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Experimental Investigation of Black Cotton Soil by Flyash Based on Geopolymers

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ABSTACT: The increasing demand for sustainable construction materials has prompted the exploration of alternative stabilizing agents for problematic soils, such as black cotton soil, known for its expansive nature. This experimental investigation focuses on the stabilization of black cotton soil using fly ash-based geopolymer binders. Geopolymers, synthesized by the alkali activation of fly ash, offer a promising eco-friendly solution for soil stabilization by enhancing the soil's engineering properties. In this study, various proportions of fly ash were mixed with black cotton soil, activated using alkaline solutions, and cured for specific durations. The effects of the geopolymer binder on soil compaction characteristics, unconfined compressive strength, swelling potential, and permeability were systematically analyzed. Results indicate significant improvements in the engineering properties of black cotton soil, with increased strength and reduced plasticity, swelling, and permeability. The study suggests that fly ash-based geopolymers are an effective and sustainable alternative for stabilizing expansive soils, offering potential applications in construction and infrastructure projects.

KEYWORDS: Black Cotton Soil, Fly Ash, Soil Improvement, Soil Stabilization, Strength properties, Engineering Properties, Sustainable Construction, Soil Mechanics

I. INTRODUCTION

Stabilization Suggest for improving the engineering properties of soils and granular materials used for pavement base courses, sub-base courses and subgrades like gradation Liquid limit, Plastic limit, Swelling & Shrinkage properties Density, CBR, Texture by the use of additives/stabilizers, which are mixed into the soil/granular materials to affect the desired improvement. A number of additives are available to improve the physical and engineering properties of these materials; however, this in this video we learn procedure for stabilizers such as lime only, Except Cement, Fly ash or a mixture of the above additive. Black cotton soil is expansive and has poor engineering properties, making construction difficult. To improve its stability, fly ash, a byproduct of coal combustion, is used as a stabilizing agent.
Main objective of our research is to stabilize the locally available black cotton soil near Akola city.

The stabilization is done for the following reasons.

Soil stabilization is widely used in connection with road, pavement and foundation construction.

It improves the engineering properties of the soil, e.g.:

a) Strength – to increase the strength and bearing capacity,
b) Volume stability – to control the swell-shrink characteristics caused by moisture changes,
c) Durability – to increase the resistance to erosion, weathering or traffic loading.
d) To reduce the pavement thickness as well as cost.

II. LITERATURE REVIEW

Black cotton soil (BCS) is a highly problematic expansive soil with poor engineering properties, including high plasticity, low bearing capacity, and significant volume changes due to moisture fluctuations. Various stabilization techniques have been explored, with fly ash being a widely studied material due to its pozzolanic properties and cost-effectiveness. This literature review summarizes previous research on the effectiveness of fly ash in stabilizing black

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cotton soil. Black cotton soil is known for its high shrink-swell potential, which can cause damage to structures built on it. The addition of fly ash and rice husk ash can help stabilize the soil and reduce its shrink-swell potential, making it more suitable for construction. Construction purposes. Swelling capacity.

Soil Type	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)
0	83.27	29.76	53.51
5	66.19	26.24	39.95
10	66.02	23.96	42.06
15	60.65	10.86	49.76
20	59.91	18.55	41.36

III. METHODOLOGY

1. Soil Sample Collection – Black cotton soil is collected and tested for properties such as plasticity index, shrinkage, and shear strength.

2. Fly Ash Addition – Fly ash is mixed with black cotton soil in varying proportions (e.g., 5%, 10%, 15%, 20%) to determine the optimal mix.

3. Mixing Process – The soil and fly ash are thoroughly mixed using dry or wet mixing techniques.

4. Compaction – The stabilized mixture is compacted to achieve the required density.

5. Curing – The soil sample is allowed to cure for a specific period (usually 7, 14, or 28 days) to gain strength.

6. Testing – The stabilized soil is tested for properties such as California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), and permeability.

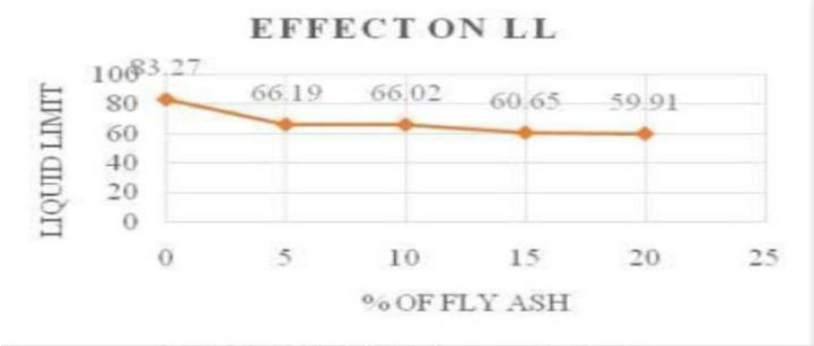

Fig 1: Liquid limit distribution curve for fly ash

Soil and Material Selection:
• Collect representative BCS samples and fly ash from a consistent source.
Soil Characterization:
• Determine the index properties, compaction characteristics, and strength parameters of the untreated soil.

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Geopolymer Solution Preparation:
• Prepare sodium hydroxide solutions with varying molarities and mix with sodium silicate to create alkaline activators.

Soil Treatment:
• Mix BCS with fly ash in different ratios, add alkaline activators, and thoroughly blend.
• Compact the mixture into molds to achieve desired density.

Curing:
• Cure the samples under controlled conditions, either at room temperature or elevated temperatures, for specified durations.

Testing:

• Evaluate the unconfined compressive strength, durability, and microstructural properties of the stabilized soil.

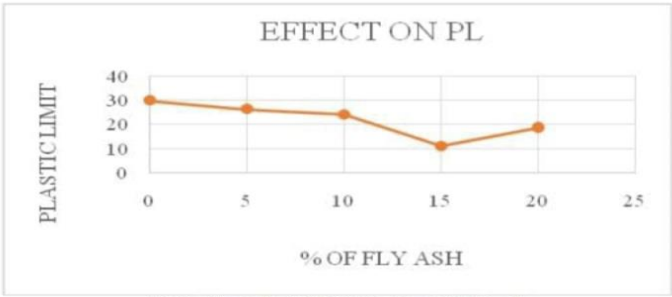

Fig 2: Plastic limit distribution curve for fly ash

IV. CONCLUSION

The results confirm that fly ash effectively stabilizes black cotton soil by reducing swelling, increasing strength, and enhancing durability. The optimal fly ash content is typically 15-25%, depending on soil conditions. These improvements make the soil suitable for roads, embankments, and foundation work enhanced soil properties:
Incorporating fly ash-based geopolymers into BCS has been shown to improve compressive strength, reduce plasticity index, and decrease liquid limit, making the soil more suitable for
Construction purposes**.**

Effective for Subgrade Applications:
Research indicates that fly ash-based geopolymers can effectively stabilize BCS for use in Highway subgrades and sub-bases, providing a viable alternative to traditional stabilization Methods.

Environmental Benefits:
Utilizing fly ash, a byproduct of thermal power plants, in soil stabilization not only enhances Soil properties but also promotes sustainable construction practices by repurposing industrial
Waste.

V. RESULT

1.Unconfined Compressive Strength (UCS):
• Incorporating fly ash and other stabilizers into BCS has led to substantial increases in UCS. For instance, adding 5%geopolymer to BCS resulted in UCS values of 216 kN/m², 259 kN/m², and 324 kN/m² after curing periods of 7, 15, and 28 days, respectively.

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2. Plasticity Index and Liquid Limit Reduction:

• The addition of fly ash and other stabilizers has been shown to decrease the plasticity Index and liquid limit of BCS, enhancing its workability. For example, introducing 5% Fly ash reduced the liquid limit by 1.35%, and a combination of 10% fly ash with 5% Steel slag reduced it by 3.86%.

3. Microstructural Enhancements:

• Scanning Electron Microscopy (SEM) analyses have revealed that treating BCS with Fly ash and cinder fines alters its microstructure from a laminated to a more flocculated And coherent mass. This transformation contributes to improved soil stability and Strength**.**

4. Durability and Performance:

•Studies have demonstrated that fly ash-based geopolymers effectively stabilize BCS for Subgrade and sub-base applications in road construction. The treated soil exhibits Enhanced durability, making it suitable for supporting heavy traffic loads.

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