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Effect of Sawdust Ash and Coir Fibre on the Strength Characteristics of Kaolinite Clay

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***Abstract*—Indiscriminate disposal of waste material causes serious problems to the environment and to humans. Sawdust is a waste material produced from wood mills in large quantities and less care is taken for their disposal. They result in severe landfill and health problems. Effective utilization of sawdust can be done by checking its suitability as a stabilizer in soil. The present study aims at finding the effect of sawdust ash on the strength characteristics of kaolinite clay along with the addition of randomly distributed coir fibre. Coir fibre is a natural fibre abundantly available in Kerala. The various percentages of sawdust ash is added and its optimum is obtained. Coir fibre were added at varying percentages to sawdust ash soil mix. The tests conducted were standard proctor test and unconfined compressive strength tests in order to check if sawdust ash and coir fibre can be effectively used to improve the strength characteristics of kaolinite clay thereby helping in curbing the landfill problems. The test result shows that the addition of sawdust ash and coir fibre increased the strength characteristics of kaolinite clay.**

Keywords—Sawdust ash; Coir Fibre; Compaction; UCC;

I. INTRODUCTION

Soil stabilization is the process of treating a soil in such a manner so as to maintain, alter or improve the performance of the soil. The changes in soil properties are brought about by the incorporation of additives or by mechanical blending of different soil types. It can be also referred to as the process of changing the soil properties to improve strength and durability. The use of soil stabilization finds it way as abandoned sites due to undesirable soil bearing capacities dramatically increased, and the outcome of this was the scarcity of land and increased demand for natural resources. The most commonly used methods are using additives like cement, lime or flyash or by mechanical means such as a vibro compaction. The suitability of the additive and its effect on the soil properties can be determined using laboratory tests followed by field tests. The main properties of soil which are of interest to engineers are volume stability, strength, compressibility, permeability and durability.

The primary purpose of reinforcing soil is to increase the bearing capacity and reduce the lateral deformations. The random distribution of fibre generally interlock soil particle and aggregates into a single coherent mix.

Sawdust is the term given to the product formed after grinding of wood log. Huge quantity of sawdust is generated due to urbanization. The sawdust thus generated causes damage to health and environment. As a method of their disposal the sawdust is disposed in open areas and landfill causing environmental pollution and landfill problems. The use of sawdust ash in soils can prove to be an effective method for the disposal of sawdust. This study aims in finding the suitability of sawdust as a stabilizer in soils. The figure shown below shows the improper disposal sawdust ash near the sawmills. It can be seen that sawdust even posses threat to the proper working of the machine.

Coir fibre is a naturally occurring fibre obtained from the husk of coconut. They are mainly classified into brown fibre and white fibre. Brown fibres are strong, thick and are resistant to abrasion. When the fibres are extracted from immature coconuts they are white in colour having soft touch properties and lesser strength compared to brown fibres. The advantages of coir fibre are its initial strength and stiffness. They are very cheap and easily available. They have longer lige compared to other natural fibres due to its high lignin content. They are environment friendly and are biodegradable.

II. LITERATURE REVIEW

Butt etal., (2016) conducted extensive experimental demonstrate the soil improvement prospective of saw dust ash (SDA) by performing California bearing ratio (CBR) and unconfined compression strength tests. The experimental study has revealed that the addition of SDA results a significant increase in CBR and unconfined compressive strength.

Venkatesh and Srinivasa Reddy (2016) observed that 5. 4% of dry density was increased in addition of 2% of WSDA and then dry density was reduced gradually on increasing the percentage of Waste Saw Dust Ash. Permeability of soil was also reduced.

Rao etal.,(2012) Sawdust was mixed in soil in 5%, 10%,15%, 20% and 25% in dry weight of the soil. It was found that the O.M.C of the marine clay decreased by 15.37% on addition of 15% Sawdust and it has been further decreased by 17.91% when 4% lime was added. The utilization of industrial wastes like saw dust is an alternative to reduce the construction cost of roads particularly in the rural areas of developing countries.

Rout et al.,(2017) studied the influence of the inclusion of fly ash and coir fiber on strength properties of soft soil. Fly ash and coir fibre increased CBR and dry density.

III. OBJECTIVES

- To find the changes in the strength characteristics of kaolinite clay with addition of varying percentages of sawdust ash i.e. 4%, 6%, 8% and 10% and find the optimum percentage of sawdust ash from the UCC test results.

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- To find the changes in the strength characteristics of soil-sawdust ash mix with the varying percentages of fibre i.e 0.25%, 0.5%, 0.75% and 1%.
- To find the optimum percentages of soil-sawdust ash-fibre mix.

IV. MATERIALS USED

A. Soil

The soil used for the study was Kaolinite clay collected from English India Clay Limited, Thiruvananthapuram, Kerala. The basic properties of the kaolinite clay used for the study is shown in table 1. The soil falls under the category of highly compressible clay.

Table 1: Properties of soil

Sl No.	***Properties***	***Results***
1.	% clay	67.4%
2.	% silt	34.02%
3.	Liquid Limit	72%
4.	Plastic Limit	25%
5.	Plasticity Index	47%
6.	Shrinkage Limit	18%
7.	Optimum Moisture Content	34%
8.	Maximum dry density	1.4 g/cc
9.	Unconfined Compressive Strength	103 kN/m^2
10.	CBR	3.8%
11.	Specific Gravity	2.58
12.	Soil Classification	CH

B. Sawdust Ash

The sawdust ash used for the study was collected from nearby sawmills.

Fig 1. Sawdust Ash

Table 2. Chemical composition of Sawdust Ash.

Sl No.	***Chemical Composition***	***Value***
1.	SiO_2	65.42
2.	Al_2O_3	5.69
3.	Fe_2O_3	2.16
4.	CaO	9.82
5.	MgO	4.23
6.	SO_3	1.06
7.	Na_2O	0.04
8.	K_20	2.38
9.	$CaCO_3$	7.89

C. Coir Fibre

The coir fibre was collected from Alleppy District, Kerala. The coir fibre was cut into uniform length of 15mm.

Fig 2. Coir Fibre

V. METHODOLOGY

Standard proctor test and unconfined compressive strength tests were conducted with clay and sawdust ash at 4%, 6%, 8% and 10%. The optimum percentage was taken as the percentage which gave the maximum unconfined compressive strength value. To the optimum percentage of soil sawdust ash mix coir fibre was added at 0.25%, 0.5%, 0.75% and 1%. Unconfined compressive strength tests were conducted. The percentage of soil-sawdust ash-coir fibre which gave the maximum strength was taken as the optimum value.

A. Standard Proctor Test

The standard proctor test was carried out as per IS 2720 (part VII) 1980 at 4%, 6%, 8% and 10% of sawdust ash by dry weight of the soil. As per IS 3 kg of soil is to be taken for the compaction test and to the soil water is added at varying percentages. The soil mixed with a certain water content is filled in the mould in 3 layers with 25 blows for each layer. The test is repeated with varying water content and the dry density vs moisture content graph is plotted. The peak density value gives the maximum dry density and the corresponding water content will be the optimum moisture content. The optimum moisture content and dry density was found out for varying percentages of sawdust ash after plotting the variation of dry density and moisture content for each percentage of soil-sawdust ash mix.

B. Unconfined Compressive Strength Test

The mixture of soil- sawdust ash was compacted in 50mm diameter and 100mm height of cylindrical mould at maximum dry density and optimum moisture content obtained from standard proctor test. Then the sample was extracted from the mould for the unconfined compressive strength test. The experiments were performed at a consistent strain rate of 0.125mm per min according to Indian Standard 2720 (part 10) 1991. The UCS value was calculated from the Stress-Strain curve.

After conducting the UCC tests at varying percentages od sawdust ash, mixture of soil-sawdust ash-coir fiber was compacted in 50mm diameter and 100mm height of cylindrical mould to standard proctor's MDD. The samples were prepared with inclusion of soil with optimum percentage of sawdust ash and soil and 0.25%, 0.5%, 0.75% and 1% of coir fiber. The UCS value was calculated from the Stress-Strain curve.

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VI. METHODOLOGY

A. Compaction Characteristics:

From fig 2. It can be seen that the dry density value with varying percentage of sawdust is lower than the density of the soil. It is mainly be due to the replacement of soil particles with sawdust ash of lower specific gravity. It can also be seen that the optimum moisture content increased with increase in percentage of sawdust ash. This may be due to higher amount of water required to hydrate the surface of sawdust ash particle.

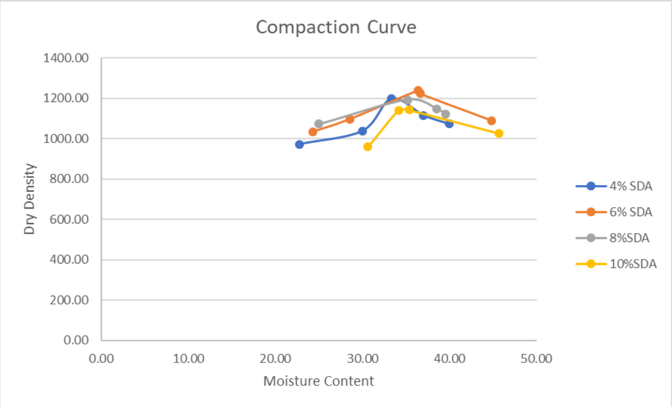

Fig 3. Compaction Curve

B. Unconfined Compressive Strength

- Soil-Sawdust Ash mix.

The Unconfined Compressive strength of soil with varying percentage of sawdust ash is given in Table 3.

The Sawdust ash was added at 4%, 6%, 8% and 10& percentage weight of the soil taken.

Table 3. UCC values of soil-sawdust ash mix

Percentage of sawdust ash(%)	***UCC(kN/m^2)***
0	103
4	89.6
6	106.52
8	147.82
10	96.4

From the UCC values obtained, it can be seen that 8% Sawdust ash gave the maximum unconfined compressive strength with an increase of 44% from the UCC value of kaolinite clay. Therefore 8% sawdust ash was taken as the optimum percentage of sawdust ash in the soil. The increase of the unconfined compressive strength may be due to the bond formed between soil and sawdust ash due to the pozzolanic reactions between soil and sawdust ash.

- Soil-Sawdust ash-Coir fibre.

The UCC value of coir fibre reinforced saoil-sawdust ash mix is given in table 4.

Table 4. UCC values with 8% Sawdust Ash and varying percentages of fibre

Percentage of sawdust ash and coir fibre	***UCC(kN/m^2)***
8% SDA+0% fibre	147.82
8% SDA+0.25% fibre	151.88
8% SDA+0.5% fibre	152.96
8% SDA+0.75% fibre	161.65
8% SDA+1% fibre	150.78

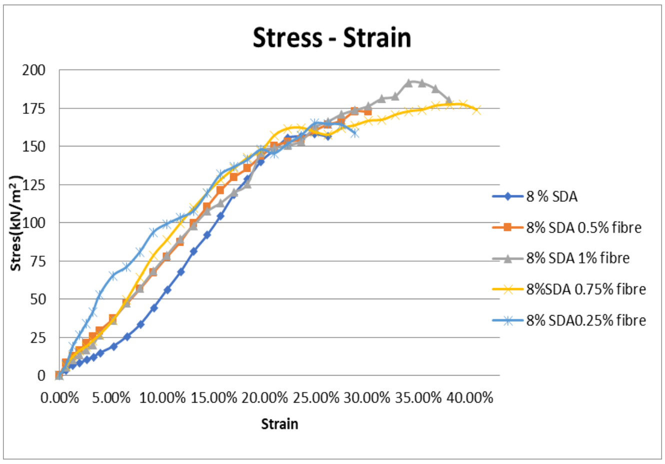

Fig 4. Stress-Strain curve with varying percentages of coir fibre

From table 4 it can be seen that the UCC value increased with increase in fibre content. At 0.75% and 8% sawdust ash fibre content the value increased by 57% of that of kaolinite clay. From the graph it can be seen that the strain is higher for fibre reinforced soil when compared to stabilized soil. The higher strain value indicates that the behavior the stabilized soil changed from brittle to ductile on the addition of coir fibre showing that the soil could undergo larger deformation prior to its failure with the addition of coir fibre.

The UCC value was maximum at 0.75% fibre showing an increase of 10% from the value obtained for unreinforced stabilized soil. The decrease in the UCC value after 0.75% if fibre may be due to the lesser soil-fibre interactions as fibre-fibre interaction will be more pronounced. The decrease of UCC after 8% sawdust ash may be due to replacement of lesser density sawdust ash particle replacing higher density soil particle. Therefore 8% SDA and 0.75% coir fibre can be adopted as the optimum percentage of stabilizer and coir fibre for kaolinite clay

VII. CONCLUSION

From the various laboratory tests conducted, the following conclusions were drawn.

- With increase in sawdust ash content there was decrease in dry density and increase in the optimum moisture content.
- With increase in sawdust ash content to 8% the unconfined compressive first decreased and then increased by 44% and after that it again decreased.
- With the inclusion of coir fibre the unconfined strength increased by 10% at 0.75% coir fibre.
- With the inclusion of randomly distributed coir fibre the strain value increased showing ductile behavior of the sawdust ash stabilized soil.
- The addition of coir fibre limited the potential plane of weakness resulting in the ductile behavior of the soil.

With the above listed conclusions it can be inferred that sawdust ash can enhance the strength characteristics of kaolinite clay and further increase in strength was achieved with addition of coir fibre.

Therefore 8% sawdust ash and 0.75% fibre can be considered as the optimum percentages of stabilizer and coir fibre for kaolinite clay.

Therefore, the landfill and environmental problems caused by sawdust ash can be reduced.

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