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Improving of Soil Properties with Partial Replacement of Palm Oil Fiber Ash and Roofing Tiles Waste Powder

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***Abstract*:- The utilization of waste materials for soil improvement has gained significant attention in recent years due to its potential for sustainable and cost-effective solutions. This abstract focuses on the use of palm oil fiber and roofing tiles waste for improving the properties of soil.Palm oil fiber, a byproduct of the palm oil industry, and roofing tiles waste, generated from construction and demolition activities, are two abundant waste materials that can be potentially utilized for soil stabilization and enhancement. This study aims to investigate the effects of incorporating these waste materials into soil and assess their impact on various soil properties. Mix proportions of palm oil fibre and roofing tiles waste is 5%,10%,15% of dry weight of soil. By using palm oil fiber ash and roofing tiles waste powder strength and load bearing capacity of soil are improved.**

***Keywords*: Soil, Palm oil fiber ash, Roofing tiles waste powder**

1. INTRODUCTION

Soil is a base of structure, which actually supports the structure from beneath and distributing the load efficiently. Since soil stabilization is done mostly for expansive soils, there is need for stabilizing agents. Almost all over India Expansive soils are wide spread. For Civil Engineers major problem arises during stabilization of these Expansive Soils. This is because Expansive Soils swell significantly when come in contact with water and shrink when the water squeezes out. Therefore these soils are also known as Shrink-Swell Soils. Black Cotton Soils is one of the Expansive Soils which exhibits the same behaviour just like the Expansive Soils. Due to this alternate Shrink Swell behaviour volume changes will occur in soil and it can cause cracking and settlement of different Civil Engineering structures.Number of techniques are available to improve the engineering properties and index properties of Black Cotton Soils. Stabilization is one of these techniques. Stabilization using dust/powder like waste materials with or without binder like lime and cement, Quarry dust, marble dust, brick powder etc. Soil can be either modified or stabilized by many methods, including chemical, mechanical, thermal and electrical. Modification is generally short term and includes, benefits such as improvement in workability. Stabilization generally results in a longer term strength gain.

2. LITERATURE REVIEW

Abdullah (2009) The performance of the stabilized silty soil will decrease if the ratio of POFA and lime exceeding 2:6. The strength development of soil treated with lime and POFA is increasing with respect to the curing time. As a conclusion, POFA can be used to treat the silty soil as well as reduce the environmental problem.

Foo and Hameed (2009) the expanding of oil palm ash in numerous field of application represents a plausible and powerful circumstance, for accruing the worldwide environmental benefit and shaping the national economy.

Pourakbar et al (2015) Palm oil fuel ash (POFA) in both cost-effective and environmentally friendly ways has potential applications in soft soil stabilization. The results of the compaction test indicate that the utilization of POFA and POFA/cement mixture in soft soil stabilization decreases the optimum moisture content and increases the maximum dry density across selected binder dosages. The results show that using POFA alone to stabilize clayey soil results in a slight increase in the UCS of the specimens until the 28 days of curing, whereas combining POFA with cement results in a sharp increase in the UCS of the samples in the same curing time.

Mujah et al (2015) The result showed that the improvement factor portrayed by the smaller particle size of the ground POFA was much more pronounced as compared to the larger particle size. Similar trend was found in the consolidation results especially when the soft soil sample was fully saturated. Also, the shear strength parameters of the reinforced soft soil with ground POFA increased significantly at about 50%–60% for both the internal

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friction angle and the cohesion values.

Otoko et al (2016) The fly ash (palm ash) is classified as class F according to ASTM C618. It is siliceous and aluminous with virtually little or no cementation value. Therefore for pozzolanic reaction it has to be combined into a little lime. An Optimum of 5 % lime was obtained for pozzolanic reaction. This combines with 3 % optimum palm ash to give best results of soaked and unsoaked CBR. Thus, the palm ash can successfully be used for soil subgrade stabilization.

Upadhyay And Kaur (2016) Soil stabilization using waste ceramic dust is one of such method, which can be used to improve the geotechnical properties of soil. For satisfactory performance of the structure put on such soil, the properties of such soil need to be improved. The ceramic waste can be mixed with waste materials to obtain better results.

Neeladharan et al., (2017) On the basis of different composition of tile waste and sodium hydroxide as binder, liquid limit test, plastic limit test, falling head permeability test, standard proctor test, California bearing ratio test(CBR), direct shear test were conducted on soil sample and checked the improvement in engineering properties of soil.

Cabalar et al., (2017) Waste ceramic tile contents in the mixtures were 0 %, 5 %, 10 %, 15 %, 20 %, and 30 % by dry weight of the specimens. Test results revealed that addition of waste ceramic tile increases the CBR value of soil, while addition of it reduces the UCS value of soil. Besides, an increase in dry unit weight (γ_{dry}) and a decrease in corresponding water content (w) by an increase in the amount of waste ceramic tile were observed in the compaction tests. Further, the results of the tests show a decrease in the void ratio (e) with an increase in the amount of waste ceramic tiles.

James and Pandian (2018) The results indicated that the addition of CD resulted in a marginally negative influence on the early strength of the stabilized soil at three days of curing whereas it enhanced the delayed strength of the soil at 28 days of curing, gaining between 12-14 % strength. The effect of CD on the plasticity and swell-shrink of lime stabilized soil indicated a further reduction in plasticity and swell-shrink nature.

Sukmak et al.,(2019) The optimum Na_2SiO_3:NaOH ratios providing the highest strength were at 40:60, 50:50, and 60:40 for POFA:SS ratios of 30:70, 40:60, and 50:50, respectively. The L providing the highest strength was determined at the optimum liquid alkaline activator content, OLC ($L = 22.8\%$), 1.2OLC ($L = 31.4$ %) and 1.4OLC ($L = 44.55$ %) for POFA:SS ratios at 30:70, 40:60, and 50:50, respectively.

Asrah et al., (2020) The maximum compressive strength of 39.2 MPa was obtained with UF-10 at 24 days curing. Increasing the amount of ultrafine POFA to 40 % decreases the strength to 19.26 MPa. The utilization of ultrafine POFA into bricks has produced bricks with good engineering properties compared to the unground POFA brick.

Iravanian et al., (2020) With using addition ceramic waste liquid limit LL, plastic limit PL and plasticity index PI of soil reduces. California bearing ratio CBR of clay soil increase with more amount of ceramic waste. There is 150 % rise in soaked CBR performance of treated soil compared to untreated soil by increasing 30 % in ceramic dust.

Mahmood et al., (2020) Results showed that the dry density of the peat samples increased with the increase in POFA content. The POFA-peat composites showed an increase of 4 times the untreated peat value. Also, CBR values for these composites increased from 31 to 42 fold, in comparison with untreated peat. The peat-POFA CBR values are rated as good materials for the purpose of road base or subbase construction.

Yaba (2021) The study showed that with an increase in ceramic dust from 0 to 5, and 10%, liquid limit, plastic limit, plasticity index, optimum moisture content of the clay soil decreased. On the other hand maximum dry density, unconfined compressive strength and California bearing ratio increased.

Hokabi et al., (2021) The results showed a decrease in the specific gravity with the addition of POFA and an increase with gypsum alone, as well as a decrease with a mixture of POFA and gypsum and a decrease in the soil plasticity index due to a better increase in the plasticity limit compared to the liquid limit. This is considered a sign of improved geotechnical properties and reduced linear shrinkage.Wahab et al., (2021) While the partial replacement of cement dosage in four others mixing proportions were replaced with 5 %, 10 %, 15 %, and 20 % of POFA. At 28 curing days, C85P15 achieved the highest value in unconfined compressive strength (UCS) test which was 107.6 kPa. In comparison to C100 and C80P20, C85P15 had lower carbon content, higher calcium content and lower silica and alumina content. Therefore, the ability of POFA to enhance the peat strength and effectively reduce the cement usage in peat stabilization is proved.

Chong et al., (2022) the optimum moisture content and plasticity index were reduced with the addition of ceramic tile dust. The unconfined compressive strength was improved about 1.4 times for residual soil with 30 % of ceramic tile dust

Edeh et al., (2022) Test results show that the properties of LS improved with oil palm fibre ash and cement treatment. The maximum dry density decreased with corresponding increase in optimum moisture content as the cement content increased from 0 % to 6 % and the LS content of the mixtures decreased with increased oil palm fibre ash, at a fixed per cent of cement. The peaked California bearing ratio of 190.09 % (soaked) recorded for the 80 % LS + 14 % OPFA + 6 % C mix proportion, with 14th day unconfined compressive strength of 785.75 kN/m^2, cohesion of 140 kN/m^2 and angle of internal friction of 25°, can be used as a base material in road construction.

Toyeb et al., (2023) The Soil-treated POFA stabilization gained the maximum compressive strength after curing for 28 days. Exhibit the increasing of compressive strength from 0.55 MPa to 1.04 MPa. The economic advantage with add of 20 % treated POFA was able to replace the cement between 5 % - 7.5 %. Thus, treated POFA is feasible to be used as a soil stabilization material by considering the curing times.

Isa et al., (2023) A range of soil mixtures was prepared by adding the different percentages of fine tile waste (TW): 5 % to 40 %. Including tile waste in the soil led to a decrease in

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its water-holding capacity, reducing the optimum moisture content required for optimal compaction. Meanwhile, the maximum dry density increased. The UCS, IDT, and FS improved when the optimum 15 % of TW was used in the mixes. However, the strength decreased after 20 % of the TW addition.

3. EXPERIMENTAL STUDY

3.1 Black cotton soil: The black soil is formed by the weathering of lava and cooling of lava after a volcanic eruption. The soil in the deccan plateau consist of black basalt soil, which is rich in humus iron and also contain high quality of magnesia lime and alumina. The texture and composition of this soil is formed by lava-the breakdown of igneous rocks using the volcanic action.

3.2 Palm oil fiber ash: Palm oil fiber ash is a byproduct obtained from the combustion of palm oil fibers. It has pozzolanic properties, meaning it can react with lime and moisture to form cementitious compounds. This makes it useful in soil stabilization and construction applications. The ash can enhance the mechanical properties of soil, such as strength and durability, making it a potential eco-friendly solution for improving soil conditions in various engineering projects.

3.3 Roofing tiles waste powder: The use of roofing tiles powder in soil stabilization involves incorporating this material into the soil to enhance its engineering properties. Roofing tiles powder, often a waste product from tile production, can function as a pozzolan, similar to other industrial byproducts. It may improve soil strength, reduce plasticity, and enhance durability when mixed with soil.Consider conducting laboratory tests to determine the appropriate dosage and effectiveness of roofing tiles powder for stabilizing the specific type of soil you're working with. This process can help optimize the mixture's performance in terms of load-bearing capacity and resistance to environmental factors.

3.4 METHODOLOGY:

Trail 1 (only black cotton soil)

Trail 2 (5 % Palm oil fiber ash + 5 % Roofing tiles waste powder + 90 % Black cotton soil)

Trail 3 (5 % Palm oil fiber ash + 10 % Roofing tiles waste powder + 85 % Black cotton soil)

Trail 4 (5 % Palm oil fiber ash + 15 % Roofing tiles waste powder + 80 % Black cotton soil)

Materials replaced by weight

4. TEST RESULTS

4.1 FREE SWELL INDEX

This is performed by pouring 10g of dry soil, passing through 425 micron sieve, into 100 ml graduatedcylinder filled with water. The volume of swelled soils is read after 24 hours.

$$\text{Free swell (\%)} = \left(\frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}}\right) \times 100$$

Table: 1 Test results of swelling

% of swelling	Trail 1	Trail 2	Trail 3	Trail 4
	70	37.5	23.07	00

Figure 1: swelling test

4.2 LIQUID LIMIT

Liquid limit is the watercontent where the soil starts to behave as a liquid. Liquid limit is measured by placing a clay sample in a standard cup and making a separation (groove) using a spatula. The cup is dropped till the separation vanishes. The water content of the soil is obtained from this sample.

Table: 2 Test results of liquid limit

Liquid limit at 25 blows (%)	Trail 1	Trail 2	Trail 3	Trail 4
	45	34	31.6	34.4

Figure 2 : Liquid limit test

4.3.1 PLASTIC LIMIT

Plastic limit (PL) is the moisture content at which a fine-grained soil cannot be remolded without cracking. The plastic limit test requires repeated rolling of a soil sample into a thread until it reaches a point where it crumbles.

Table: 3 Test results of plastic limit

Plastic limit (%)	Trail 1	Trail 2	Trail 3	Trail 4
	38.88	19.04	11.1	13.6

Figure 3: Plastic limit test

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4.3.2 PLASTICITY INDEX (PI)

The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL).

Table: 4 Plasticity index

Plasticity index (%)	Trail 1	Trail 2	Trail 3	Trail 4
	6.12	14.96	20.49	20.8

4.4 SPECIFIC GRAVITY

The ratio of specific gravity of the solid to the specific gravity of water. It can be obtained by measuring the weight of the solid to the weight of water occupying equivalent volume of water

Table: 5 Test results of specific gravity

Specific gravity	Trail 1	Trail 2	Trail 3	Trail 4
	2.11	2.38	2.34	2.63

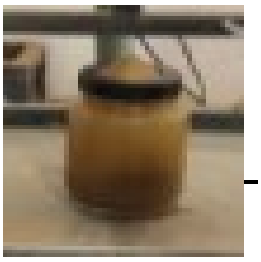

Figure 4: Specific gravity test

4.5 STANDARD PROCTOR COMPACTION

Densification of soil by reducing air voids by application of mechanical energy to improve their strength by increasing their unit weight

Table: 6 Test results of standard proctor compaction

Trails	Trail 1	Trail 2	Trail 3	Trail 4
Optimum moisture content (OMC) (%)	23.52	17.39	12.81	15.09
Maximum dry density (MDD) (g/cc)	1.62	1.71	1.74	1.84

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Figure 5 : Standard proctor Compaction test

4.6 CALIFORNIA BEARING RATIO (CBR)

The California Bearing test is an empirical test for determining the relative bearing ratio & expansion characteristics under known surcharge weight of base, sub-base and sub-grade soils for design of roads, pavements & runways.

Table: 7 Test results of CBR

Trails	**Trail 1**	**Trail 2**	**Trail 3**	**Trail 4**
CBR (%) at 2.5mm penetration	0.13	0.50	0.54	0.61
CBR (%) at 5mm penetration	0.10	0.56	0.54	0.56

Figure 6: CBR test

4.7 UNCONFINED COMPRESSION TEST (UCS)

The unconfined compression test is a type of triaxial test in which the confining pressure is taken as zero. The test is onlybe conducted in clayey soil specimens which can stand without confinement because of this case. The test is generally performed on intact (non-fissured), saturated clay specimens.

Table: 8 Test results of UCS

Cohesion (C_u) (Kg/Cm^2)	**Trail 1**	**Trail 2**	**Trail 3**	**Trail 4**
	106.81	194.64	226.14	315.93

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Figure 7: UCS test

4.8 GRAIN SIZE ANALYSIS

Sieve analysis is a method that is used to determine the grain size distribution of soils that are greater than 0.075 mm in diameter. It is usually performed for sand and gravel but cannot be used as the sole method for determining the grain size distribution of finer soil

Table: 9 Test results of grain size analysis

Trails	**Trail 1**	**Trail 2**	**Trail 3**	**Trail 4**
Co efficient of uniformity (C_u)	3.78	4.11	4.61	5.04
Co efficient of curvature (C_c)	0.82	0.52	0.59	0.73

Figure 8: Grain size analysis test

5. CONCLUSIONS

- The differential free swell of soil decreases with increase in the percentage of palm oil fiber ash and roofing tiles waste powder.
- With the addition of palm oil fiber ash and roofing tiles waste powder plastic limit and plasticity index of soil decreases.
- Specific gravity of soil increased from 2.11 to 2.63 with increase in the percentage of palm oil fiber ash and roofing tiles waste powder.
- Optimum moisture content of soil decreases as the percentage of palm oil fiber ash and roofing tiles waste powder increases.
- California bearing ratio of soil increases with the increase in the percentage of palm oil fiber ash and roofing tiles waste powder.
- The unconfined compressive strength of the soil increases with the increase in the percentage of palm oil fiber ash and roofing tiles waste powder.

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