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Soil Stabilization by Using Fly Ash

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Abstract: *Soil stabilization is the alteration of soil properties to improve the engineering performance of soils. The properties most often altered are density, water content, plasticity and strength. Modification of soil properties is the temporary enhancement of subgrade stability to expedite construction. In developing country like India, due to industrial development there is an increase in a demand for energy which has resulted in construction of considerable coal-burning power plants. This development brought with the problem of safe disposal or beneficial utilization of large quantities of by-product like fly ash every year and there is a signal requirement to be carried out toward management of fly ash disposal and utilization. Fly ash is utilized in cement and construction. However, the rate of production is greater than consumption. The present study aimed to determine the effect of optimum fly ash content on Atterberg limit, dry density and compression strength of red soil. In various proportions like 5%, 15%, 20% fly ash was added to the red soil and the changes in compression strength before and after adding the fly ash is determined.*
Keywords: *Atterberg limit, by-product, coal-burning power plants, dry density, disposal.*

I. Introduction

Class C fly ash and Class F-lime product blends can be used in numerous geotechnical applications common with highway construction:

- To enhance strength properties
- Stabilize embankments
- To control shrink swell properties of expansive soils
- Drying agent to reduce soil moisture contents to permit compaction

Fly ash has been used successfully in many projects to improve the strength characteristics of soils. Fly ash can be used to stabilize bases or subgrades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. Typical stabilized soil depths are 15 to 46 centimeters (6 to 18 inches). The primary reason fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils The unused fly ash is disposed into holding ponds, lagoons, landfills and slag heaps. Coals contains significant quantities of various trace elements, and during combustion of coal as a result of carbon loss as carbon-di-oxide and the trace elements are associated with the surface of the fly ash particles due to evaporation and condensation. The disposal of fly ash is considered a potential source of contamination due to enrichment and surface association of trace sediments in the ash particles. The toxic elements can contaminate ground water and surface water therefore, effective water management plans are required for fly ash disposal.

II. Materials Used

Red Soil:

The red soil has been collected from Dr.M.G.R Nagar, Hosur at a depth of 2.0 m beneath the ground surface. The soil is primarily allowed to dry for 2 days and dried soil is thoroughly grinded. Its engineering and index properties tested.

Flyash:

As well as the fly ash is collected from Mettur thermal plant.

Tests Conducted On Soil Sample:

Sieve analysis, Specific gravity, Plastic limit, Liquid limit, Shrinkage limit, Standard proctor test, Triaxial compression test.

Experimental Programme

Specific Gravity:

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air. The specific gravity of the soil with varying percentage of Fly Ash is given in table 1 and fig 1.

Table 1: Specific gravity for Red soil + Fly ash (5%, 15%, 20%

Sl.No	Specimen (red soil%+fly ash %)	Specific gravity
1	100 + 0	2.158
2	95 + 5	2.327
3	85 + 15	2.317
4	80 + 20	2.042

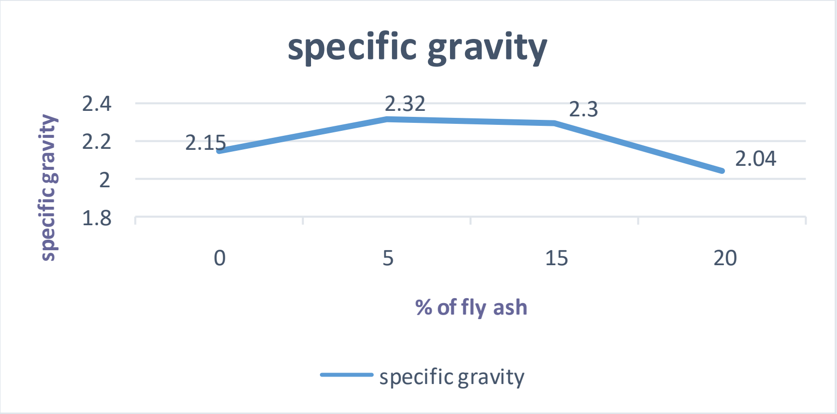

Fig 1: Specific gravity (Soil+ Fly ash)

Liquid Limit:

The knowledge of this property is much useful in solving problems involving yield of water bearing strata, seepage through earthen dams, stability of earthen dams, and embankments of canal bank affected by seepage, settlement etc. The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid and plastic states of consistency. The moisture content at this boundary is arbitrarily defined as the water content at which two halves of a soil cake will flow together, for a distance of ½ in. (12.7 mm) along the bottom of a groove of standard dimensions separating the two halves, when the cup of a standard liquid limit apparatus is dropped 25 times from a height of 0.3937 in. (10 mm) at the rate of two drops/second. The liquid limit of the soil with varying percentage of Fly Ash is given in table 2 and fig2

Table 2: Liquid limit for Red soil + Fly ash (5%, 15%, 20%)

Sl.No.	Specimen (soil% & fly ash %)	liquid limit %
1	100+0	32
2	95+5	25
3	85+15	28
4	80+20	30

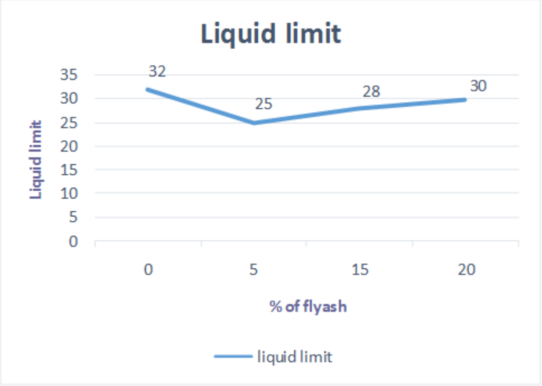

Fig 2: Liquid limit (soil + Fly ash)

Plastic Limit

The moisture content at which soil has the smallest plasticity is called the plastic limit. For the determination purpose, the plastic limit is defined as the water content at which a soil will just begin to crumble when rolled into a thread of 3mm in diameter. The difference in moisture contents between the liquid limit and plastic limit is termed as plasticity index. Knowing the liquid limit and plasticity index, soil may be classified with the help of plasticity chart according to Indian standard soil classification [IS1498-1970]. The plastic limit of the soil with varying percentage of Fly Ash is given in table 3 and fig3

Table 3: Plastic limit for Red soil + Fly ash (5%, 15%, 20%)

Sl. No	Specimen [soil% & fly ash%]	Plastic limit %
1	100 + 0	22.03
2	95 + 5	21.79
3	85 + 15	24.14
4	80 + 20	44.79

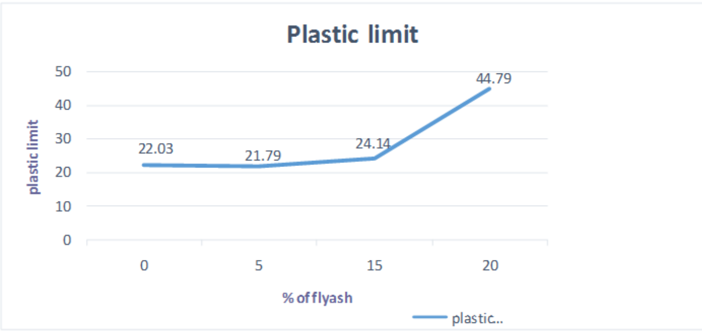

Fig 3: Plastic limit (soil + Fly ash)

Shrinkage Limit

Shrinkage limit is defined as the maximum water content at which a reduction in water content will not cause a decrease in the volume of a soil mass. It is the lowest water content at which a soil can still be completely saturated. Shrinkage ratio is defined as the ratio of a given volume change expressed as percent of dry volume to the corresponding change in water content above the shrinkage limit expressed as a percentage of the weight of oven dried soil. Shrinkage ratio of a soil is equal to the mass specific gravity of the soil in the dry state. The shrinkage limit of the soil with varying percentage of Fly Ash is given in table 4 and fig 4

Table 4: Shrinkage limit for Red soil + Fly ash (5%, 15%, 20%)

Sl.No	specimen soil% + fly ash%	shrinkage Limit (%)	shrinkage ratio	Volumetric shrinkage (%)
1	100 + 0	41.633	0.2037	21.88%
2	95 + 5	3.579	0.193	19.26%
3	85 + 15	6.60	0.226	20%
4	80 + 20	7.865	0.279	21.5%

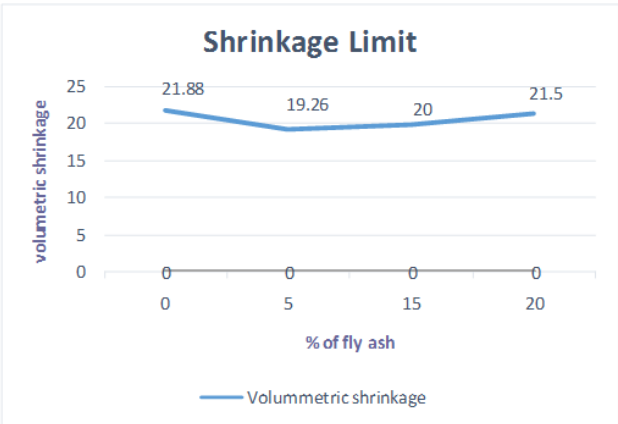

Fig 4: Shrinkage limit (soil + Fly ash)

Standard Proctor Test

For construction of highways, airports, and other structures, it is often necessary to compact soil to improve its strength. Proctor (1933) developed a laboratory compaction test procedure to determine the maximum dry unit weight of compaction of soils, which can be used for specification of field compaction. This test is referred to as the Standard Proctor Compaction Test. It is based on compaction of soil fraction passing No. 4 U.S. sieve. The optimum moisture content and max.dry density of the soil with varying percentage of Fly Ash is given in table 5 and fig 5

Table 5: Standard proctor test for Red soil + Fly ash (5%, 15%, 20%)

Sl.No	specimen [soil%+ fly ash%	Optimum moisture content (%)	Max. dry density (gm/cc)
1	100 + 0	8.9	2.11
2	95 + 5	8.2	2.31
3	85 + 15	11.6	1.96
4	80 + 20	12.9	1.04

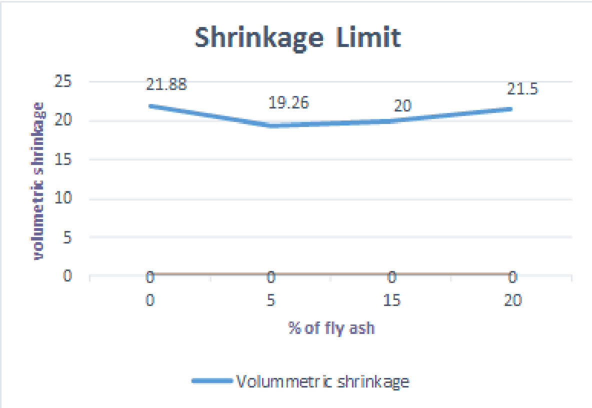

Fig 5: Standard proctor test (Soil+ fly ash)

Triaxial Compression Test

The shear strength of the soil is the resistance to deformation by continuous shear displacement of soil particles upon the action of shear. Triaxial test used for all types of soils under different drainage conditions. Cylindrical specimen is stressed under the conditions of axial symmetry. In the first stage the specimen is consolidated under all round confining pressure. Second stage additional axial stress, known as deviator stress is applied. The angle of internal friction and cohesion of the soil with varying percentage of Fly Ash is given in table 6 and fig 6,7.

Table 6: Triaxial compression test for Red soil + Fly ash (5%, 15%, 20%)

Sl.No	Specimen[soil%+fly ash%]	angle of internal friction[Ø]	Cohesion [C] kg/cm
1	100 + 0	26°	0.81
2	95 + 5	28°	0.82
3	85 + 15	26°	0.80
4	80 + 20	27°	0.75

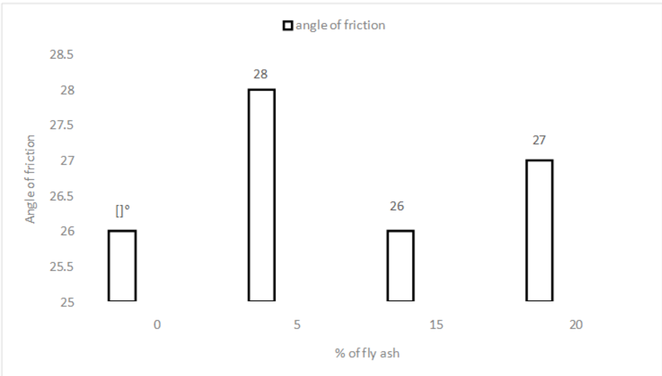

Fig 6: Triaxial compression test (Red soil + Fly ash)

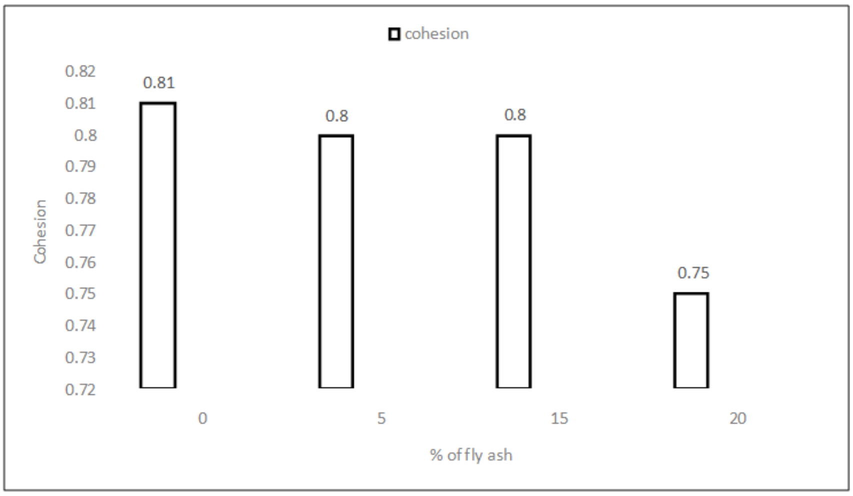

Fig 7: Triaxial compression test (Red soil + Fly ash)

III. Conclusion

- The specific gravity, plastic limit, shrinkage limit and standard proctor test gives positive results when 5% of fly ash is added to the red soil.
- It is because of its fineness [i.e. 10 – 100 microns] that contributes to the binding nature with that of the soil.
- On further addition of fly ash of about 15% and 20% to the soil sample, which does not improve the properties of the soil.
- The silt sized particles is increased when fly ash is added to the soil sample which absorbs the water more than before and thus decrease in liquid limit.
- When 5% of fly ash is added to the soil the cohesion value are increased. Further addition of fly ash leads to decrease in cohesion values.
- As the amount of fly ash increased, the maximum dry density and the optimum moisture content of the soil decreases which is due to the occurrence of hydration reaction that reduces the capillary tension.
- From the above results, we could conclude that the optimum amount of fly ash to be added to attain maximum stability of red soil will be 5%.

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