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Integration of Fly Ash and Calcium Chloride for Stabilization of Soft Soil

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Abstract: Soft soils possess high compressibility, low permeability, low shear strength, high water content, a large void ratio, and particular structural properties that necessitate appropriate consideration before developing foundations or any structures. A variety of stabilizing procedures have been widely used to enhance the geotechnical properties of soft soil. In the current investigation, fly ash and calcium chloride were combined to improve the soft soil's strength characteristic. The fly ash was mixed at 10% and 15% by dry weight of soft soil, while the calcium chloride was combined at 4% and 6% by dry weight of soft soil. Modified proctor compaction test, Direct Shear Test (DST), and California Bearing Ratio (CBR) tests were used to measure strength properties.

Keywords: **Soft soil, Fly ash, Calcium chloride, strength parameters.**

I. Introduction

Fly ash is a fine-grained grey powder produced as a byproduct of coal-fired thermal power plants. The majority of fly ash particles are glassy and spherical. Fly ash generated by plants must be effectively disposed of since it has adverse effect on the environment [1–6]. In dry conditions, fly ash exhibits zero cohesion (negligible) and an angle of internal friction ranging from 29° to 37° [7]. According to study, thermal power plants in India create almost 200 million tonnes of fly ash. This information is not consistent and may change over time.

Calcium chloride is a naturally occurring inorganic chemical. It is a salt composed of the chemical composition $CaCl_2$ with a white crystalline structure that is solid at room temperature and very insoluble in water. It is created by reacting hydrochloric acid with calcium hydroxide. It collects moisture from the air and emits heat as it dissolves. Calcium Chloride's hygroscopic (moisture absorbing) feature aided soil stability through moisture attraction and subsequent evaporation resistance [8], [9].

In the present research, fly ash and calcium chloride are employed for soil stabilization by improving the strength properties of the soil to give successful construction. The fly ash was mixed at 10% and 15% by dry weight of soft soil, while the calcium chloride was combined at 4% and 6% by dry weight of soft soil. Several tests on the soil were performed to assess the soil's strength metrics and distinctive qualities. The soft soil was subjected to the Modified Proctor Compaction Test, Direct Shear Test, and California Bearing Test. The CBR test was carried out in a soaked situation.

II. Materials & Experiments

The soil sample for this investigation was acquired from a farm in the Raipur district hamlet of Gondwara, while the fly ash was collected from Sarveshwar Bricks Raipur. The Calcium Chloride sample was obtained from a nearby market. The grain size distribution of soil samples was determined in accordance with IS 2720-Part IV (1985). Table 1 shows the geotechnical parameters of soil, fly ash, and calcium chloride. The sample was created by combining various amounts of soil, fly ash, and calcium chloride to improve the soil's strength qualities, as indicated in Table 2. The Modified Proctor Compaction Test, Direct Shear Test, and California Bearing Ratio (soaked) tests were carried out in accordance with IS 2720 (Part 7)- 1980, IS 2720 (Part 13)- 1986, and IS 2720 (Part 16)- 1979. The Direct Shear Test and the California Bearing Ratio test were performed on complete samples at their respective Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) (MDD).

Table 1: Geotechnical properties of material

Properties	Soil	Fly Ash
Specific Gravity	2.63	2.13
Liquid Limit	45	30
Plastic Limit	20	-
Plasticity Index	25	-
Max. Dry Density	17 kN/m^3	13 kN/m^3
Optimum Moisture Content	22	26

Table 2: Description of sample prepared for stabilization

Sample Name	Description
100% Soft Soil	S1
90% Soft Soil + 10% Fly Ash	S2
85% Soft Soil + 15% Fly Ash	S3
86% Soft Soil + 10% Fly Ash + 4% Calcium Chloride	S4
84% Soft Soil + 10% Fly Ash + 6% Calcium chloride	S5
83% Soft Soil + 15% Fly Ash + 4% Calcium Chloride	S6
81% Soft Soil + 15 % Fly Ash + 6% Calcium Chloride	S7

III. RESULTS & DISCUSSIONS

3.1 Strength Characteristics

The Modified Proctor Compaction Test, Direct Shear Test, and California Bearing Test were used to determine the strength of complete samples.

3.1.1 Compaction Characteristics

The Modified Proctor Compaction Test was done on complete samples that were being stabilized. Table 3 shows the Optimal Moisture Content and Maximum Dry Density of all seven samples. In this case, the proportion of fly ash utilized in the test ranges from 0% to 15%, whereas the percentage of calcium chloride ranges from 0% to 6%. It was discovered that the optimal moisture content increases while the maximum dry density drops, which might be attributed to the fly ash's low specific gravity.

Table 3: Optimum Moisture Content and Maximum Dry Density of all samples.

Sample Name	S1	S2	S3	S4	S5	S6	S7
Optimum Moisture Content (%)	22	23	23.50	24	24.50	25	25.50
Maximum Dry Density (kN/m^3)	17	16	15.5	15	14.5	14	14

3.1.2 Direct Shear Test

To measure cohesiveness and angle of friction, complete samples were subjected to the Direct Shear Test. The samples were produced at their optimum moisture content and maximum dry density. Table 4 displays the shear strength parameter values. Cohesion increases as the proportion of fly ash increases, but the angle of friction decreases, which may be owing to the self-cementing capabilities and hardening of the fly ash in the presence of water.

Table 4: Shear strength parameters of all samples.

Sample Name	Cohesion (c) kN/m^2	Angle of Friction (Degree)
S1	18	22°
S2	17	24°
S3	16	26°
S4	19	26°
S5	20	27°
S6	18	27°
S7	20	28°

3.1.3 California Bearing Ratio (CBR) Test

The California Bearing Ratio Test was done on complete soft soil samples and the results are shown in Fig. 1. The test findings show that the CBR value increases as the proportion of fly ash and calcium chloride increases, which might be attributed to frictional resistance between the particles.

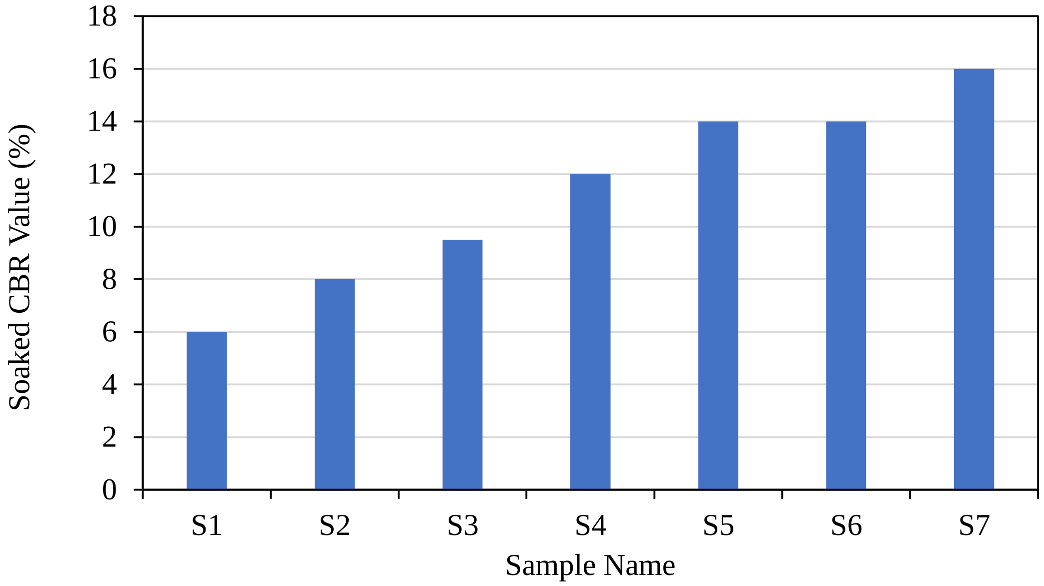

Fig. 1: Soaked CBR values of all sample.

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IV. Conclusion

Various conclusions are reached based on the experiment and the subsequent tests:

• As the amount of Fly ash and Calcium Chloride rises, the Optimum Moisture Content (OMC) of the soft soil sample increases while the Maximum Dry Density (MDD) drops. This might be owing to fly ash's low density and specific gravity.
• As the amount of Calcium Chloride and Fly Ash rises, the cohesion value increases while the angle of friction decreases.
• The CBR value increases to some extent when the amount of fly ash and calcium chloride increases.
• In soft soil, a suitable proportion of Calcium Chloride to Fly Ash is near to the optimal quantity for early high strength and long-term strength.

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