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BIO-ABATEMENT OF PIPING OF SOIL

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Abstract—As water flows within a soil mass of an earthen dam, retaining structures, embankments it can lead to an internal erosion known as the piping of soil. It occurs when the seepage velocity is more than the critical velocity. This phenomenon is highly destructive which can lead to the failure of the structure. In this paper the effect of dry bamboo leaves to reduce piping of soil is considered. Dry bamboo leaves content varied from 0-15% with an increment of 5%.The main test carried out was Harvard Miniature compaction test. A series of compaction tests were conducted on different proportion of bamboo leaves mixed with soil. It was found that addition of dry bamboo leaves effectively reduced the piping of soil.

Index Terms—bio-abatement, piping, Harvard miniature compaction, internal erosion

1 INTRODUCTION

Internal erosion is the phenomenon that small grains are washed out through the voids between the coarse grains by seepage flow leaving the soil skeleton. It results in changes in void ratio and increases hydraulic conductivity. Piping is a subsurface form of internal erosion. Piping erosion is described as the formation of an open channel, or "pipe", within or beneath the soil mass of a water-retaining embankment. If the channel is able to connect the wet (upstream) side to the dry (downstream) side, stored water can rush through the opening due to the difference in hydraulic head between the two sides of the structure. Continued erosion caused by the increasing flow of water enlarges the channel size. This can ultimately undermine the integrity of the embankment and eventually lead to failure and collapse of the entire structure. Thus the process of piping erosion has four phases-initiation and continuation of erosion, progression to form a pip and formation of breach/failure. The Required conditions for piping erosion are source of water, flow path, erodible material in flow path and unprotected exit. 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. Traditional remediation methods include filters, cutoff walls, impermeable blankets and berms, and combinations of toe trenches, drains, and pressure relief wells. Recent studies have recognized the ability of organic materials to reduce the severity of piping erosion in sand. It preliminary investigation into a bio-remediation method in which the piping potential of an erodible granular soil is reduced through the addition of organic soil. Various researchers have studied the efficacy of the use of fiber reinforcement in improving the piping resistance of soil using laboratory experiments .Since fibers are distributed throughout a soil mass, they impart strength isotropy and reduce the possibility of formation of weak zones and contribute to improved piping resistance. Previous studies concluded that piping resistance of soil increases when mixing short fibers to effectively restrict soil particles movement and the resistance of piping is improved.

Prof.Poddor P (2016) has explained that short arecanut leaf sheath (ALS) fiber (2-3 mm) reinforced polypropylene (PP) composites were prepared by compression molding technique. Heat and cold press were used. Chemical composition of the fiber was analyzed and the percents of lignin, α-cellulose and hemicellulose were determined. Fiber content in the composites was optimized with the extent of mechanical properties and composites with 10% arecanut leaf sheath fiber showed higher mechanical properties. Tensile strength (TS), Bending strength (BS), elongation at break (EB%), water absorption capacity, scanning electron microscopy (SEM), thermo gravimetric analysis (TGA), differential scanning calorimetry (DSC) and biodegradation properties of arecanut leaf sheath/PP composites were investigated. ATR spectra of the polypropylene and composites were also analyzed.

Prof.KamolDey, SumonGanguly (2013) explained that composite materials enjoy great attraction in material science. The objective of this research was to fabricate natural fiber reinforced polymer matrix composites and to increase performances through physical and chemical methods. Areca nut fiber (50 % by weight) reinforced polycaprolactone (PCL) based unidirectional composites were prepared by compression molding. Tensile strength (TS), tensile modulus (TM), bending strength (BS), bending modulus (BM) and impact strength (IS) of the composite were found to be 32 MPa, 685 MPa, 45 MPa, 820 MPa and 15 kJ/m2, respectively. Six different formulations (F1-F6) of vinyl trimethoxysilane (VTMS) (1-6%) along with methanol (97-92%) and photo-initiator Darocur-1173 (2%) were prepared in order to modify the surface of areca nut fiber. Areca nut fiber were soaked for 15 min in different formulations and then exposed under gamma radiation of various doses (250-1000krad). Composite made of areca nut fiber treated with 4% silane and at 500 krad dose of gamma radiation performed the highest mechanical properties. TS, BS, TM, BM and IS of the composite were found to be 43 MPa, 64 MPa, 1015 MPa, 1423 MPa and 20 kJ/m2, respectively. Polymer loading (PL) of the gamma treated and untreated fiber was studied. Degradation test of the composites was carried out for 6 weeks in soil medium and it was found that the treated composite retained much of its original strength. It can be concluded that silane and gamma radiation are important tools to improve the mechanical property of the composite materials.

Prof.Rasmi Bade, Tasneem Khan (2016) explained that soil stabilization can be the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality

of the soil. The main objective of the soil stabilization is to increase the bearing capacity of the soil. The best way to stabilise such type of soil is to disturb the soil sample by physically adding an additive. In the present work an organic waste product which is readily available and is quite effective and cost friendly is used. The material used is the shell of coconut which is easily available waste product in every household. The laboratory investigation has shown that it increases the strength of soil effectively without affecting the foundation of the structure.

Prof.G.LSivakumarbabu, A.K Vasudevan (2014) has explained that in the context of sustainable watershed management, natural fibers mixed with soil have applications in irrigation and drainage projects such as river levees, contour bunds, temporary canal diversion works, temporary check dams, soil structures, stream restoration, etc., for controlling seepage. In this study, a number of experiments were carried out for determining the seepage velocity and piping resistance of different types of soils mixed randomly with coir fibers. Three types of soils are used in this study. The experiments were carried out for various hydraulic heads, fiber contents, and fiber lengths. Discharge velocity and seepage velocity of flow of water through soil is calculated in each case and compared with plain soil. It is observed that fibers reduce the seepage velocity of plain soil considerably and thus increase the piping resistance of soil. Regression equations based on experiments are developed for quantifying the seepage velocity and piping resistance considering hydraulic gradient, fiber contents, and fiber lengths. Suitability of coir fibers for field applications with typical examples is also highlighted. The results show that coir fiber mixed soil can be used to increase the piping resistance and reduce seepage velocity in the above mentioned applications

Prof. Y.E Sheela (2015) has explained that the pond ash is used as a structural fill material in embankments and drainage projects. Seepage induced failures in the form of piping can weaken and affect the performance of embankments constructed with coal ash as a structural fill material. Coir fiber, derived from coconut husk, is a natural material used as a reinforcing material to improve piping resistance. This study was done to examine the effect of coir fibres and coir geotextiles on the piping behavior of pond ash. One dimensional piping tests were carried out for different fiber contents and fiber lengths. Seepage velocity, critical hydraulic gradient.

1.2 Objectives : To understand the mechanism governing the piping erosion of soil. ◉ To investigate the possibility of applying bio-abatement to reduce piping of soil. underground passages used to pass obstacles without disturbing the overburden.

2 Methodology

The soil sample was collected from paddy field near AmaravilaNeyyatinkara. Various laboratory test were carried out to determine the index as well as the engineering properties of the soil. In this experiment

1. The grain size distribution was eliminated to develop a preliminary understanding of role of addition of bamboo leaves.
2. The effect of varied bamboo leaf content on piping erosion progression was also noted.

The experimental methods were designed to test a soil's overall resistance to erosion along a pre-existing piping channel. The test setup borrowed the concept of the constant-head hole erosion test (HET). A constant head of 15cm was maintained.

The test was conducted on specimen of 8.5cm diameter and 10.5 cm in length. Tamping rod of diameter 4.5cm and length 16cm was used. Clear acrylic tubing and end caps were used for the specimen mould and allowed for easy observation of the specimen mould and allowed for easy observation of the specimen during all phases of testing. The end caps were designed in such a way that eroded soil particles were able to exit from the specimen unhindered from the specimen for collection within buckets directly beneath the specimen. Initial properties of the soil sample was found out.

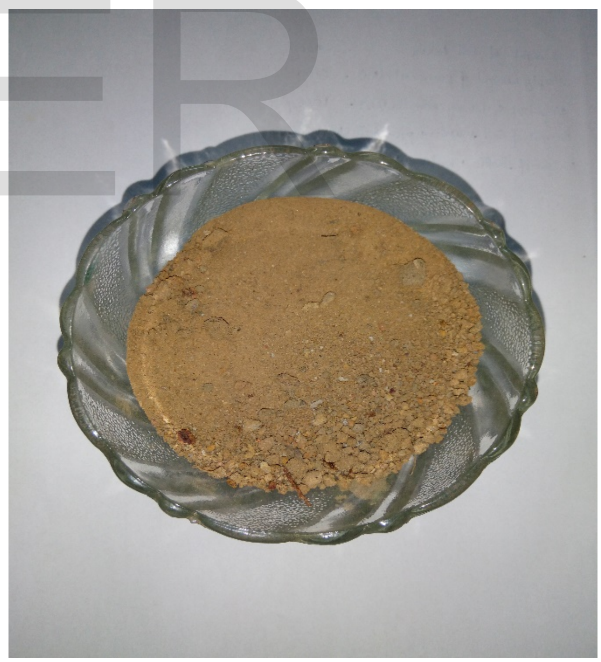

FIGURE 1: SOIL SAMPLE

FIGURE 2: BAMBOO LEAVES

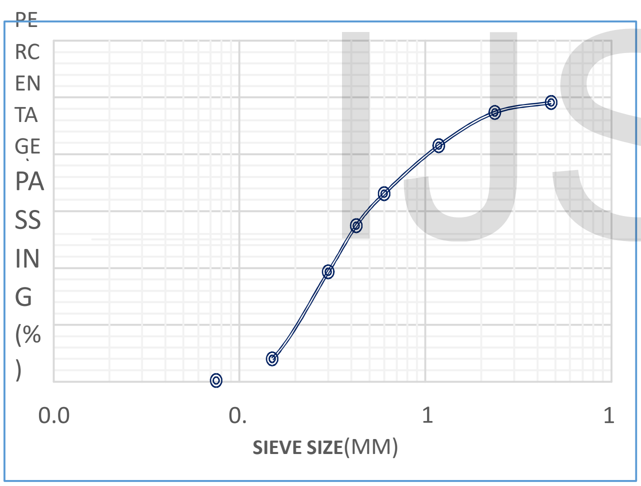

FIGURE 3 : PARTICLE SIZE DISTRIBUTION CURVE

2.1SAMPLING

The specimen was created by compacting soil directly within the mould to its maximum dry density in thin, uniform layers at the optimum moisture content. The maximum dry density and optimum moisture content were obtained using the Standard proctor apparatus. In the Standard proctor compaction test, each of the three uniform layers of the specimens received 25 tamps

Table 1:Initial properties of soil sample

Percentage clay	0.4%
Percentage sand	97.8%
Percentage gravel	2.8%
Optimum moisture content	14%
Maximum dry density	1.23g/cc
Specific gravity	2.41
Angle of internal friction	32^o
Cohesion	$0.1kg/cm^2$

FIGURE 4: EROSION TESTING APPARAUS

2.2 TESTING PROGRAM

A concentrically located hole was performed during specimen compaction using a metal rod with a diameter of 4.5 mm. This hole simulated an initial piping channel and spanned the entire length of the specimen. A specially designed tamper covering nearly the entire cross-sectional area of the specimen was used to achieve consistent densification within each layer. The tubular handle of the tamper was hollow and closely encased the metal rod that was used to form the initial piping hole. This ensured that the soil adjacent to the piping hole was not over- or undercompacted. Each specimen was tested for a constant head of 15cm or until failure, whichever occurred first. Failure was defined as enlargement of the initial piping hole to the perimeter of the mould. The enlargement of the piping hole was visually monitored through the transparent mould. When the piping hole enlarged to the perimeter of the mould, the erosion test was terminated. The total dry mass of eroded soil particles was measured for each effluent collection increment. This value was determined through decanting and drying of the collected the soil sample.

3 Analysis and Discussion

The results of the erosion test is shown in the table 2.

.TABLE 2: ERODED RATE

Percentage bamboo leaf (%)	Wet weight (g)	Dry weight (g)	Time (hours)	Eroded soil (g)
0	1022	976.56	1hr	45.44
5	971	931.39	2hr 20min	39.61
10	920	911.5	4hr 10min	8.5
15	868.7	867.18	5hr 45min	0.52

FIGURE 5: HOLE EROSION TEST FOR 0%,5%,10%,15% BAMBOO LEAVES

4 Conclusion

- From the experiment it was clear that the addition of bamboo leaves to the soil increased the stability of the soil.
- Also it increased the piping resistance and reduced the piping of the soil.
- When 15% bamboo leaves was mixed with the soil the eroded quantity was 0.52g

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