Stabilization of soft clay soil using Fly ash and Lime stone dust

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Abstract— Soft clay soils exhibit high plasticity characteristics, low shear strength properties and high swell shrinkage characteristics. Soft Clay has particle sizes less than about 0.002mm, it is the finest of all and. even it can only be clearly monitored by using microscopic tools. Foundation settlements are the most emergence problems happened in building constructions on soft clay soil. Fly ash and Lime stone dust are both waste substances typically an industrial waste which is commonly used for stabilization of soils. The requirement of stabilization is to improve the adequate strength of soil by adding lime stone dust and fly ash. The objective of stabilizing the soil is to reduce the moisture holding capacity, plasticity to improve stability of soil. This paper investigates the complete analysis of the improvement of the soil properties and stabilisation using fly ash and lime stone dust. In this study laboratory experiments were conducted on soft clay soil with replacement by various percentage of fly ash and lime stone dust. The various laboratory experiments such as compaction test, UCC,Permeability, etc were conducted on both soft clay soil and clay soil mixed with various percentages of fly ash and lime stone dust. The study has shown that the addition of additives , lime stone dust and fly ash has shown the significant improvement in the strength and decreased moisture content and stiffness of the soil, more importantly it exhibits greater toughness, durability and stability as compared to soil alone.

Keywords: Soft clay, fly ash, lime stone dust, dry density, OMC ,Compaction , UCC, Permeability

1 INTRODUCTION

Often project sites are located in areas with soft or weak soils. Soft soils shows high plasticity characteristics, low shear strength properties and high swell shrinkage characteristics. Depending on the nature of the project the design solution may involve the expensive option of removal and replacement of the weak or compressible soils. The replacement option typically include use of crushed rock, gravel or lightweight aggregates. Other options involve using ground improvement alternatives such as stone columns, grouting, wick drains and chemical admixtures such as cement or lime. Among them, one of the most effective and economical method is to use chemical additives. Fly ash is a waste by product from thermal power plants. It spread out in thousands hectares of precious land for its disposal and also causing severe health and environmental hazards. The processing of limestone results in approximately twenty percentage limestone dust (LSD) waste and this also require a large area of landfill for the disposal. Therefore it is better to utilise such type of waste materials as additives for soil stabilization to protect the environment. The main objective of soil stabilization is to improve the strength and stability of soil and mainly to lower the construction cost. This paper analyse the effectiveness of adopting soil-stabilisation technique to improve the geotechnical properties of soft soil. In this paper, fly ash and lime stone dust were used as additives for stabilisation to improve the geotechnical properties of soft clay. An experimental programme was conducted on both soft clay soil and stabilised soil to investigate the combined effect of lime stone dust & fly ash added at different percentages to soft soil on geotechnical properties. Various laboratory tests like grain size distribution, consistency limits, compaction, unconfined compressive strength and permeability test were conducted on both the stabilised and un-stabilised soils. The results obtained include reduction in plasticity properties of the clay, improvement in the dry density and unconfined compressive strength.

The main objective of the present project is to study the improvement in geotechnical properties of stabilised expansive soil treated with fly ash and lime stone dust. It includes-

- To study the basic properties of soft soil, fly ash and lime stone dust.
- To study the compaction and strength characteristics of both soft soil and stabilized soil.
- To study the effect of different amounts of fly ash and lime stone dust added to clay soil on the geotechnical properties of soft soil.
- To find out the optimum quantity of fly ash and lime stone dust by weight added to the soft soil where it shows the higher strength and minimal value of swell.
- To analyses the effectiveness of the adopting soil-stabilization technique in improving the geotechnical properties of soft soil quantitatively.

2.0 METHODOLOGY

The main admixture used in this study is Class C fly ash and lime stone dust. Experimental programme were carried out on both soft clay and soft clay treated with different proportions of fly ash and lime stone dust to achieve the given objectives of the present study. Test conducted includes. Specific gravity test, Grain size analysis, Atterberg's limits, compaction test ,Unconfined Compressive strength (UCC) test and Permeability.

Untreated Clayey soil:

Table :1 Plasticity characteristics

Sl.NO.	Plastic Properties	Typical values
1.	I.S. classification	CI
2.	Plastic limit	34.75%
3.	Liquid limit	78.21%
4.	Shrinkage limit	6.63%

Specific Gravity was found to be 2.61

Table: 2 Compaction Characteristics

Sl.NO.	Properties	Typical values
1	Max Dry Density	1.36g/cc
2	Optimum moisture content	29.4%

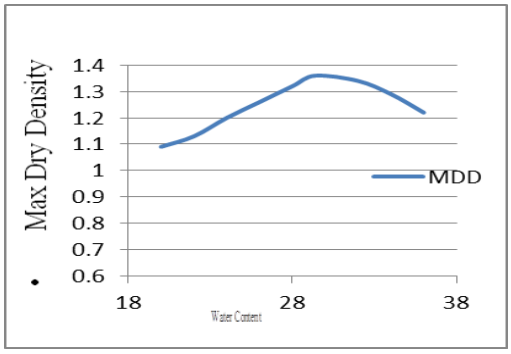

FIG 1: Moisture dry density relationship for clay soil.

I .Clay soil treated with Fly ash:

Table : 3 Plasticity Characteristics:

Sl. No.	% of fly ash	Liquid limit	Plastic limit	Shrinkage limit
1.	0%	78.21 %	30%	18%
2.	3%	76.4%	32%	19.6%
3.	6%	72.4%	33%	22.3%
4.	9%	70%	35%	22.9%

Compaction characteristics

The effect of addition of limestone dust on the compaction properties (optimum water content and maximum dry unit weight) of optimum soil fly ash mix was investigated by conducting light compaction test. The Standard Proctor curves for the soil - fly ash - limestone dustmix are shown in Figure 2. Table 4. shows the maximum dry density and optimum moisture content obtained for different limestone dust percentages. The shift of the compaction curve to the left and upwards is considered an indication of improvement in the compaction characteristics of the treated soil with respect to the untreated soil.

Table: 4 Dry density water content

Fly ash	Max dry density (g/cc)	OMC (%)
3	1.443	28.1
6	1.46	27.5
9	1.485	26.7
12	1.474	27
14	1.463	27.4

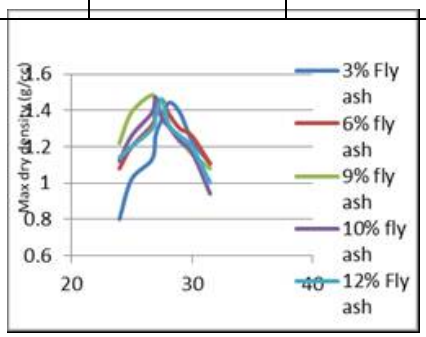

Fig 2: Moisture- dry density relationship for soil-fly ash mixture at different fly ash contents

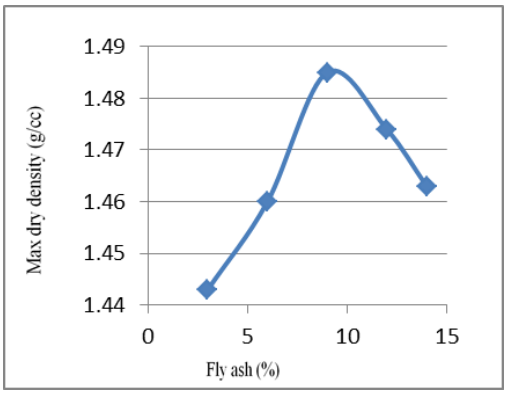

Fig3: Variation of maximum dry density with different fly ash percentage in the soil.

II.Clay soil With Lime stone dust.

The OMC and dry density of clay soil with different percentage lime stone dust are shown in fig and table.

Table: 5 Compaction Test

% 0f lime stone .	Max. Dry density (g/cc)	OMC(%)
3	1.461	28.2
4	1.49	27.4
6	1.583	26.3
9	1.61	25.7
10	1.63	24.3
12	1.62	25.1

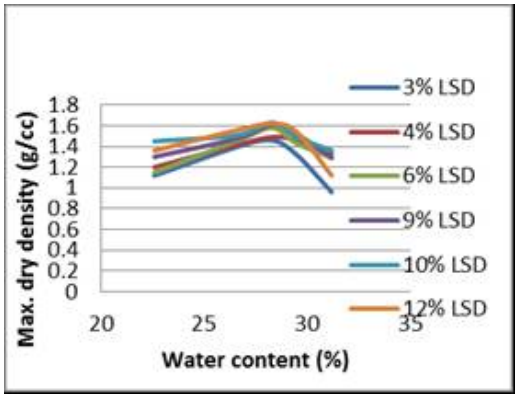

Fig 4: Moisture- dry density relationship for soil-limestone dust Mixture at different limestone dust contents

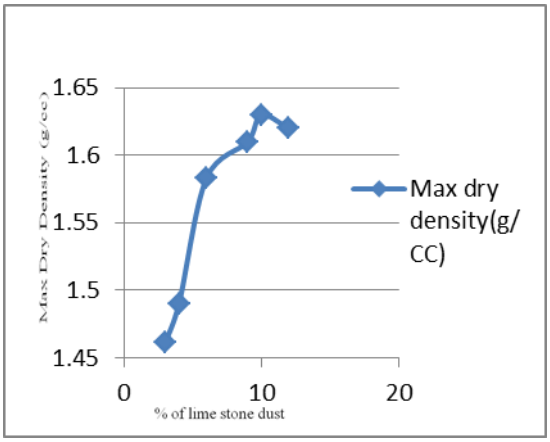

Fig 5: Variation of maximum dry density with different Lime-stone dust percentage.

III. Combination of clay,lime stone dust and fly ash

The maximum dry density and optimum moisture content of clayey soil stabilised with different % of fly ash and lime stone dust.

Table : 6

S.N .	Fly ash %	Lime ston e %	Max. Dry density(g/cc)	Optimum moisture content (%)
1.	9	3	1.57	24.3
2.	9	6	1.63	23.7
3.	9	9	1.67	22.3
4.	9	10	1.74	21.4
5.	9	12	1.71	21.9

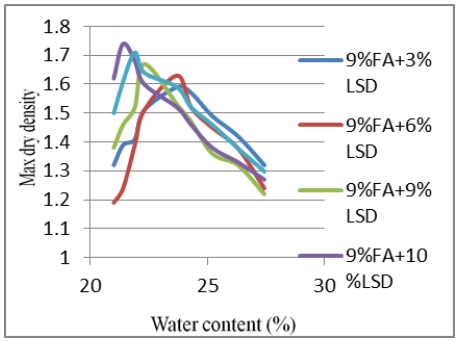

Fig 6: water content dry density relationship

D) UNCONFINED COMPRESSION TEST

Table : 7

S.N	Fly ash	Lime-stone	strain	Stress(kg/cm^2)
1.	9%	3%	0.194	0.153
2.	9%	6%	0.213	0.172
3.	9%	9%	0.230	0.185
4.	9%	10%	0.263	0.197
5.	9%	12%	0.219	0.178

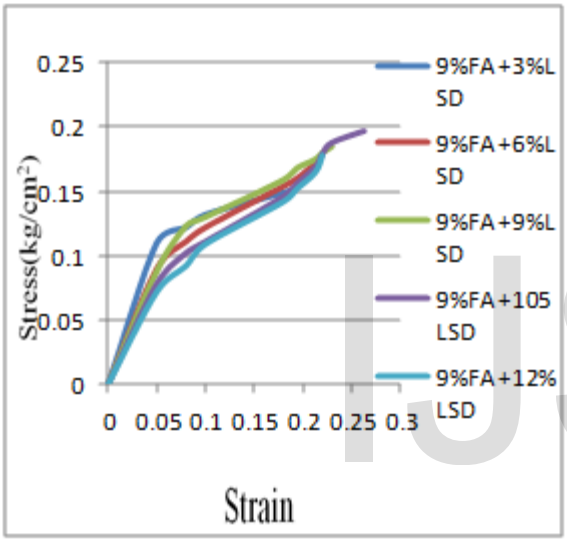

Fig:7 Graphical representation of comparison between maximum stress and maximum strain for Fly ash 9% and LSD(3%,6%,9%,10% & 12%

E) PERMEABILITY TEST:

In order to determine the effect of limestone dust on the permeability of the optimum soil-fly ash mix, falling head permeability test was conducted and the result shows that there is an decrease in the permeability of the soil.

Table : 8

SN	Fly Ash (%)	Lime Stone Dust(%)	Permeability
1.	9	3	0.00023cm/s
2.	9	6	0.00021cm/s
3.	9	9	0.000175cm/s
4.	9	10	0.000145cm/s
5.	9	12	0.000020cm/s

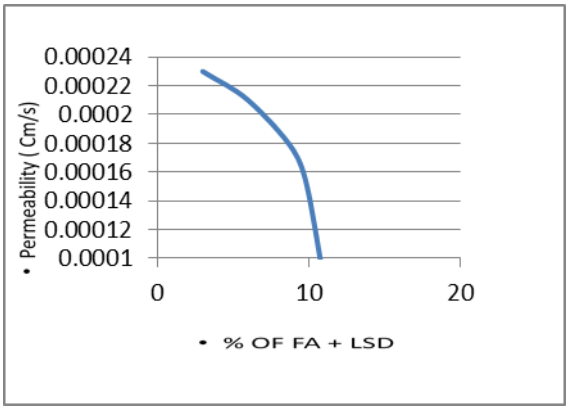

Fig: 8 permeability of clay soil mixed with various % of FA and LSD

3.0 CONCLUSIONS:

During test performance we found that standard proctor test and Unconfined Compression Test (UCS) are very important for testing the properties of used soil for the construction process. All the results were described above in detail, some conclusion were taking out from the study are given below:

1) The dry density of the sample in increases with decrease in water content.
2) Maximum water content during performing Standard proctor Test of soft clayey soil is 29.8% at 1.39 g/cc.
3) Mixing material like lime stone dust and fly ash must be available in high potential for this type of soil.
4) The soil stabilised with fly ash only showed maximum strength of 1.49g/cc at 9% fly ash.
5) The soil stabilised with lime stone dust only showed maximum strength of 1.40g/cc at 10% lime stone dust.
6) Maximum strength of soil 1.71g/cc is from the composition of 9% fly ash and 10% lime stone dust.
7) The compressive strength of used mixture increases for a particular composition after that it goes falling down.
8) For this kind of soil treatment mixing of soil with right composition is not very easy process and is also very important process for best performance at low cost.

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