Soil stabilization by vetiver

Sawant Pooja Rajesh
BE – Department of Civil Engineering
Alamuri Ratamala Institute of Engineering and Technology
Shahapur, India
Pradnyasawant2509@gmail.com

Shinde Siddhi Prakash
BE – Department of Civil Engineering
Alamuri Ratamala Institute of Engineering and Technology
Shahapur, India
sidshinde28@gmail.com

Pawar Komal Sanjay
BE – Department of Civil Engineering
Alamuri Ratamala Institute of Engineering and Technology
Shahaapur, India
Pawarkomal580@gmail.com

Mhanere Devendra Hanumant
BE – Department of Civil Engineering
Alamuri Ratamala Institute of Engineering and Technology
Shahapur, India
dev.deven510@gmail.com

Abstract- Soil bio engineering is the concept of utilizing the plant resources including its roots strength to stabilize the poor strength soil such as natural and manmade slopes, this technique is widely used in many countries and also being practiced in India. Most of the research works done related to soil bio engineering is by ecological researchers, geotechnical research works related to utilizing the plant roots as reinforcement is still in its juvenile stage in India. In this research works authors took an attempt to study the strength variation in a landslide affected soil by stabilizing the same with roots obtained from the plants prevailing in the same locality. The roots are obtained and a particular root mass is introduced in the soil and the geotechnical property changes are verified. It is found that addition of root in the soil matrix not only improves the stability of the soil but also helps in various other parameters and hence its highly suggested that vetiver roots can also be used as soil reinforcing agents.

Keywords -vetiver root, shear strength, compressive strength, permeability, bio engineering.

I. 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.

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.

II. MATERIALS

A. SOIL.

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil is a natural body called the pedosphere which has four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of Earth's atmosphere; it is a habitat for organisms; all of which, in turn, modify the soil

B. VETIVER

Vetiver, commonly known as Khus grass is a perennial grass of Indian origin. Vetiver roots contain fragrant essential oil, which is a perfume by itself. Aroma chemicals such as vetriverol, vetriverone and vetriveryl acetate are prepared from this volatile oil. In India it is mainly used in perfumes, cosmetics, aromatherapy, food and flavouring industries. Since the plant has extensive finely structured fibrous roots, it is useful in both soil and water conservation and the plant itself is drought tolerant. The world production of vetiver oil is around 300 tons per annum of which India contributes about 20-25 tons only. The world major producers are Haiti, India, Java and Reunion.

TYPES OF VETIVER:-

There are two Vetiver species being used for soil conservation purposes: Vetiveria zizanioides L.and V. nigritana. The latter is native to Southern and west Africa, its application is mainly restricted to the sub continent, and as this species produces viable seeds its application should be restricted to their home lands.
There are two V.zizanioides genotypes being used in south Asia for soil and water conservation purposes:

- The wild and seeded north Indian genotype
- The sterile or very low fertility south Indian genotype

C. NEED OF SOIL STABLILZATION:-

Stabilization in a broad sence incorporates the various method employed for modifying the various properties of soil to improve its engineering of engineering works, the most common application being in construction of road and airfield pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making the best use of locally available materials.

D. PRINCIPLES OF STABILIZATION:-

Natural soil is both a complex and variable material. Yet because of its universal availability and its low cost winning it offers great opportunities for skilful use as an engineering material.
Not commonly, however the soil at any particular locality is unsuited, wholly or partially, to the requirements of the construction engineer. A basic decision must therefore be made whether to:
Accept the site material as it is and design to standards sufficient to meet the restrictions imposed by its exsiting quality.
Remove the site material and replace with asuperior material.
Alter the properties of existing soil so as to create a new site material capable of better meeting requirements the task in hand. The latter vhoice, the alteration of soil properties to meet specific engineer ing requirements is known as “Soil Stabilization”.

III. METHODS OF SOIL STABILIZATION:-

There are two methods of soil stabilization that may be grouped under two main types:-
1. Modification or improvement of soil properties of existing soil without any admixtures.
2. Modification of the properties with the help of admixtures.
Compaction and drainage are the examples of the first type, which improve the inherent shear strength of soil.
Examples of the second type are: Mechanical stabilization, stabilization with cement, lime, bitumen, flyash and chemicals etc.

A. LIME STABILIZATION

Lime provides an economical way of soil stabilization. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction (Sherwood, 1993). In soil modification, as clay particles flocculates, transforms natural plate like clays particles into needle like interlocking metalline structures. Clay soils turn drier and less susceptible to water content changes (Roger et al, 1993). Lime stabilization may refer to pozzolanic reaction in which pozzolana materials reacts with lime in presence of water to produce cementitious compounds (Sherwood, 1993, EuroSoilStab, 2002). The effect can be brought by either quicklime, CaO or hydrated lime, Ca (OH)2. Slurry lime also can be used in dry soils conditions where water may be required to achieve effective compaction (Hicks, 2002).

B. CEMENT STABILIZATION:-

Cement is the oldest binding agent since the invention of soil stabilization technology in 1960’s. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required (Sherwood, 1993; EuroSoilStab, 2002). Cement reaction is not dependent on soil minerals, and the key role is its reaction with water that may be available in any soil (EuroSoilStab, 2002). This can be the reason why cement is used to stabilize a wide range of soils. Numerous types of cement are available in the market; these are ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and desired final strength. Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water and other components for a desired application resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, but it will not change the structure of soil (EuroSoilStab, 2002). The hydration reaction is slow proceeding from the surface of the cement grains and the centre of the grains may remain unhydrated (Sherwood, 1993).

Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay. Cement stabilized soils have the following improved properties:

- decreased cohesiveness (Plasticity)
- decreased volume expansion or compressibility
- increased strength (PCA-IS 411, 2003).

C. FLYASH STABILIZATION:-

Fly ash is a byproduct of coal fired electric power generation facilities; it has little cementations properties compared to lime and cement. Most of the fly ashes belong to

secondary binders; these binders cannot produce the desired effect on their own. However, in the presence of a small amount of activator, it can react chemically to form cementitious compound that contributes to improved strength of soft soil. Fly ashes are readily available, cheaper and environmental friendly. There are two main classes of fly ashes; class C and class F (Bhuvaneshwari et al, 2005, FM 5-410). Class C fly ashes are produced from burning subbituminous coal; it has high cementing properties because of high content of free CaO. Class C from lignite has the highest CaO (above 30%) resulting in self-cementing characteristics (FM 5-410). Class F fly ashes are produced by burning anthracite and bituminous coal; it has low self-cementing properties due to limited amount of free CaO available for flocculation of clay minerals and thus require addition of activators such as lime or cement.
soil fly ash stabilization has the following limitations

- Soil to be stabilized shall have less moisture content; therefore, dewatering may be required.
- Soil-fly ash mixture cured below zero and then soaked in water are highly susceptible to slaking and strength loss

D. *OBJECTIVES*

- To improve the stability of soil ,to study their present condition and characteristics of soil. Vetiver is not only the good soil binder but it also helps to control the soil erosion from steep slope.
- By using different types of vetiver stabilizing soil and doing coast comparison for the vetiver method with respect to other methods available for soil stabilization.
- To calculated strength of soil using vetiver stabilization method.

IV. LITERATURE REVIEW

A. Grimshaw et.al. 1994

Grimshaw et.al. 1994 Vetiver grass (Vetiveria zizanioides) has been utilized to reduce soil erosion in many countries throughout the world for a long time. It is well understood that the root properties of vetiver grass can help reduce soil erosion and strengthen slope stability when planted properly. Vetiver hedgerows cultivated across slope soil can block the passage of soil particles and develop terraces between the hedges enhancing stability of the slope. Some previous studie2s on vetiver have elucidated the morphological properties of the root and their qualitative significance for erosion control and slope stabilization

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 develops 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. Therefore it is essential to determine tensile root strength properties in the process of evaluating a plant species as a component in slope stabilization.

B. *Erocon Sdn. Bhd., Malaysia*

For the determination of tensile root strength, mature root specimens were sampled from two-year-old vetiver plants grown on an embankment slope. The specimens were tested in fresh condition limiting the time elapsed between the sampling and the testing to two hours maximum. The unbranched and straight root samples, about 15-20 cm long, were vertically connected to hanging spring balance via a wooden clamp at one end while the other end was fixed to a holder that was pulled down manually until the root failed. At failure, the maximum load was monitored. Subsequently, the mode of failure was examined for each sample and the results of end sheared samples and those with unusually altered rupture points were discarded. To calculate the tensile root strength, the root diameter without bark was used since the bark failedbefore the root due to its weaker strength properties, and eventually the total tensile stress transferred to the root core. About 80 vetiver root specimens of different diameter classes varying from 0.2 to 2.2 mm were tested and the results were interpreted as the ultimate tensile force and tensile strength in relation to root diameter without bark.

G. RESULTS AND ANALYSIS

1. *SHEAR STRENGTH*

TABLE 1 SHEAR STRENGTH READINGS

Soil	***Before vetiver Plantation***	***After 1 month of plantation***	***After 3 month of plantation***
Shear Strength (%)	14.6	15.2	15.9

2.*COMPACTION TEST*

TABLE .2 COMPATION TEST READINGS

Soil	***Before vetiver Plantation***	***After 1 month of plantation***	***After 3 month of plantation***
Compaction (%)	96.2	96.7	97.4

3.OPTIMUM MOISTURE CONTENT

Table3- Optimum Moisture Content Reading

Soil	***Before vetiver Plantation***	***After 1 month of plantation***	***After 3 month of plantation***
O.M.C (%)	12.2	12.8	13

4.PERMEABILITY TEST:

Table no 4 – Permeability Test Readings

Soil	***Before vetiver Plantation***	***After 1 month of plantation***	***After 3 month of plantation***
Permeability (mm)	140	140.02	139

CONCLUSION

In this study it is found that growth 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 growth of root, reduction in permeability obviously ends up in more density and also in increased shearing resistance. The study is conducted with varying growth 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 growth 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.

References

1. Bestun J. Nareeman and Mohammed Y. Fattah (2012), ‘Effect of Soil Reinforcement on Shear Strength and Settlement of Cohesive-Frictional Soil’, Int. J. of GEOMATE, Vol. 3, No.1, pp. 308-313.
2. Ying Liu, Jiarong Gao, Huipin Lou, Jinrui Zhang and Qiang Cui (2011), ’ The root anchorage ability of Salix alba var. tristis using a pull-out test,’ African Journal of Biotechnology, Vol. 10(73), pp. 16501-16507.
3. Preti F. and Giadrossich F. (2009), ’Root reinforcement and slope bioengineering stabilization
4. by Spanish Broom (Spartium junceum L.), Hydrol. Earth Syst. Sci., vol. 13, pp. 1713–1726.
5. Clark J.E., Howell J.H. (1992), ’Development of bioengineering strategies in rural mountain areas,’ Erosion, Debris Flows and Environment in Mountain Regions (Proceedings of the Chengdu Symposium, July 1992), IAHS Publ. no. 209.
6. Kurt S. Pregitzer, jared L. Deforest, Andrew J. Burton, Michael F. Allen, Roger W. Ruess, and Ronald L. Hendrick. (2002), ‘fine root architecture of nine north american trees’, Ecological Monographs, vol. 72 (2), pp. 293-309.
7. David F. Polster, M.Sc. R.P.Bio. (2009), ‘Soil Bioengineering Treatments for Degraded Riparian Ecosystems,’ Polster Environmental Services Ltd.5953 Deuchars DriveDuncan, B.C., Vol. 9, pp. 1-5.
8. Normaniza Osman, Mohamad Nordin Abdullah & Che Hassandi Abdullah. (2011), ’Pull-Out and Tensile Strength Properties of Two Selected Tropical Trees,’ Sains Malaysiana, vol. 40(6), pp. 577–585.
9. Yangming Luo, Depei Zhou, Junyun Zhang. (2012), ’The Study on Stability Mechanism of Red Bed Slopes withEco-protection in the Southwest of China’, International Conference on Ecology, Waste Recycling, and EnvironmentAdvances in Biomedical Engineering, Vol.7.
10. Abdi E., (2014), ‘Effect of Oriental beech root reinforcement on slope stability (Hyrcanian Forest, Iran)’, Journal of Forest Science, Vol. 60(4), pp. 166–173.
11. Hamed fathi, Mojan mirzanejad, Ali Ebadi, Hossein moradi, Hesam Aryanpour (2014), ‘Effects of wastewater irrigation on the growth of two bean spices and soil chemical properties under greenhouse conditions’, International Journal of Soil and Crop Sciences, Vol. 2(2), pp. 033-038.
12. Patrik Peeters L., Leen De Vos, Bart Vandevoorde, Jentsje van der Meer (2013), ‘Application of Grass Cover Failure Models Following in Situ Wave Overtopping Experiments in Belgium’, Universal Journal of Geoscience.