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Soil Stabilization Using Fly Ash in Road Construction

Dhirendra Kumar[1],

Asst Proff, Dept. Of Civil Engineering , IIMT College of Engineering Greater Noida

Piyush Thakur[2], Prince Dedha [3], Sagar Kumar [4], Shivam Lodhi[5], Raj Kumar Chauhan[6]

Student, Dept. Of Civil Engineering , IIMT College of Engineering Greater Noida

Abstract

Soil stabilization is essential for improving the engineering properties of soil for use in road construction. Traditional methods often use cement and lime; however the high cost and environmental impact of these materials have led researchers to explore industrial by products as sustainable alternatives. Fly ash, a residue from coal combustion in thermal power plants, has shown promising potential as a stabilizing agent due to its pozzolanic properties. This research investigates the effectiveness of fly ash in stabilizing sub grade soils for flexible pavement, analyzingstrength, compaction, and durability parameters. Laboratory tests such as Atterberg limits, California Bearing Ratio (CBR), and Unconfined compressive strength (UCS) were conducted for untreated soil and soil mixed with varying percentages of fly ash. Results demonstrate enhanced engineering characteristics of soil with optimal fly ash content, suggesting its suitability as an eco friendly stabilizer in road construction.

Keywords

Soil Stabilization, Fly Ash, Road Construction, Pozzolanic, California Bearing Ratio, Unconfined Compressive Strength

I Introduction

Road infrastructure plays a critical role in economic development by facilitating transportation of goods and people. The performance of road pavement largely depends on the strength and durability of the underlying soil. Many native soils often lack adequate engineering properties, leading to premature pavement failure. Soil stabilization enhances these properties to support vehicular loads and resist environmental effects.

Fly ash, a by product of coal combustion, is generated in large quantities around the world. Its disposal raises environmental concerns, motivating its use in construction materials. The present study examines fly ash as a stabilizing agent, focusing on its ability to improve soil properties for road subgrade and base layers.

II Literature Review

Several researchers have studied fly ash in soil stabilization:

- **Sherwood(1993)** stated that fly ash can enhanced soil strength through pozzolanic reactions forming cementitious compounds.
- **Bell (1996)** reported improvements in plasticity, workability, and reduced swell potential when fly ash was blended with clayey soils.
- **Singh & Sharma (2008)** concluded that fly ash significantly increases the CBR value of subgrade soils, making them suitable for pavement applications.

These studies indicate that fly ash has a dual role of improving soil quality and addressing waste management concerns.

III Materials & Methodology

3.1.Materials

- **Soil:** Locally obtained soil classified as CL (clay with low plasticity) as per Unified Soil Classification System (USCS).
- **Fly Ash:** Class F fly ash sourced from a nearby thermal power plant.
- **Water:** potable water for compaction and curing.

3.2.Methodology

The study involved mixing soil with fly ash in different proportions (0%, 5%, 10%, and 15% by dry weight). Tests Conducted include:

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

Standard procedures from ASTM and Indian Standards (IS) were followed for all tests.

IV Results and Analysis

4.1.Atterberg Limits

Fly Ash %	Liquid Limit %	Plasticity Index %
0	45	22
5	42	18
10	38	15
15	35	12

Observation: Increasing fly ash reduced the platicity of soil, improving workability.

4.2.Compaction Test

Fly Ash %	Optimum Moisture Content %	Max. Dry Density (g/cm^3)
0	16	1.68
5	17	1.70
10	18	1.72
15	19	1.74

Observation: Additives increased optimum moisture and achieved higher dry densities, indicating denser packing.

4.3.CBR Values

Fly Ash %	CBR @ 2.5 mm (%)
0	5.5
5	8.2
10	12.7
15	15.3

Observation: Maximum CBR was achieved at 15% fly ash, showing enhanced load bearing capacity.

4.4.UCS Results

Fly Ash %	UCS (kPa)
0	220
5	310
10	450
15	575

Observation: Higher fly ash content increased compressive strength, important for pavement stability.

5.Discussion

The test results indicate that fly ash significantly improves engineering properties of the soil. Reduction in plasticity suggests better stability and reduced shrink swell behaviour. Higher CBR and UCS values confirm that fly ash enhances resistance to deformation and increases load bearing capacity of the subgrade.

This improvement is attributed to pozzolanic reactions between fly ash silica and soil alumina in the presence of moisture, forming calcium silicate hydrates. Additionally, the fine particles of fly ash fill voids, leading to denser soil structure.

6.Advantages of Using Fly Ash

- Improves soil strength and stability.
- Reduces plasticity and swelling behaviour of clay soils.
- Economical compared to traditional stabilizing agent.
- Utilizes industrial Waste and reduces environmental pollution.

7.Conclusion

The study demonstrates that fly ash is an effective stabilizing agent for soil used in road construction. Key finding include:

- Fly ash reduces plasticity and enhances compaction characteristics.
- Strength parameters such as CBR and UCS improved with increased fly ash content.
- Optimal performance was observed at 15% fly ash addition.

Therefore, fly ash can be considered a sustainable and economical alternative to traditional stabilization materials, offering both environmental benefits and improved mechanical performance.

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