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Performance of Clayey Soil Stabilized with Coir Fibre: A Review

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***Abstract**: For construction purposes one of the most important aspect is soil stabilization. It is used for construction, foundation, bricks, pavements it gives strength for the soundness of the structure. Clayey soil, which are also called swell shrink soil have tendency to shrink and swell with variation in moisture content. This soil may be an expansive soil within which it expands in its volume in wet condition and shrinks in dry condition. Clayey soils are not suitable for construction due to their undesirable characteristics such as poor grading, low strength, and tendency to shrink and swell so soil stabilization is done to improve the engineering properties of the soil. The basic ways of stabilization are cementation, bituminization ways victimization chemical science or thermal action, and these will cause some effects on the atmosphere. So without causing any harmful effect on atmosphere the use of natural waste like coir fibre is desirable for soil stabilization. Reinforcing the soil with fibre Coir Fibre may be a cost effective solution to the ground/soil improvement issues. This study deals with the utilization of Coir Fibre for soil stability. The study includes the properties of fibre Coir Fibre.*

***Keywords:** Coir Fibre, Clayey Soil.*

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I. Introduction

Soil is a collection or deposit of earth material, which is derived from disintegration of rocks. Clayey soils, which are also called as swell-shrink soil, have tendency to shrink and swell with variation in moisture content. As a result of this variation in the clayey soil, significant distress occurs in soil which is subsequently followed by damage to the overlying structures and reducing its strength. Clayey soil are not suitable for use in runways, highways, dams and embankments due to their undesirable properties such as low strength, tendency to swell-shrink, low settlement et. Since for clayey soil with undesirable properties it has been necessary to improve its properties to make them acceptable for construction. Improvement of clayey soil is can be achieved by incorporating stabilization technique. This stabilization technique can increase the service life of clayey soil.

Various waste materials were used to improve the properties of clayey soil. Fly ash when used in weak soil improves the CBR values of the clayey soil by the clayey soil-fly ash interlocking phenomenon [1, 2, and 3]. Industrial wastes such as blast furnace slag, rice husk ash, foundry sand, foundry slag, cement kiln dust when used to stabilize clayey sand have shown satisfactory strength and durability characteristics [4, 5]. Inclusion of coir fibers in clayey soil along with fly ash is found to increase the shear strength parameter [6, 7, and 8]. Peat soils stabilized with polypropylene fibers have showed considerable increase in CBR value in the order of 15 to 22 times [9].

India is one of the leading countries in the production of coconut. Coconut palm is one of the most useful tropical palms and one of the important industries related to coconut palm is coir industry. It is estimated that the coir-processing industries in India produce roughly 0.5 million tonnes of coir waste [10]. These coir wastes are accumulated along the sides of the production units thus creating environmental solution problems. Open disposal of coir pith into heaps acts as a bacteria growing medium and results in poor hygiene of the surrounding areas. A major portion of the coir pith is utilized as a fuel in domestic stoves which creates air pollution. Also, dumping of coir waste into water bodies like rivers, lakes etc, may affect the life within water bodies.

1.1 Different stabilization

Fly ash stabilization: Fly ash has been used in many projects to improve the strength of weak soils. The reason fly ash is used in soil stabilization is to improve the compressive strength and shearing strength of soils. Experimental studies carried out to investigate utilization of fly ash for stabilization of subgrade soil and concluded that OMC attains its highest value of 29.27 % for 10 % of fly ash as compare to 21.38 % for unstabilized soil whereas, CBR value increases from 5.64 % to 20.53 % for 20 % of fly ash [11]. The study deals with the sub grade characteristics of locally available expansive soil mixed with fly ash and randomly

distributed fibers. The result of his study shows that proportion of 70 % soil and 30 % fly ash was the best proportion having maximum dry density and maximum CBR value [12]. The effect of fly ash on properties of expansive soils and stated that optimum moisture content decreased and maximum dry unit weight increased with an increase in fly ash content [13]. Bearing capacity of Elmadag soft soil can be improved substantially and swell can be reduced significantly by using fly ash at different varying percentage of fly ash [14].

Lime stabilization: Lime and cement addition to the clayey soil may cause a decrease in the maximum dry density and increase in optimum moisture content. Maximum strength was obtained at 4% of lime for the clayey soil [15]. Dry density of soil decreases with lime content and C.B.R. value of soil increases from 1% to 2.74, 3.89 and 6.51% due to stabilization with 2.5, 5 and 7.5% lime content [16]. The clay lime compound provides the cemented material in soil [17]. Lime could be effective in the improvement of compressibility and swelling properties of soil and optimum results are achieved by adding 3% of lime [18]. Investigation with lime stabilization on high plasticity clay shows an increase in shear strength of soil as 4% lime is added [19]. Investigation on the marine clay to stabilized using lime and saw dust resulted in an increase in CBR value of marine clay by 129.76% on addition of 15% sawdust and it has been improved more by 283.12% when 4% lime is added [20]. Large amount of increase in compressive strength was observed due to addition of lime and cement to fibre reinforced soil [21].

Fibre stabilization: The aim of reinforcing soil is to improve its strength, stability, increase its bearing capacity and lower the settlement. [22]. The better effect of fibres in the engineering properties of soil by use of fibers for soil stabilization [23]. The effect on engineering properties of soil due to addition of polypropylene fiber and lime admixture reported that with increase in lime and fiber content, OMC increases and MDD decreases [24]**.**

The use of fibres in construction of earth structures and pavements is more popular nowadays. Natural fibres such as straw, tree leaf, grass, etc. have been used for construction purpose. The use of geo-grids, geo-textiles and metallic strips has been commonly used in soil mass to improve the tensile resistance. The tensile resistance provided by these includes seems to be in a particular direction which may create potential failure planes in the soil mass. By randomly distributing fibres in soil, the chances for potential plane of weakness at any point in the soil mass can be avoided.

The use of a strong base becomes difficult when the fill materials are not locally available in enough quantity and brought from distant places for embankments of road, etc. In such cases the use of randomly distributed fibre-reinforcement for the improvement of the soil may provided for improve its quality. Placing a compacted layer of fibre-reinforced soil with high strength over soils of weak bearing capacity and having low strength can be used for cheap and economically low-budget building projects, for which adopting deep foundation is not a cost effective method considering the overall cost of the project. The method has many other applications for soil improvement and it may be considered similar to the use of other admixtures (cement, lime etc.) used for soil stabilization and improving load carrying capacity of soil mass. The method is cost effective because the fibres are comparatively cheap then other admixture and easily available.

II. Coir Fibre

Soil is the most cost effective construction material. Soil is the major and most typically used material within the field of civil engineering. It is used for construction, foundation, bricks, and pavements to give respectable strength for the soundness of the structure. For property development of soil we can use domestically offered materials and waste product so we can save lots of the natural resources. There are many varieties of waste product found in INDIA like fly ash, stone quarry, plastics, recycled combination, and lime etc. however coir fibre is used during this analysis paper.

Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. By using natural fibres like coir fibre is an ancient idea. The Coir fiber is natural fiber. Coir fiber is also called the coconut fiber. Coir fibers are fibrous material collected from the matured coconut of the coconut tree. Coir fiber is extracted from the outer covering of a coconut. The common name, scientific name and plant family of coconut fiber is: Coir, Cocos nucifera and Arecaceae (Palm). Coir fibers are thick, strong and have high abrasion resistance. It is renewable resource and CO2 neutral material and non-toxic in nature, biodegradable, low density and very cheap. Coir fiber diameter is approximately 0.1 – 1.5 mm and length is 3 – 15 cm.

The inclusion of fibres as a soil reinforcement had a significant influence on the engineering behaviour of soil. The inclusion of randomly distributed polypropylene fibers resulted in reducing the consolidation settlement of the clayey soil. A soil characteristic has an insignificant effect of length of fibres, whereas fiber contents proved more influential and effective. There is decrease in plasticity and increase in hydraulic conductivity due to the addition of fibres. So, there has been a growing interest in soil-fiber reinforcement. The addition of fibres in soil improves overall property of soil. Fiber mixed with soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Addition of fiber with soil is effective in all types of soils (i.e. sand, silt and clay).

Coir fiber belongs to the group of hard structural fibers. The coir fibers are elastic enough to twist without breaking. The coir fiber is one of the most advantageous natural fiber available because of its high content of lignin and much more advantageous to different application for reinforcement, soil erosion control and stabilization of soil and is preferred to any other natural fibers [25].

For all the above reasons clayey soils are generally poor materials for construction. To improve the characteristics of soil, soil stabilization or soil reinforcement is done. Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. Using natural fibers to reinforce soil is an old and ancient idea. Accordingly, randomly distributed fiber reinforced soils have increasing attention in geotechnical engineering [26].

Fig 1: Coir Fibre

2.1 Advanatges of coir fibres:

a) It's a renewable resource and CO2 neutral material.
b) The fibre has a high degree of retaining water and also rich in micronutrients.
c) The fiber is abundant, non-toxic in nature, biodegradable, low density and very cheap.
d) The fibres instead of going to waste are explored for new uses, which in turn provide gainful employment to improve the standard living condition of individuals [27].

2.2 Physical properties of coir fibre [28]

Density (g/cc)	1.40
Diameter in mm	0.1-0.5
Length in inches	6-8
Tenacity (g/Tex)	10.0
Rigidity of Modulus	1.8924 dyne/cm^2
Breaking Elongation%	30%

2.3 Chemical properties of coir fibre [28]

Lignin	45.84%
Cellulose	43.44%
Hemi-Cellulose	0.25%
Water soluble	5.25%
Ash	2.22%
Pectin's and related compound	3.0%

III. Review Of Literature

Nithin and Sayida 2012 [29] presenteds the experimental program in laboratory on silty sand mixed with fly ash and with coir fibres and establish that discrete and randomly distributed coir fibres are improving the bearing capacity of soil. The silty sand (low plasticity soil) has been considered using different percentage of fly ash from 5 to 20% by weight of given soil and the effect of curing period is also considered. Coir fibres are used in different percentage from 0.5 – 5%.

Tiwari et al. 2014 [30] analyzed the characteristics of black cotton soil with various percentages such as Atterberg's Limits, Proctor Compaction test, Shrinkage Limit, CBR test, Swelling Pressure, Permeability test and Direct Shear test, effect of Fly Ash, Coir fiber and crushed Glass. They use combination of the above proportion of ingredients, which are waste products instead of construction materials like cement, lime, etc. To achieve the experimental results with 48 trial soil samples were prepared. Firstly, they were carried out the physical properties of soil which is specific gravity, Atterberg's limits, grain size analysis, proctor compaction test, swelling pressure, CBR test, direct shear test and permeability test values are determined. Secondly, all test were carried out for black cotton soil using different percentages of Fly Ash , Coir fiber and Crushed glass fiber (FA: 10%, 15%, 20% and 25%, CF: 0.25%, 0.5%, 0.75% and 1%, CGF: 3%, 5% and7%, glass crushed to have gradation of sand size).

Singh et al. 2014 [31] aimed to analyze CBR value of soil both (unsoaked and soaked) increases with the increase in coir fiber content. Both values of CBR are increases such as Soaked CBR value increases from 4.75% to 9.22% and unsoaked CBR value increases from 8.72% to 13.55% of soil with addition of 1% coir fiber. UCS of the soil increases from 2.75 kg/cm² to 6.33 kg/cm² with addition of 1% randomly distributed coir fiber. By using coir fiber reports that it reduces the thickness of pavement as well as cheap in cost and it is economical in terms of cost and energy to increase the bearing capacity of the soil. So, the economy of the highway construction will be achieved. Coir fibres are used to improve the strength, characteristics and behaviour of soil.

Singh and Arif 2014 [32] were conducted an laboratory test on silty sand (SM) (local soil) mixed with different percentage of coal ash 20%, 30%, 40% and 50% and coir fibre 0.25, 0.50, 0.75 and 1.0% by weight. They conducted UCS test and CBR tests on the soil mixed with coal ash, coir fibre. They observed the improvement in UCS and CBR value by addition of 20% of coal ash in the soil. Their results showed that the UCS value is maximum (1.81 kg/cm2) for 20% of coal ash added with soil and the un-soaked and soaked CBR values was increased from 10.5% and 5.6% to 27.7% and 14.6%, respectively. Increase in CBR values further decreases with the addition of coal ash beyond 20%. Randomly distributed coir fibre is added in optimum soil-coal ash mix (i.e. 80% soil and 20% coal ash) and coir fibre varies as 0, 0.25, 0.50, 0.75 and 1.0%. UCS value increases with addition of coir fibre in soil - coal ash mix. The optimum percentage of soil mixed with coal ash and coir fibre is achieved at 79.75:20:0.25 (by weight).

John and Rachel 2016 [33] investigate the effect of randomly distributed bamboo fibers on strength behaviour of fly ash improving black cotton soil. The optimum percentage of fly ash was used to be 20% by weight of soil. In this study Bamboo fiber of average diameter 0.45 mm and 25 mm length is used. It was randomly mixed with the fly ash treated soil at four different percentages of fiber content, i.e. 0.25, 0.5, 0.75 and 1% (by weight). The reinforced soil samples were subjected to UCS test and compaction tests. They found that strength properties of Black Cotton soil-fly ash specimens reinforced with bamboo fibers is better than untreated Black Cotton soil. For black cotton soil treated with fly ash the optimum fibre content of 1% (by weight) is recommended for strengthening.

Singh and Mittal 2014 [25] investigate the effect on clayey soil with addition of coir fibres in varying percentage. Soil samples are prepared for unconfined compression strength (UCS) and California bearing ratio (CBR) tests at its MDD corresponding to its OMC in the mould without and with coir fiber. The laboratory test were conducted on different percentage of coir fiber by weight of soil is taken as 0.25%, 0.50%, 0.75% and 1% and corresponding to each coir fiber content unsoaked and soaked CBR and UCS tests are done. Both unsoaked and soaked CBR value of soil increases with the increase in fiber content. Soaked CBR value increases from 4.75% to 9.22% and unsoaked CBR value increases from 8.72% to 13.55% of soil mixed with 1% coir fiber. UCS of the soil increases from 2.75 kg/cm² to 6.33 kg/cm² with addition of 1% randomly distributed coir fiber. Adding of coir fiber reduces thickness of pavement due to increase in CBR values and reduce the cost of construction.

Peter et al. 2014 [34] they found soft soils form problematic subgrade for pavements due to its low bearing capacity and strength. Pavement loads coming on the soft soil which may cause pumping actions when they are located in areas with high water table which causes both construction problems. The common solutions on such problems include excavation and replacement of soil, lime treatment, or chemical stabilization. Excavation and replacement of soil becomes very expensive. Stabilization of soil using various additives can improve the properties of soils. A recent trend in stabilization is to utilize locally available industrial or natural wastes to improve the properties of soft soils. This method has the two advantage which are they increased the strength of soil and such wastes are easily dispose. Coir waste includes coir pith and coir fibre is a by-product of coir manufacturing industry gained from coconut husk. This paper presents a study on the behaviour of soil stabilized with varying percentages of coir pith (0-3%) and coir fibre (0-1%) by carrying out laboratory tests. The results of test showed that stabilization with coir fibre waste had a significant effect on the compaction, Elastic modulus as well as CBR characteristics.

IV. Concluding Remarks

1. Coir fibre is a helpful biodegradable waste which improves characteristics of all types of soil.
2. Coir Fibre used in different proportion and different lengths have an effect on the soil properties.
3. Additional work is done on degradation of fibre waste. Coir fibre mixed with using fly ash further increases the characteristics of soil used for different construction work.
4. The C.B.R. value of soil reinforced with coir fibres is increased. Therefore addition of coir fiber is helpful in increasing CBR value and hence, thickness of pavement reduces in high rainfall area. If fly ash and coir fibre used for soil stabilization it will overcome the environmental hazard caused by coir fibre. For improvement of ground it wills cheapest method.

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