

Soil Stabilisation Using Fly Ash for Improvement of Silty Clay Soil

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Abstract: Soil stabilisation is a vital ground improvement technique used to enhance weak soil properties for construction purposes. In regions like Nashik, silty clay soils derived from Deccan Trap basalt exhibit low bearing capacity, high plasticity, and moderate swelling characteristics, making them unsuitable for direct use in road subgrades. This study investigates the effectiveness of Class F fly ash obtained from Nasik Thermal Power Station (NTPS) in improving the engineering properties of such soils.

Fly ash was added in varying proportions ranging from 0% to 30% by dry weight of soil. Laboratory tests including Standard Proctor Compaction, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), Atterberg Limits, and Free Swell Index were conducted as per IS 2720 standards.

The results indicate significant improvement in soil properties with increasing fly ash content. The Plasticity Index reduced by more than 50%, Free Swell Index decreased from high to negligible range, and soaked CBR increased from 2.8% to 24.5% at 20% fly ash content. UCS also showed a fivefold increase after 28 days curing. The optimum fly ash content was found to be 20%, providing maximum strength improvement with economic benefits.

This study concludes that fly ash stabilisation is a cost-effective, sustainable, and technically efficient solution for improving weak soils in road construction.

Keywords: Fly Ash, Soil Stabilisation, CBR, UCS, Atterberg Limits, Expansive Soil, Subgrade Improvement

I. INTRODUCTION

Rapid infrastructure development in India has increased the need to construct on weak and problematic soils. In Maharashtra, especially Nashik region, silty clay soils exhibit low strength, high plasticity, and swelling behavior, making them unsuitable for direct construction use.

Traditional soil replacement methods are costly and environmentally unsustainable. Fly ash, a by-product of thermal power plants, provides an economical and eco-friendly alternative for soil stabilisation. This project investigates the use of Class F fly ash to improve the engineering properties of silty clay soil.

II. PROBLEM STATEMENT

Silty clay soils in Nashik have low bearing capacity (CBR 2–4%), high plasticity, and swelling characteristics, which lead to pavement failure and structural issues. At the same time, large quantities of fly ash generated from thermal power plants remain underutilised, causing environmental problems. This study aims to utilize fly ash effectively to improve soil properties and reduce construction costs while addressing environmental concerns.



III. METHODOLOGY

The experimental study was carried out by mixing fly ash with soil in proportions of 0%, 5%, 10%, 15%, 20%, 25%, and 30%.

A. Soil and Fly Ash Collection

- Soil collected from Nashik region
- Fly ash obtained from NTPS (Class F)

B. Laboratory Tests Conducted

- Standard Proctor Test (MDD & OMC)
- California Bearing Ratio (CBR)
- Unconfined Compressive Strength (UCS)
- Atterberg Limits (LL, PL, PI)
- Free Swell Index (FSI)
- Permeability Test

C. Curing Period

- Tests performed at 0, 7, 14, and 28 days

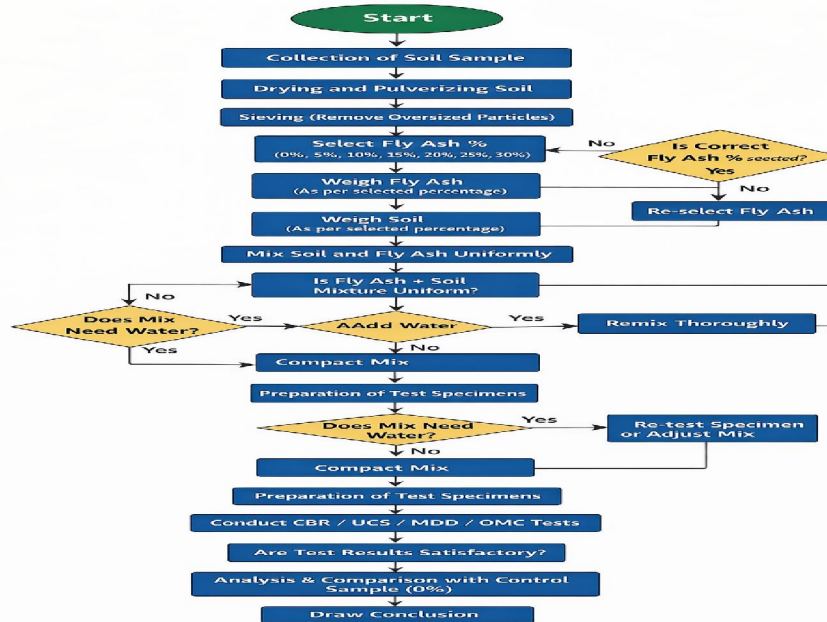
D. Analysis

Results were analyzed based on IS codes and compared with IRC requirements for road subgrade.

Mix Proportions

Fly Ash (%)	Description
0	Soil + Fly Ash
5	Soil + Fly Ash
10	Soil + Fly Ash
15	Soil + Fly Ash
20	Soil + Fly Ash
25	Soil + Fly Ash
30	Soil + Fly Ash





The experimental procedure for soil stabilization using fly ash begins with the collection of a representative soil sample. The collected soil is then dried and pulverized to break down lumps and achieve uniformity. After drying, the soil is sieved to remove oversized particles. Different proportions of fly ash, namely 0%, 5%, 10%, 15%, 20%, 25%, and 30%, are selected for the study. The required quantities of soil and fly ash are then weighed according to the chosen percentages and mixed thoroughly to obtain a uniform blend. Water is added to the mixture as required to achieve the desired moisture content.

The prepared mix is then compacted properly, and test specimens are prepared. These specimens are subjected to various laboratory tests such as Optimum Moisture Content (OMC), Maximum Dry Density (MDD), California Bearing Ratio (CBR), and Unconfined Compressive Strength (UCS). The results obtained from these tests are carefully recorded and analyzed. Finally, the performance of the stabilized soil is compared with the control sample (0% fly ash) to evaluate the effectiveness of fly ash stabilization, and conclusions are drawn accordingly.

Materials Required

Soil Sample

Collected from the site (disturbed or undisturbed as required)

Fly Ash

Obtained from thermal power plants

Should be dry and free from impurities

Water

Clean potable water for mixing and compaction

Equipment / Apparatus Required

Weighing Balance

For accurate measurement of soil and fly ash

Oven

For drying the soil sample



Sieve Set

For particle size separation (e.g., 4.75 mm sieve)

Mixing Tray / Pan

For uniform mixing of soil and fly ash

Compaction Equipment

Standard/Modified Proctor apparatus

Moulds

For specimen preparation (CBR mould, UCS mould)

Rammer

For compaction

CBR Testing Machine

For California Bearing Ratio test

UCS Testing Machine

For Unconfined Compressive Strength test

Moisture Content Containers

For determining water content

Graduated Cylinder / Measuring Jar

For measuring water

IV. RESULTS AND DISCUSSION

- Plasticity Index reduced from 25% to 11.3%
- Free Swell Index reduced from 62.9% to 18.5%
- Soaked CBR increased from 2.8% to 24.5%
- UCS increased from 98 kPa to 515 kPa
- Maximum improvement observed at 20% fly ash content

The improvement is due to pozzolanic reactions forming cementitious compounds (CSH & CAH), which increase strength and reduce swelling.

V. CONCLUSION

Fly ash stabilisation significantly improves the engineering properties of silty clay soil. The optimum fly ash content is found to be 20%, providing maximum strength and stability.

This method is:

- Economical (65–70% cheaper than cement/lime)
- Environmentally sustainable
- Suitable for road subgrade and embankment construction

Hence, fly ash stabilisation is recommended for large-scale implementation in Maharashtra.

VI. ACKNOWLEDGMENT

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REFERENCES

- [1]. IS 2720 (Various Parts) – Methods of Test for Soils
- [2]. IS 3812 – Fly Ash Specification
- [3]. IRC Guidelines for Road Construction



- [4]. Phani Kumar & Sharma (2004) – Fly Ash Stabilisation Study
- [5]. Pandian et al. (2001) – CBR Behaviour of Fly Ash

