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Evaluation of Soil Reinforcement Potential of Grass Variety

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Abstract
Reinforcement potential of plant root is studied by many researches across the globe. This work aims to analyze the effect of grass root in the improvement of engineering properties of soil. Plant roots being a natural material help in enhancing the shear strength of soil. Field and laboratory studies were conducted on a grass variety (Co-4) and the soil reinforcement potential of the plant is studied. It is found that the root zone enhances the shrinkage characteristics of soil, reduces the consolidation, and increases the shear strength and density. The effect on specific gravity, saturation ratio is insignificant but the liquid and plastic limit is increased.

***Keywords**: Root reinforcement, stability, root cohesion*

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INTRODUCTION

The presence of roots in soil provides mechanical reinforcement therefore; their presence is considered as one of the most important contributions of vegetation to soil stability. The reinforcement of soil resistance to erosion by plant roots can be attributed to two aspects. First, roots and root remnants physically bind soil particles, forming mechanical barriers to soil and water movement. The key features that have an impact on the mechanical influence of roots are root diameter, degree of bifurcation, appearance of root hairs, friction between roots and soil, and root system distribution.

Moreover, roots and root remnants emit binding agents which form a food source for microorganisms that, in turn, produce other organic bindings. Further, these bindings increase the amount of stable soil aggregates over the long term, hence reducing soil erodibility. From these two aspects, the first one is essential with respect to soil erosion by concentrated flow. To define the effect of root system on soil erosion quantitatively and to reveal the mechanism of rill and gully development as well as their relationship to root biomass distribution, soil properties, and sediment yield, it is essential to study these relationships across soil profiles under field conditions. In the present study, runoff scouring at different soil depths was conducted to inspect the vertical changes in soil resistance to runoff erosion forces. Additionally, both vertical root distribution and related soil properties were examined to reveal the relationships among those parameters[1]. Root reinforcement effect has significant role in modifying stress anisotropy and displacement behavior of the slope[2].

They emphasize the early developing deeply penetrating (sometimes up to 3.5 m) fibrous root system of Vetiver and its capability of anchoring themselves firmly into slope soil profiles. However, the strength properties of Vetiver root, which also play an important role in terms of erosion control and slope stabilization by means of their influences on the shear strength of slope soil has not yet been adequately understood. When a plant root penetrates across a potential shear surface in a soil profile, the distortion of the shear zone initiates a tension in the root; the component of this tension tangential to the shear zone directly resists shear, while the normal component increases the confining pressure on the shear plane[3]. Plant roots provide mechanical reinforcement to a soil matrix due to the different responses of soils and roots to stress.

Root reinforcement is a function of the strength of the roots crossing potential shear planes, and the number and diameter of such roots. However, previous bank stability models have been constrained by restricted field data affecting the spatial and temporal variability of root networks within stream banks. In this paper, a method is established to use root-architecture data to descend parameters required for modeling temporal and spatial changes in root reinforcement. Modifications in the root numbers over time were assumed to follow a sigmoidal curve, which represents the growth rates of organisms. Plant roots provide mechanical reinforcement to a soil matrix due to the different responses of soils and roots to stresses. Soil is strong in compression but weak in tension. On the other hand, roots are weak in compression but strong in tension.

The presence of roots in the soil thus produces a reinforced matrix in which stress is moved to the roots during loading of the soil. Initial work on root reinforcement of soils observed that the effect of roots can be considered as an apparent cohesion that can simply be added to the cohesion of the soil matrix in which they are embedded. However, this theoretical background is based on the assumption of concurrent breakage of all roots carried out experiments and investigation that displayed this assumption.

Rip Root, was therefore developed in light of the need for more precise predictions of root reinforcement. It includes an algorithm to take into account progressive breaking of roots during a soil failure, and an alternate failure mechanism by slippage rather than breakage[4]. Root reinforcement, the strength roots impart to soil, is recognized to be a significant cause affecting directly and indirectly several hydro-mechanical processes in hydrology and earth surface systems. For example, the roots of riparian vegetation may consistently influence the morphodynamic of rivers by anchoring sediments or stabilizing river banks and represent an important factor in river restoration projects. Moreover, vegetation contributes to the mitigation of erosion and shallow landslides at the catchment scale, regulating the yield and transport of sediments. In mountain catchments, root reinforcement is one of the most important contributions[5].

MATERIALS AND METHODS

Study Area

This study is conducted in Tirupur district, Tamil Nadu (11.1100° N, 77.3400° E) in a field where the grass varieties are grown. The soil in the area is mostly lateritic soil with less clay content but the area is water logged area hence the shear strength of the soil is less. The plants are grown in the field until they are mature (3–4 months) before the test is conducted; the plants are obtained from nearby field and planted in the surface. Plants are watered regularly and also manure is provided in regular intervals to ensure fullest root growth so that the root reinforcement potential is fully achieved.

Sampling and Testing

The tests were conducted in both field and in laboratory as per the need. Liquid and plastic limit tests were conducted in the laboratory with disturbed sample, UCS, direct shear and consolidation tests were conducted in undisturbed samples collected with and without the plant roots. The sample is collected with slightly large size than the mould and then trimmed back to make it fit in the respective mould. All samples collected from field are stored in polyethylene backs to avoid moisture escape, no curing is done for the soil and the tests were conducted on the same day of sampling.

Fig. 1: Field and Laboratory Testing of the Reinforcement.

Atterberg Limits

Figure 2 shows the variation of Atterberg limit with and without root reinforcement, the liquid and plastic limit studies were conducted as per Indian standard specification using Casagrande apparatus. The liquid limit of the soil is reduced which is a clear sign of increasing strength, roots consumes the water present in the soil and via evapo-transpiration reduces the water content which helps in increased cohesion in the soil. The plastic limit of the soil increases with the roots which show that the range in which the soil behaves as plastic increases with the roots.

The variation of this property shows the influence of the roots in the soil, this will also have effect on increasing other index properties but specific gravity of the soil had not shown considerable variation with and without root. Figure 3 shows the variation of field density near the roots and in plain soil which shows that the field density of the soil also increases considerably which may be the effect of roots which increases the anchorage.

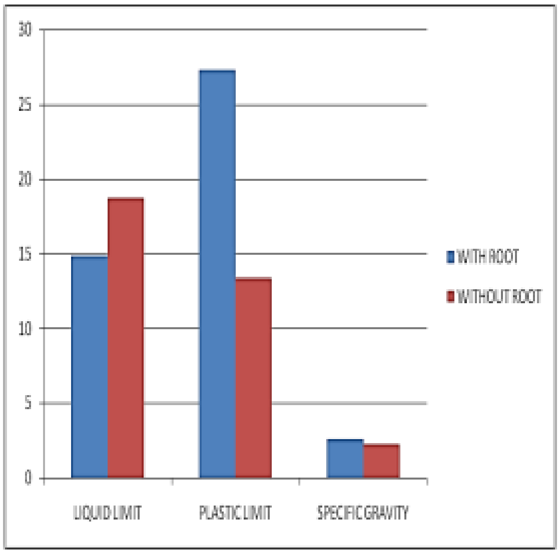

***Fig. 2:** Variation of Liquid Limit, Plastic Limit and Specific Gravity for with and Without Root.*

Strength and Drainage Characteristics

Figure 3 shows the variation of field density near the roots and in plain soil which shows that the field density of the soil also increases considerably which may be the effect of roots which increases the anchorage. The increase in density is reflected as the increase in Shear and UCS strength as shown in Figure 4 and 5; the shear value is nearly doubled with the effect of roots.

The sampling is done exactly in the area where roots are more (more root density) and the study is conducted with undisturbed sample. Even though it's not an accurate way of representing the effect of root, unavailability of other procedure forced to analyses in this method, the shear failure pattern clearly shows the effect of roots in enhancing the strength of soil.

The coefficient of consolidation also reduces drastically which will have effect on reduction in consolidation and increase in bearing capacity of soil. This may be due to the reinforcement properties of the root but since the sample size is too small this conclusion may not be appropriate without further study.

OMC was studied by Standard proctor test in a 1000 cc mould with standard proctor energy value. Concerned with OMC there is no significant effect with the root but the test is conducted with disturbed samples and the root biomass may not be maintained in the disturbed sample which might be the cause for this.

Co-efficient of permeability is affected considerably due to the impregnation of grass roots the permeability value shows steady increase. Increase in permeability is due to the micro passage channels the roots create in the soil which allows water to percolate.

It is well established that the roots helps in quick drainage of water and increases the soil stability which is clearly shown through this results.

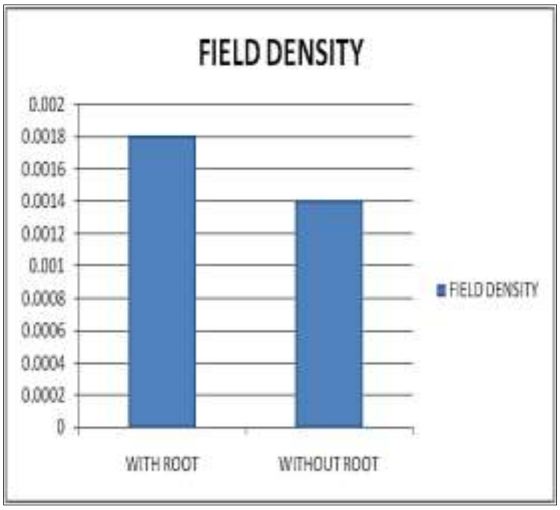

Fig.3: *Variation of Field Density for with and Without Root Zone.*

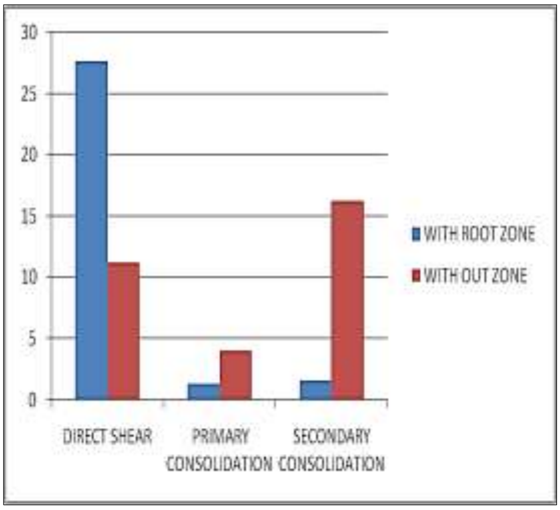

Fig. 4: *Variation of Direct Shear and Consolidation for with and Without Root.*

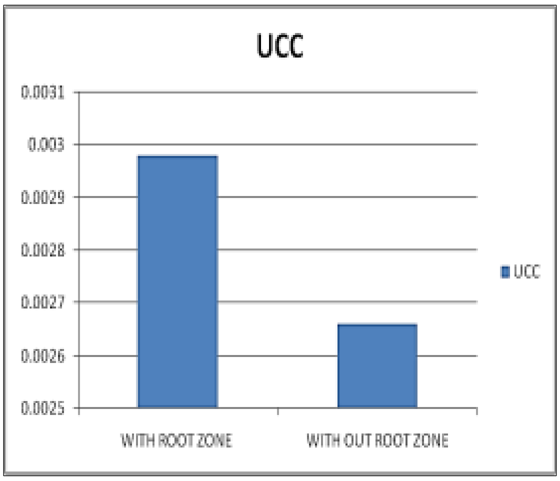

Fig. 5: *Variation of Unconfined Compressive Strength for with and Without Root Zone.*

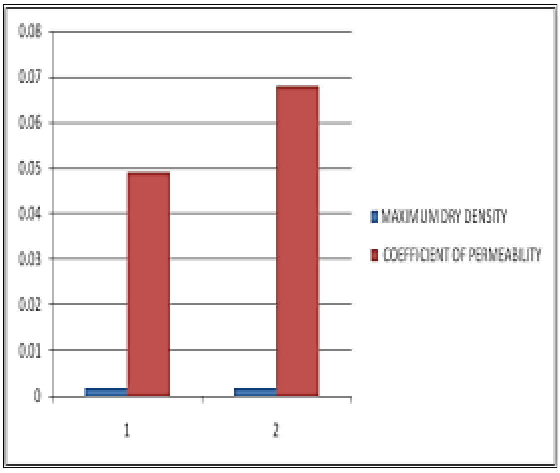

Fig. 6: *Variation of Maximum Dry Density and Coefficient of Permeability with and Without Root Zone.*

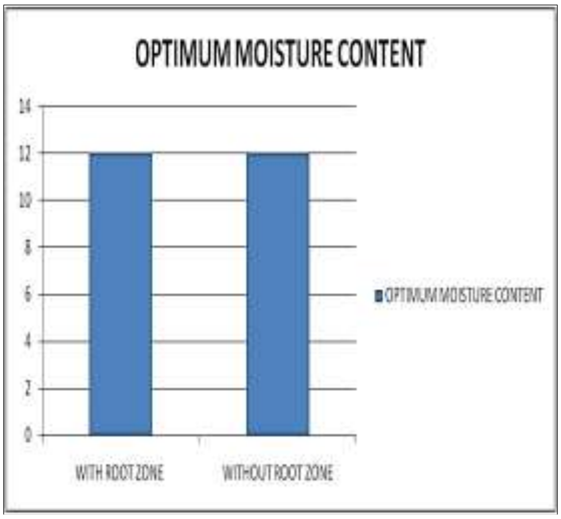

Fig. 7: *Variation of Optimum Moisture Content with and Without Root Zone.*

CONCLUSION

In this study it is found that the roots have considerable effect on the soil properties including index and other engineering properties. The liquid limit of the soil is reduced which is a clear sign of increasing strength, roots consumes the water present in the soil and via evapo-transpiration reduces the water content which helps in increased cohesion in the soil. The plastic limit of the soil increases with the roots which show that the range in which the soil behaves as plastic increases with the roots. Also it is found that there is no variation in the OMC of the soil with and without root and the OMC remains the same.

The roots in soil clearly increase the shear strength of the soil to more than 3 times and also reduce the effect of consolidation which in turn will increase the bearing capacity of the soil. Thus the effect of roots in the soil as reinforcing agent is a welcome sign and the roots can be used as reinforcing agents.

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