

Characterization of Soil Properties with Different Admixture

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Abstract

Soil is the basic foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Various methods are available in the literature for soil stabilization. In this study, fly ash and lime were mixed with clay soil to investigate the relative strength gain in terms of unconfined compression, bearing capacity and compaction. The effect of fly ash and lime on the geotechnical characteristics of clayey soil fly ash and clay lime mixtures was investigated by conducting standard Proctor compaction tests, unconfined compression tests, CBR tests and permeability test. The tests were performed as per Indian Standard specifications. The materials used for preparing the samples are Clayey soil, Fly ash and Lime. The soft clayey soil used for these experiments was brought from a Baliapur, near B.I.T.Sindri. The physical properties of the soil were determined as per IS specifications. Fly ash for the study was brought from DVC Bokaro Thermal Power Plant Bokaro Lime is another additive used, which is locally available, to improve subgrade characteristics. It is obtained by heating limestone at elevated temperatures.

Keywords: Fly Ash, Lime, Geotechnical properties

1. INTRODUCTION

Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban, more areas are covered with highly plastic and clayey soil, which is not suitable for such purpose. Extensive laboratory / field trials have been carried out by various researchers and have shown promising results for application of such soil after stabilization with additives such as sand, silt, lime, fly ash, etc. As fly ash is freely available in the Thermal Power Plants, it can be used for stabilization of soils for various uses.

Clayey soil constitutes an important group of residual soils existing under lateritic soils usually

found on western and eastern coasts of India. It is very sensitive to water and loses a greater part of its strength when saturated. In this project the behaviour of clay soil when mixed with different admixture for stabilizing the soil properties can be observed. All the geotechnical tests will carry out to obtain the satisfactory results. By analysing the test result the substantial and desirable changes in the properties of clay soil as a Civil Engineering material on application of various admixtures can be obtained for an effective disposal of fly ash avoiding environmental pollution, it is necessary to utilize it on a continuous basis for some beneficial purposes. Its bulk utilization is feasible through civil engineering applications. The test results indicate that the addition of fly ash plays an important role in the development of strength of the soil. A little addition of lime even at 5% to the soil-fly ash mixes significantly increases the unconfined compressive strength. In the further investigation UCS tests were carried out for different proportion

2. LITERATURE REVIEW

Jan and Walker (1963) and Wang et al. (1963) studies the effect of soil properties with lime. They found that the reduction in soil plasticity is maintained in the second stage (because of cementitious formation). **Eades and Grim (1966)** performed UCS on six soils with different mineralogies. They established that the percentage of added lime and the soil mineralogy are the most important factors that affect the maximum strength gain. **Bell (1996)** investigated the effects of lime addition on the engineering properties of clay minerals. Three clay mineral deposits, namely, montmorillonite, kaolinite and quartz, were considered in this study. He found that after lime treatment, the liquid limit of montmorillonite decreased, whereas those of kaolinite and quartz increased. **Parsons et al. (2001)** used five types of soils to evaluate the mixing procedure of soil modification using lime. In their study, the soil was mixed with 2.5 and 5.0% lime and the results showed that the liquid limit decreased with increasing lime content, together with the decrease in plastic limit and plasticity index. **Nalbantoglu and Tuncer (2001)** conduct a series of permeability test

on an expansive soil in Cyprus with lime percentage ranging from 0 to 7%. They found that higher permeability was obtained from lime soil mixture because of soil aggregation and flocculation. **Milburn and Parsons (2004)**) Studied the combined lime with other chemical additives in eight soil samples classified as CH, CL, ML, SM and SP. Leaching test was applied to the soil samples under constant head using distilled water. The results showed that the lime-treated samples had reduced hydraulic conductivity; this reduction was attributed to the formation of bonds between the soil particles **Alhassan (2008)** believed that the differences in soil behaviour with respect to permeability is attributed to soil mineralogy. Therefore, further comprehensive studies must be conducted to elucidate the issue.

3. METHODOLOGY



Fig .01 Sample of clayey soil

The clayey soil is collected from Baliapur, Near BIT Sindri, Dhanbad. Fly ash was collected from Bokaro Thermal Power Plant Bokaro and Lime was supplied by local market Sindri Dhanbad. The quantity of fly ash content is varied gradually as 5, 10,15and 20 percent by weight of total mix, the fly ash, lime and clayey soil are mixed fully on dry weight basis in the suitable requirement proportions. The different properties of clayey soil has been tested as per IS Code-2720 in laboratory

The following tests are conducted

- A. Sieve Analysis
- B. Compaction
- C. Liquid limits
- D. Plastic limits
- E. CBR
- F. Permeability Tests

Sieve analysis

GRAIN SIZE DISTRIBUTION OF SOIL

The grain size analysis on natural soil were conducted according to I.S 2720(Part IV)-1975.

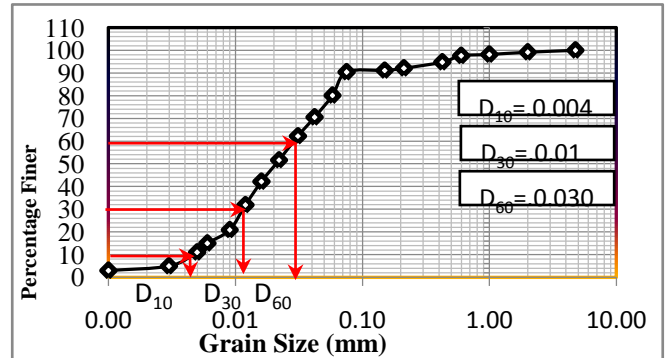


Fig.2 Grain size distribution curve

From the above fig.1 Cu is greater than six and Cc values lies between one and three .Liquid limit also greater than 50%.Hence the soil is Inorganic clays of High plasticity (CH).

TABLE-1

PROPERTIES OF SOIL SAMPLE

SL.NO	PARAMETERS	VALUES
1	SPECIFIC GRAVITY	2.25
2	OPTIMUM MOISTURE CONTENT	23.3
3	MAXIMUM DRY DENSITY	1.43
4	LIQUID LIMIT	57.7
5	PLASTIC LIMIT	24

CHEMICAL COMPOSITION OF LIME

Constituent	Chemical Formula	Composition
Calcium oxide	CaO	75.77
Magnesium oxide	MgO	3.70
Ferric Oxide	Fe ₂ O ₃	0.16
Aluminium Oxide	Al ₂ O ₃	0.12
Silicon dioxide	SiO ₂	0.31
Sulphur trioxide	SO ₃	0.02
Chlorine	Cl	0.04
Potassium oxide	K ₂ O	0.03
Manganese Oxide	MnO	< 10
Titanium dioxide	TiO ₂	0.01

Atterberg’s limits

The tests on the liquid limits (LL), plastic limits (PL) and plasticity index (PI) of the soil- additive



Fig.03 liquid limits
Compaction Test

The compaction tests to obtained the moisture-density relationship of the soil-additive mixtures were conducted according to I.S 2720 (Part viii)-1965.



Fig-04 Compaction Tests

California Bearing Ratio Test

The CBR tests were conducted according to I.S 2720 (Part-VIII).

4. OBJECTIVE OF PROJECT

- To enhance the engineering properties of clayey soil (OMC, MDD, CBR, Unconfined compressive strength and Permeability)
- To upgrading the properties of clayey soil for construction of different structure.
- Consumption of Industrial waste of fly ash and lime.
- To increase bearing capacity of clayey soil.

5. RESULTS AND DISCUSSIONS

These were the results obtained for the basis tests conducted on clayey soil.

Table-5.1 Test results of clayey soil with lime additive

Mat .	OM C (%)	MDD (g/cm ³)	Sp. Gr (G)	LL %	PL %	PI %	CB R (%)	UC S (Kg / cm ²)	K (cm/s) x 10 ⁻⁶
c +0% L	23.3	1.43	2.25	57.7	24.0	33.7	2.46	1.25	2.78
c +5% L	25.0	1.40	2.29	57.2	24.7	32.5	4.44	1.45	2.52

c +10 % L	26.0	1.39	2.31	53.5	25.5	28.0	5.94	1.56	2.45
c +15 % L	26.5	1.32	2.48	53.2	26.7	26.5	8.70	1.79	2.15
c +20 % L	27.0	1.31	2.53	53.0	27.8	25.2	6.32	1.68	2.10

Table-5.2 Test results of clayey soil with fly ash additive

Mat.	OMC %	MDD g/cm ³	Sp . gr.	LL %	PL %	PI %	CB R (%)	UCS (Kg/ cm ²)	K (cm/s) *10 ⁻⁶
c+0% F	23.3	1.43	2.25	57.7	24.00	33.70	2.46	1.25	2.78
c+5% L	24.8	1.43	2.27	54.8	28.03	26.77	4.39	1.41	2.49
c+10% L	25.7	1.38	2.29	53.7	30.47	23.23	5.74	1.54	2.40
c+15% L	26.3	1.36	2.42	53.3	31.83	21.47	8.03	1.75	2.10
c+20% L	26.8	1.32	2.51	52.8	31.95	20.85	9.47	1.83	1.80

Compaction Test

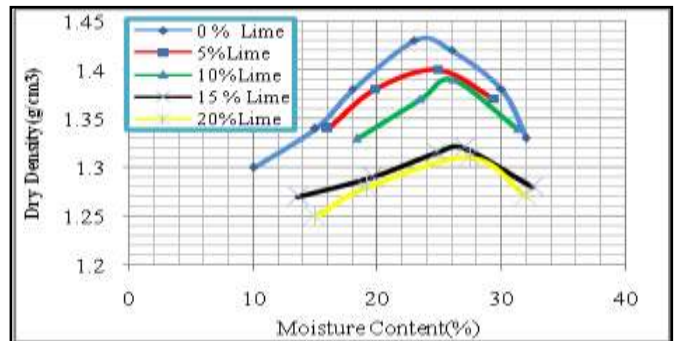


Fig.05 Compaction curve of clayey soil with lime

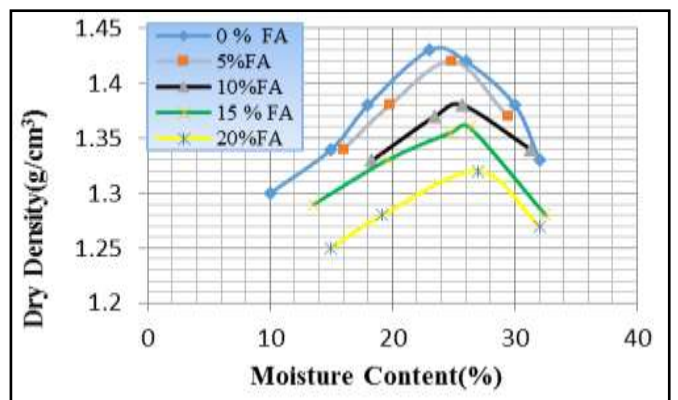


Fig.06 Compaction curve of clayey soil with fly ash

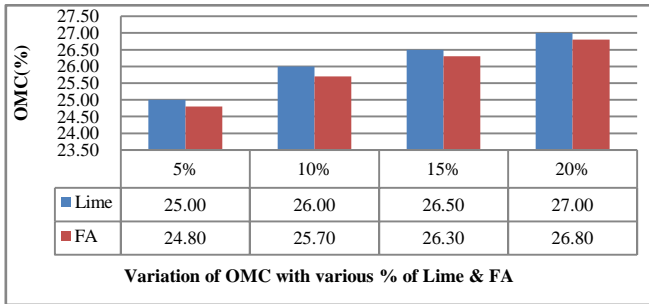


Fig-07 Variation of OMC with various percentages of Lime and Fly ash

The figure 07 shows that the variation of OMC with varying percentage of additives, the OMC increase with increase in additives. When the lime and fly ash are used in of soil stabilizing additive, soil becomes large size clusters resulting in texture change. The enlarge particle size causes the void ratio to increase. Due to increase void ratio, the OMC is increase.

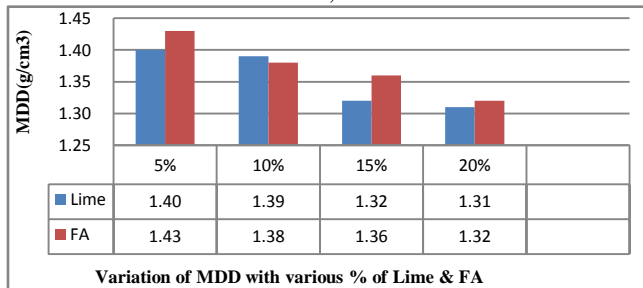


Fig-08 Variation of MDD with various percentages of Lime and Fly ash

The figure 08 shows that the variation of MDD with varying percentage of additives, the MDD decrease with increase in additives. When the lime and fly ash are used in of soil stabilizing additive, soil becomes large size clusters resulting in texture change. The enlarge particle size causes the void ratio to increase. Due to increase void ratio, the MDD is decrease.

Atterberg's Limits

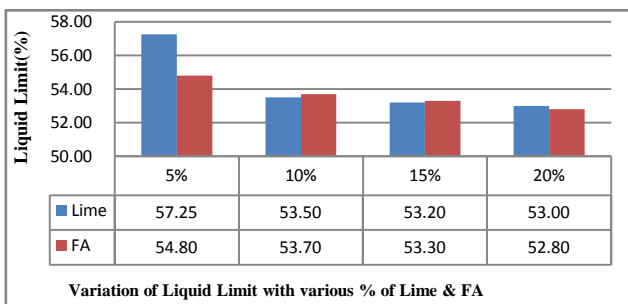


Fig-09 Variation of Liquid Limit with various percentages of Lime and Fly ash

The above figure 09 shows that the variation of LL with varying percentage of additives, the LL decrease with increase in additives. This is due to the presence of Ca^{2+} , Si^{2+} and Al^{3+} cation with increase in lime and fly ash they are reacts with soil particle.

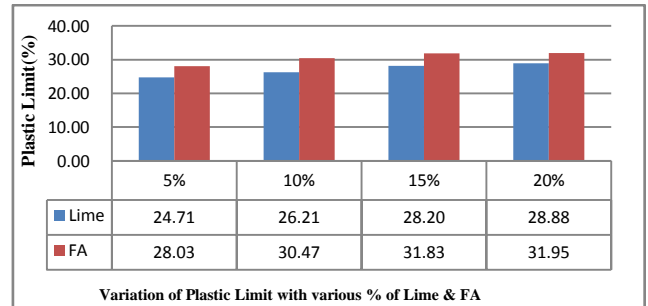


Fig-10 Variation of PL with various % of Lime and Fly ash

The figure 10 shows that the variation of PL with varying percentage of additives, the PL increase with increase in additives. This is due to the presence of Ca^{2+} , Si^{2+} and Al^{3+} cation with increase in lime and fly ash they are reacts with soil particle.

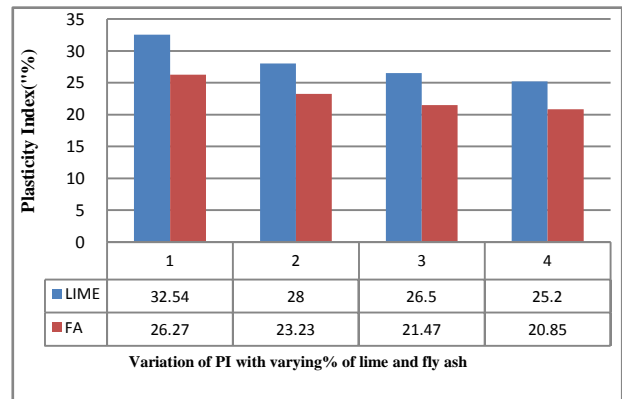


Fig-13 Variation of Plasticity Index with various percentages of lime and Fly ash

The above figure 13 shows that the variation of PI with varying percentage of additives, the PI decrease with increase in additives. This is due to the decrease of LL and increase of PL.

Permeability Test

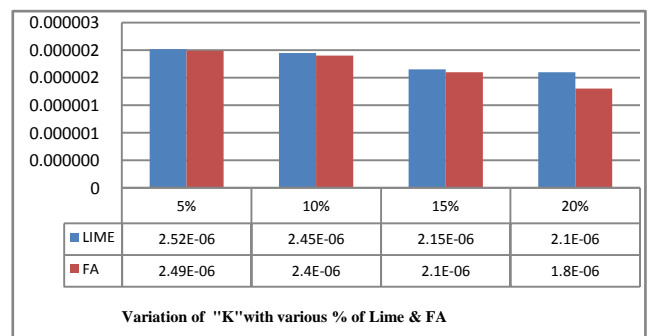


Fig-11 Variation of Permeability (K) with various percentages of Lime and Fly ash

The above figure 11 shows that the variation of "K" with varying percentage of additives, the "K" decreases with increase in additives. Due to increase

in finer particle- granular material simultaneously of lime and fly ash.

Unconfined Compressive Strength Test

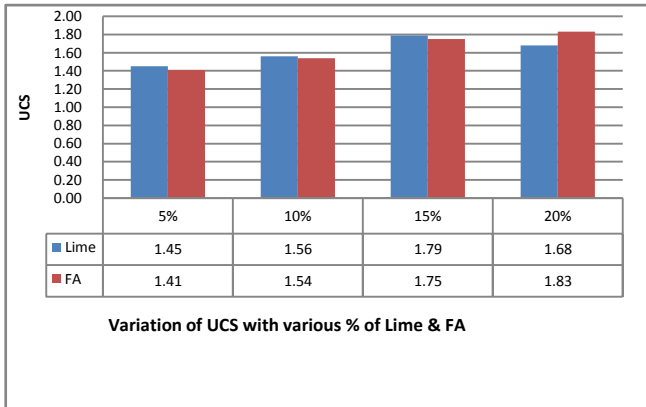


Fig-12 Variation of UCS with various percentages of Lime and Fly ash

The above figure 12 shows that the variation of UCS increase with varying percentage of additives ,the addition of lime and fly ash at 15% gives an optimum 1.79 and 1.75 respectively. This is due to the addition of lime and fly ash make additional percentage of silica than that of in natural soil.

CBR Test

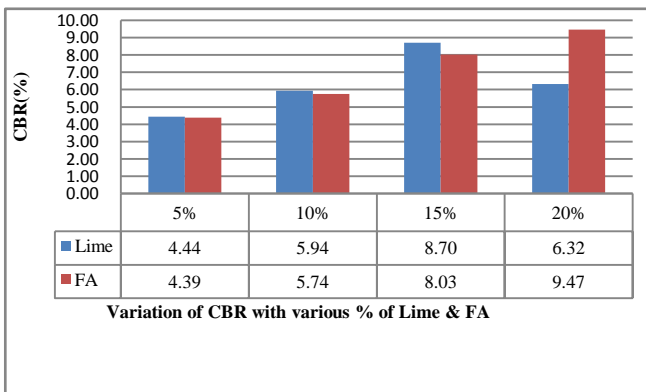


Fig-14 Variation of CBR with various percentages of lime and Fly ash

The above figure 14 shows that the variation of CBR with varying percentage of additives ,the addition of lime and fly ash at 15% gives an optimum 8.70% and 8.03% respectively. Due to Ca²⁺ and Si²⁺ cation in lime and fly ash it reacts with water, than calcium-silicate-hydrates is formed. Which is similar to formed in cement.

Specific Gravity

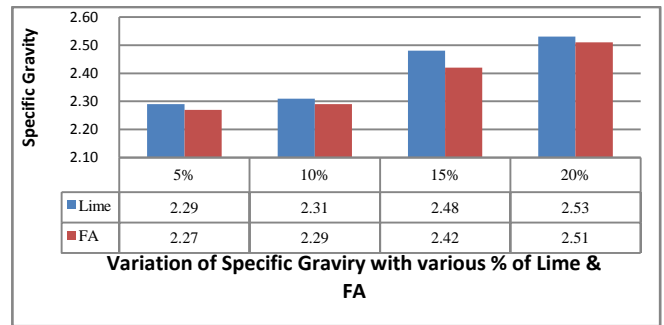


Fig-15 Variation of Specific Gravity with various percentages of lime and Fly ash

The above figure 5.8 shows that the variation of Specific gravity with varying percentage of additives, the optimum value increases with increase in different additives. The value of lime and fly ash are 2.53 and 2.51 at 20% increment respectively.

5. CONCLUSION-

Based on the obtained results and discussion some of the following conclusions are drawn-

1. Specific gravity increases with increase in percentage of lime and fly ash.
2. Liquid limit decreases with increase in percentage of lime and fly ash.
3. Plastic limit increases with increasing percentage of lime and fly ash.
4. Optimum moisture content increases with increase percentage of lime and fly ash.
5. Increases percentage of lime and fly ash, the compressive strength increase but compressive strength will be optimum at 15% lime mixed.
6. Plasticity index of soil decreases with increase the percentage of lime and fly ash.

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