Erosion Control Through Coir Fiber Mixed Soils

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***Abstract*— Seepage may be defined as the infilteration downward and lateral movement of water into soil or substrata from a source of supply such as reservoir or irrigation canal .Seepage velocity is the velocity of ground water calculated from Darcy's law .Increasing of piping resistance reducing seepage of water in soil.Two types of soils are used in this study.The test procedure were carried out for various hydraulic heads,fiber contents and fiber lengths.The test showed positive result in which the seepage velocity was reduce and the piping resistance of the soil specimen was increased.**

Keywords: Seepage,Hydraulic gradient,Fibers

I. INTRODUCTION

Seepage flow refers to the flow of a fluid through permeable soil layers.The fluid fills the pores in the unsaturated bottom layer and moves into the deeper layers as a result of the effect of gravity. The soil has to be permeable so that the seepage water is not stored. Soil permeability is the property of the soil to transmit water and air and is one of the most important qualities to consider for fish culture. A pond built in impermeable soil will lose small amount of water through seepage. The more permeable the soil, the greater the seepage. Piping of base soils is a common problem downstream of earth embankments under the influence of upward seepage. Seepage induced failures in the form of piping are generally observed in irrigation and drainage projects for sustainable watershed management such as river levees, contour bunds, temporary canal diversion works, temporary check dams, and soil structures. When the seepage velocity exceeds the critical velocity, piping occurs and the soil in the constructed areas flows out and the structures are weakened. Therefore, effective countermeasures against the piping are needed and the coir fiber mixed soil is useful in this application. Coir fiber can be effectively control the seepage through soil. Seepage velocity decreases as fiber content increases and hence piping resistance also increases and hence increase in fiber content.

II.LITERATURE REVIEW

From ancient time onwards soil is strengthen using fibrous materials. Natural and synthetic fibres are the two types of fibres used in stabilization of soil. This chapter is devoted to bring about the salient points of published literatures and other reported works using various fibres mainly coir fibre for strength improvement of soil and various chemical treatments used to improve the tensile strength of coir.

G.L Sivakumar Babu and A .K Vasudevan (2020)conducted study on Seepage velocity and piping resistance of coir fiber mixed soils.The experiments were carried out for various hydraulic heads,fiber contents and fiber length.it observed that fibers reduce the seepage velocity of plain soil.the result show that coir fiber mixed soil can be used to increase the piping resistance and reduce seapage velocity.

Muhammed Bazith Nassar,Muhsina P.M, Nakul Shaju,Shihin A.N ,Basil Jaimon(2014) conducted study on Effect of coir fiber on the piping behaviour of soil.The laboratory investigation was conducted for studying the efficiency fiber reinforcement in reducing seepage velocity and improving piping resistance of soil.Experimental investigation was conducted on unreinforced soil and fiber reinforced special compacted in a custom developed one dimensional piping setup.The test is carried out for samples of soil reinforced with coir fiber of length 1.5cm,2cm,4cm,5cm and fiber content of 0.5%,0.75 and 1%

Sivakumar Babu et al (2008) reports the results of comprehensive experimental investigations using tri-axial shear tests, swelling, and consolidation tests to quantify the improvement of strength, swelling and compressibility characteristics of black cotton soil reinforced with coir fibres in a random manner. The study facilitates the use of combination of black cotton soil and coir fibres for sustainable development purposes.

Ramesh.H et al.(2010) conducted study on effect of limecoir fiber on geotechnical properties of black cotton soil .A series of Compaction and Unconfined Compressive Strength tests were conducted to study the effects of Randomly Distributed Coir fiber inclusions and lime on the geotechnical properties of BC of Black Cotton soil as one combination and effect of bitumen coating on coir fiber reinforced BC soil as another combination. These UCS tests were conducted up to 180 days

of curing. Indian brown colour coir fiber was mixed with optimum percentage of lime to BC Soil in different proportions. The strength increases up to 30 days linearly with curing period, with further curing the increase in the strength is marginal. Optimum fibre of 1.0 % by weight with 0.5 cm length was identified for improving the strength of BC Soil. From UCS test with 180 days of curing it is found that addition of bitumen coated coir fibre in BC soil is less beneficial.

Karthika et.al (2011) have stabilized the soil with coir geotextile. For performing the CBR test, the geotextile was placed at a mid depth of the mould while compacting. In the field simulation test for the measurement of rut depth, a layer of geotextile was provided at a depth of 15cm and above that the soil was compacted in layers to form the subgrade and CBR of soil reinforced with geotextile is increased to 12 %. CBR of soil stabilized with 5 percent fly ash and 2.5 percent cement and reinforced with geotextile is found to be excellent and comes to 28 percent.

III.EFFECT OF FIBER CONTENT ON SEEPAGE VELOCITY.

The experiments were carried out with fibre contents of 0.5%, 0.75%,1% by dry weight of soil. seepage velocity decreases as fibre content increases and hence piping resistance also increase.

IV.EFFECT OF FIBER LENGTH ON SEEPAGE VELOCITY.

The test was done with fibers having length of 0.5cm,1cm,1.5cm length. If the Length of fibres are less the effect of fiber is not observed. Similarly if the fibres are having more lengh it will not help in reducing the seepage.

V.OBJECTIVES OF WORK

To determine the various index properties of different soil.

To determine coefficient of permeability at varying proportion.

To determine seepage velocity at variable hydraulic head.

To minimize the failure due to piping at varying proportions.

VI. METHODLOGY

Seepage velocity is observed to be varing with length of fiber .Piping failure will occur in coir fiber mixed soil at varying hydraulic gradients.The methodology is to find fisrt to determine the index properties of soils like specific gravity,maximum dry density,optimum moisture content,Atterberg limits,unconfined compressive strength. Standard proctor compaction test,unconfined compression test ,plastic limit and liquid limit are experiments were conducted for determining the index properties.The main test was conducted by the prepared mould for determining permeability and compailing the results.

VII. THEORETICAL CONSIDERATIONS

Discharge velocity of water flowing through the soil by using Darcy's law,

$$v=ki$$

where v is the discharge velocity and k is the coefficient of permeability of soil and i is the hydraulic gradient,and to find k value by using,

$$k=QL/Aht$$

where Q be the discharge in cm^2,L be the length of the soil specimen in cm,h be the hydraulic heads,and t is the time in second.

Seepage velocity is calculated by using

$$v_S=v/n$$

Piping resistance of soils should have a magnitude equal to that of seepage force.So for equilibrium,piping resistance should have a mangnitude equal to that of seepage force and line of action of these should be the same.

For calculating seepage force

$$P=\gamma_w hA$$

Where P be the seepage force at critical gradient, γ_w be the unit weight of water,h be the critical hydraulic gradient and A is the area of cross section of the soil specimen.

VIII.MATERIALS USED

A. KUTTANAD CLAY

Kuttanad clays are soft deposits of silt or clay found in the kuttanad region of Alappuzha district, Kerala .It is well known for failure of pavement and foundation structure constructed over in the past . This is due to the weak soil characteristics which the soil posses such as high settlements and low strength.

B. LATERITE SOIL

Laterite is both a soil and a rock type rich in iron and aluminium.Laterite soil develops in areas with high temperature and heavy rainfall.Laterite soil have high clay content,which means they have higher cation exchange capacity and water holding capacity than sandy soils.

C.COIR FIBER

The use of natural fibers was widely adopted in ancient period due to the eco-friendly behaviour of natural fiber. Now a days proper use of natural fibers like coconut coir fiber can give strength along with elasticity. Some advantages include high

water-holding capacity, better air penetration and acceptable pH levels. Coir readily absorbs water, so a wetting agent is not needed. Because of its high lignin content, coir breaks down slowly which keeps the medium structure open.The use of natural fibers such as coir for soil improvement is highly attractive in countries like India where such materials are locally and economically obtainable, in view of the preservation of natural environment and cost effectiveness. The coir fiber is one of the hardest natural fiber available because of its high content of lignin.

IX. PHYSICAL AND MECHANICAL PROPERTIES OF COIR FIBER

TABLE 1

PROPERTY	VALUE
Avg.dia of fiber(µm)	100-450
Toughness(Mpa)	10.5
Density(g/cm^3)	0.86-1.2
Tensile strength(Mpa)	95-595
Modulus of Elasticity(Mpa)	4-6
Elongation (%)	4-50
Specific Modulus(Gpa)	4.5

X. INDEX PROPERTIES OF KUTTANAD CLAY

TABLE 2

Specific Gravity	2.55
Natural moisture content(%)	120
Optimum moisture content(%)	28.8
Maximum dry density(g/cm3)	1.24
Liquid Limit(%)	95.6
Plastic Limit(%)	35.38
Unconfined compressive strength(Kg/cm^2)	1.36

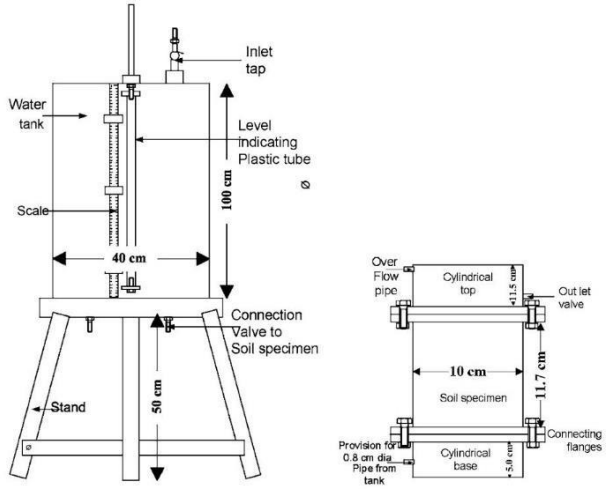
XI.INDEX PROPERTIES OF LATERITE SOIL

Specific Gravity	2
Natural moisture Content(%)	22
Optimum moisture content(%)	33
Maximum dry density(g/cm^3)	1.3
Liquid Limit(%)	74.6
Plastic limit(%)	41
Unconfined compressive strengthKg/cm^2	3.6

XII.EXPERIMENTAL PROGRAM

This experiments were conducted for different fiber contents(0.5%,0.75%,1% of dry weight of soil) and fiber lengths of (0.5cm,1cm,1.5cm).Mould was prepared inorder to determine the seepage velocity .

a)



b)

FIG .1 a) Mould design b) Prepared Mould

XIII. ANALYSIS OF RESULTS

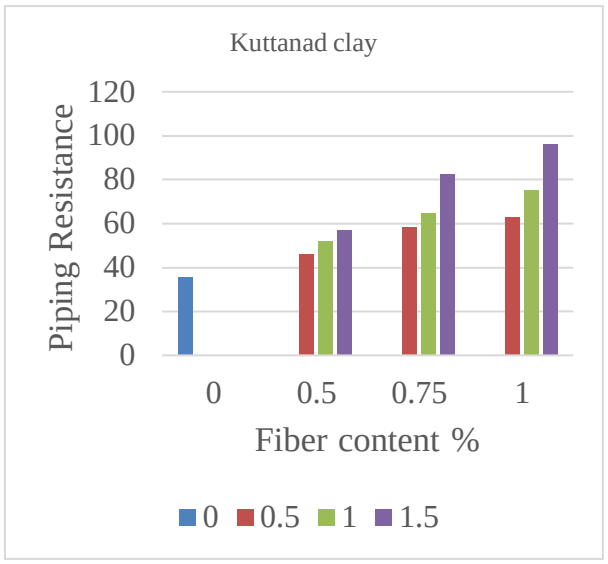


FIG 1. Fiber content v/s Piping resistance of Kuttanad clay

- In FIG 1 for each percentage of fiber content, piping resistance increases with the increase in length of fiber..For fixed 0.5% fiber content ,the piping resistance tends to increase . There is a percentage increase of 28.8%,45.31 %and 59.22 % for the fiber length of 0.5cm ,1cm and 1.5cm respectively. For 0.75% fiber content ,the piping resistance tends to increase . There is apercentage increase of 62.84%,80.15%,130.02% for the fiber length of 0.5cm ,1cm and 1.5cm respectively.And for 1% fiber content ,the piping resistance tends to increase . There is a percentage increase of 76.27%,109.61%,168.33% for the fiber length of 0.5cm ,1cm and 1.5cm respectively

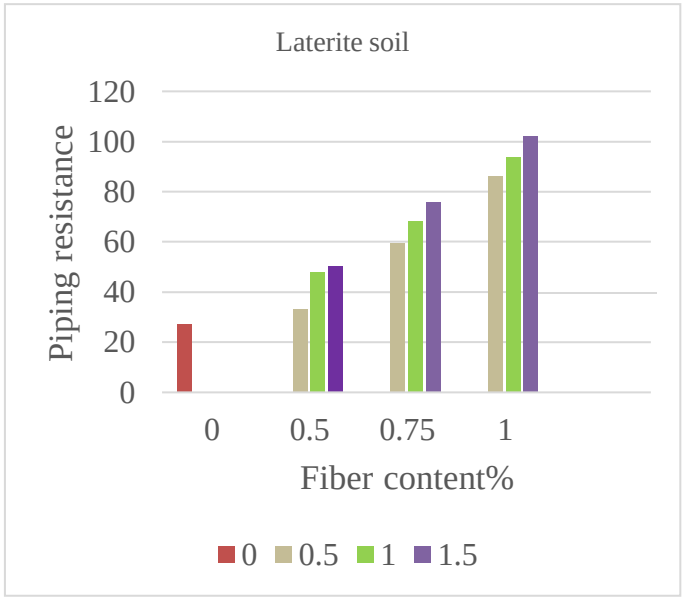


FIG 2. Fiber content v/s Piping resistance of Laterite soil

- In FIG 2 for each percentage of fiber content, piping resistance increases with the increase in length of fiber..For fixed 0.5% fiber content ,the piping resistance tends to increase . There is a percentage increase of 23.40%,77.67%,86.57% or the fiber length of 0.5cm ,1cm and 1.5cm respectively. For 0.75% fiber content ,the piping resistance tends to increase . There is a percentage increase of 121.06%,153.56%,180.78%, for the fiber length of 0.5cm ,1cm and 1.5cm respectively.And for 1% fiber content ,the piping resistance tends to increase . There is a percentage increase of 220.73%,247.92%,279.45% for the fiber length of 0.5cm ,1cm and 1.5cm respectively.

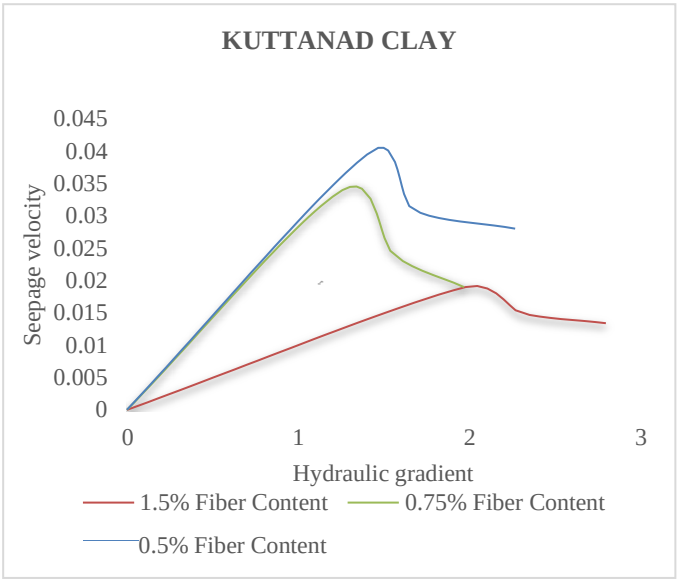


FIG 3. Hydraulic gradient v/s Seepage velocity of Kuttanad clay

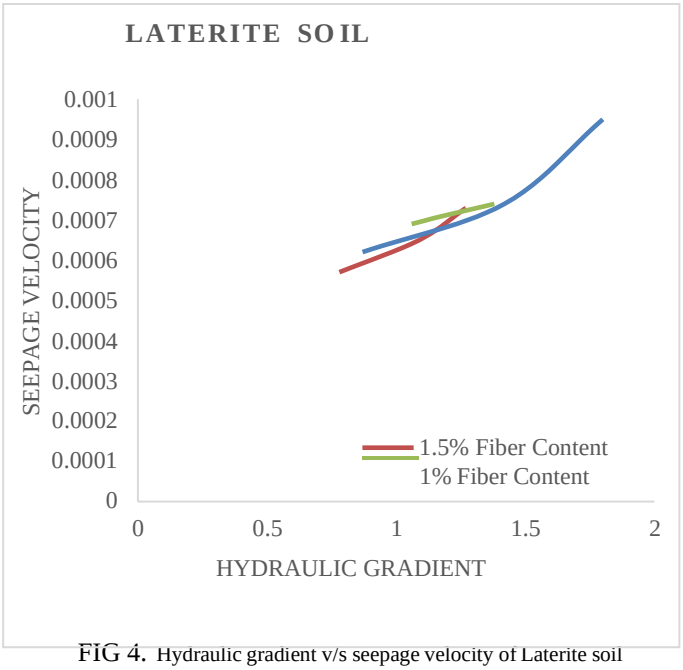


FIG 4. Hydraulic gradient v/s seepage velocity of Laterite soil

- FIG 3 shows the variation of hydraulic gradient with seepage velocity for samples reinforced with fiber contents of 0.5%,0.75%,and 1% at varying fiber length of 0.5cm,1cm and 1.5 cm . There is an optimum fiber content and length combination for maximum piping resistance and reducing seepage velocities

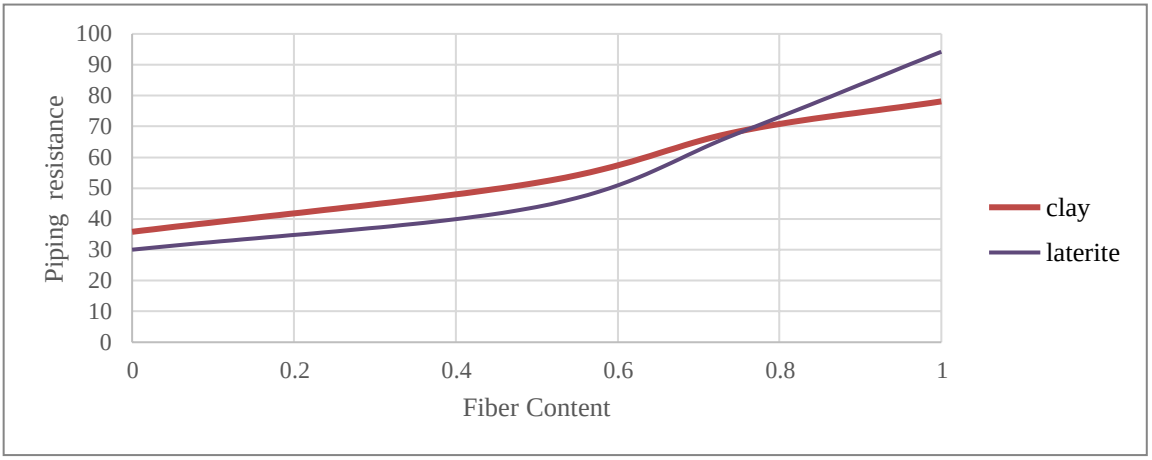


FIG 5.Fiber content v/s Piping resistance

- FIG 5 shows the variation of piping resistance with different fiber content .As the fiber content was gradually increases 0.5 cm to 1.5 cm the piping resistance increases.

XIV.CONCLUSION

- Reinforcing soil specimens with coir fibers reduced seepage velocity and improving piping resistance.
- Inclusion of fiber soil reduced the lifting of soil particles and extent of piping when water flowed in the upward direction.
- Long fibers and higher dosage of fibers mixing becomes difficult and there are more chances of bunding and non uniformities in the evolved fiber blended soil.
- Coir fibers are effectively control the seepage through soil .Seepage velocity increases and hence piping resistance also increases with increase in fiber content.
- Seepage velocity is observed to be vary as fiber length changes.
- Piping failure will occur in coir fiber mixed soil at large hydraulic gradients where as plain soil will fail due to piping at comparatively low hydraulic gradient.

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