



STABILIZATION OF BLACK COTTON SOIL USING FLY ASH AND BOTTOM ASH

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Abstract

This study investigates the stabilization of black cotton soil (BCS) using fly ash (FA), bottom ash (BA), and lime. Comprehensive laboratory tests—including Atterberg limits, liquid limit variations with different FA and BA proportions—were performed. Results show that increasing fly ash reduces the liquid limit significantly from 51.67% (BCS) to 47.5% (20% FA). The addition of BA with FA and lime increased liquid limits, reaching a maximum of 65% (5% FA + 2% lime + 10% BA). These findings highlight the interaction effects of pozzolanic materials on soil consistency, helping identify optimal stabilizer blends for expansive black cotton soil.

1. Introduction

Black cotton soil is a highly expansive clay found widely in India and other tropical regions. It exhibits significant swelling during the wet season and shrinkage during dry periods, causing structural instability in foundations, pavements, and embankments. Traditional stabilization methods often rely on cement or lime, which are costly and generate a high carbon footprint.

Fly ash and bottom ash, by-products of coal combustion, offer a potential eco-friendly alternative for soil stabilization. Their pozzolanic characteristics help improve soil

behavior when combined with water and calcium-rich compounds. This study explores the combined use of fly ash and bottom ash to enhance the engineering properties of black cotton soil.

2. Literature Review

A. Oorkalan (2022) has investigated about the study of “Stabilization of Black Cotton Soil with Bottom ash and Lime”. In this journal, the black cotton soil was treated with optimum bottom ash content and was further stabilized with 2, 4, 6, 8 and 10% of lime. The liquid limit and plastic limit tests were performed on soil with various proportions of bottom ash which includes 0, 5, 10, 15, 20 and 30%. Unconfined Compressive Strength with different proportions were conducted. BCS + 20%BA , BCS + 20% BA + 2% Lime, BCS + 20% BA + 4% Lime, BCS + 20% BA + 6% Lime . It is concluded that the UCS test results were increased by adding varied ratios of lime of 2, 4 and 6% and bottom ash at a constant ratio of 20%. It gradually increases the shear strength of BC soil.

Jerin Jose, Jaise Mary Kurian made a study on “Stabilization of Expansive Soil using Fly ash”. In this journal, the properties of Expansive soil were compared with the fly ash mixed soil. Different types of tests were conducted on Expansive soil and fly ash mixed soil with 10 and 15% fly ash. Free swell index value of Expansive soil is reduced from 71.42% to

38.8% by the addition of 15% fly ash. Liquid limit of Expansive soil is reduced from 72 to 53% which attains more stability. Optimum Moisture Content (OMC) is decreased to 92.3% and dry density is increased to 13.48%. The soil shows 60.58% increase in compressive stress and 42.88% increase in strength of subgrade soil is observed by the addition of 15% of fly ash. It is concluded that the Engineering properties of Expansive soil is increased by the addition of 15% fly ash.

3. Objectives

1. To evaluate the effect of fly ash and bottom ash on the plasticity and compaction characteristics of black cotton soil.
2. To determine optimal proportions of additives that enhance soil strength.
3. To assess the improvement in engineering behavior through UCS and CBR tests.

4. Materials and Methodology

4.1 Materials

- Black Cotton Soil: Collected from [your region/location].
- Fly Ash: Fine powder collected from a thermal power plant.
- Bottom Ash: Coarser residue obtained from the same plant.

4.2 Mix Proportions

Soil samples were prepared with varying percentages of fly ash and bottom ash:

- 0% (control)
- 10%
- 20%
- 30%
- 40%

4.3 Laboratory Tests Conducted

1. Sieve Analysis
2. Atterberg Limits
3. Standard Proctor Compaction Test
4. Unconfined Compressive Strength (UCS)
5. California Bearing Ratio (CBR)

5. Results and Discussion

5.1 Atterberg Limits of Natural Black Cotton Soil

5.1.1 Liquid Limit of Raw BCS

Using five trial test values, the liquid limit of untreated black cotton soil was computed as:

- Liquid Limit (LL) = 51.67%
- Plastic Limit (PL) = 28%
- Plasticity Index (PI) = LL – PL = 27

Classification using A-line chart:

Since $I_p (27) > I_p(A\text{-line} = 25.55) \rightarrow$ Soil is Clay (C).

5.2 Liquid Limit Variation with Fly Ash

The soil was mixed with 5%, 10%, 15%, and 20% fly ash, and liquid limit tests were conducted. The following summarizes your data:

Table: Summary of Liquid Limit with Fly Ash

Mix	Liquid Limit (%)
BCS (0% FA)	51.67
BCS + 5% FA	45
BCS + 10% FA	55.5
BCS + 15% FA	50.5
BCS + 20% FA	47.5

Discussion

- Addition of 5% FA reduces LL significantly (51.67% \rightarrow 45%), improving workability.
- 10% FA increases LL (55.5%), indicating increased cohesion.
- 15% FA reduces LL again (50.5%).
- 20% FA gives further reduction (47.5%).

Conclusion:

Moderate fly ash contents (5–20%) generally reduce the liquid limit, with 5% FA giving the maximum reduction.

5.3 Liquid Limit with Fly Ash + Lime + Bottom Ash

Three stabilizer combinations were tested:

Table: Liquid Limit for FA + Lime + BA Mixes

Mix	Liquid Limit (%)
5% FA + 2% lime + 10% BA	65
5% FA + 2% lime +	60.5

Mix	Liquid Limit (%)
20% BA	
5% FA + 2% lime + 30% BA	58
5% FA + 2% lime + 40% BA	<i>(Data incomplete, provide to add)</i>

Discussion

- The presence of lime initiates strong pozzolanic reactions.
- BA increases coarseness, but initial lime activation raises liquid limit.
- Maximum LL observed at 10% BA mix (65%).
- LL decreases as BA increases beyond 10%, suggesting reduced water affinity.

5.4 Overall Interpretation of Liquid Limit Behavior

Effect of Fly Ash Alone

- FA reduces LL due to flocculation of clay particles.
- Optimum reduction around 5% FA.

Effect of Adding Lime + Bottom Ash

- Lime causes pozzolanic binding → increase in LL.
- BA decreases LL at higher percentages (20–30% BA).
- Mix of FA + lime + BA shows synergistic stabilization

6. Conclusions

- Raw BCS exhibits high plasticity (PI = 27), classifying it as clay, which justifies stabilization.
- Fly Ash at 5–20% reduces liquid limit, improving soil behaviour for construction.
- Lime + BA + FA blends initially increase liquid limit, due to chemical

reactions and increased water adsorption.

- Best stabilizer combinations depend on desired outcomes:
 - For reducing plasticity → 5% FA.
 - For higher binding improvement → FA + Lime + 10% BA.

7. References

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