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Effect of KOH Treated Coir Pith on Compressive Strength of Clayey Silt

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Abstract: *Kuttanad soils are low strength soft clay or silt deposits found in the Kuttanad areas of the Alappuzha district, Kerala. Due to its low load-bearing and high shrinkage characteristics, the structures and pavements constructed over were unstable. Treatment with appropriate chemical additives is one of the accustomed and economic techniques in soil stabilization practice for improving the characteristics of weak soil. Traditional stabilizing agents like cement, lime, etc. are becoming less environmentally friendly and costly. Coir pith (treated and untreated) is proposed in this study. Coir pith was treated using potassium hydroxide. Initial tests like natural water content, specific gravity, Atterberg's limit test, hydrometer analysis, compaction test, unconfined compressive strength tests were conducted to find the properties of natural soil. Proctor compaction tests, unconfined compression tests are to be performed to investigate the effectiveness of the coir pith to control the volume change and increase the soil strength. Maximum dry density increases with treated coir pith whereas OMC decreases. UCS test results shows an increase in strength which confirm that treated and untreated coir pith are able to effectively stabilize the natural expansive soil.*

Keywords: KOH, Coir pith, CP, UCC test, Standard proctor test.

I. INTRODUCTION

Kuttanad comprises an area of about 900 sq.km in Central Kerala. The place is well known for its very low shear strength and high compressibility. The soil in this region is soft organic silt or clay formed by the slow silting up of an excessive backwater tract. At many places road embankments have failed due to the poor bearing capacity of the subsoil. Continuous settlements of road embankments are common. Designing foundations for bridges and other bearing structures is a highly complicated problem in this area and there has been many examples of failures or heavy settlements of built-in abutments of bridges. Soil in this region is characterized by low bearing capacity hence construction works on Kuttanad soil is often problematic and expensive. Traditionally stabilization in Kuttanad soil is done by hydrated lime, Portland cement, fly ash, etc. Stabilization of weak soil with industrial by products are commonly adopted nowadays because of its economical as well as environmental benefits. Coir pith is light in weight and will cause environmental nuisance if it is disposed on open site. Chemical treatment improves the physical, mechanical, and thermal properties of the coir composite. Therefore, in order to effectively utilize coir pith, it is treated with KOH and used in this work for stabilizing the soil.

II. MATERIALS USED

2.1 Soil

The soil to be used in the study is collected from Muttar region of Kuttanad, Alappuzha district. The soil is collected from a depth of 1.0 m from the ground surface. The properties of soil sample are presented in table 1. From the plasticity characteristics as per IS specification the soil is found to have high plasticity.

Table 1: Properties of Soil

Property	Value
Specific gravity	2.16

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Natural water content (%)	95.4
Clay content (%)	21
Silt content (%)	63
Liquid limit (%)	58
Plastic limit (%)	43.82
MDD (g/cm3)	1.3
OMC (%)	32
UCC (kPa)	44

2.2 Coir Pith

Coir pith was obtained from an online purchasing site. It was kept in water for expanding and then sun dried. Later it was sieved through 4.75mm sieve.

Table 2: Properties of coir pith

Property	**Content**
Specific surface area (m^2/g)	167
Micropore Area	89.3
Micropore Volume	75
Moisture Content	6.35 ± 1.12
pH	5.68 ± 0.01
Porosity	93.11

2.3 Potassium Hydroxide

Potassium hydroxide commonly referred to as *caustic potash,* is a base that is marketed in several forms including pellets, flakes, and powders. It is used in various chemical, industrial and manufacturing applications. Potassium hydroxide is used in food to adjust pH, as a stabilizer, and as a thickening agent.

III. EXPERIMENTAL WORK

Coir pith content was varied as 3,6,9,12,15% by weight of the soil. Standard proctor tests, unconfined compressive strength tests were performed on each specimen to determine the maximum dry density, compressive strength values. Later coir pith was treated with 5% concentration of KOH and the above tests were repeated.

3.1 Untreated Coir Pith

3.1.1 Standard Proctor Test

Indian standard light compaction tests were performed with different percentages of coir pith as per IS-2720-part 7(1980). Maximum dry density and optimum moisture content was determined.

3.1.2 Unconfined Compressive Strength Test

Unconfined compressive strength tests were performed with different percentages of coir pith as per IS-2720-part 10(1991).

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3.2 Treated Coir Pith

3.2.1 Standard Proctor Test

Indian standard light compaction tests were performed with different percentages of coir pith treated with 5% KOH as per IS-2720-part 7(1980). Maximum dry density and optimum moisture content was determined.

3.2.2 Unconfined Compressive Strength Test

Unconfined compressive strength tests were performed with different percentages of coir pith treated with 5% KOH as per IS-2720-part 10(1991).

IV. RESULTS AND DISCUSSION

4.1 Untreated Coir Pith

4.1.1 Standard Proctor Test

Standard proctor tests are conducted on soil samples with 3, 6, 9, 12, 15% coir pith. Maximum dry density decreases with increase in coir pith content. This is due to low specific gravity of coir pith which replaces the soil. MDD reduced to 1.19g/cc for 3% CP and further reduced to 0.99g/cc for 12% CP content. OMC increased to 44% at 12% CP. Optimum coir content was found to be 12%. Fig 1,2 represents the variation of MDD and OMC with addition of varying percentages of coir pith.

Table 3: MDD, OMC values for varying percentages of CP

CP (%)	MDD (g/cc)	OMC (%)
3	1.19	33
6	1.13	36
9	1.05	41
12	0.99	44
15	1.3	38

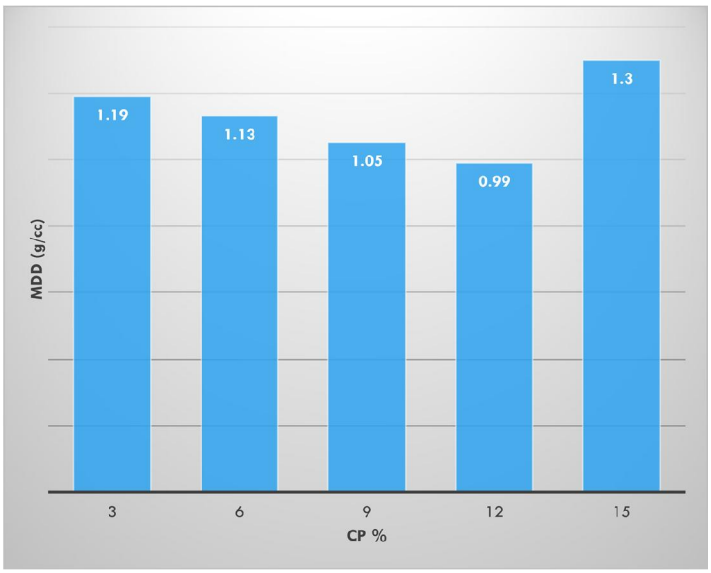

Fig 1: MDD values for varying % of CP

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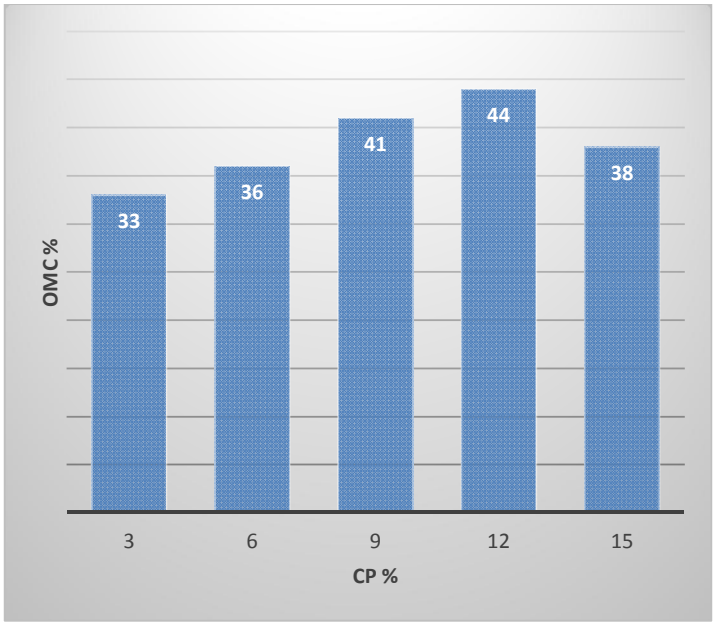

Fig 2: OMC values for varying % of CP

4.1.2 Unconfined Compressive Strength Test

UCS tests are conducted on soil samples with 3, 6, 9, 12, 15% coir pith. Compressive strength increases due to bonding between soil and coir pith. Bonding increases up to optimum content and then it decreases resulting in loss of strength. Optimum coir content was found to be 9%. Fig 7 represents the variation of compressive strength with addition of varying percentages of coir pith. UCC value of plain soil was 44 kN/m^2 and increased to 95.93 kN/m^2 by the addition of 9% coir pith to soil. Later it reduced to 74.61 kN/m^2 at 15% of coir pith.

Table 4: q_u values for varying percentages of CP

CP (%)	q_u (kN/m^2)
3	56.44
6	76.73
9	95.93
12	87.39
15	74.61

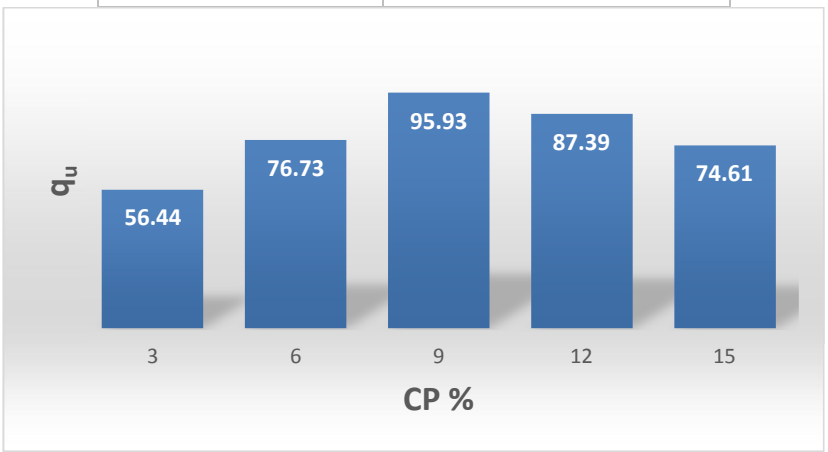

Fig 3: q_u values for varying percentages of CP

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4.2 Treated Coir Pith

4.2.1 Standard Proctor Test

Compaction tests are conducted on soil samples with 3, 6, 9, 12, 15% coir pith +5% KOH. Maximum dry density increases with increase in coir pith content. This is due to improved characteristics of coir pith. MDD increased to 1.44g/cc for 12% CP+5% KOH and further reduced to 1.41g/cc for 15% CP+5% KOH. OMC decreased to 28% at 12% CP+5% KOH. Optimum coir content was found to be 12%. Fig 4, 5 represents the variation of MDD and OMC with addition of varying percentages of additive.

Table 5: MDD, OMC values for varying percentages of CP + 5% KOH

CP (%) + 5% KOH	MDD (g/cc)	OMC (%)
3	1.34	37
6	1.36	35
9	1.38	33
12	1.44	31
15	1.41	30

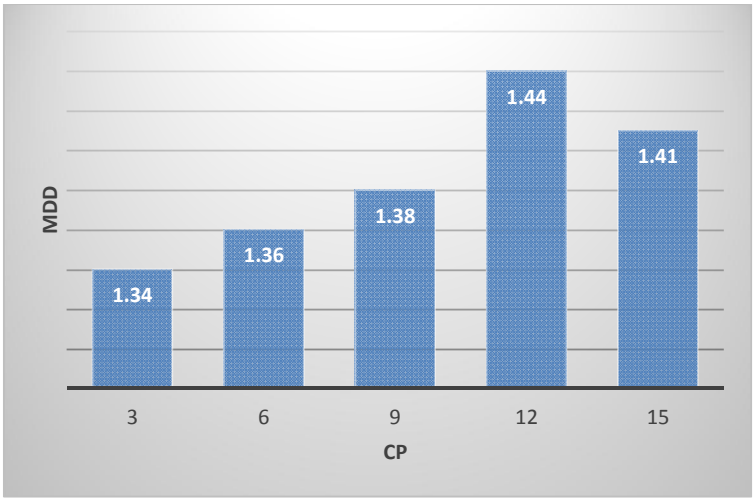

Fig 4: MDD values for KOH treated CP in varying percentages

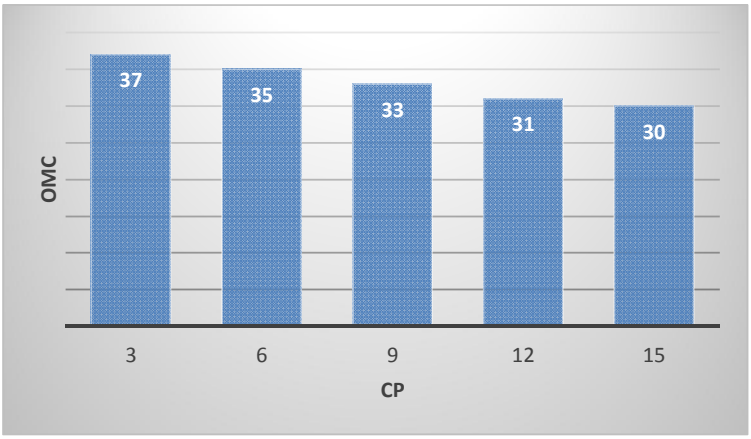

Fig 5: OMC values for KOH treated CP in varying percentages

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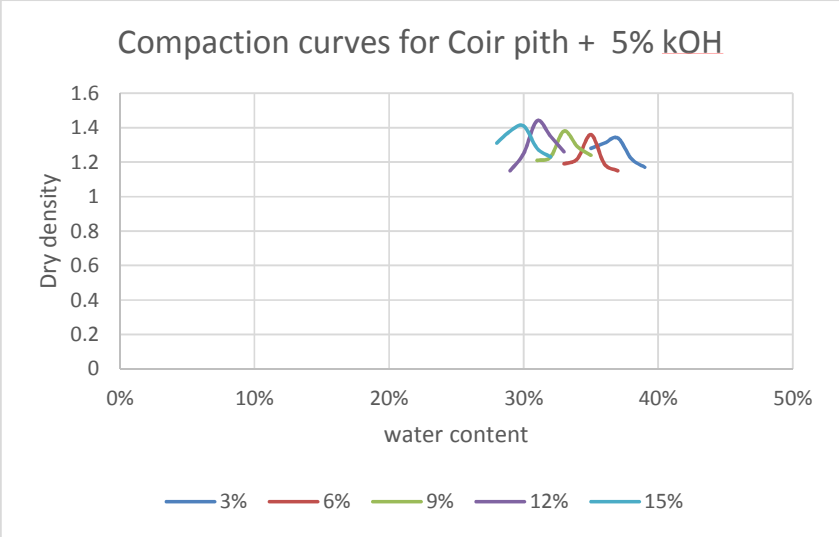

Fig 6: Compaction curves for coir pith + 5% KOH in varying percentages

4.2.2 Unconfined Compressive Strength Test

UCS tests are conducted on soil samples with 3, 6, 9, 12, 15% coir pith treated with 5% KOH. Compressive strength increases due to bonding between soil and coir pith. Bonding increases up to optimum content and then it decreases resulting in loss of strength. Optimum coir content was found to be 9%. Fig 7 represents the variation of compressive strength with addition of varying percentages of coir pith +5% KOH. UCC value increased to 92.46 kN/m^2 by the addition of 9% coir pith +5% KOH to soil. Later it reduced to 60.87 kN/m^2 at 15% of additive.

Table 6: q_u values for varying % of Coir pith + KOH

CP (%)	q_u (kN/m^2)
3	48.32
6	68.24
9	92.46
12	87.17
15	60.87

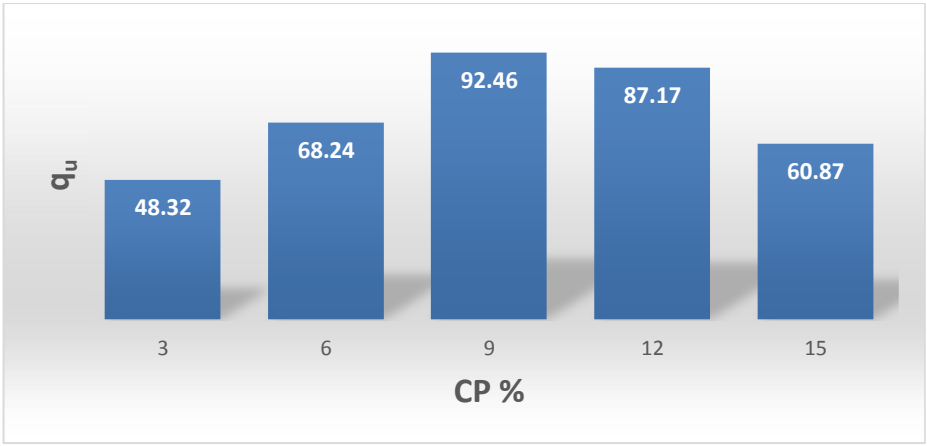

Fig 7: q_u values for varying % of Coir pith + KOH

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V. CONCLUSION

The unconfined compressive strength tests were carried out as per Is-2720 – part 10. (1991) and unconfined compressive strength of each soil- coir pith mix was obtained. Bonding between the soil and fibre increases up to optimum content. When the fibre content increases after optimum content, there is a lack of proper bonding between the soil and fibre content. Optimum coir pith was obtained as 9% as per UCC test. Indian standard light compaction tests were performed with different percentages of coir pith treated with 5% KOH as per IS-2720-part 7(1980). Maximum dry density and optimum moisture content was determined. As the untreated coir pith content increases maximum dry density of soil decreases. This may be due to the replacement of soil with coir pith of specific gravity less than the soil. MDD increased when KOH treated coir pith was added to soil, optimum content being 12% as per standard proctor test. 10.77% improvement in MDD was observed in KOH treated CP – soil mixture. Percentage improvement of UCC value for KOH treated CP soil mixture was 110.13%.

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