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Study on Soil Stabilization by Using Natural Fiber for Artificial Lake Liner – A Review

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***Abstract*: Soil stabilization is an essential aspect of civil engineering, and in recent years, natural fibers have been gaining popularity as a viable alternative to synthetic materials for soil reinforcement. This study focuses on the use of natural fibers, particularly coir fiber, as lining materials for soil stabilization. Coir fiber is obtained from the outer husk of coconuts and is widely used in soil stabilization due to its unique mechanical properties, including high tensile strength, excellent biodegradability, and high moisture retention capacity. Coir fiber is particularly well suited for soil reinforcement applications in regions with high rainfall and moisture content. Compared to other natural fibers like jute, sisal, and kenaf, coir fiber exhibits superior mechanical properties such as higher tensile strength and modulus of elasticity, making it more effective in resisting soil erosion and slope instability. Moreover, coir fiber is highly resistant to microbial degradation, making it a durable material for long-term soil stabilization projects. Standard proctor test (SPT), Permeability test and California Bearing Ratio (CBR) test to find out physical properties of the stabilised soil.**

***Keywords*: compaction, lining material, natural fibre, permeability.**

1. Introduction

An artificial farm pond is a man-made body of water constructed specifically for irrigation purposes on a farm or agricultural property. These ponds are designed to store water during periods of excess rainfall or snowmelt and release it during times of drought or low water availability. Artificial farm ponds can be a cost-effective and eco-friendly solution for irrigating crops and supporting livestock.

To build an artificial farm pond, the site must be evaluated to determine its suitability for pond construction based on factors such as soil type, topography, and drainage. Once a suitable site is identified, the area is excavated to create the pond basin. The pond is filled with water and a water supply system is installed to pump water to fields or other irrigation systems.

However, the problem of gradual seepage of water reduces the amount of water stored in pond causing water deficiency. The major reasons behind the seepage are the increased permeability of soil, which is caused due to various reasons. Cracks formed in the soil due to expansion and contraction of soil, which is caused by temperature variation, is one such example of increased water permeability. Less density of soil, less water retention capacity, index properties of the soil are few important reasons of increase in permeability.

To tackle this problem the permeability of the soil of artificial pond needs to be reduced. Until now, various researches have been done to solve this seepage problem by stabilizing the soil of artificial pond. This stabilization was done by either compaction of soil or addition of chemical admixture or by addition of various natural and artificial fibres. Our study proposes the usage of coir fibre, bentonite clay and bitumen to stabilize the soil. Currently we are going to used red soil, black cotton soil for analysis purpose.

A. Aim

To find the optimal proportion of Coir fibre, black cotton soil, red soil, bentonite clay for stabilization of soil.

B. Research Objective

1) To study different natural fibre and soil improvement techniques.
2) To decide proportion of black cotton soil, red soil, bentonite, coir fibre.
3) To conduct geotechnical test on soil.
4) To access strength and suitability of soil sample.
5) To recommend best proportion based on enchantment of soil properties.

C. Problem Statement

M/s Ajan Homes Pvt. Ltd. constructed an artificial lake at Solapur for storage of water. The lake has cohesion less soil as a bed material. There is small pocket of BC soil bellow the lake. The lake constructed with soil bed, which has granular soil with compacted layer. To avoid erosion of bed it is covered with jute cloth in 2.19. It is observed that the employed system does not prevent percolation of water. The full lake gets in to no water condition in 28 days. The current problem was further taken for deciding bed material with mixture of BC soil, red soil and Bentonite in best proportion, worked out based on geotechnical test. The same material was implemented as a bed material and found good in retaining water by controlling percolations. It is further observed that the provided bed layer (Liner) gets crack

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as a part of shrinkage after drying. It is necessary to stabilize the bed material with help of micro fibers and similar kind of material.

D. Lining Material

1) Black Cotton Soil

Black cotton soil is a type of expansive clay soil commonly found in tropical and subtropical regions such as India, Africa, and Australia. It is characterized by its high clay content, low shear strength, and high plasticity, which makes it a challenging material to work with in geotechnical engineering projects. The soil's unique behaviour when exposed to water, known as swelling and shrinking, can cause damage to foundations, structures, and roads built on top of it. However, its high water-holding capacity and nutrient retention make it suitable for crops such as cotton, sorghum, and millet. Various methods, including stabilization with lime or cement, replacement with more stable soil, and compaction or preloading, are used in geotechnical engineering to mitigate the effects of black cotton soil's swelling and shrinking behaviour.

2) Red Soil

Red soil offers a few benefits in this context. One of these is its looseness, which makes it simple to excavate and relocate during construction activities. Furthermore, the relative lightness of red soil can simplify the transportation and handling processes on job sites. Lastly, red soil is often widely available and is a cost-effective option for specific types of construction projects.

3) Bentonite

Bentonite is a clay mineral that primarily consists of montmorillonite. It is soft, pliable, and can expand significantly when exposed to water. The clay forms due to volcanic ash alteration and is typically found in close proximity to volcanoes. Bentonite has a distinct structure that allows it to absorb vast amounts of water, making it highly beneficial in multiple industries, including agriculture, construction, and drilling. Its applications include serving as a binding agent in foundry molds, a suspending agent in drilling fluids, a sealant in ponds and landfills, and a soil conditioner in agriculture.

4) Coir Fibre

Coir fiber is a natural fiber derived from the husk of coconut shells, and it has been widely used in various applications, including as a soil stabilizer. This fiber has several excellent properties, including strength, durability, and water absorption, which make it an ideal material for soil stabilization. When coir fiber is mixed with soil, it can significantly increase the soil's strength, reduce erosion, and improve stability. Additionally, it is eco-friendly because it is biodegradable and does not contain any harmful chemicals, making it an ideal choice for soil stabilization. Coir fiber can also improve soil fertility by retaining moisture and providing essential nutrients to plants. As a result, it has become a popular option for various soil stabilization applications, including highway embankments, slope stabilization, and landfill covers. Coir fiber is an affordable and sustainable solution for soil stabilization, making it a highly attractive option for many projects.

2. Literature Review

Improvement of local subgrade soil for road construction by the use of coconut coir fiber.

According to the test results, shear strength increases are closely correlated with fibre area ratios, and shear strength envelopes for fiber-reinforced sand clearly demonstrate the presence of a threshold restricting stress below which the fibre tries to slip or pull out. Dimensions are 0.5 mm. The coir is divided into 3 to 5 cm pieces with a percentage of 0.25, 0.50, 0.75, and 1%. Waste coir fibre could be used as a sub foundation for both flexible and stiff pavements. With an increase in coir fibre content, the soil-coir mixture's OMC rises. The soil-coir fibre mixture's CBR and UCS values rise when the percentage of fibre is increased. When 1% of coir is added to the soil, U.C.S. and C.B.R. values show the greatest improvement.

Effect of natural coir fibres on cbr strength of soil subgrade. The CBR test was used to determine whether the subgrade soil's improved load carrying capacity. The ideal length of the coir fibres, which range from 0.5 cm to 3 cm, was 1.5 cm. The percentage of coir fibre ranges from 1% to 8%, with 5% being the ideal value.

This experiment was carried out to determine how coir geotextiles affected the functionality of subgrade soil. The ideal fibre proportion was 5% of the sample's overall weight. The best length of fibre was 1.5 cm.

The top position of the subgrade was optimum for inserting the coir geotextiles, whereas the bottom position yielded the lowest value.

The subgrade strength is increased by using coir geotextiles, extending the life of the pavement.

Experimental study on stabilization of clay soil using coir fibre. The results of the current study are highly encouraging, and the following key conclusions may be made:

Coir fibre is a waste product that could be used to stabilise clay soil. As the percentage of coir fibre in the soil-coir combination rises, so does its strength. The soil-coir fibre mix's CBR and UCS values rise as the percentage of fibre content does. When 0.5% of coir is added to the soil, U.C.S. and C.B.R. values improve the most. It has been determined that 0.5% of coir fibre in soil is the ideal percentage for materials with the highest soaked CBR value. This ratio can therefore be economically employed to stabilise clay soil.

Soil stabilization using natural fiber coir. To make soil usable for construction purposes, it needs to be stabilised because it has weak bearing and shearing strength. In this study, coir, a natural fibre used to stabilise soil, was isolated from coconuts. Enhancing the qualities of soil through stabilisation utilising natural fibre is a practical and environmentally responsible strategy. The usage of natural fibre is a move to preserve the balance of nature because chemical-based or synthetic fibres hurt our ecosystem. This study explores the use of coir fibre to reinforce soil and contrasts the engineering characteristics before and after stabilisation. Direct shear tests and unconfined compression tests are conducted on two separate soil samples as part of the study to assess the impact of coir fibre on soil shear strength.

The increase in cohesiveness for the soil sample with fibre reinforcement of 0.5%, 1.0%, and 1.5% was determined to be 10%, 4.8%, and 3.73%, respectively, according to the results of the direct shear test.

Overall, it can be said that soil reinforcement with fibres can be viewed as a beneficial ground improvement approach, particularly for engineering projects on brittle soils, where it can be used in place of deep or raft foundations to cut costs.

Experimental study on soil stabilization using fibres. The collected fine-grained soil's geotechnical qualities are affected by the addition of fibres, as demonstrated by this experimental study. The following conclusion is drawn from the results: Results of standard proctor compaction tests performed on fine-grained soil were obtained by embedding fibres in the soil. The maximum dry density increased with the addition of fibres, reducing the optimal moisture content from 12% without fibres to 10% with natural fibres and 10.8% with artificial fibres, indicating that the inclusion of fibres is helpful in boosting soil failure ductility. When natural and synthetic fibres are used in place of fine-grained soil, which has zero angles of internal friction, the resulting surface has an angle of 20.05' and 20.06' 43 09’ respectively.

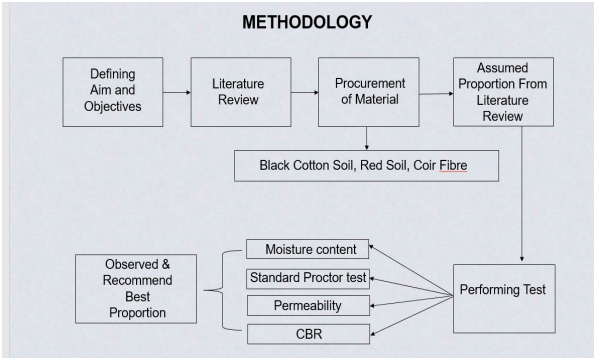

Fig. 1. Methodology

3. Test to Be Done

A. Moisture Content Test

Testing for moisture content is crucial because it can affect the quality, safety, and performance of the material or product. There are several methods for determining moisture content, including the oven-drying method, and microwave moisture measurement. The selection of the method to use depends on the material being tested, the required level of accuracy, and the availability of equipment. In construction, moisture content testing can help avoid damage to building materials and maintain their structural integrity.

B. Standard Proctor Test

The Standard Proctor Test is a laboratory test used to determine the maximum dry density and optimum moisture content of a soil sample. It involves compacting a soil sample with a standard compaction effort and determining the dry density and moisture content. The results of the test are useful in assessing the suitability of the soil for construction purposes and evaluating its shear strength, compressibility, and permeability.

C. Falling Head Permeability Test

The falling head permeability test is a laboratory procedure used to determine the hydraulic conductivity of soil samples, which is a measure of their ability to allow water to flow through them. During the test, a soil sample is placed inside a permeameter, a cylindrical device designed to control the flow of water through the soil. Water is then allowed to pass through the sample from a reservoir at the top of the permeameter, with the head gradually decreasing over time to allow the water to flow under gravity. The rate of water flow is measured and used to calculate the hydraulic conductivity of the soil sample.

D. California Bearing Ratio

The California Bearing Ratio (CBR) test is a widely used method for measuring soil strength, specifically its ability to support load for flexible pavement systems. The test involves measuring the pressure required to penetrate a soil sample with a plunger of a specific size and rate, and comparing it to a standard material's pressure, typically crushed limestone or gravel. A higher CBR value indicates greater soil strength to support load.

4. Conclusion

Natural fiber for soil stabilization in the construction of an artificial lake can be a feasible solution. The application of natural fiber for soil stabilization in the construction of an artificial lake offers several benefits. Natural fibers, such as coir, jute, and sisal, are readily available and biodegradable, making them an environmentally friendly choice. When mixed with soil, these fibers can enhance its strength, stability, and erosion resistance, which is particularly vital for an artificial lake's construction, where water can cause erosion.

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References

[1] Ahmad, S., Aslam, M. and Shafiq, M. Reducing water seepage from earthen ponds, Agriculture Water Management. ICAR-Central Research Institute for Dryland Agriculture (CRIDA), 30, 1966, 69-76, pp. 336.

[2] Jayanthi, M., Rekha, P.N., Muralidhar, M. and Gupta, B.P. Seepage reduction in brakish water ponds with different material. Eco. Env. And Cons. 10(3), 2004, 257-260.

[3] Riaz, M. and Sen, Z.Aspects of design and benefits of alternative lining systems. Europian Water 11/12, 2005, 17-27.

[4] Saha, R., Ghosh, P.K., Mishra, V.K. and Bujarbaruah, K.M. Low cost microrainwater harvesting technology (jalkund) for new livelihood of rural hill farmers. Research Account. Current Science 92(9), 2007.

[5] Manoj P. S. and Satapathy, K.K. Concreted rainwater harvesting technologies suitable for hilly agroecosystems of Northeast India. Current Science, 95, 2008, 9-10.

[6] Goyal, R.K., Rainwater Harvesting a Key to Survival in Hot Arid Zone of Rajasthan. (In) Proceedings of the National workshop cum Brainstorming, CRIDA, Hyderabad, 21–22, 2009, pp. 29-38

[7] Deopura, B.L. and Chahar, B.R. Water seepage control through novel sheet materials. Rain water harvesting and reuse through farm ponds. Proceedings of national workshop cum brainstorming. pp. 24-28, 2009.