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Research Article

Study and Analysis of Stabilization of Soil with Stone dust

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ABSTRACT

Expansive soil (ES) is characterized by its significant volume change with variations in moisture content, leading to potential structural instability. These soils, predominantly composed of clay minerals, pose challenges in geotechnical engineering due to their swell-shrink behavior. This study investigates the effectiveness of stone dust (SD), a byproduct of crushing stones, as a stabilizing agent to improve the engineering properties of expansive soil. Stone dust is widely available and commonly used as a subbase material in construction. The experimental program involved blending stone dust with expansive soil in varying proportions (0%, 10%, 20%, 30%, and 40%) and conducting a series of laboratory tests, including Liquid Limit, Plastic Limit, Free Swell Index (FSI), Standard Proctor Compaction, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR). The results indicate that the addition of stone dust significantly enhances the strength and reduces the swelling potential of expansive soil, demonstrating its potential as a cost-effective and sustainable stabilizing material.

Keywords: Low-Density Polyethylene Expansive soil (ES),Stone Dust (SD),California Bearing Ratio (CBR),Unconfined Compressive Strength (UCS), Soil Stabilization, Engineering Properties

1. INTRODUCTION

Expansive soils are problematic geotechnical materials known for their tendency to undergo considerable volume changes in response to fluctuations in moisture content. These soils, which typically contain a high percentage of montmorillonite or other clay minerals, exhibit swelling when wet and shrinkage upon drying. Such behavior often leads to structural damage in buildings, pavements, retaining walls, and other civil engineering infrastructures constructed on or within these soils. Therefore, the stabilization of expansive soils is a critical concern in geotechnical engineering.

Traditional methods of soil stabilization involve the use of chemical additives such as lime, cement, and fly ash. However, these materials may not always be cost-effective or environmentally sustainable, especially in developing regions. In recent years, there has been growing interest in utilizing industrial by-products and locally available materials to improve soil properties. One such material is stone dust, a by-product generated during the crushing of rocks in quarrying and aggregate production. Stone dust is generally considered waste material and is available in abundance at low cost.

2. AIM AND OBJECTIVE OF THE STUDY

The objective of this study is to evaluate the suitability of stone dust as a stabilizing agent for expansive soil. By mixing varying proportions of stone dust with expansive soil, the changes in key engineering properties such as Atterberg limits, compaction characteristics, strength, and swell potential were assessed. The aim is to determine the optimal percentage of stone dust that can improve the performance of expansive soil, thus offering an economical and sustainable solution for subgrade and foundation applications.

3. LITRATURE REVIEW

Expansive soils are known for their volumetric instability due to moisture variation, which leads to severe structural issues in pavements and foundations. As the demand for sustainable and cost-effective stabilization techniques

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grows, industrial by-products like stone dust have gained attention due to their wide availability and pozzolanic characteristics.

Agate et al. (2024) explored the stabilization potential of bamboo charcoal, lime, and quarry dust. Their findings showed that the addition of quarry dust substantially increased the CBR value and reduced the plasticity index, indicating enhanced soil stability and workability for road construction applications.

Maurya et al. (2023) conducted a study on the stabilization of expansive soils using stone dust in varying percentages. They observed significant improvements in Atterberg limits, compaction characteristics, and strength parameters such as California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS), making stone dust a viable alternative to traditional stabilizers.

Basack et al. (2021) compared the stabilization performance of bagasse ash and stone dust on soft clay soils. The study found that stone dust improved soil gradation and compaction behavior, resulting in increased load-bearing capacity. Their results suggest that stone dust can be effectively used in subgrade applications.

Singh et al. (2020) investigated the combined effects of stone dust and jute fiber on expansive soil. The inclusion of stone dust not only reduced plasticity but also enhanced shear strength and decreased swell potential, especially when used in combination with natural fibers.

4. MATERIALS & METHODS

4.1 Description of Expansive Soil

The expansive soil used in this study was collected from a site known for swelling clay deposits. The soil was air-dried, pulverized, and sieved through a 4.75 mm sieve. The index properties of the soil are presented in Table 1. Based on the results of the Atterberg limits and soil classification tests, the soil was classified as CH (Clay with high plasticity) according to the Unified Soil Classification System (USCS).

Table 1: Index Properties of Untreated Expansive Soil

Property	Value	Standard
Liquid Limit (%)	68	IS 2720 (Part 5)
Plastic Limit (%)	29	IS 2720 (Part 5)
Plasticity Index (%)	39	-
Specific Gravity	2.62	IS 2720 (Part 3)
Free Swell Index (%)	85	IS 2720 (Part 40)
Optimum Moisture Content (OMC) (%)	20.1	IS 2720 (Part 7)
Maximum Dry Density (g/cm³)	1.54	IS 2720 (Part 7)

4.2 Source and Properties of Stone Dust

Stone dust used in this study was obtained from a local stone crusher plant. It is a by-product of crushing granite rocks and contains fine inert particles. The physical properties are summarized in Table 2.

Table 2: Properties of Stone Dust

Property	Value
Specific Gravity	2.68
Particle Size	< 4.75 mm

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Fineness Modulus	2.6
Color	Grey
Nature	Non-plastic, angular

4.3 Experimental Methodology

4.3.1 Sample Preparation

Soil samples were prepared by mixing oven-dried expansive soil with stone dust in various proportions: 0%, 10%, 20%, 30%, and 40% by dry weight of soil. Each blend was thoroughly mixed to achieve homogeneity.

4.3.2 Testing Program

The following tests were conducted to evaluate the effects of stone dust on soil:

- Atterberg Limits: To determine Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) as per IS 2720 (Part 5).
- Free Swell Index (FSI): Measured using IS 2720 (Part 40) to assess swell potential.
- Standard Proctor Test: Conducted to determine OMC and MDD per IS 2720 (Part 7).
- Unconfined Compressive Strength (UCS): Evaluated at 7-day curing as per IS 2720 (Part 10).
- California Bearing Ratio (CBR): Both soaked and unsoaked CBR values were tested as per IS 2720 (Part 16).

5. RESULTS & DISCUSSION

5.1 Effect on Atterberg Limits

The Liquid Limit and Plasticity Index decreased consistently with increasing stone dust content. The reduction in plasticity indicates reduced swelling potential and better workability of the soil.

5.2 Compaction Characteristics

With the addition of stone dust, the Maximum Dry Density (MDD) increased and Optimum Moisture Content (OMC) decreased. This is attributed to better gradation and filler action by the stone dust particles.

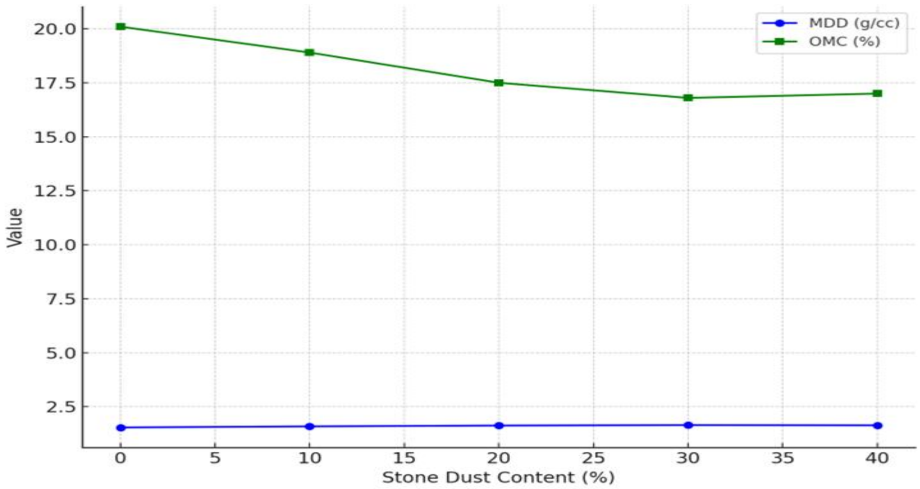

Figure 1: Variation of MDD and OMC with stone dust content

Here is Figure 1 showing the variation of Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) with increasing stone dust content.

5.3 Free Swell Index

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The FSI of untreated soil was 85%, which reduced drastically to 22% at 40% stone dust content, showing a significant improvement in swell behavior.

5.4 Unconfined Compressive Strength

The UCS increased from 110 kPa (untreated) to a maximum of 230 kPa at 30% stone dust, then slightly declined at 40%, indicating the optimal mix.

5.5 California Bearing Ratio

The CBR value improved from 2.8% (untreated) to 9.6% at 30% stone dust, showing improved load-bearing capacity. Beyond 30%, the strength gain plateaued.

Table 3: Summary of Key Test Results

SD Content (%)	LL (%)	PI (%)	FSI (%)	MDD (g/cc)	UCS (kPa)	CBR (%)
0	68	39	85	1.54	110	2.8
10	60	33	60	1.59	160	5.3
20	53	28	41	1.63	200	7.2
30	49	25	30	1.65	230	9.6
40	46	23	22	1.64	215	8.9

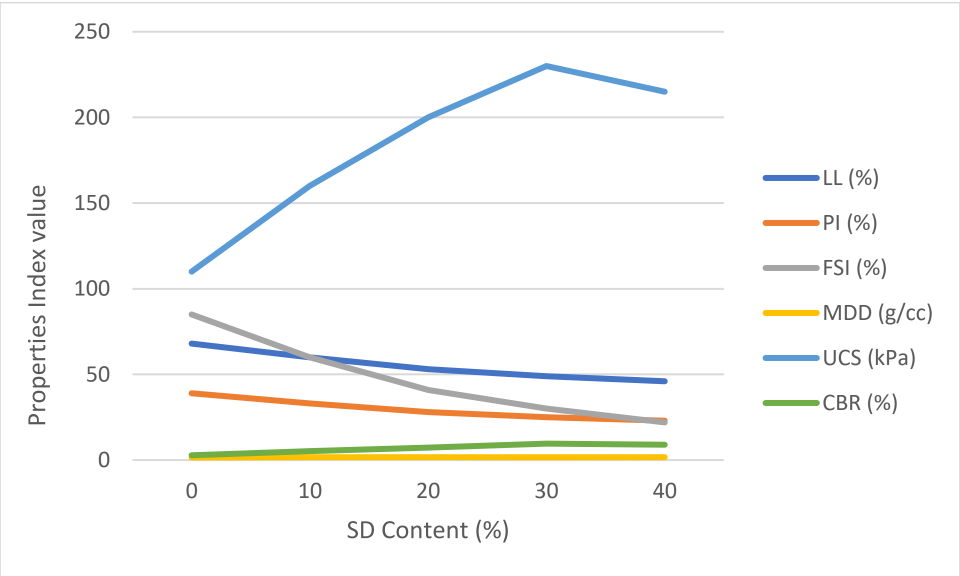

Figure 2: Test Analysis Results

6. CONCLUSION

This study demonstrates that stone dust can significantly improve the engineering properties of expansive soil. The key findings are:

- Plasticity and swell potential decreased with increased stone dust content.
- Maximum Dry Density increased while Optimum Moisture Content decreased.
- Strength parameters such as UCS and CBR improved notably, with the optimal performance observed at 30% stone dust.

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- Stone dust, being a low-cost industrial by-product, presents a sustainable and efficient option for stabilizing expansive soils in road subgrades and foundation applications.

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