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# Evaluation of Effect of Saw Dust Ash on Strength Characteristics of Expansive Soil for Pavement Construction

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**ABSTRACT:** The study aims to investigate the effectiveness of sawdust ash (SDA) as a stabilizing agent for expansive soils, which are known for their poor strength and high swelling potential, making them unsuitable for pavement construction. The research employs laboratory tests to evaluate the effect of different percentages of sawdust ash on the strength characteristics of the soil, including unconfined compressive strength (UCS) and California bearing ratio (CBR). The findings of the study show that the addition of sawdust ash to the expansive soil improves its strength properties. The results suggest that sawdust ash can be a promising alternative to conventional stabilizing agents for the improvement of expansive soil properties, making them suitable for pavement construction. The study demonstrates that the use of sawdust ash as a stabilizing agent has the potential to reduce the cost and environmental impact of pavement construction while improving the strength and stability of expansive soils. The results showed that the addition of saw dust ash to the expansive soil improved its strength characteristics. The optimum saw dust ash content was found to be 9% by weight of the soil. At this optimum content, the CBR value increased by about 275.43%, which indicates that the soil can now support higher traffic loads.

**KEYWORDS:** Expansive soil, Saw dust ash, UCS and CBR.

## I. INTRODUCTION

Expansive soil is a type of soil that has the tendency to swell and shrink as its moisture content changes. It is often referred to as swelling soil, and it can cause significant problems in construction and engineering projects [1]. Expansive soils are typically composed of clay minerals such as montmorillonite and smectite, which have the ability to absorb water molecules between their layers. When expansive soil is wet, it expands and swells, exerting pressure on anything that is in contact with it, such as building foundations, roads, and sidewalks [2]. This can cause serious damage to structures built on or near expansive soil, such as cracks, heaving, and uneven settling [3]. When the soil dries out, it shrinks and can cause structures to settle and become unstable. To prevent damage from expansive soil, engineers and builders can use several techniques, such as soil stabilization, moisture control, and foundation design. Soil stabilization involves adding materials to the soil to reduce its ability to swell and shrink. Moisture control involves controlling the amount of water in the soil through proper drainage and irrigation. Foundation design involves designing the foundation to withstand the forces exerted by the soil [4]. Sawdust ash is the residue that remains after sawdust is burned in a furnace or boiler. It is a fine powder with a gray or brownish colour, and it has a high content of calcium carbonate, which makes it alkaline. Sawdust ash also contains other minerals such as potassium, magnesium, and phosphorus, which can vary depending on the type of wood that was burned [5]. Expansive soils are problematic materials for pavement construction due to their high potential for volume change under varying moisture conditions. This often leads to pavement distress and failure, resulting in high maintenance costs. One potential solution to this problem is the use of soil stabilization techniques, such as the addition of pozzolanic materials, to improve the strength characteristics of the soil. Sawdust ash is a waste material generated from the burning of sawdust, and it has been shown to possess pozzolanic properties. Its use in soil stabilization has been investigated in various studies, but there is a lack of research on its effect on expansive soils for pavement construction. The objective of this study is to investigate the effect of sawdust ash on the strength characteristics of expansive soil for pavement construction. Specifically, the study aims to determine the optimum sawdust ash content required to improve the soil's strength characteristics and investigate the potential cost savings associated with the use of sawdust ash in pavement

construction. The significance of this study lies in its potential to provide a sustainable solution to the problem of pavement distress and failure caused by expansive soils. The use of sawdust ash as a pozzolanic material can reduce the cost of pavement construction and maintenance while also addressing the issue of sawdust waste disposal. Furthermore, the findings of this study can contribute to the body of knowledge on the use of alternative materials for soil stabilization in pavement construction.

## II. RELATED WORK

Numerous inorganic and organic stabilizers have been added to soil, and the results of this study have revealed improved soil qualities. SDA is usually used as a stabilizer to enhance the characteristics of expansive soils. There is, however, relatively few research on how black cotton soil responds to the addition of SDA.

[6] **Ogunribido, T. H. T., (2012)** reviewed the research done to assess how sawdust ash affected the geotechnical characteristics of soil from three places in southwest Nigeria. By adding 2, 4, 6, 8 and 10% of sawdust ash, these experiments were carried out in both unsterilized and stabilized phases. According to the results, saw dust ash has improved the geotechnical characteristics of the soil samples: for samples A and B, shear strength increased from 50.92 to 71.07kN/m<sup>2</sup> and maximum dry density increased from 1403 to 1456 Kg/m<sup>3</sup> and 1730 to 1785 Kg/m<sup>3</sup>, respectively. Optimum moisture content also increased from 23.6 to 28.2% and 26.2 to 29.2%.

[7] **Shawl, Z. Z., et al. (2017)** the primary goal of the work was to investigate the stabilization of clayey soil using lime and sawdust ash. It was discovered what the parent soil's index properties, Atterberg Limits, compaction characteristics, and UCS were for both the parent soil and soil that had been treated with sawdust ash and lime. When both SDA and lime were provided, it was found that the plasticity index substantially dropped, making the soil more workable. When both SDA and lime are used, with a proportion of 6% lime and 12% SDA, it is observed that the maximum dry density is reduced to the lowest value of 1.37 kN/m<sup>2</sup>. It has been found that using 5% lime and 8% SDA results in the stabilized soil having the highest compressive strength. As a result, it may be said that sawdust ash works well as a stabilising agent for clayey soils.

[8] **Sharma, S., et al. (2018)** in this research, the impacts of sawdust and marble dust powder mixes on the engineering characteristics of clayey/expansive soil are examined. With the addition of sawdust ash, the samples' specific gravities are decreasing. At 2% sawdust, OMC reduced by 0.77%. Additionally, at 4% and 6% sawdust, it reduced by 1.27% and 1.73%, respectively. The OMC is reduced by 2.82% when 8% sawdust is added, and by 4.18% when 10% sawdust is added. For 2% sawdust, MDD was reduced by 0.33 percent. At 4% and 6% sawdust, it is further reduced by 4.98% and 11.06%. It decreases by 12.74% when the 8% sawdust is added, and by 13.04% when the 10% sawdust is added. With 6% sawdust content, the C.B.R. value of black cotton soil increases significantly to 10.16 percent.

[9] **Kale, R. Y. et al. (2019)** examined the Soil is an important natural resource that supports the foundation and distributes the load. The soil should be strong enough to support the load without failing from a construction aspect. The goal of this study is to examine how SDA and lime affect expansive soils in order to improve their compressive strength and swelling/shrinking characteristics and make them more suitable for use in buildings. The ratios of 1%, 2%, 3%, 4%, and 5% were selected for the addition of SDA and lime. As SDA and the lime level rise to 2%, the liquid limit (LL) decreases. After that, as the SDA and lime content rises, the liquid limit does too. As the SDA and lime content rises to 2%, MDD rises. After that, MDD reduces as SDA and lime content rise. As the SDA and lime concentration rises by up to 1%, OMC decreases. After that, it abruptly rises at 2% and then decreases as the SDA and lime content rises. Up to 2%, the SDA and Lime content enhance the UCS; after that, the UCS gradually decreases as the SDA and Lime content rises. The CBR value rises as SDA and lime concentration rises up to 2%; after that, it decreases somewhat as SDA and lime content rise.

[10] **Rajashekhar, D., et al. (2021)** studied the problem of soil stabilization in building engineering has grown significantly. There may not be enough land available for the development of buildings, roads, and other structures as a result of the population boom and urbanization. It is evaluated in the laboratory to determine how Stone Dust (SD) affects the values for Liquid Limit, Plastic Limit, Plasticity Index, Dry Density, Optimum Moisture Content (OMC), and California Bearing Ratio (CBR). With the addition of stone dust, the OMC of the soil decreases while the MDD of the soil increases. The OMC is 18.91% at 15% stone dust, and the MDD is 1.94 gm/cc.

### III. METHODOLOGY

#### Material Used

According to Fig. 1(a), the soil sample was acquired at Jabalpur, Madhya Pradesh, India. As shown in Fig. 1(b), Saw dust ash was gathered in rural Prayagraj district, Uttar Pradesh, India. Table 1 lists the expansive soil's engineering characteristics.

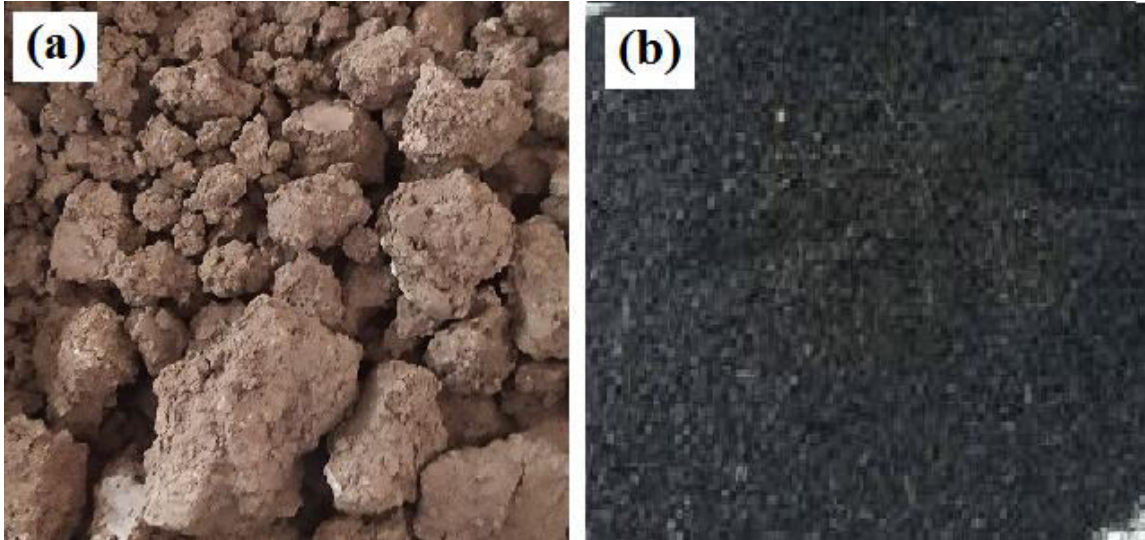


Fig. 1 Material (a) ES (b) SDA

Table 1 Engineering properties of Expansive soil

| S. No. | Test name                       | Value                    | Units |
|--------|---------------------------------|--------------------------|-------|
| 1.     | Specific gravity                | 2.63                     | ---   |
| 2.     | Free swell index                | 133.56                   | %     |
| 3.     | Shrinkage limit                 | 9.82                     | %     |
| 4.     | Liquid limit                    | 65.35                    | %     |
| 5.     | Plastic limit                   | 26.76                    | %     |
| 6.     | Plasticity index                | 38.59                    | %     |
| 7.     | Soil classification             | CH                       | ---   |
| 8.     | Compaction                      | Optimum moisture content | 22.23 |
|        |                                 | Maximum dry density      | 1.543 |
| 9.     | Unconfined compressive strength | 162.95                   | kPa   |
| 10.    | California bearing ratio        | 2.89                     | %     |

#### Sample Preparation with Methodology

##### Methodology

According to IS: 2720, the following laboratory tests have been performed. Both natural soil and stabilized soil with sawdust ash collection were used for the tests.

1. Atterberg limit - IS: 2720 (Part-5) 1985
2. Free Swell Index test – IS: 2720 (Part-40) 1977
3. CBR test – IS: 2720 (Part-16) 1987
4. Unconfined compression strength test – IS: 2720 (Part-10)1991

5. Compaction test – IS: 2720 (Part-7) 1980

### Sample Preparation

The soil sample is collected, and it should be air-dried to remove any moisture content. Spread the soil on a clean, flat surface and leave it to air dry for 24-48 hours. If the soil contains large stones or debris, it should be removed before air-drying.

IS 2720 Part-5 specifies the standard test method for determining the liquid limit and plastic limit of soils. The procedure for liquid and plastic limit determination is as follows: for the liquid limit, take a representative soil sample of approximately 120g. Lift the cup and allow it to drop through a distance of 1 cm and count the number of drops required to close the groove for a distance of 12mm. Record the number of blows as the liquid limit. For the plastic limit, take a representative soil sample of approximately 25g and add sufficient water to form a paste. Roll the paste into a thread of 3mm diameter and 10cm length using the palms of the hands on a flat non-porous surface. If the thread cracks, roll it again until no further cracks are visible. Determine the water content of the sample at the point where the thread starts to crumble and break apart. Record the water content as the plastic limit.

The compaction test, also known as the Proctor test, is used to determine the maximum dry density and optimum moisture content of the soil. The procedure for conducting the compaction test according to IS: 2720 Part-7 is as follows: Air-dry the sample and sieve it through 20mm and 4.75mm sieves. Compact the soil using a standard compaction method, such as a rammer of 2.6 kg weight falling through a height of 310 mm, with 25 blows in three layers for a 1000 cc mould. Determine the dry density of the specimen using the weight and volume measurements.

The UCS (Unconfined Compressive Strength) test is used to determine the compressive strength of cohesive soil. The procedure for conducting the UCS test according to IS: 2720 Part-10 is as follows: Trim the sample to remove any irregularities, and prepare a cylindrical specimen of 38 mm diameter and 76 mm height. The ends of the specimen should be parallel and smooth. Place the top plate of the testing machine on the specimen and apply a vertical load at a constant rate of strain (1.25 mm/min) until failure occurs. Record the maximum load (P) at failure and the corresponding deformation (d).

The CBR (California Bearing Ratio) test is used to determine the load-bearing capacity of a soil subgrade or base course. The procedure for conducting the CBR test according to IS: 2720 Part-16 is as follows: Soak the soil sample in water for 96 hours or until it attains a fully saturated state. Place the sample in the mould of 150mm diameter and 175mm height in 3 layers, each layer being compacted by 55 blows of a 4.89 kg hammer with a free fall of 457mm. apply a vertical load to the specimen at a constant rate of penetration (1.25mm/min) and record the load at every 2.5 mm of penetration.

The Free Swell Index (FSI) test is used to determine the swelling characteristics of the soil. The procedure for conducting the FSI test according to IS: 2720 Part-40 is as follows: Air-dry the sample and sieve it through a 425-micron sieve. Weigh a 10-gram soil specimen accurately and place it in a porcelain evaporating dish.

## IV. EXPERIMENTAL RESULTS

### Consistency Limit

The liquid limit and plasticity index of the virgin soil was found to be respectively 65.35% and 38.59%. The liquid limits were determined to be 61.25, 58.56, 55.72, and 51.00%, respectively, for 3, 6, 9, and 12% of SDA-treated soil. The Plasticity Index for 3, 6, 9, and 12%, respectively, was calculated to be 32.80, 27.71, 23.60, and 16.47%, as shown in Fig. 2. [11].

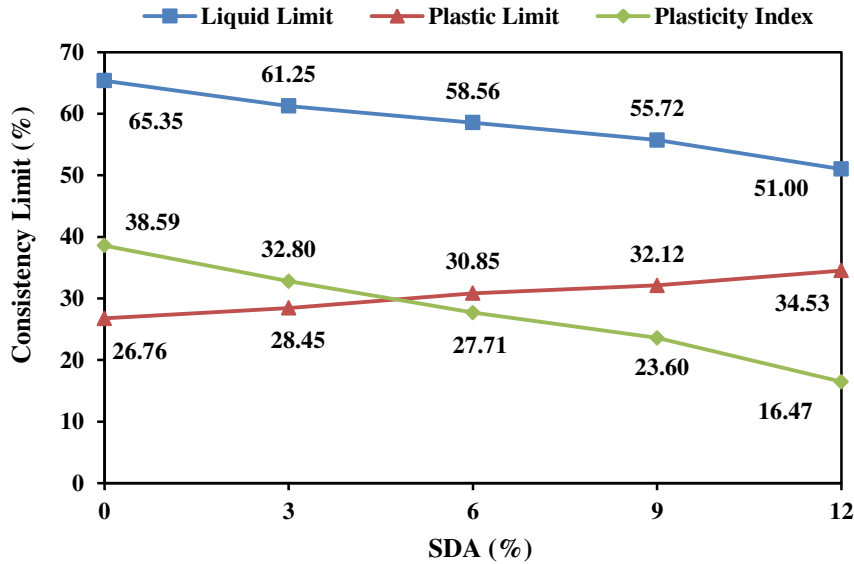


Fig. 2 Consistency limit of ES treated of SDA

**Compaction Characteristics**

The Standard Proctor Method is used to calculate the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) in accordance with IS 2720 (Part-7) 1983 [12]. For the natural soil, OMC and MDD are found to be 22.23% and 1.543 g/cc, respectively. In accordance with Fig. 3, the OMC for the 3, 6, 9, and 12% of the SDA-treated soil samples, respectively, is determined to be 23.56, 24.98, 27.32, and 28.02%. For 3, 6, 9, and 12% of SDA, respectively, MDD is calculated to be 1.536, 1.524, 1.515, and 1.507 g/cc as depicted in Fig. 4.

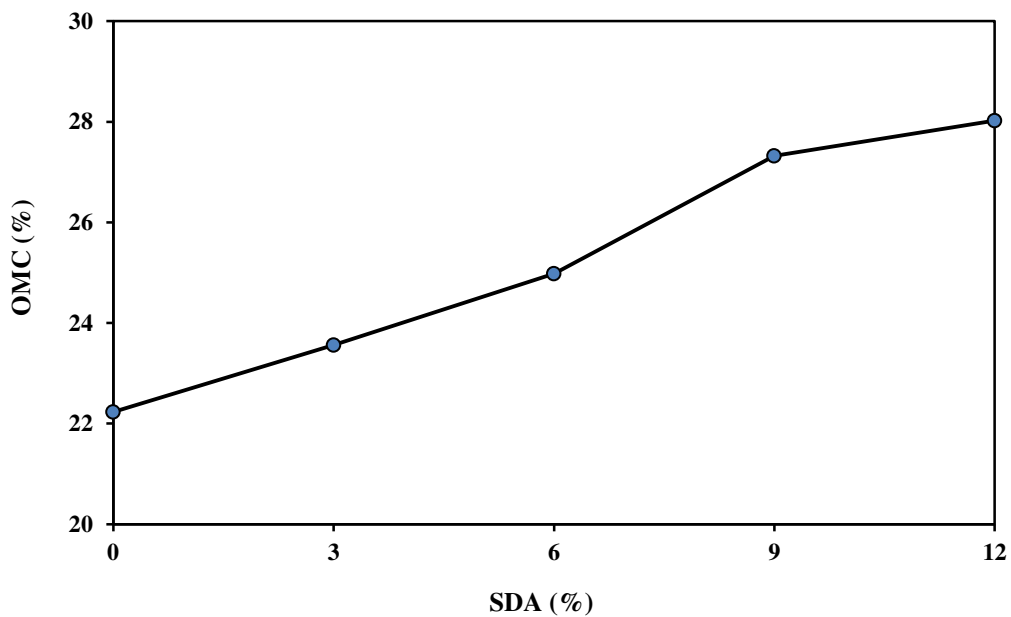


Fig. 3 OMC variation of ES treated with SDA

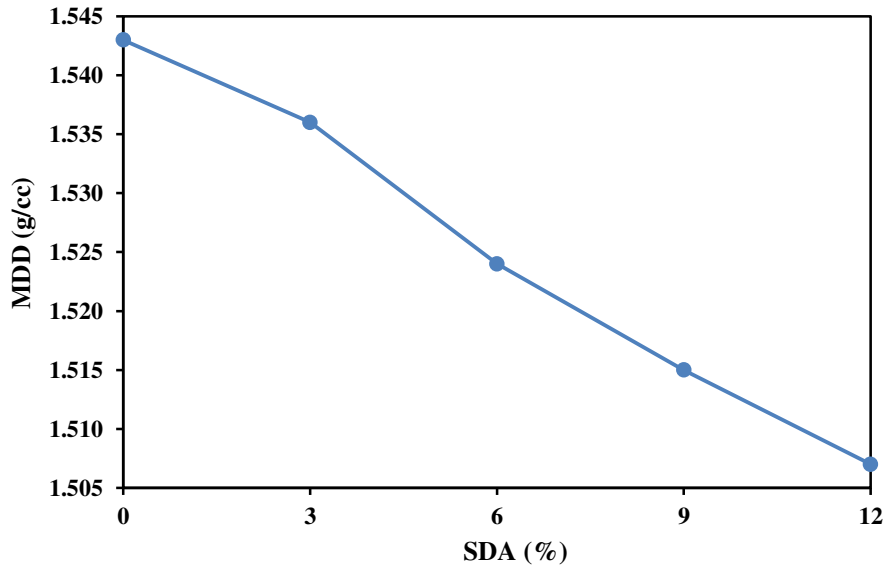


Fig. 4 MDD variation of ES treated with SDA

### Unconfined Compressive Strength

According to IS: 2720 (Part 10), the Unconfined Compressive Strength (UCS) of both natural and SDA-treated soil is calculated [13]. The UCS value of natural soil is determined to be 165.23 kPa in Fig. 5. For 3, 6, 9 and 12% of SDA at 7 days of curing, the UCS values of SDA-treated soil were determined to be 193.85, 210.56, 222.46 and 244.56 kPa, respectively. After 14 days of curing, the UCS values of soil treated with 3, 6, or 12% SDA were determined to be 210.84, 229.56, 281.79, and 310.25 kPa, respectively as shown in Fig. 5. At 28 days of curing, 3, 6, 9 and 12% of SDA were found to have UCS values of 250.03, 290.85, 320.32 and 390.99 kPa, respectively, in SDA-treated soil as depicted in Fig. 5.

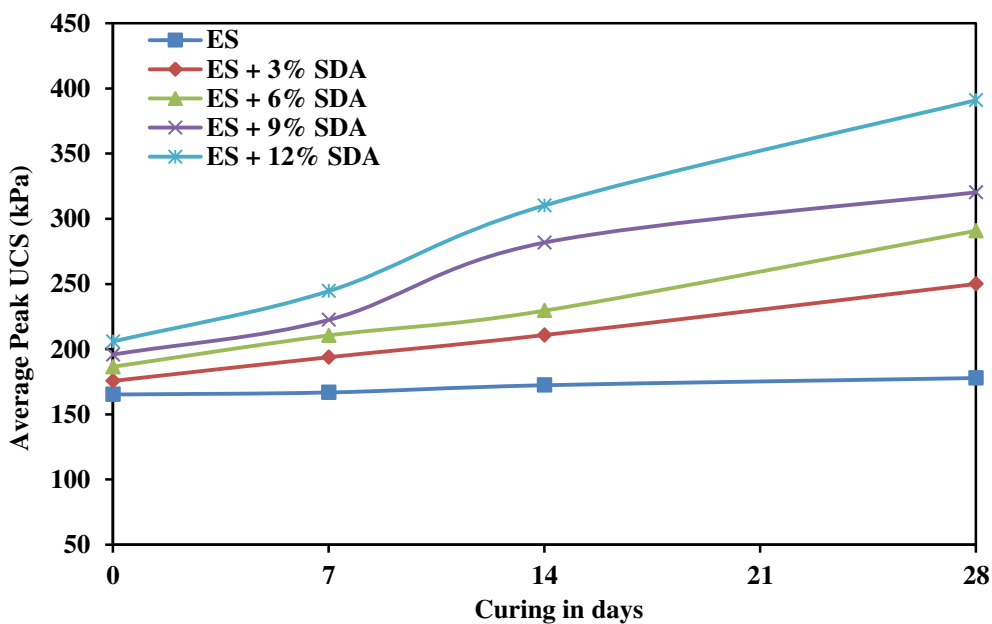


Fig. 5 UCS values of ES treated with SDA at 0, 7, 14 and 28 days of curing



### California Bearing Ratio

The California Bearing Ratio (CBR) is determined for both natural and SDA-treated soil in accordance with IS: 2720 (Part-16) [14]. The CBR value of the natural soil was determined to be 2.89%. The CBR values for soil treated with 3, 6, 9, and 12% of SDA are, respectively, 4.52, 7.84, 10.85, and 10.67%, as shown in Fig. 6.

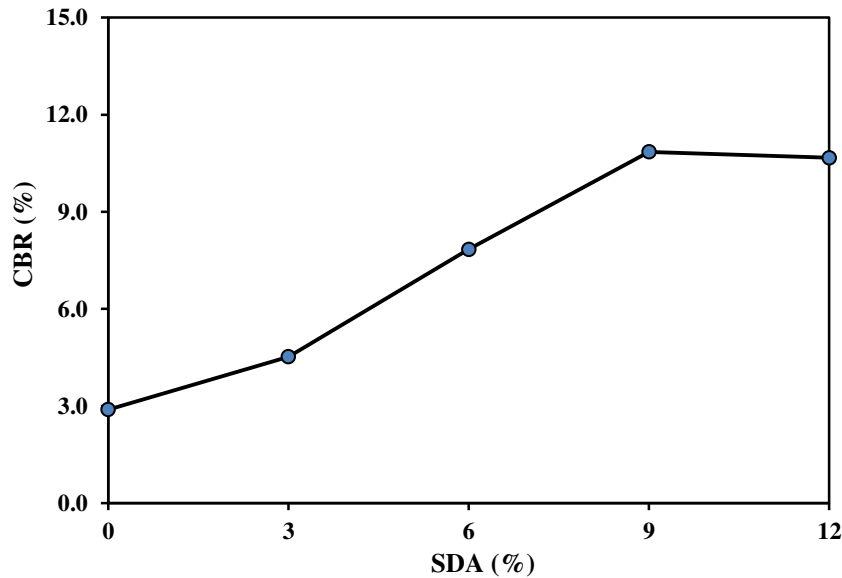


Fig. 6 CBR value of ES treated with SDA

### Free Swell Index

The Free Swell Index (FSI) is determined for both natural and SDA-treated soil in accordance with IS: 2720 (Part 40) [15]. The FSI of natural soil is 133.56%, which is a very high value. The FSI for soil treated with 3, 6, 9, and 12% SDA was calculated to be 124.55, 121.02, 116.57, and 112.35%, respectively, according to Fig. 7.

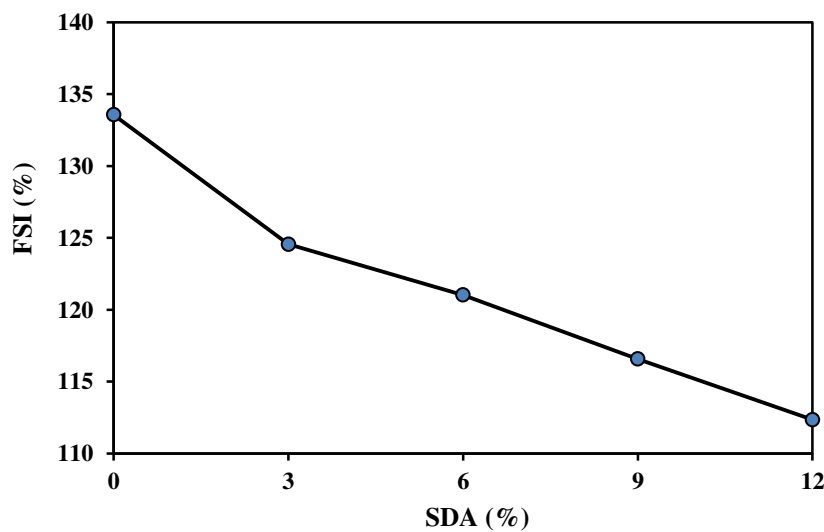


Fig. 7 FSI variation of ES inclusion of SDA



## V. CONCLUSION

In conclusion, the study suggests that saw dust ash can be a viable option for stabilizing expansive soils for use in pavement construction. This can potentially reduce the cost of pavement construction and maintenance, while also addressing the issue of sawdust waste disposal.

1. With a 12% increase in SDA, the liquid limit and plasticity index reduced by 21.95 and 57.32%, respectively, in comparison to virgin soil.
2. When virgin soil was treated with SDA up to 12%, OMC increased by 26.05% and MDD decreased by 2.33% in comparison to natural soil samples containing SDA up to 12%.
3. The UCS value increased by up to 46.64, 80.04, and 119.83% at 7, 14, and 28 days of curing, respectively, with the addition of SDA.
4. With an increase in SDA percentage of up to 9%, the optimum CBR value improved by 275.43% when compared to a virgin soil sample.
5. When compared to a normal soil sample, the FSI of the treated soil created by mixing SDA was reduced by 15.88%.

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