EVALUATION OF STONE DUST FOR STABILIZATION OF EXPANSIVE SOIL FOR PAVEMENT CONSTRUCTION

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Abstract - *An Expansive soil (ES) is soil that has the ability to swell or shrink significantly due to changes in moisture content. It is also known as swelling soil, shrink-swell soil, or clay soil. Expansive soils are typically composed of clay minerals that have the ability to absorb water and expand, and then release water and shrink. This study used stone dust (SD) for the improvement of engineering properties. Stone dust, also known as crusher dust or quarry dust, is a type of fine material that is made by crushing stones and rocks. It is often used as a subbase material for paving projects such as roads, driveways, and construction projects. Different tests to evaluate the Liquid and Plastic limit, free swell index (FSI), compaction, unconfined compressive strength (UCS), and California bearing ratio (CBR) are used to characterize the effects of adding stone dust in expansive soil. According to the test results, stone dust with a percentage of 0, 10, 20, 30 and 40% improves the engineering characteristics of expansive soil so that it may be utilized for constructing pavement.*

Key Words: *Expansive soil, Stone dust, UCS and CBR*

1. INTRODUCTION

Expansive soil is soil that swells and shrinks significantly as the moisture content in it changes. It is also known as swelling soil. Expansive soils are typically composed of clay minerals that have the ability to absorb and hold water molecules [1]. When these clay minerals absorb water, they expand and push against anything that is above them, including foundations, roads, and sidewalks. The swelling and shrinking of expansive soils can cause damage to structures built on them, such as cracks in walls and foundations, uneven floors, and other structural problems. This is because the soil's movement can cause the foundations of buildings to shift, which can lead to structural damage. Expansive soils are found in many parts of the world, but they are particularly common in arid and semi-arid regions where there is a large fluctuation in soil moisture levels between wet and dry seasons. To mitigate the effects of expansive soils, engineers and architects use specialized foundation designs and building techniques that can accommodate the soil's movement, such as using flexible materials and creating a moisture barrier around the foundation. Expansive soils are particularly prevalent in the states of Uttar Pradesh, Rajasthan, Haryana, Punjab, Maharashtra, Gujarat, and Andhra Pradesh [2]. In these states, expansive soils can cover large areas, sometimes encompassing entire districts or regions. For example, the Indo-Gangetic plain, which spans across several states in northern India, is known for its expansive soils [3]. Stone dust is created when larger stones are crushed into smaller pieces. The dust is produced during the crushing process, as the stones are broken down into smaller and smaller pieces [4]. Stone dust is often mixed with other materials, such as sand or cement, to create a stable base for a variety of construction projects. The use of stone dust for stabilizing expansive soil for pavement construction has been studied in several research studies. Stone dust has been found to be an effective stabilizer for expansive soils due to its ability to improve soil properties such as compaction, shear strength, and permeability. One study evaluated the use of stone dust for stabilizing expansive soil in pavement construction in India [5]. The study found that the addition of stone dust to the expansive soil improved its California Bearing Ratio (CBR), which is a measure of the soil's strength and load-bearing capacity. The study also found that stone dust reduced the soil's plasticity index and improved its permeability. Another study conducted in Nigeria evaluated the use of stone dust for stabilizing expansive soil in pavement construction. The study found that stone dust improved the soil's CBR and reduced its swell potential [6]. The study also found that the addition of stone dust improved the soil's workability and reduced its susceptibility to erosion. Overall, the use of stone dust for stabilizing expansive soil for pavement construction has shown promising results in various studies. However, it is important to note that the effectiveness of stone dust as a stabilizer may depend on factors such as the type and amount of stone dust used, the soil properties, and the environmental conditions. Therefore, it is recommended to conduct site-specific testing and evaluation to determine the most appropriate stabilizer and application rates for a particular project.

2. LITERATURE REVIEW

In the past few years, a lot of work has been done to stabilize the black cotton soil. Here are a few important papers that are related to this paper.

[7] Zuhaib Zahoor Shawl et al. (2017) with the addition of 4%, 8%, and 12% stone dust, respectively, the clayey soil's

plastic limit has raised from 24.4% to 25.58%, 26.2%, and 27.45%, making the soil more workable. It was demonstrated that adding 4%, 5%, and 6% lime, respectively, caused the liquid limit to first rise from 33.8% to 35.3% and subsequently fall to 35% and 34.6%. With lime compared to stone dust, there was a higher reduction in the plastic limit.

[8] Rakesh Verma et al. (2017) studied the Stabilization of soils is an effective method for improvement of soil properties and the pavement system performance. The poorest soil among all is Black Cotton Soil (BC Soil). It was observed that the addition of 2% of Cement and 1% Sawdust decreases the liquid limit by 3.70%. M.D.D. increased slightly by 6.29% and 5.59% at 2 % of Cement and 1% Sawdust. It was observed that there was a decrease in O.M.C. of 3.4% at 2 % of Cement and 1% Sawdust content. The C.B.R. value of black cotton soil improves considerably to 4.60 times with 2 % of Cement and 1% Sawdust content.

[9] Sujit Vaijwade et al. (2018) from this paper, the maximum dry density (MDD) of soil increases with the addition of stone dust and plastic strips with soil and the optimum moisture content (OMC) is decreasing with the addition of stone dust and plastic strips. The maximum dry density is 1.94 g/cc and the optimum moisture content is 18.91% at 15% stone dust and 1.5% plastic strip. This is the optimum percentage of addition of material. Further addition of stone dust and plastic strips the maximum dry density decrease and the optimum moisture content increases.

[10] Sharma S. et al. (2018) [10] This paper aims at studying the effects of marble dust powder and sawdust content as mixtures in clayey/expansive soil and its engineering properties. OMC was decreased by 10.74% at 10% on the addition of marble dust. Further it is decreased at 20% marble dust by 20.26%. MDD of marble dust powder at 10% is increased by 2.18% and it is increased by 9.83% at 20% marble dust. The UCS value is increased by 2.12% on the addition of 10% marble dust and 4.78% at 20% of marble dust. The C.B.R. value of black cotton soil improves considerably to 10.16% on 6% Sawdust content.

[11] R. Y. Kale et al. (2019) OMC decreases as the stone dust and Lime content increases up to 1%. Thereafter it suddenly increases at 2% and decreases thereafter with an increase in stone dust and Lime content. The Unconfined Compressive Strength increases as the stone dust and Lime content increase up to 2% thereafter it decreases gradually with an increase in stone dust and Lime content. The CBR value increases as the stone dust and Lime content increase up to 2% thereafter it decreases slightly with an increase in stone dust and Lime content.

3. MATERIAL USED

The soil sample was collected from Jabalpur, Madhya Pradesh, India as shown in Fig. 1(a). Stone dust was collected from Mirzapur, Uttar Pradesh, India as depicted in Fig. 1(b). Engineering properties of expansive soil as listed in Table 1.

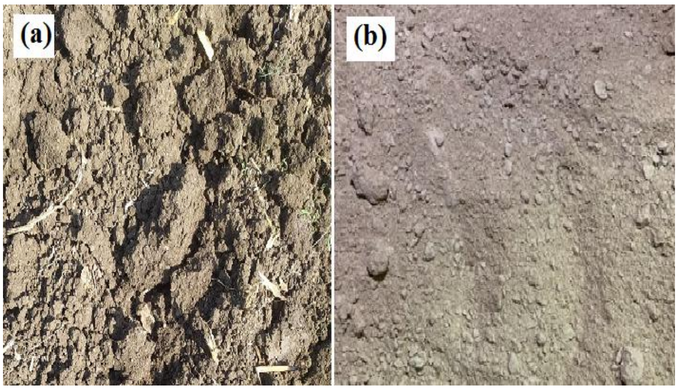

Fig. 1 Material (a) Expansive soil (b) Stone dust

Table 1 Engineering properties of Expansive soil

Test name		Value	Units
Specific gravity		2.63	---
Free swell index		133.56	%
Shrinkage limit		9.82	%
Liquid limit		65.35	%
Plastic limit		26.76	%
Plasticity index		38.59	%
Soil classification		CH	---
Compaction	OMC	22.23	%
	MDD	1.543	g/cc
Unconfined compressive strength		162.95	kPa
California bearing ratio		2.89	%

4. SAMPLE PREPARATION FOR THIS STUDY

Once the soil is air-dried, it should be crushed and sieved to remove any large particles or debris. A soil crusher can be used for this purpose, followed by a series of sieves to separate the soil into different size fractions. The following are the sample preparation steps for the atterberg limit, free swell index, compaction, UCS and CBR test according to Indian Standard IS:2720 (Part-5) -1985, IS:2720 (Part-40) -1977, IS:2720 (Part-7) -1980, IS:2720 (Part-10) -1991 and IS:2720 (Part-16) -1987.

5. RESULT AND DISCUSSION

5.1 Consistency Limit

The virgin soil's liquid limit and plasticity index were found to be 65.35% and 38.59%, respectively. For 10, 20, 30, and 40% of SD-treated soil, the liquid limits were found to be 63.42, 60.07, 56.82, and 51.11%, respectively. According to Fig. 2, the Plasticity Index for 10, 20, 30, and 40%, respectively, was determined to be 39.37, 38.09, 36.69, and 32.76% [12].

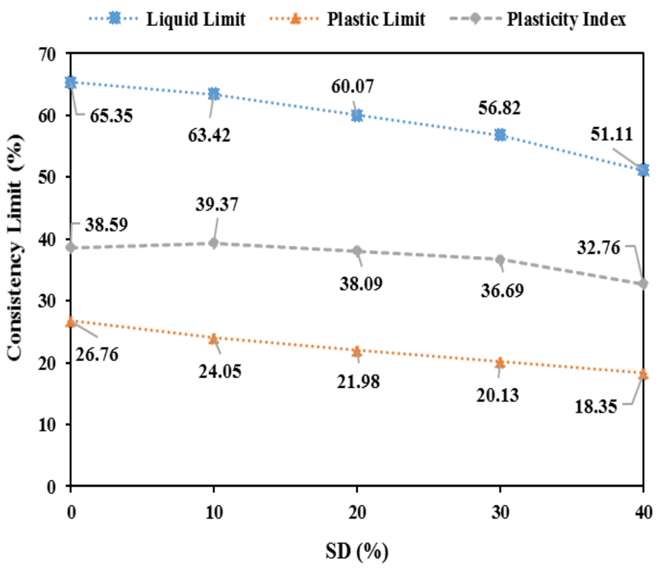

Fig. 2 Consistency limit of ES inclusion of SD

5.2 Compaction Characteristics

According to IS 2720 (Part-7) 1983, the Standard Proctor Method is used to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) [13]. OMC and MDD are determined to be 22.23% and 1.543 g/cc for the natural soil, respectively. According to Fig. 3, OMC is found to be 20.75, 19.98, 18.46, and 17.62% for 10, 20, 30, and 40% of SD treated soil samples, respectively. According to Fig. 4, MDD is determined to be 1.540, 1.534, 1.526, and 1.521 g/cc for 10, 20, 30, and 40% of SD, respectively.

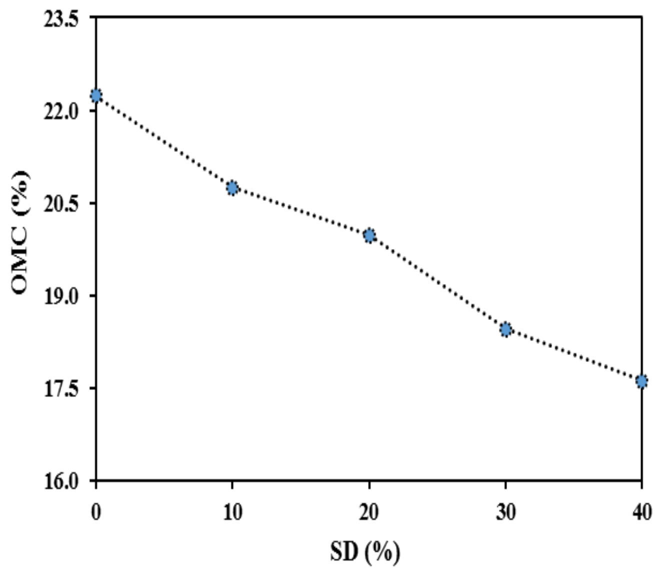

Fig. 3 OMC variation of ES treated with SD

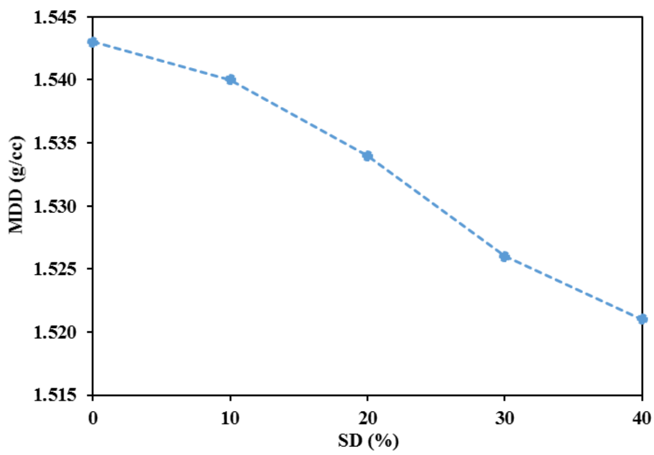

Fig. 4 MDD variation of ES treated with SD

5.3 Unconfined Compressive Strength

Unconfined Compressive Strength (UCS) is determined for natural soil and for SD treated soil as per IS 2720 (Part 10) [14]. According to Fig. 5, The UCS value of natural soil is found to be 165.23 kPa. The UCS value of SD treated soil is found to be 180.23, 188.86, 200.58 and 222.89 kPa for 10, 20, 30 and 40% of SD at 7 days of curing respectively. The UCS value of SD treated soil is found to be 190.12, 220.77, 240.82 and 270.36 kPa for 10, 20, 30 and 40% of SD at 14 days of curing respectively. The UCS value of SD treated soil is found to be 250.03, 290.85, 320.32 and 390.99 kPa for 10, 20, 30 and 40% of SD at 14 days of curing respectively.

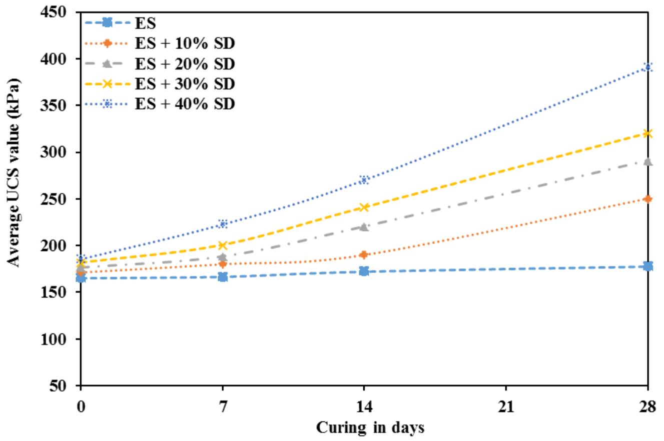

Fig. 5 UCS values of ES treated with SD at 0, 7, 14 and 28 days of curing

5.4 California Bearing Ratio

According to IS: 2720(Part 16), the California Bearing Ratio (CBR) is calculated for both natural and SD-treated soil [15]. The natural soil's CBR value is found to be 2.89%. According to Fig. 6, the CBR values for soil treated with 10, 20, 30, and 40% of SD are 5.12, 8.56, 10.85, and 11.01%, respectively.

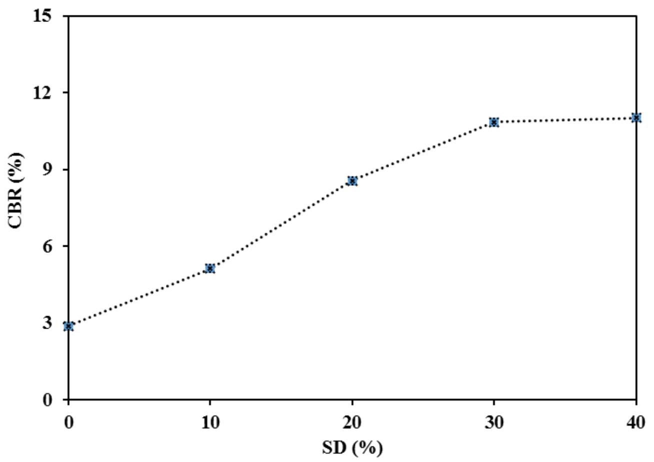

Fig. 6 CBR value of ES treated with SD

5.5 Free Swell Index

According to IS: 2720 (Part 40), the Free Swell Index (FSI) is calculated for both natural and SD-treated soil [16]. Natural soil has an FSI of 133.56%, which is a very high value. According to Fig. 7, the FSI for soil treated with 10, 20, 30, and 40% SD was determined to be 126.85, 123.87, 119.02, and 116.73%, respectively.

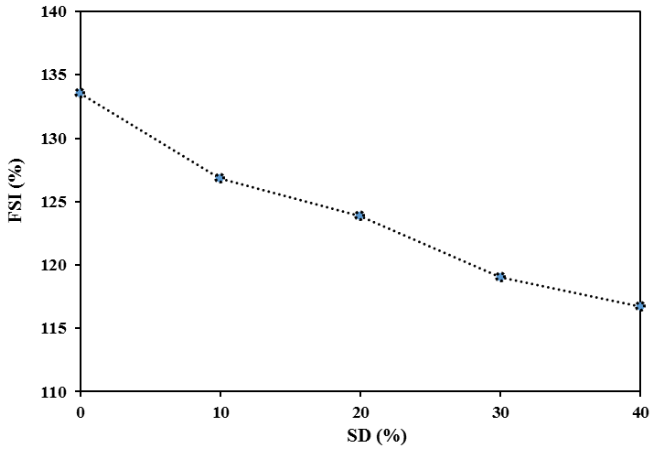

Fig. 7 FSI variation of ES inclusion of SD

6 CONCLUSIONS

The locally accessible clay soil stabilized with stone dust greatly enhanced the geotechnical qualities of the subgrade in view of expected improvements in the soil subgrade. The primary conclusions that can be taken from the results and discussions above are as follows.

1. Liquid Limit and plasticity index with the increase in the percentage of Stone dust up to 40% increased by 21.79 and 15.11% as compared to virgin soil respectively.

2. As compared to the natural soil samples containing SD up to 40%, OMC was reduced by 20.74%, and MDD increased by 1.43% compared to virgin soil treated with SD up to 40%.

3. With the inclusion of SD, the UCS value has improved by up to 33.64, 56.89, and 119.83% at 7, 14, and 28 days of curing, respectively.

4. In comparison to a virgin soil sample, the CBR value increased by 280.96% with an increase in SD percentage up to 40%.

5. FSI of treated soil by mixing of SD was decreased by 12.60% as compared to the natural soil sample.

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