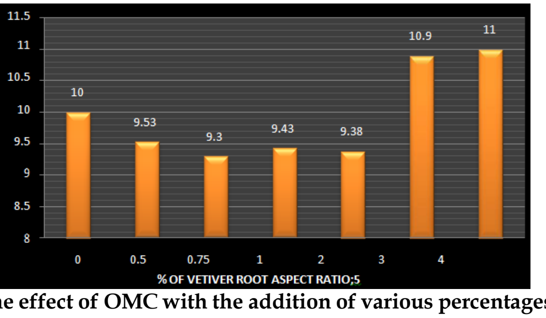

Image showing the effect of OMC with the addition of various percentages of vetiver roots

C. Effect on shear strength

Soil usually fails mostly due to shear failure and thus its mandatory to initiate the shear strength, in this tests its found that there is considerable increase of shear strength is obtained with the increase of root mass in the soil. The shear strength is studied in undisturbed soil samples and hence it can be ascertained that the shear strength increase is purely attributed to the roots tensile strength and the root bio mass.

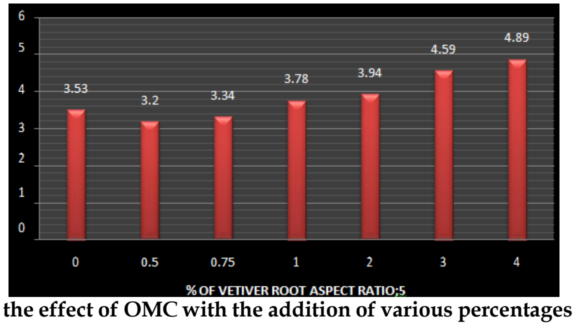

Image showing the effect of OMC with the addition of various percentages of vetiver roots

D. Effect on Unconfined Compressive Strength

The UCS of the soil-root mixtures increased with increasing root content in the soil The UCS of the soil with 4% root content almost doubled that of the natural soil sample. The predominance of sand in the soil (with only about 17% clay present) can attribute to the generally low UCS and cohesive force with the particles of the nature soil.

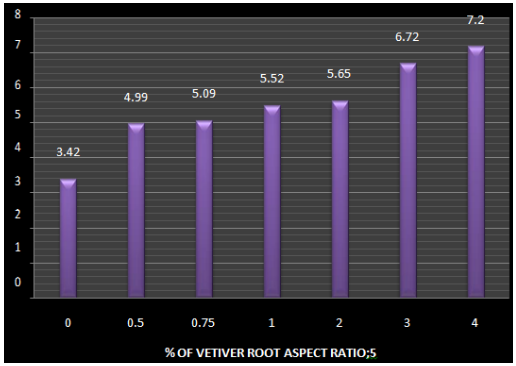

Image showing the effect of OMC with the addition of various percentages of vetiver roots

E. **Effect on permeability**

The effects of varying the veitver root content in soil on the permeability soil samples having various densities are graphically illustrated. For e soil samples having densities of 1200 kg/m³ and 1450 kg/m³, the permeability of the root reinforced soil decreases with increasing veitver root content. However the effect of the variation of the veitver root content on the soil sample having a density 1600 kg/m³ seem not to be well-defined. The general reduction in the permeability of the soil samples with increasing veitver root content can be attributed to the plugging of void spaces in the soil by the root system.

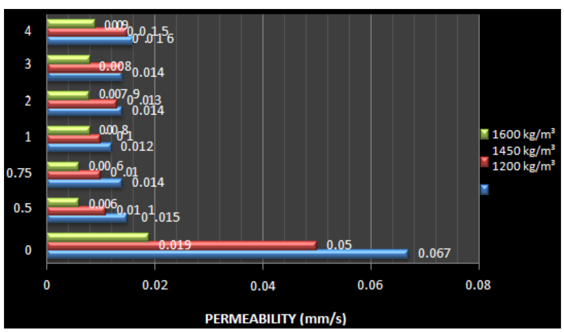

Image showing the effect of OMC with the addition of various percentages of vetiver roots

CONCLUSION

In this study it is found that addition of roots as a root matrix is a viable solution for increasing both strength and stability characteristics. The permeability of the soil steadily found to be decreasing with the increasing root content, reduction in permeability obviously ends up in more density and also in increased shearing resistance. The study is conducted with varying density to verify the accuracy of reduction in hydraulic properties and it is found that the roots also adds up more reduction in the permeability other than densification of soil. Also it is found that the roots take up some amount of water added in the soil particles and thus results in increased OMC values in higher root percentage. This matches up with the results provided by other researchers who used various other natural roots in the soil for increasing the shearing resistance. Shearing resistance grows steadily with the increase of root content in the soil the roots creates a fiber matrix and with the increase in matrix density and the variation of fibers the strength value steadily increases. The acute problem that may be faced by the addition of root as roots is the degradation of roots inside the soil after certain period, but this case is common for all types of roots added in soil. Concerned with the soil-root matrix the humus that may be produced due to the composite degradation of root-soil matrix may add more stability.

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