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Laboratory Study on Soil Stabilization Using Fly ash Mixtures

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Abstract—: Soil stabilization is one of most important for the construction which is widely used in connection with road pavement and foundation construction because it improves the engineering properties of soil such as strength, volume stability and durability. In the present investigation is to evaluate the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixtures. The percentage of fine and coarse fly ash mixtures which is used in black cotton soil varied from 5 to 30. In the study concludes that with percentage addition of fine, coarse fly ash improves the strength of stabilized black cotton soil and exhibit relatively well-defined moisture-density relationship. It was found that the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash.

***Index Terms—* Black Cotton Soil, Fine and Course Fly Ash Mixture, Soil Stabilization.**

I. INTRODUCTION

Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soils to enhance their engineering properties. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the desired engineering properties. Benefits of the stabilization process can include higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and improves the strength of soils. In the field of geotechnical engineering, it has long been known that swelling of expansive soils caused by moisture change result in significant distresses and hence in severe damage to overlying structures. Expansive soils are known as shrink swell or swelling soils. Different clays have different susceptibility to swelling. Such soils expand when they are wetted and shrink when dried. This movement exerts pressure to crack sidewalks, basement floors, pipelines and foundations (kaniraj SR and Havanagi VG 1999).

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 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 (Bardet JP and young, j 1997).

As according to ASTM C-618, two major classes of fly ash are recognized i.e. Class C and Class F. These two classes are related to the type of coal burned. Class F fly ash is normally produced by burning anthracite or bituminous coal while Class C fly ash is generally obtained by burning sub bituminous or lignite coal. Therefore, essentially all Class F fly ashes presently available are derived from bituminous coal. Class F fly ashes with calcium oxide (CaO) content less than 6%, designated as low calcium ashes, are not self hardening but generally exhibit pozzolanic properties. These ashes contain more than 2% unburned carbon determined by loss on ignition test. Quartz, mullite and hematite are the major crystalline phases identified fly ashes, derived from bituminous coal. In the presence of water, the fly ash particles produced from a bituminous coal react with lime or calcium hydroxide to form cementing compounds similar to those generated on the hydration of Portland cement. Class C fly ashes, containing usually more than 15% CaO and also called high calcium ashes, became available for use in concrete industry only in the last 20 years in the 1970s. Class C fly ashes are not only pozzolanic in nature. The specific

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gravity of fly ash is reported to be related to shape, color as well as chemical composition of fly ash particle. It is adopted as an indirect performance parameter for determining the performance of fly ash in soil mixtures. In ASTM C618, for quality control of fly ash, the uniformity of the fly ash is monitored by limiting the variability of the specific gravity and fineness as measured by the amount retained on 45 µm mesh sieve. In general specific gravity of fly ash may vary from 1.3 to 4.8 whereas those of the American ashes have specific gravity between 2.14 and 2.69. Coal particles with some minerallic impurities have specific gravity between 1.3 and 1.6 as the amount of quartz and mullite increases, the specific gravity decreases. The particle density of fly ash is typically 1.5 - 2.5 mg/m^3 the lower density associated with a high loss of ignition. There is some variability in the density of particles, with smaller ones having higher densities. This is due to air voids within many of the particles, and between 1% and 5% contains sufficiently large voids that they float on water. The variation in particle density means that sedimentation techniques for determining the particle size distribution are not suitable and more appropriate methods are now used e.g. Laser scattering

II. COMPACTION OF SOIL FLY ASH MIXTURES

The density of soil with coal ashes is an important parameter since it controls the strength, Compressibility and permeability. The compacted unit weight of the material depends on the amount and method of energy application, grain size distribution, plasticity characteristics and moisture content at compaction. The variation of dry density with moisture content for fly ashes is less compared to that for a well-graded soil, both having the same grain size. The tendency for fly ash to be less sensitive to variation in moisture content than for soil is due to higher air void content of fly ash. The higher void content could tend to limit the buildup of pores pressures during compaction, thus allowing the fly ash to be compacted over a larger range of water content.

III. MATERIALS

Natural black cotton soil was obtained from Gadag district in Karnataka State. The soil was excavated from a depth of 2.0 m from the natural ground level. The soil is dark grey to black in color with high clay content. The obtained soil was air dried, pulverized manually and soil passing through 425 µ IS sieved was used. This soil has a property of high moisture retentively and develops cracks in summer. This soil predominantly consists of expansive montmorillonite as the principal clay mineral. The physical properties of the soil used in this investigation are given in Table Sieve analysis**,** hydrometer analysis, and Atterberg's limits were performed to classify the soil the index properties, Compaction characteristics and unconfined compressive strength test were carried out for both fine and coarse soil mixtures. The soils were classified in accordance with Indian Standard classification of soils for engineering purpose.

Nature Water content	Specific Gravity	Grain size distribution			Atterberg's Limit			
		Gravel	Sand	Silt & clay	Liquid limit	Plastic limit	Plasticity Index	Shrinkage limit
8.95%	2.68	00 %	10.06%	89.94%	66%	37.12%	28.88%	11.63%

Table 1: Physical properties of soil

Max dry density in g/cc	Optimum moisture content in %	Compressive Strength in Kpa
1.48	21	112.3

Table 2: Mini compaction and compressive strength of black cotton soil

Fly ash is a fine residue collected from the burning of pulverized coal in thermal power plants. The worldwide production of fly ash is growing every year. Fly ash is silt – size non cohesive material having a relatively smaller specific gravity than the normal soils. The disposal of the fly ash is a serious hazard to the environment that consumes millions of rupees towards the cost of its disposal. Fly ash has been used in a variety of construction applications, such as compacted fills, concretes, bricks, liners, construction of embankments in many countries including India. Fly ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. In the present study, fly ash of class "F" Category procured from Raichur thermal power

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station (RTPS), in Karnataka, India, called Raichur Fly ash (RFA), has been used. The fly ash used was grey in color and the physical properties and chemical composition of fly ash are given below

Specific gravity	Grain size distribution			Atterberg's Limit		
	Gravel	Sand	Silt and clay	Liquid limit	Plastic limit	Shrinkage limit
2.13	00 %	58 %	42%	35%	Non plastic%	18.50%

Table 3: Physical properties of Fly ash

IV. COMPACTION TEST FOR SOIL MIXTURES

Three identical samples were prepared for their Maximum Dry Density and Optimum Moisture content based on the compaction curves obtained. The sample was subjected to various curing periods (1, 7, 14, 28 days) according to their trial combination chosen. Samples intended for long term testing were kept in desiccators to maintain 100% humidity and to prevent loss of moisture from samples. Water was sprinkled at regular intervals and was cured in the desiccators. All the samples intended for immediate testing were tested immediately. The unconfined compression test was carried out according to IS 2720(part 10) - 1973. The test was conducted using unconfined Compressive test apparatus at a strain rate of 1.25 mm/ minute. The specimen to be tested was placed centrally in between the lower and upper platform of testing machine. Proving ring reading was noted for 30 divisions on a deformation dial gauge. The loading was continued until three or more consecutive reading of the load dial showed a decreasing or a constant strain rate of 20% had been reached.

V. RESULTS AND DISCUSSIONS

The unit weight of soil fly ash mixture is an important parameter since it controls the strength, compressibility, permeability and densification. The strength of soft soil can be altered by the addition of fly ash in varying percentage and the unit weight of the compacted mixtures depends on the method of energy application, amount of energy applied, Grain size distribution, Plasticity characteristics, and moisture content at compaction.
In the present investigation a series of compaction tests were carried out by varying soil and fine fly ash is compacted at respective optimum moisture content(OMC), the corresponding maximum dry density and optimum moisture content are presented in the Table 4.

Soil+ Fine fly ash	Optimum Water Content (%)	Max Dry density(g/cc)
95%+5%	22.5	1.35
90%+10%	23.8	1.20
85%+15%	25.0	0.90
80%+20%	26.0	0.80
75%+25%	28.0	0.65
70%+30%	30.0	0.60

Table 4: Compaction of fine fly ash mixtures

The variation of maximum dry unit weight with fly ash content for different proportions of soil fly ash mixtures is presented in Fig1. From the Fig1 it can be observed that with the increase in optimum water content the dry density decreases up to 30% moisture content and with further increase in water content the dry density decreases gradually. Hence the addition of fly ash to black cotton soil in various percentages affects the compaction characteristic which is primarily due to alteration of gradation of soil mixtures. The decrease of the maximum dry unit weight with the increase of the percentage of fly ash is mainly due to the lower specific gravity of the fly ash compared with expansive soil and the immediate formation of cemented products by hydration which reduces the density of soil. It can also be observed that the optimum moisture content was increased with further increase in fly ash content. The maximum dry density was observed to be about 1.35 g/cc for 95% soil and 5% fly ash mixture and lowest density was about 0.6g/cc. for 70% soil and 30% fly ash mixture.

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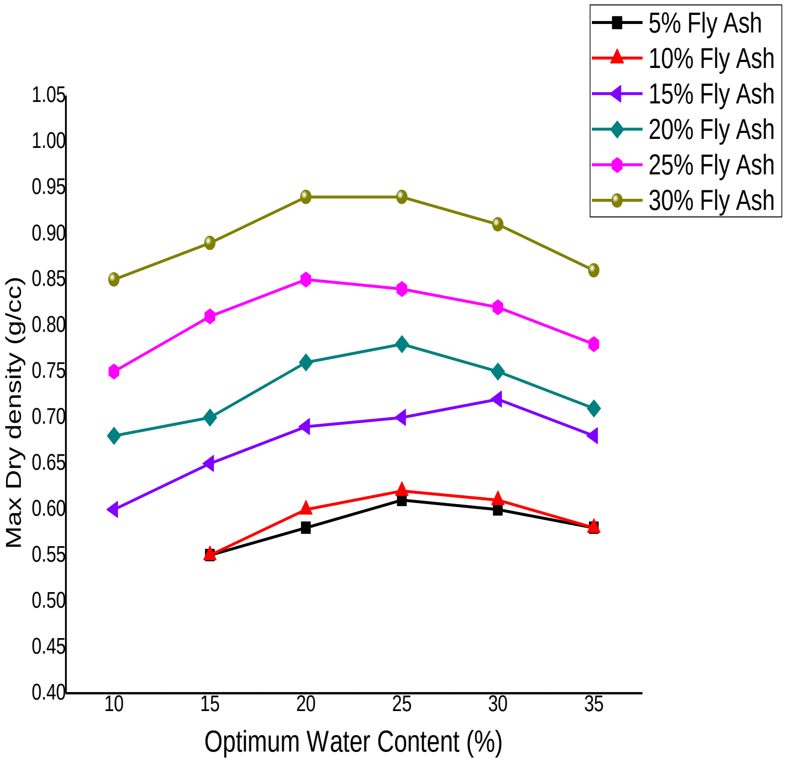

Fig 1: Compaction with soil and Fine Fly Ash

And also a series of compaction test were carried out by varying soil and Coarse fly ash which is compacted at respective optimum moisture content, the corresponding maximum dry density and optimum moisture content are presented in Table 5. It is observed that with the increase of Coarse Fly ash content the maximum dry density decreases.

Soil+ Fly ash (Coarse)	Optimum Water Content (%)	Max Dry density (g/cc)
95%+5%	10.5	1.35
90%+10%	14.5	1.30
85%+15%	16.0	1.22
80%+20%	18.5	1.19
75%+25%	20.0	1.10
70%+30%	21.0	1.00

Table 5: Compaction of coarse fly ash mixtures

The variation of maximum dry unit weight with coarse fly ash content for different proportions of soil fly ash mixtures is presented in Fig 2. It is observed that with the increase in optimum water content the dry density decrease up to 30% moisture content and with further increase in water content the dry density decreases gradually. Hence the addition of fly ash to black cotton soil in various percentages affects the compaction characteristic which is primarily due to alteration of gradation of soil mixtures. The decrease of the maximum dry unit weight with the increase of the percentage of fly ash is mainly due to the lower specific gravity of the fly ash compared with expansive soil and the immediate formation of cemented products by hydration which reduces the density of soil. It is also be observed that the optimum moisture content was increased with further increase in fly ash content. The maximum dry density was observed to be about 1.35 g/cc for 95% soil and 5% fly ash mixture and lowest density was about 1.0g/cc. for 70% soil and 30% fly ash mixture.

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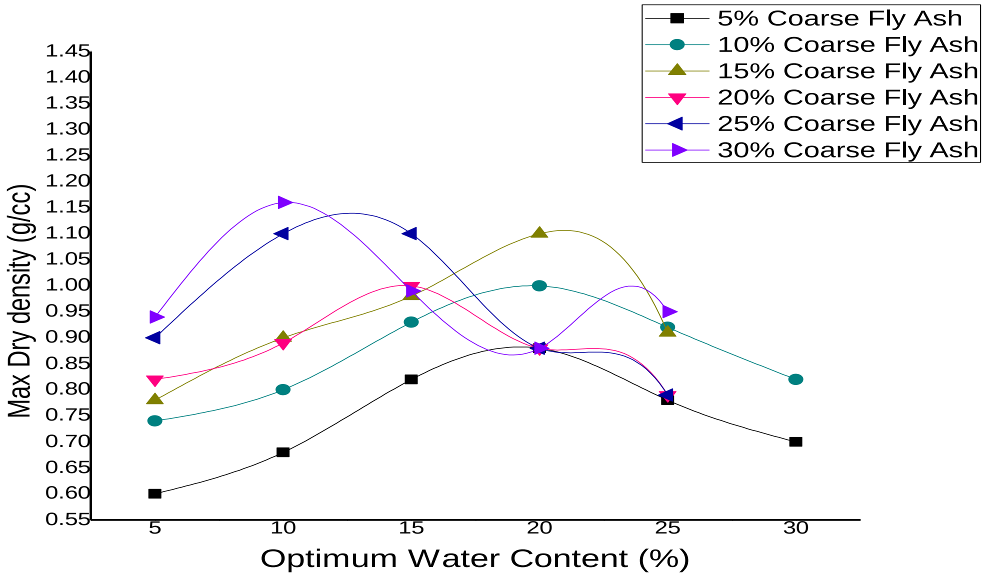

Fig 2: Compaction with Soil and Coarse Fly Ash

VI. SUMMARY AND CONCLUSIONS

It was observed that with the increase in water content the dry density decreases up to 20-30% moisture content and with further increase in water content the dry density decreases gradually. The maximum dry density is in the range of 1.35 g/cc for 95% soil and 5% fly ash mixture and lowest density was about 0.6g/cc for 70% soil and 30% fly ash mixture. This variation of density is primarily due to alteration of gradation of soil mixtures. The decrease of the maximum dry unit weight with the increase of the percentage of fly ash is mainly due to the lower specific gravity of the fly ash compared with expansive soil and the immediate formation of cemented products by hydration which reduces the density of soil. The decrease in dry density with increase in fine fly ash content is due alteration of gradation of soil mixtures. Whereas decrease in dry density with the increase in coarse fly ash mixture was attributed due to cat ion exchange between additives and expansive soil which decreases the thickness of electric double layer and promotes the flocculation.

REFERENCES

[1] CHOI S.K LEE S. SONG Y.K Leaching characteristics of selected Korean fly ashes and its implications for the ground water composition near the ash mound. Fuel. 81, 1080, 2002.

[2] IYER R. The surface chemistry of leaching Coal fly ash. J.Hazard material.B93, 321, 2002.

[3] Kezdi, J.E, 1992, engineering properties of soils and their measurements, MC Grawhill. Inc, New York.

[4] Determination of liquid limit and plastic limit. Indian standard methods for testing of soils-IS2720 (a) Indian standard Institution, New Delhi, India, part 5, pp 109-144,1985.

[5] Sivapullaiah P.V Prashanth J. P Reactive silica and strength of fly ash, Geotechnical And Geological Engineering Vol.16, 1998, pp239-250.

[6] ASTM, Standard test method for 24-h batch –type measurement of Contaminant by soils and sediments, International American Standard testing method D464687 (reapproved2001. USA, 2001.

[7] Dmitri's dermatas Xiaoguang Meng. Utilization of fly ash for Stabilization/Solidification of heavy metal Contaminated soils, Engg Geology., 70, 2003, PP377-394.

[8] Arif Ali Baig, Sivapullaiah.P.V, Heavy metal leach ability of low lime fly ashes, in Indian Geotechnical Conference-2008, Advances in geotechnical Engineering Vol II, 2008, PP470-473.

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[9] Dmitri's dermatas Xiaoguang Meng. Utilization of fly ash for Stabilization/Solidification of heavy metal Contaminated soils, Engg Geology., 70, 2003, PP377-394.

[10] Sivapullaiah P.V Prashanth J. P Reactive silica and strength of fly ash, Geotechnical and Geological Engineering Vol.16, 1998, pp239-250.

[11] KanirajS R, Havanagi V.G Geo technical characteristics of fly- ash soil mixtures. Geo technical Engineering journal, 1999, 30 (2):129-147.

[12] Bardet, J P and Young, J (1997) Grain size analysis by Buoyancy method, Geotechnical testing Journal, GT JODJ, Vol20, No-4, 1997, pg 481-485.