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Soil Stabilization by Using Fly Ash

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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 upcoming loads. In such cases, soil stabilization is needed. Numerous methods are available in the literature for soil stabilization, but sometimes, some of the methods like chemical stabilization; fly ash stabilization, lime stabilization, cement stabilization etc. adversely affects the chemical composition of the soil. In this study, fly ash mixes with black clay soil to investigate the relative strength gain in terms of unconfined compression, bearing capacity and compaction. The effect of fly ash on the geotechnical characteristics of clay-fly ash was investigated by conducting standard Proctor compaction tests, Atterberg limit, Specific Gravity Test, CBR tests and. The tests were performed as per Indian Standard specifications.

I. INTRODUCTION

Soil stabilization is a technique used to improve the engineering properties of soil, such as strength, durability, and compaction, to make it more suitable for construction and engineering applications. One of the common methods for soil stabilization involves the use of additives, and fly ash is a popular choice. Fly ash is a by-product of coal combustion in power plants and is widely used in the construction industry for stabilizing soils, particularly those with poor properties such as high plasticity, low strength, and moisture sensitivity.Fly ash stabilization works by mixing fly ash with soil to improve its properties through chemical reactions and physical bonding. The use of fly ash for soil stabilization not only enhancesthe performanceof
soils but also offers environmental benefits by recycling industrial waste. This method is particularly effective for treating clayey, silty, or weak soils, making them more suitable for construction projects such as roads, pavements, embankments, and foundation works.

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

Soil was obtained from at road construction site P.R. Pote College of Institute Amravati district in Maharashtra State. The soil was excavated from a depth of 1.0 m from the natural ground level. The soil is black 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**,** and Atterberg's limits were performed to classify the soil the index properties, Compaction characteristics and CBR 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.

Table 1: Physical properties of soil

Nature Water content	Specific Gravity	Grain size distribution			Atterberg's Limit			
		Gravel	Sand	Silt & clay	Liquid limit	Plastic limit	lasticity Index	Shrinkage limit
11.88%	2.85	38.7%	53.4%	7.9%	62%	30.4%	32.4%	13.6%

Table 2: compaction and compressive strength of Soil

Max dry density in g/cc	Optimum moisture content in %	Compressive Strength in K pa
1.44	18.7%	119.8

Fly Ash is a fine, powdery by-product that is produced during the combustion of coal in thermal power plants Amravati. It is collected from the flue gases by electrostatic precipitators or other filtration systems before they are released into the atmosphere. Fly ash is rich in minerals such as silica, alumina, and iron oxide, and its composition and properties can vary depending on the type of coal burned and the conditions in the combustion process.

Fly ash is widely used in construction and civil engineering as a supplementary material to enhance the properties of concrete, stabilize soils, and improve the quality of roads. Due to its potential to recycle waste and reduce the environmental impact of construction activities, fly ash has become an essential component in the building materials industry. Several studies have revealed that fly ash reduces the flexibility index of organic dirt while increasing the liquid and plastic limits. As a result of adding fly ash, the dry density of the fly ash dirt mixture increases dramatically, while the water demand decreases.

Table 3: Physical properties of Fly ash

Specific gravity	Grain size distribution			Atterberg's Limit		
	Gravel	Sand	Silt and clay	Liquid limit	Plastic limit	Shrinkage limit
2.14	00 %	28.3 %	67.2%	46%	17%	19.4%

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 California Bearing Ratio test was carried out according to IS 2720 (part 16) 1987.

V. RESULTS AND DISCUSSIONS

The soil fly ash mixture is an important parameter since it controls the strength, compressibility, and Atterberg limits. The strength of soil can be alteredby the addition of fly ash in varying percentageand, Grain size distribution, Liquidlimit, Plastic limit, and moisture content, Maximum dry density.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.

Table 4: Compaction of fine fly ash mixtures

Soil + Fine Fly Ash	Specific Gravity	Liquid Limit	Plastic Limit	Optimum Moisture Content(%)	Max Dry Density(g/cc)
100% +0%	2.85	62%	32.4%	18.7	1.44
95% +5%	2.65	59%	31%	20.3	1.33
90% +10%	2.61	52%	29.6%	23.5	1.37
85% +15%	2.58	49%	28%	24.8	1.44
80% +20%	2.52	46%	24%	27.6	1.51
75% +25%	2.51	48%	24.5%	31.6	1.47

The StandardProctor compaction test is a laboratory method of experimentally determining the optimum moisture content at which a given soil type will become most dense and achieve its maximum dry y density. The test is named in honor ofRalph Roscoe Proctor[de], who in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil com paction His original test is most commonly referred to as the standard Proctor compaction test; his test was later updated to create the modified Proctor compaction test.The proctor compaction test is a laboratory method of experimentally determination the optimal moisture content at which a given soil type will become most dense and achieved its maximum dry density.

It can also be observed that the optimum moisture content was decreased with further increase in fly ash content. The maximum dry density was observed to be about 1.72 g/cc for 85% soil and 15% fly ash m mixture and lowest density was about 1.50g/cc. for 100% soil and 00% fly ash mixture

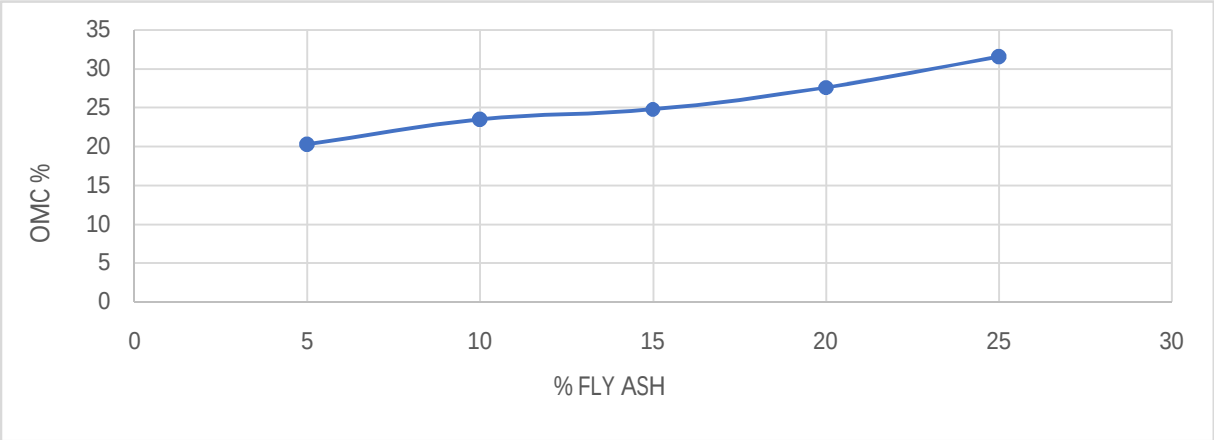

Table 5: Effect of fly ash on OMC

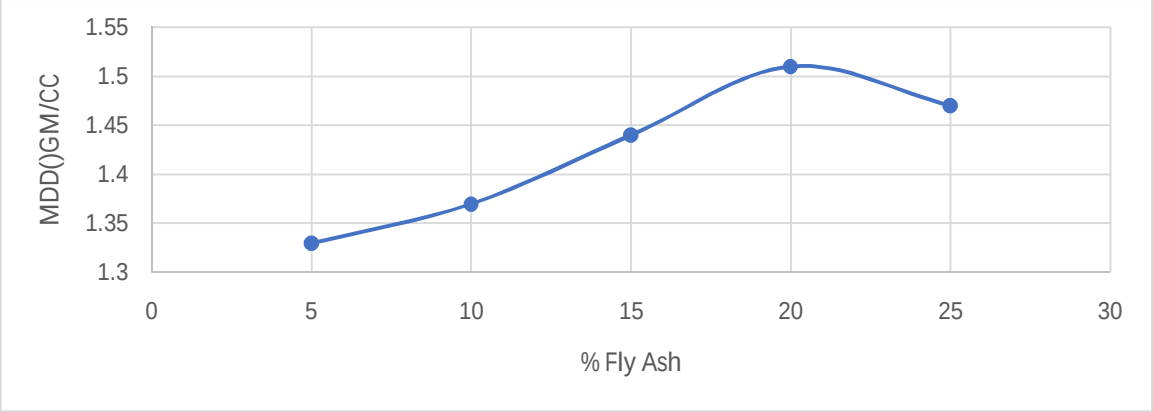

Table 6: Effect of fly ash on MDD

VI. SUMMARY AND CONCLUSIONS

Fly ash as a stabilizer is being widely used in the geotechnical field of engineering. In this study, different aspects concerning fly ash, Lime and cement stabilization have been reviewed concerning the literature available. The basic mechanism of fly ash stabilization involves action exchange and flocculation in the initial stage and then pozzolanic reactions occur which continue for a longer period of time. Significant changes occur in soil properties but these changes are dependent on soil mineralogy, fly ash type, time, temperature, etc. In the initial stage, we see a marked decrease in the soil plasticity owing to the reduction in diffuse double layer thickness and increase in the viscosity of pore water due to flocculation and action exchange. However, these changes in consistency limits witness a decrease and sometimes a reversal beyond particular fly ash content. The moisture density relation also shows marked variations with a decrease in optimum moisture content and an increase in dry density. we have conducted Standard proctor test and CBR to check for the influence of fly ash treatment on the overall soil strength and they reported a net increase in shear strength, tensile strength and bearing capacity up to an optimum value of fly ash addition owing to the cementation process due to continuous pozzolanic reactions. Studies show differences among researchers about the permeability changes with some reporting an increase while others observed a decrease and a few more reported variabilities in values with increasing fly ash content. Soils treated with fly ash have also shown a remarkable decrease in compressibility and have an increased resistance against strength loss due to alternate wetting-drying or freezing-thawing cycles. fly ash stabilization have been and is being used in a great number of areas like, we have fly ash Columns which help in stabilizing soils underneath buildings, embankments and roads, these columns reduce settlements, dewater soils, increase strength, etc. besides other benefits. Similarly, lime treatment. Adding fly ash (especially 10–20%, 20% being optimum percentage of fly ash mixed) improves the strength, compaction, and stability of black clay soil. It reduces plasticity and Liquid limit, making the soil more suitable for construction applications like subgrade improvement, embankments, and low-cost road bases.

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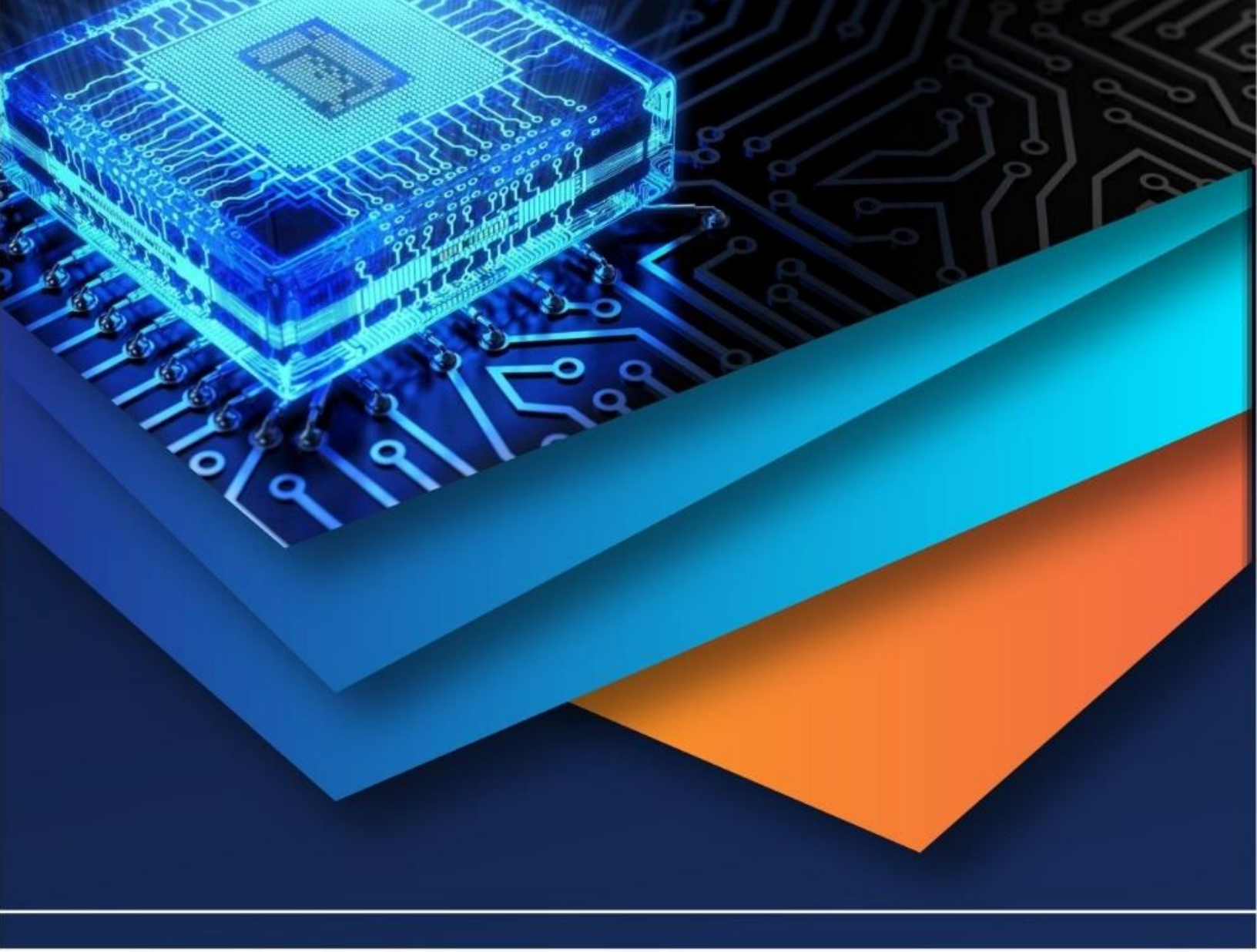

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