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Stabilization of Soil 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 oncoming 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; lime stabilization etc. adversely affects the chemical composition of the soil.
In this study, fly ash mixes with 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, unconfined compression test, CBR tests and permeability test. The tests were performed as per Indian Standard specifications.
Index Terms: Soil, Fine Fly Ash Mixture, Soil Stabilization.

I. INTRODUCTION

Transport in republic of India is an important part of the nation's economy. Roads are vital lifelines of the economy making possible trade and commerce. The are the most preferred modes of transportation and considered as one of the cos effective modes. An efficient and well-established network of roads is desired for promoting trade and commerce in any country and fulfils the needs of a sound transportation system for sustained economic development. To provide mobility and accessibility, all weather roads should connect every nook and corner of the country. To sustain both static and dynamic load, the pavement should be designed and constructed with utmost care. The performance of the pavement depends on the quality of materials used in road construction.Sub grade is the in situ material upon which the pavement structure is placed.

Although there is a tendency to look at pavement performance in terms of pavement structures and mix design alone, the sub grade soils can often be the overriding factor in pavement performance. The construction cost of the pavements will be construction of lower layer of pavements such as sub grade, sub base etc. If the stability of local soils is not adequate for supporting the loads, suitable methods to enhance the properties of soil need to be adopted. Soil stabilization is one such method. Stabilizing the sub grade with an appropriate chemical stabilizer increases sub grade stiffness and reduces expansion tendencies, it performs as a foundation.

Fly ashes are finely divided residue resulting from the combustion of ground or powdered coal from electric generating plants

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 Khordha district in OdishaState. The soil was excavated from a depth of 2.0 m from the natural ground level. The soil is grey t 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.

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	Plasticity Index	Shrinkage limit
9.00%	2.78	00 %	10.10%	90.4%	64%	32.2%	29.8%	11.43%

Table 2: compaction and compressive strength of Soil

Max dry density in g/cc	Optimum moisture content in %	Compressive Strength in Kpa
1.50	20	110.1

Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water the fly ash forms a cementations compound with properties very similar to that of Portland cement. Because of this similarity, fly ash can be used to replace a portion of cement in the concrete, providing some distinct quality advantages. The concrete is denser resulting in a tighter, smoother surface with less bleeding. Fly ash concrete offers a distinct architectural benefit with improved textural consistency and sharper detail. Fly Ash is also known as Coal ash, Pulverized Flue ash, and Pozzolona. Fly ash closely resembles volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term "pozzolan". A pozzolan is a siliceous or siliceous/aluminous material that, when mixed with lime and water, forms ancementitious compound. Fly ash is the best known, and one of the most commonly used, pozzolans in the world. Instead of volcanoes, today's fly ash comes primarily from coal-fired electricity generating power plants. These power plants grind coal to powder fineness before it is burned. Fly ash - the mineral residue produced by burning coal - is captured from the power plant's exhaust gases and collected for use. Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. The difference between fly ash and Portland cement becomes apparent under a microscope. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete.

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
2.22	00 %	52 %	40%	32%	Non plastic%	15.50%

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.

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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.

Table 4: Compaction of fine fly ash mixtures

Soil+ Fine fly ash	Optimum Water Content (%)	Max Dry density(g/cc)
95%+5%	21.2	1.35
90%+10%	22.2	1.20
85%+15%	24.0	0.90
80%+20%	26.0	0.80
75%+25%	28.0	0.65
70%+30%	30.0	0.60

The **Proctor compaction test** is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The test is named in honor of Ralph 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 compaction 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 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.

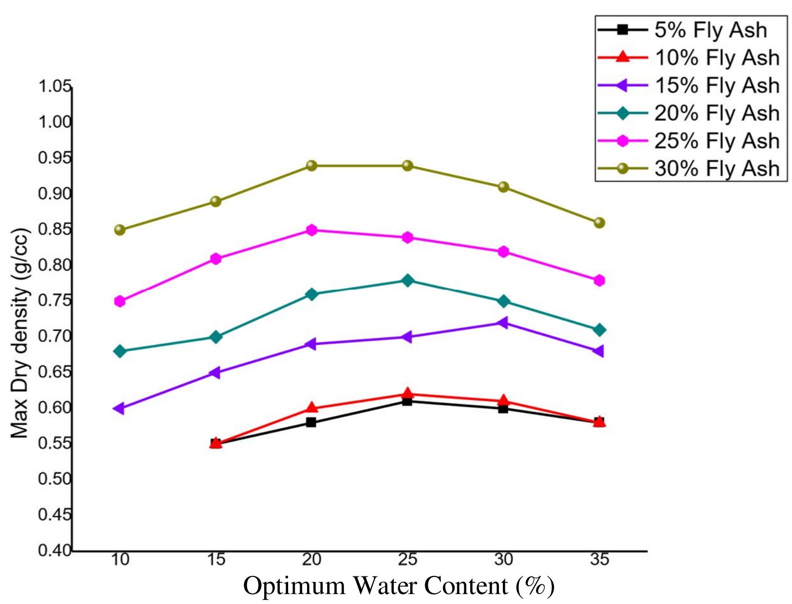

Fig 1: Compaction with soil and Fine Fly Ash

It is observed that with the increase of Coarse Fly ash content the maximum dry density decreases.

Table 5: Compaction of coarse fly ash mixtures

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%	15.0	1.22
80%+20%	17.5	1.18
75%+25%	21.0	1.12
70%+30%	23.0	0.95

VI. SUMMARY AND CONCLUSIONS

and fly ash as a stabilizer is being widely used in the geotechnical field of engineering. In this study, different aspects concerning Lime and fly ash stabilization have been reviewed concerning the literature available. The basic mechanism of lime and 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, lime 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 lime content. The moisture density relation also shows marked variations with an increase in optimum moisture content and a decrease in dry density. Researchers have conducted UCS, CBR and Triaxial tests to check for the influence of lime and 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 lime 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 variability's in values with increasing lime and fly ash content. Soils treated with lime and fly ash have also shown a remarkable decrease in compressibility and have an increased resistance against strength loss due to alternatewetting-drying or freezing-thawing cycles. Lime and fly ash stabilization has been and is being used in a great number of areas like, we have Lime 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.

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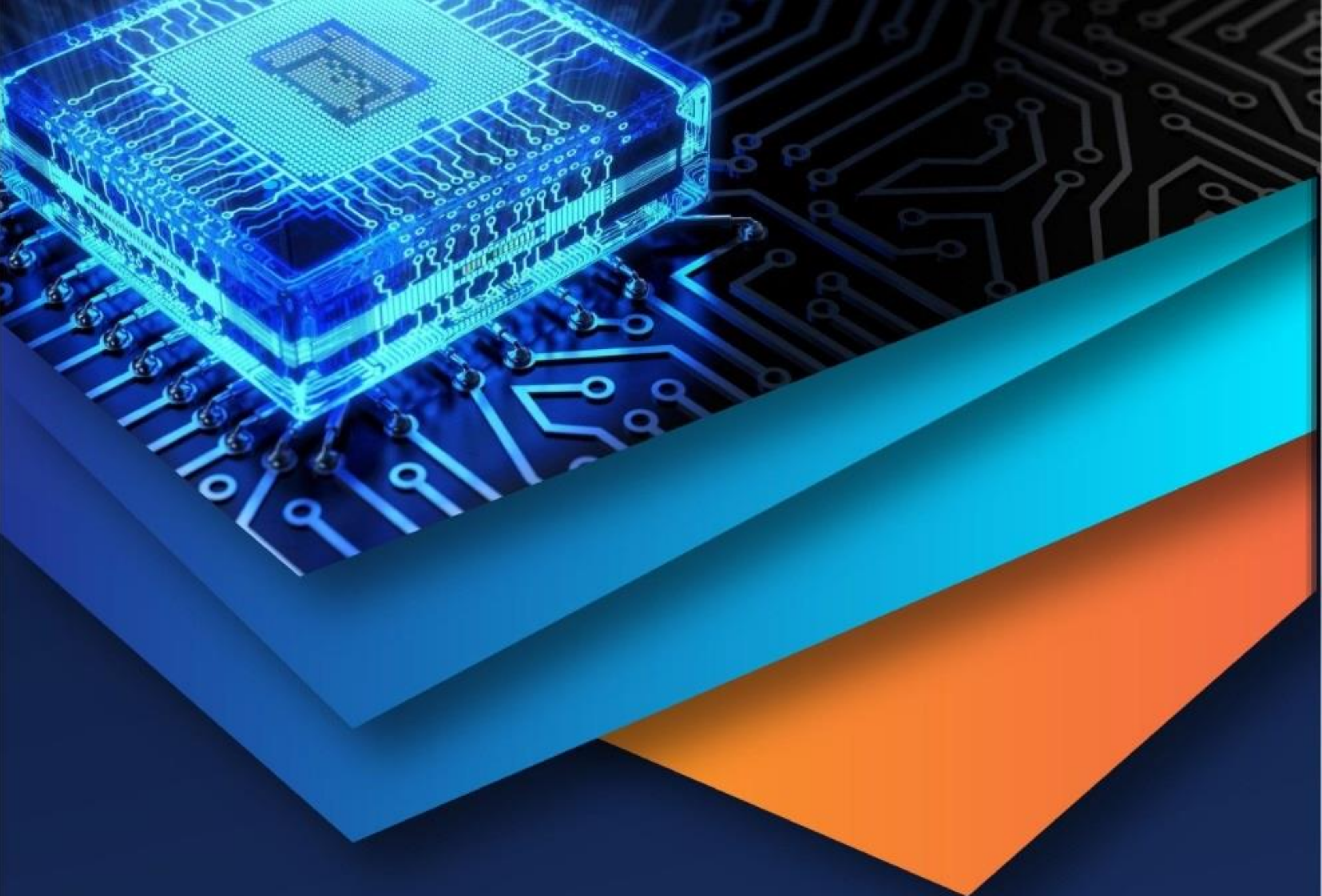

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