

Effect of Curing on the Strength and Plasticity Characteristics of Clay- Fly Ash Mix

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ABSTRACT: This paper presents the study of the fly ash as stabilizer in improving the engineering properties of marine clay. The variation in properties of clay was studied with addition of different percentage of fly ash (0, 10%, 20% and 30%). The tests as per IS standards were carried out to determine the variation in liquid limit, plastic limit, plasticity index, compaction characteristics and unconfined compressive strength (UCC) of clay with varying fly ash content. Results indicate that fly ash content equal to 20% by weight of clay gives the maximum strength. The influence of curing time on the strength and plasticity characteristics was studied for the optimum clay –fly ash mix. It is observed that there is a significant increase in strength with increase in curing period.

KEYWORDS: Fly ash, Stabilisation, Plastic limit, Liquid limit, Curing period

I. INTRODUCTION

Soil stabilization is a technique used to enhance physical, chemical and mechanical properties of soil to maintain its stability. Clay usually have the undesirable properties such as low bearing capacity, high shrinkage, high plasticity, difficult compaction and swelling characteristics. Stabilization increases the bearing capacity of the soil, control the swelling shrink characteristics caused by moisture changes in soil, increases the resistance to erosion, weathering or traffic loading and reduce the pavement thickness as well as cost of stabilization. Fly ash is the waste material extracted from the flue gases of a furnace fired with coal. Fly ash has been used successfully in many projects to improve the strength characteristics of soils. The effect of fly ash stabilization on soil properties varies widely depending on the type of fly ash and its composition.

II. LITERATURE REVIEW

Fly ash by itself has little cementations value but in the presence of moisture it reacts chemically and forms cementations compounds and attributes to the improvement of strength and compressibility characteristics of soils. Sivapullaiah et al (1996) reported that the index properties of expansive soil significantly varied by addition fly ash. Neeraj Kumar Sharma et al (2012) found that the plasticity index is reduced by about 50% when the fly ash content is 20%. Phanikumar and Sharma (2004) in his study found that there is an increase in the optimum moisture content and maximum dry unit weight with an increase in percent of fly ash. The objectives of the studies reported in this paper is to determine the optimum fly ash content in improving the engineering properties of marine clay and to investigate the effect of curing time on the strength and plasticity characteristics of optimum clay –fly ash mix.

III. MATERIALS USED

III.A. Marine clay

Marine clay was collected from a piling site near Vallarpadam at Kochi. Samples of clay were collected by bore holes advanced by shell and auger method. For uniformity, samples collected from same depth but different bore holes were

pooled together and mixed thoroughly into a uniform mass and preserved in polythene bags. The air-dried specimen was prepared by spreading the representative samples for moist soil in large trays and drying to constant weight. The sample towards the end of drying were pulverised by heavy hammers and passed through 425 micron sieve without loss of material. The properties of air-dried marine clay are presented in Table 1.

Table 1: Properties of Air-dried Marine clay and fly ash used in the study

Properties	Air-dried Marine Clay	Fly ash
Initial moisture content (%)	3%	
Specific gravity	2.60	2.44
Liquid Limit (%)	67.00	-
Plastic Limit (%)	27.20	-
Plasticity Index (%)	39.80	-
OMC (%)	24.00	
Maximum dry density (g/cc)	1.45	
Grain size distribution		
Sand (%)	7	1.99
Silt (%)	65	68.3
Clay (%)	28	29.71

III.B. Fly ash

The fly ash used for this study was collected from Hindustan Newsprint Limited, Vellore. The properties of fly ash are presented in Table 1.

IV. METHODOLOGY

To study the effect of fly ash on the engineering properties of soil various tests were performed on untreated clay and clay with different percentage of fly ash. The tests were carried out to determine the atterberg limits, compaction characteristics and unconfined compressive strength of the samples. These properties were investigated using methods prescribed in Indian Standard codes. The influence of curing time on the plasticity characteristics and unconfined compressive strength of stabilised soil was investigated.

The percentage of fly ash added varied from 0%-30%. To prepare the clay-fly ash mixtures required amount of fly ash was mixed uniformly with specific amount of clay in the dry state after which measured quantity of water was added and mixed thoroughly to ensure a homogeneous mixture. All mixing was done manually and proper care was taken to prepare homogeneous specimens. To study the influence of curing period on the plasticity characteristics and unconfined compressive strength, the samples of clay with 20% fly ash were prepared and kept in the desiccators for curing. Tests were conducted after 3, 7, 14 and 28 days of curing period.

V. RESULTS AND DISCUSSIONS

The variation in properties of clay was studied with addition of different percentage of fly ash (0, 10%, 20% and 30%). The influence of curing time on the strength and plasticity characteristics was studied for the optimum clay-fly ash mix. Tests were conducted after 3, 7, 14 and 28 days of curing period.

V.A Effect of fly ash on plasticity characteristics

Tests to find the atterberg limits were carried out on the soil samples with different fly ash contents. The variation of liquid limit, plastic limit and plasticity index for varying percentages of fly ash are represented in table 2 and figure 1. Results shows that increasing fly ash content from zero to 30% by weight of clay, decreases the liquid limit, increases the plastic limit and decreases the plasticity index. The addition of fly ash reduced the plasticity characteristics of soil.

Table 2: Plasticity characteristics of clay- fly ash mix

Samples	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Clay + 0% Fly Ash	67	27.20	39.80
Clay + 10% Fly Ash	57	26.10	30.90
Clay + 20% Fly Ash	57	26.85	30.15
Clay + 30% Fly Ash	53	26.96	26.04

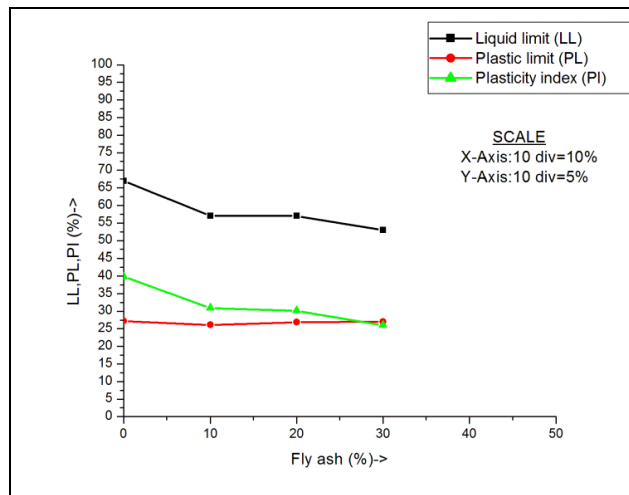


Fig. 1: Variation of plasticity characteristics with fly ash

V.B. Effect of fly ash on unconfined compressive strength

The unconfined compressive test of samples was conducted for varying percentages of fly ash (0-30%). Test specimens were prepared at optimum moisture content and maximum dry density. Table 3 shows the UCC values, strain at failure for varying percentage of fly ash.

Table 3: Test results of UCC with varying Fly ash

Fly Ash Content (%)	UCC (kg/cm ²)	Strain At Failure
0	0.231	0.0130
10	0.680	0.0210
20	0.972	0.0730
30	0.159	0.0280

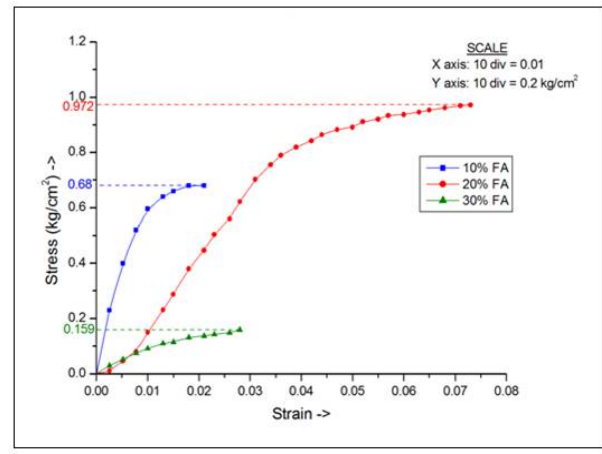
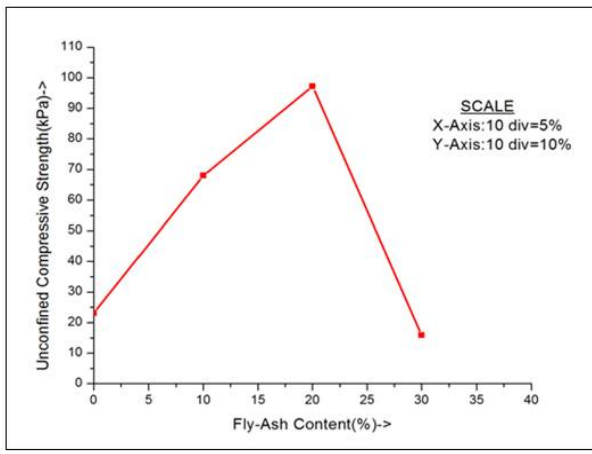


Fig. 2:(A) Variation of unconfined compressive strength with fly ash (B) stress v/s strain curve for clay - fly ash mix

It was seen that the unconfined compression value will first increases on addition of fly ash to a certain percentage and decreases on further addition slightly. The variation of UCC value with fly ash content is presented in figure 2 (A) and (B).

V.C. Optimum Fly ash content

Tests to find the atterberg limits, compaction characteristics and unconfined compressive strength were carried out on the soil samples with different fly ash contents. The proportions were 0%, 10%,20% and 30% respectively. The results shows that increasing fly ash content from zero to 30% by weight of clay decreases the liquid limit, increases the plastic limit and decreases the plasticity index. Unconfined compressive strength was carried out to assess the stress strain characteristic of clay-flyash mix. Examination of the results shows that at a fly ash content of 20%, the maximum strength of 97.20 KPa was obtained. The optimum dosage of fly ash content was determined based on the strength test conducted. Fly ash content equal to 20% by weight of clay was selected as optimum dosage to stabilize clay. The compaction characteristics of optimum mix are presented in figure 3.

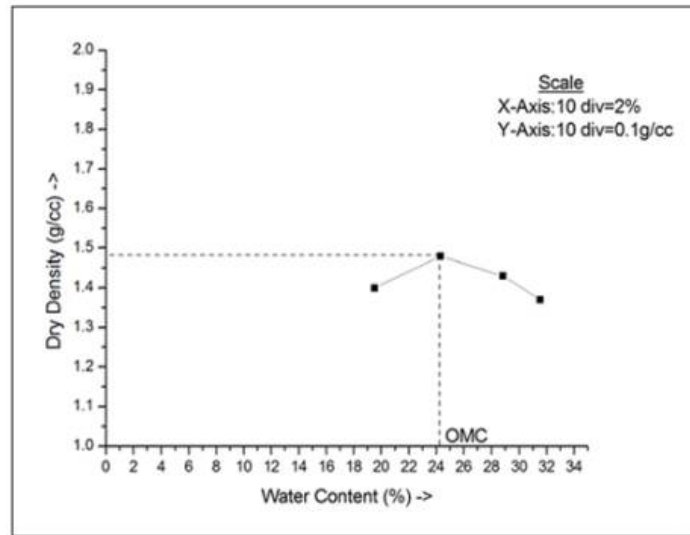


Fig. 3. Compaction curve for clay-20% fly ash

V.D. Effect of curing on the plasticity characteristics

The samples of clay with 20% fly ash were prepared and kept in the desiccators for curing. Then the tests for atterbergs limits were conducted on 3rd, 7th, 14th and 28th day. The test results are presented in table 4.

Table 4: Plasticity characteristics of clay-20% FA mix on curing

Curing period	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
0 Days	57.00	26.85	30.90
3 Days	60.50	30.08	30.42
7 Days	60.00	30.18	29.82
14 Days	59.00	30.52	28.48
28 Days	58.00	33.62	24.38

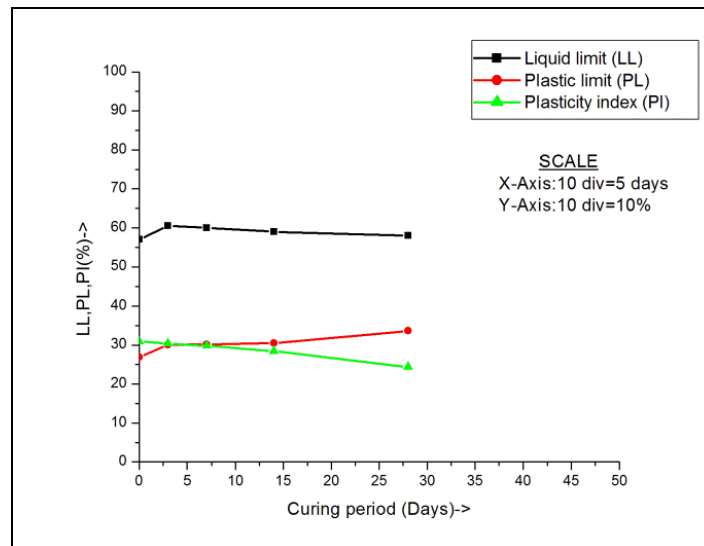


Fig.4: Variation of plasticity characteristics of clay-20% fly ash mix with curing period

It is observed that as curing period increases the liquid limit decreases, plastic limit increases and plasticity index decreases. Figure 4 shows the variation of plasticity characteristics of clay-20% fly ash mix with curing period.

V.E. Effect of curing on the strength characteristics

The sample of clay with 20% fly ash at maximum dry density and optimum moisture content was prepared and kept for curing in the desiccators. The unconfined compressive tests were conducted on 3rd, 7th, 14th, and 28th day of curing. The results are presented in Table 5. Results indicate that the strength increases with the increase of the curing time. Fig 5 (A) shows the variation of UCC values with curing period and (B) shows the stress strain characteristics of optimum clay -fly ash mix on different curing periods.

Table 5: Test results of UCC of clay-20% fly ash mix on curing

Curing period	UCC (kg/cm ²)	Strain at failure
0 Days	0.972	0.0730
3 Days	0.856	0.0390
7 Days	0.984	0.0500
14 Days	1.197	0.0550
28 Days	1.270	0.0842

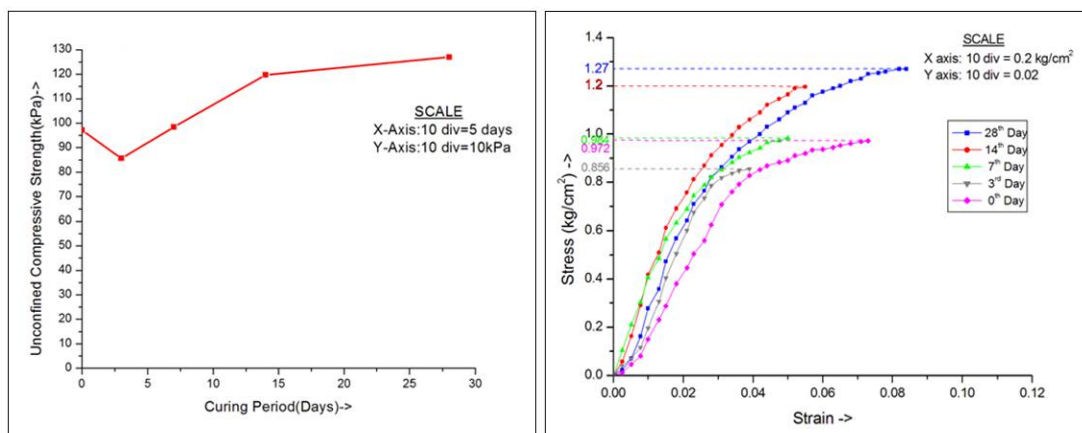


Fig.5:(A) Variation of unconfined compressive strength with curing period (B) stress v/s strain curve for clay - 20% fly ash mix

VI. CONCLUSION

In the study, the effect of fly ash in improving the properties of marine clay was investigated. Results indicate that increasing fly ash content from zero to 30% by weight of clay, decreases the liquid limit, increases the plastic limit and decreases the plastic index. The optimum dosage of fly ash content was determined based on the strength test conducted. Fly ash content equal to 20% by weight of clay was selected as optimum dosage to stabilize clay. The curing period had a significant effect on the strength and plasticity characteristics. The plasticity index decreased 38.74% at the end of 28 day curing. The UCC value of clay-fly ash mix was increased to 1.27kg/cm² as the curing period increased.

REFERENCES

- [1] Sivapullaiah et al. ; "Effect of fly ash on the index properties of black cotton soil"; Soils and Foundations, Japan, 36, 1996, 97-103.
- [2] Phanikumar B.R., &RadheyS.Sharma, "Effect of fly ash on Engg properties of Expansive Soil", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 130, No. 7,July2004,.
- [3] Pandianet.al.;" Effect of Fly ash on the CBR characteristics of the black cotton soil."; International Journal of Research in Engineering and Technology; 2008.
- [4] Neeraj Kumar Sharma , S. K. Swain , Umesh C. Sahoo ; "Stabilization of a Clayey Soil with Fly Ash and Lime:A Micro Level Investigation"; GeotechGeolEng DOI 10.1007/s10706-012-9532-3; 17 November 2011 / Accepted: 11 June 2012.
- [5] B.V.Suresh Kumar, Ganapati Naidu. P, P.V.V.Satyanarayana, S.Adishesu;" Effect of curing periods and strength characteristics of lime and calcium tri-silicate stabilized flyash";International Journal of Engineering Research and Applications (IJERA),Vol. 2, Issue 5, September-October 2012.