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Stabilization of Soil Using Sawdust Ash, an Ecofriendly Approach

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***Abstract*— Silty soils have proved to be problematic to most Civil Engineering structures. Several researchers have tried to look for different materials which can alter the properties of these poor soils, and among them are lime and cement, which are expensive. Considering the vast quantities of sawdust produced in woodwork departments, they can be used as a secondary stabilizer, thus leading to sustainable technologies. Sawdust not only acts as a cheap stabilizer but also reduces the problem of environmental pollution caused by its poor disposal. This paper examines the geotechnical properties of expansive soil stabilized by sawdust ash. The sawdust used as partial replacement of soil in the ratio of 0, 2, 4, 6and 8% by the dry soil weight. The investigation was done by conducting laboratory tests on both stabilized and non-stabilized soils and the settlement analysis is also done on the same using Plaxis 2D software.**
***Keywords*: Saw dust ash, soil stabilization**

I. INTRODUCTION

Stabilization of soil using sawdust ash is a sustainable approach gaining attention in construction and civil engineering. Sawdust ash, a by-product of the wood industry, is rich in silica and pozzolanic materials. When mixed with soil, it can enhance its engineering properties, providing stability and durability to the construction material. This method not only reduces the environmental impact of sawdust ash disposal but also offers a cost-effective solution for soil improvement in various construction projects. The stabilization of soil using sawdust ash is a sustainable and innovative approach in civil engineering and construction. Sawdust ash, a by-product of the wood industry, offers unique properties that can enhance the engineering characteristics of soil. This method not only addresses waste management concerns but also contributes to the development of environmentally friendly construction practices. In this discussion, we will explore the benefits, mechanisms, and applications of stabilizing soil with sawdust ash, shedding light on its potential to revolutionize soil stabilization methods.

Soil stabilization, a crucial aspect of geotechnical engineering, has witnessed a paradigm shift towards sustainable and environmentally conscious practices. Among the innovative approaches gaining prominence, the utilization of sawdust ash as a soil stabilizer emerges as a promising solution. This byproduct, generated from the combustion of sawdust, possesses unique properties that can significantly enhance the engineering characteristics of soil. At its core, soil stabilization aims to improve the mechanical and geotechnical properties of soil, ensuring its suitability for construction and infrastructure projects. Traditionally, cement and lime have been employed for this purpose, but the environmental impact and resource consumption associated with these materials have prompted a search for more sustainable alternatives. Sawdust ash, a residue from biomass combustion, provides an eco-friendly option due to its pozzolanic nature. The pozzolanic reaction is a key mechanism driving the effectiveness of sawdust ash in soil stabilization. When incorporated into soil, sawdust ash reacts with calcium hydroxide, a byproduct ofcement hydration, to form additional cementitious compounds. This chemical process results in the development of a stable and durable material, effectively mitigating the challenges associated with weak or expansive soils. One of the notable advantages of using sawdust ash lies in its ability to enhance the strength characteristics of soil. The pozzolanic reaction leads to the formation of compounds like calcium silicate hydrate (CSH), contributing to increased cohesion and improved load-bearing capacity. This enhancement is particularly valuable in areas with weak or problematic soils, where traditional stabilization methods may fall short. Beyond strength improvement, sawdust ash aids in reducing soil compressibility. The pozzolanic reaction alters the soil's microstructure, minimizing void spaces and promotion a denser matrix. This reduction in compressibility not only enhances the soil's load-bearing capacity but also mitigates issues related to settlement, making it an attractive solution for construction projects where soil consolidation is a concern. Durability is another critical aspect of soil stabilization, especially in regions prone to environmental stresses. Sawdust ash, with its pozzolanic properties, imparts resistance to chemical attack and weathering, ensuring the stabilized soil maintains its integrity over time. This durability factor enhances the longevity of structures built on stabilized soil, contributing to sustainable construction practices.

I. LITERATURE REVIEW

.1. J B Niyomukiza et al;(2019): In the study conducted by J. B. Niyomukiza et al. in 2019, the focus was on evaluating the suitability of soil as a subgrade material in its natural state. The findings revealed that the inherent properties of the soil were relatively weak, prompting the exploration of stabilization methods to enhance its engineering characteristics. One notable approach involved the replacement of soil with sawdust, and this substitution had several significant impacts on the soil's behavior. The introduction of sawdust led to a reduction in the plasticity index of the soil. As a result, the workability of the soil was improved, indicating that the modified soil was more manageable for engineering purposes. The study also investigated the effects of different percentages of sawdust replacement on key soil strength parameters. At 3% and 5% replacement levels of sawdust based on the dry unit weight of the soil, there was a noteworthy enhancement in both unconfined compressive strength and shear strength. In fact, these strengths increased by 1.4 times compared to the unstabilized soil, showcasing the potential of sawdust as a stabilizing agent. However, the researchers observed that the positive trend did not continue when the sawdust replacement reached 7%. Beyond this threshold, there was a decline in both unconfined compressive strength and shear strength. This suggests that there is an optimal range of sawdust content for achieving the desired improvements in soil properties. In conclusion, the study proposed that small percentages of Keruing sawdust can be effectively utilized as an affordable additive to expansive soils, offering a practical means of enhancing their engineering properties. Importantly, the use of sawdust as a stabilizing agent also addresses environmental concerns related to its disposal, presenting a sustainable and eco-friendly solution for soil improvement in construction and civil engineering applications.

2. Wajid Ali Butt et al;(2016): The research conducted by Wajid Ali Butt et al. in 2016 focuses on the use of SDA (Silica Fume and Demolished Aggregate) as a stabilizing material to improve the engineering properties of clayey soils. The study examines various soil characteristics, including liquid limit, plastic limit, plasticity index,
specific gravity, un-soaked CBR (California Bearing Ratio), and unconfined compressive strength. One key finding of the research is that the addition of SDA led to improvements in several important soil parameters. The liquid limit, plastic limit, and plasticity index, which are indicators of a soil's plastic and cohesive properties, were observed to change positively with the incorporation of SDA. This implies that the SDA acted as a stabilizing agent, mitigating the problematic characteristics of clayey soils. A noteworthy observation was a reduction in the maximum dry unit weight of the soil with an increase in SDA content. While this might suggest a decrease in soil density, it's essential to consider that the primary focus was on improving the engineering properties rather than achieving maximum compaction. The optimum moisture content (OMC) increased as SDA content rose, indicating a shift in the moisture-density relationship. The study identified a specific percentage of SDA content, namely 4%, as the optimum for achieving significant improvements in soil properties. At this level, the CBR value increased by an impressive 103.11%, highlighting the enhanced load-bearing capacity of the stabilized soil. Additionally, the unconfined compressive strength exhibited a substantial increase of 26.35%, emphasizing the soil's improved resistance to deformation and stress. The research concludes that SDA can be considered a cost-effective stabilizing material for sub-grade and subbase applications in clayey soils. This has practical implications for road construction, particularly in rural areas of developing countries like India, where the utilization of industrial wastes such as SDA can offer an alternative to traditional stabilizing agents, potentially reducing construction costs. Overall, the study underscores the potential of SDA as a satisfactory and economically viable stabilizing agent for enhancing the geotechnical properties of clayey soils in construction projects.

3. Shaheer Khan et al;(2015): In the study conducted by Shaheer Khan et al. in 2015, the focus was on assessing the impact of sawdust ash (SDA) on the strength parameters of soil. The research found that increasing the quantity of sawdust ash in the soil led to improvements in the soil's strength characteristics. The specific strength parameters were not explicitly mentioned, but they typically include factors such as shear strength, compressive strength, and California Bearing Ratio (CBR). Additionally, the study provided insights into the influence of sawdust ash on the shrinkage limit of the soil. Shrinkage limit refers to the moisture content at which further loss of moisture does not cause a decrease in the volume of the soil. While the effect of sawdust ash
content on the shrinkage limit was not directly tested, one of the samples with a 12% sawdust ash addition exhibited a shrinkage value of 38%, compared to its initial value of 29.15%. This suggests that the addition of sawdust ash resulted in an increase in the shrinkage limit of the soil. The increase in shrinkage limit is significant because it is an indicator of the expansiveness of the soil. Expansive soils tend to undergo volume changes with changes in moisture content, leading to issues such as swelling and shrinking, which can be detrimental to construction projects. By increasing the shrinkage limit, the study suggests that the addition of sawdust ash reduces the expansiveness of the soil. This reduction in soil expansion is crucial for applications such as embankments, where minimizing soil movement is essential to prevent the development of cracks. In practical terms, the conclusion drawn from the research implies that the incorporation of sawdust ash can contribute to the stabilization of soil, making it a potentially valuable additive in construction and geotechnical engineering. The findings suggest that the use of sawdust ash not only improves the strength parameters of the soil but also mitigates issues related to soil expansiveness, offering a more stable and reliable material for construction projects, particularly in scenarios where the development of cracks is a concern.

4. R. Saisubramanian et al;(2019): The research conducted by R. Saisubramanian et al. in 2019 delves into the transformation of untreated marine clay through the incorporation of various additives. The study reveals distinctive changes in the clay's properties, shedding light on its potential applications in construction and environmental engineering. Initially, the liquid limit and plasticity limit of the marine clay decrease as different additives are introduced, reaching an optimum concentration. Beyond this optimal point, there is a subsequent decline in these parameters. This suggests that there is a critical range of additive content that

optimizes the plastic and liquid states of the clay, and exceeding this range may have adverse effects. The California Bearing Ratio (CBR) value, a crucial indicator of soil strength, experiences a noteworthy increase with the addition of fly ash, reaching up to 20%. The introduction of lime at 6.5% further enhances the CBR value by an impressive 87%. This indicates that the combination of fly ash and lime significantly improves the load-bearing capacity of the marine clay. The study also observes changes in water content and its impact on unit cohesion. An increase in water content from 40% to 62% leads to a substantial drop in unit cohesion from 30 kPa to 10 kPa. This emphasizes the sensitivity of marine clay to water content variations, highlighting the importance of proper moisture control in engineering applications. Consolidation parameters, such as the coefficient of consolidation, show improvement with the inclusion of additives like fly ash and lime, further indicating the positive effects of these materials on the marine clay's engineering properties. The research explores the combination of lime and double layers of geotextiles applied to dredged soft marine clay, resulting in a significant enhancement in shear strength. This makes the treated clay suitable for land reclamation projects, showcasing its potential in geotechnical applications. Additionally, the study recognizes the marine clay's potential as a heavy metal absorbent for pollution control, adding an environmental dimension to its versatility. The combination of marine clay with cement and lightweight aggregate from industrial slag is identified as effective for land reclamation, enabling its use in heavy-duty applications. While the study reveals promising characteristics of marine clay in various applications, it underscores the need for further research to thoroughly comprehend its long-term behavioral effects. This acknowledgment suggests that ongoing investigations are necessary to fully unlock the potential and understand the limitations of marine clay in engineering and environmental contexts.

5. Kolo S. S et al;(2019): The study conducted by Kolo S. S et al. in 2019 focuses on the effectiveness of sawdust ash (SDA) as a pozzolanic material for stabilizing weak lateritic soil. The lateritic soil, initially classified as A-7-5 (poor clayey soil), undergoes significant improvements with the addition of varying percentages of SDA. The soil's classification undergoes a notable transformation with different SDA percentages. At 2% SDA, the soil maintains A-7-5 characteristics. However, as the SDA content increases (4%, 6%, 8%), the soil transitions into A-5 (fair silty soil). At 10% SDA, the soil reaches A-4 classification (fair silty soil). This shift in classification suggests that the addition of SDA has a substantial impact on altering the soil's composition and properties. The unconfined compressive strength of the weak lateritic soil shows a complex pattern with varying SDA percentages. A 25.7% increase is observed at 2% SDA, peaking at a 26.9% improvement at 4% SDA. However, at 8%, a slight decrease (17.5%) occurs, and at 10%, a more significant drop (33.7%) is noted. The optimal improvement in soil properties is identified at the 4% SDA replacement level. At the 4% SDA replacement, several soil characteristics exhibit positive changes. There is a reduction in the liquid limit, plastic limit, and plastic index, indicating improved workability of the soil. Additionally, a decrease in maximum dry density by 3.7% suggests enhanced compaction characteristics, implying that the soil is more effectively compacted under standard conditions. The optimum moisture content experiences a slight increase (11.11%) at 4% SDA, contributing to better soil performance. The unconfined compression strength peaks at a 26.9% improvement at this optimal stabilization level, affirming that 4% SDA is the most effective percentage for enhancing the weak lateritic soil's engineering properties. In summary, the study establishes the efficacy of SDA in transforming the engineering properties of weak lateritic soil. The optimal improvement is achieved at a 4% SDA replacement, offering a practical and effective solution for stabilizing this type of soil, with positive implications for construction and geotechnical engineering applications.

II. MATERIALS AND METHODOLOGY

PART – I MATERIALS

A. *Silty Soil*

The soil used in this study was collected from kadamakkudy, Ernakulum district. The visual inspection showed that the soil is greyish black and highly plastic. The soil samples were picked at a reasonable depth to avoid the inclusion of organic matter. The samples were air dried and oven dried before use.

Table 1: Geotechnical Properties of soil used

Properties	Value
Specific gravity	2.13
Liquid limit (%)	72%
Plastic limit (%)	25%
Plasticity index (%)	47%
Unconfined compressive strength (N /mm2)	7.5
Optimum moisture content (%)	12

B. *Sawdust ash*

The sawdust used in this study was obtained from the Paracka timber mill at kalady. After collecting the saw dust it was air dried to remove its moisture content and to facilitate in easy burning it to ash. An incinerator was used to burn the sawdust to ash by pouring all the dried sawdust contents into its container and apply 4-5 hours were given for complete combustion.

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PART – II METHODOLOGY

A. Site Scouting

The site selected for this study is kadamakudy region in Ernakulum district.

B. Material Procurement

Soil sample was collected from the decided site up to a depth of 50 cm.

C. Lab Analysis On Raw And Sawdust Ash Mixed soils

To evaluate the changes in geotechnical properties several laboratory tests like Atterberg's limit, Specific gravity, Standard proctor test and were done in both raw soil and sawdust ash mixed soil by 2%,4%,6%, 8%, and 10%.

D. Result Interpretation

After the lab analysis we have to analyze the results obtained and then compare it with the range, the raw soil results are compared with the stabilized soil to find the changes in the properties of soil before and after stabilization.

III. LABORATORY ANALYSIS

A. Specific Gravity

Specific gravity test was conducted on raw soil . Figuring out the weight ratio between a specific volume of soil and a volume of water of same weight. The void ratio, porosity, saturation level, critical hydraulic gradient, and other parameters are determined using the specific gravity of the soil particle.

B. Compaction

The raw and sawdust ash mixed samples underwent standard Proctor tests with 2,4,6,8 &12% . It was carried out to determine the highest dry density and ideal soil moisture content.

C. Unconfined Compressive Strength (UCS) Test

Both unstabilized and stabilized soil were subjected to unconfined compressive strength testing. The ideal moisture content and maximum dry density were used for the experiments.

D. Atterberg's limit

Done Atterberg limit test on both stabilized and unstabilized soil .The plastic limit and liquid limit were find out .

IV. RESULTS AND DISCUSSIONS

A. Compaction

Table.2 displays the compaction test results.

Table.2 Effect of sawdust ash on OMC and MDD

Sawdust ash (%)	OMC	MDD
0	12	1.925
2	14	1.910
4	17	1.880
6	19	1.865
8	21	1.851
10	18	1.870

It can be inferred from above table that there is increase in OMC with increase sawdust ash .The increase is due to the addition of sawdust ash , which decreases the quantity of free slit and clay fraction and coarser materials with larger surface areas were formed.The implies also that more water is needed in order to compact the soil-sawdust ash.

Fig.1 Effect of sawdust ash on proctor test

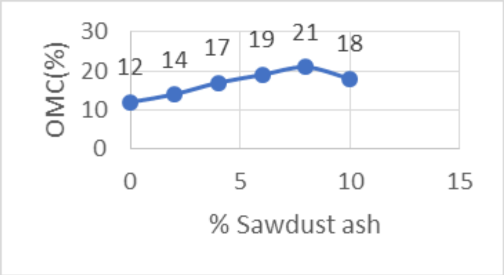

Table.3 Effect of sawdust ash on UCS

Sawdust ash Percentage (%)	Unconfined compressive strength (N/mm²)
0	7.50
2	7.50
4	7.503
6	7.659
8	7.650
10	7.241

The MDD decreases by increasing the content of sawdust ash. The decrease in the MDD can be attributed to the replacement of soil by the sawdust ash which has relatively lower specific gravity compared to that of the raw soil which is 2.1.

B. Unconfined Compressive Strength (UCS) Test

Results obtained for unconfined compressive strength of both stabilized and unstabilized soil sample as shown in Table.3

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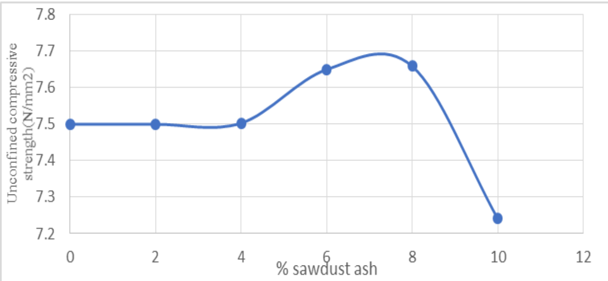

Fig.2 Effect of Sawdust ash on UCS

D. Liquid Limit

The table 4 represents the influence of sawdust ash on Liquid limit. It can be inferred from the table that there is a decrease in liquid limit value with increase in sawdust ash content up to 8%. After 8% the value is increasing.

Table.4 Influence of Sawdust Ash on Liquid Limit

Sawdust ash (%)	Liquid Limit
0	72
2	69
4	65
6	61
8	60
10	62

It can be inferred from above table that there is a decrease in liquid limit value with increase in sawdust ash content up to 8%. After 8% the value is increasing.

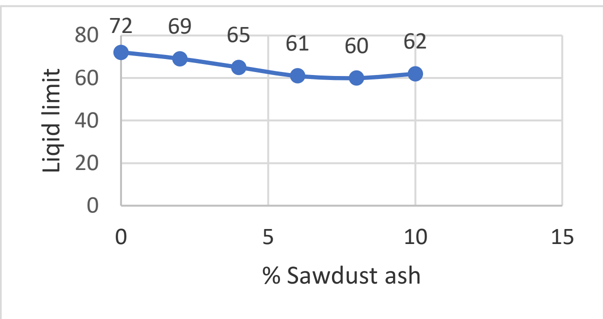

Fig.3 Effect of sawdust ash on liquid limit

IV CONCLUSION

As observed from the results of this study, following conclusions can be drawn:

. •From the analysis it was obtained that 8% of sawdust ash gives improvement in properties of soil.so 8% was selected as optimum percentage.

•OMC increased and maximum dry density decreased with increase in percentage of sawdust ash.

•Unconfined compressive strength increased with increase in percentage of sawdust ash and after 8% it was decreasing.

•With addition of sawdut ash ,there is a considerable decrease in Atterberg's limits.

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