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COMPARATIVE STUDY OF BLACK COTTON SOIL STABILIZATION USING COPPER SLAG AND FLY ASH FOR PAVEMENT CONSTRUCTION

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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 and copper slag were mixed with Black cotton soil to investigate the relative strength gain in terms of unconfined compression, bearing capacity and compaction. The effect of fly ash and copper slag on the geotechnical characteristics of clay-fly ash and clay-lime mixtures was investigated by conducting standard Proctor compaction tests, unconfined compression tests, CBR tests and permeability test. The tests were performed as per Indian Standard specifications. The black cotton soil used for these experiments was brought from bowrampet village ,near Bachupally, Hyderabad, Telangana. The physical properties of the soil were determined as per IS specifications. Fly ash for the study was brought from Dundigal (Hyderabad). It is finely divided residue resulting from the combustion of ground or powdered coal from electric generating plants. It has high water absorption capacity. Copper slag was brought from SRI SRINIVASA METALIZERS (Phase II, IDA, Cherlapally, HYD) Copper slag is a by-product extracted during the process of smelting. In the process of smelting, the impurities become slag and floated in the top surface of the molten metal which will be quenched in water produces angular granules and disposed as wastes. In this test programmer, without additives clay was tested to find the optimum moisture content, CBR value, plasticity index and unconfined compression strength. Fly ash and Copper slag were added in varying percentages and that fraction for which maximum strength is obtained was found out.

Key words: BC Soil, copper slag, fly ash, Compaction, CBR.

INTRODUCTION

Emerging trend of using waste material in soil stabilizing or soil strengthening is being operational all over the world in the present days. The main reason behind this trend is the excessive production of waste like fly ash, plastics, rice husk ash (RHA) which is not only hazardous but also creating deposition/disposal problems. Using some of these waste materials in construction practice will reduce the problem to a great extent.

The history of stabilization of soil has a long background with hundreds of research results. Several research results with waste materials such as fly ash, plastics; rice husk ash has also be published with their benefits Stabilized Sub-Grade Soil containing Copper slag and fly ash and Sensitivity Analysis of Sub-Grade Soil CBR.

The naturally occurring materials are fast depleting because of their over exploitation to meet the huge demand for construction of infrastructure projects. To study behavior of fly ash & copper slag with black soil, samples are collected from Hyderabad.

At present India is in the phase of development and huge investments are being made in the up gradation of existing roads under national highway development programme (NHDP) and construction of new roads under Pradhan Mantri Gram Sadak Yojana (PMGSY).

Therefore the naturally occurring materials are fast depleting because of their over exploitation to meet the huge demand for construction of infrastructure projects.

In a recent years there has been a growing emphasis all over the world towards promoting the use of marginal materials in road construction in order to effect cost saving reduce pressure on good quality aggregates and also protect environment.

FLY ASH

Fly ash is a coal combustion by-product – a finely divided residue resulting from combustion of coal in power plants. In the thermal power stations, coal is pulverized into fine powder and pumped into the boiler along with compressed air. Coal

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powder is fired to generate heat, which in turn produces steam to run the turbine. After burning, the coarse ash or 'bottom ash' gets collected below the boiler. The finer particles of coal are collected in the Electro-Static Precipitators (ESP).

Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates (fine particles of fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash.

Physical properties and chemical composition of fly ash

Physical Properties	
Specific gravity	2.27
Loss on ignition	11.8%
Chemical Composition	
Silica (SiO2)	58.3%
Alumina (Al2O3)+Iron oxide (Fe2O3)	26.3%
Calcium oxide (CaO)	2.2%
Magnesium oxide (MgO)	0.3%

COPPER SLAG:

Copper slag is a by-product extracted during the process of smelting. In the process of smelting, the impurities become slag and floated in the top surface of the molten metal which will be quenched in water produces angular granules and disposed as wastes. Copper slag is in black color and granular in shape has less than 1% moisture

The specific gravity of slag was 3.2 and the grain size mostly between 2.36 mm to 1.18 mm which very closely matches with sand property. Mostly the composition of copper slag contains oxides of copper, iron and silica.

Copper slag was brought from SRI SRINIVASA METALIZERS (Phase II, IDA, Cherlapally, HYD) Copper slag is a by-product extracted during the process of smelting. In the process of smelting, the impurities become slag and floated in the top surface of the molten metal which will be quenched in water produces angular granules and disposed as wastes.

Fig 2: Curtailment of Reinforcement in RCC Section Beams

Beam was cast with circular moulds to provide the opening in the transverse direction. These moulds were removed after 24 hours. Beam was unmolded and surface curing was done for 28 days.

METHODOLOGY

Index tests on the natural laterite soils were carried out in accordance with the procedures obtained in IS 2720, step percentages of bitumen emulsion and coconut shell and egg shellby dry weight of soil (5,10 and 15%) was introduced into the soil.

The following tests were carried out on the Laterite soil

- Natural moisture content test
- specific gravity (Density Bottle method)•Compaction test (Standard proctor test)
- California bearing ratio test
- Compressive Strength test
- Direct shear test

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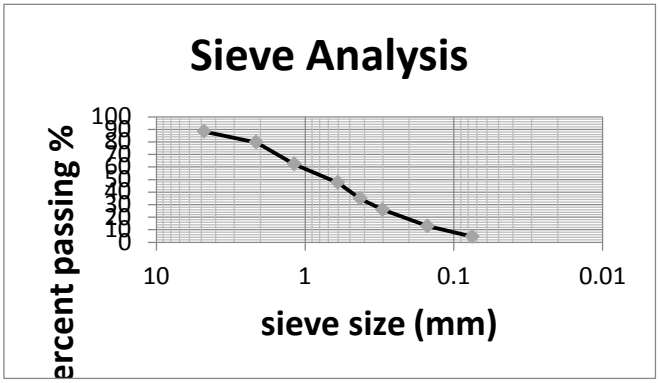
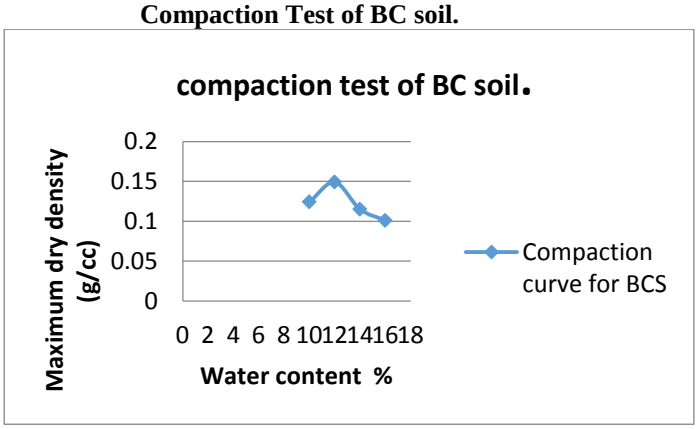


Geotechnical Properties

S.no	Parameters	Parameters
1	Specific gravity Gs	2.6
2	Atterberg's limits %	
	Liquid limit	0.7275
	Plastic limit	18.269
	Plasticity index	17.5
3	Sieve analysis%	
	Sand	30.5
	Silt	44.3
	Clay	24.5
	Effective particle size (D10) mm	0.275
	(D30)mm	0.69
	(D60)mm	61.8
	Coefficient of uniformity (Cu	11.45
	Coefficient of curvature (Cc)	0.88
4	Optimum moisture content	14
5	Maximum dry density KN/M^3	15.901
6	IS classification	CH & MH

The above graph shows sieve analysis test of BC soil Sand is 30. 5%, silt is 44.37 % & 24.5% of clay content.

Compaction Test of BC soil.



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Above graph shows the compaction test of BC soil is 12% of Optimum moisture content&15.901% maximum dry density

RESULT

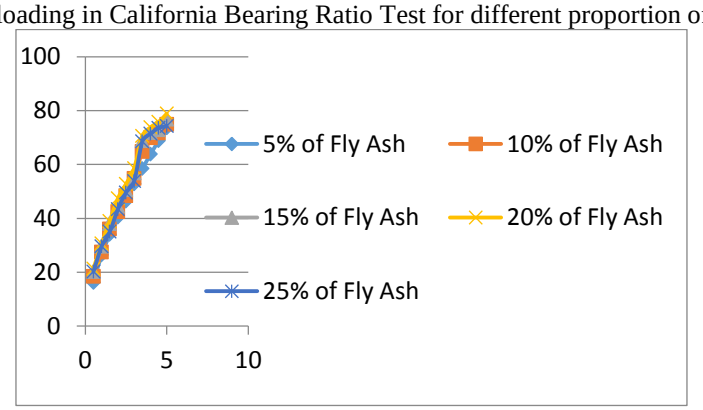
1. Coefficient of Curvature, Cc= 6
2. Uniformity Coefficient, Cu= 2.80

Therefore according to above known conditions the laterite soil taken is perfectly uniformly graded.

CBR values of Fly ash mixing with Black cotton soil with different percentages

Sl.no.	Description	CBR values	
		Penetration 2.5mm	Penetration 5.0mm
1.	Soil	28	17
2.	Soil + 5% fly-ash	29.32	24.12
3.	Soil + 10% fly-ash	31.4	28.3
4.	Soil + 15% fly-ash	32.7	31.41
5.	Soil + 20% fly-ash	33.2	32.6
6.	Soil + 25% fly-ash	38.3	36.5

1) Graph of Penetration v/s loading in California Bearing Ratio Test for different proportion of fly ash



CBR values of Copper slag mixing with Black cotton soil with different percentages

SL.no.	Description	CBR values	
		Penetration 2.5mm	Penetration 5.0mm
1.	Soil	28	17
2.	Soil + 5% Copper slag	19.23	17.01
3.	Soil + 10% Copper slag	21.41	17.32
4.	Soil + 15% Copper slag	22.8	18.6

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5.	Soil + 20% Copper slag	23.3	19.5
6.	Soil + 25% Copper slag	23.9	19.9

1) Graph of Penetration v/s loading in California Bearing Ratio Test for different proportion of Copper Slag

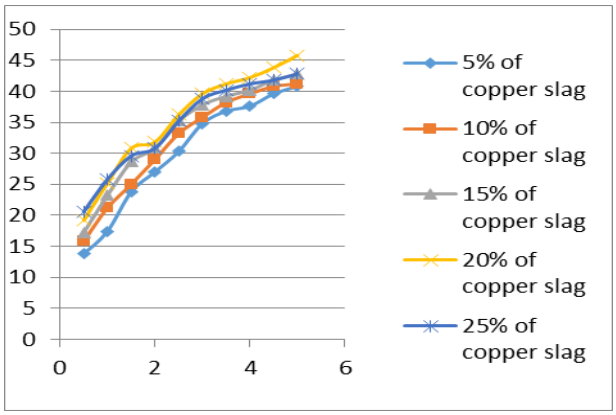
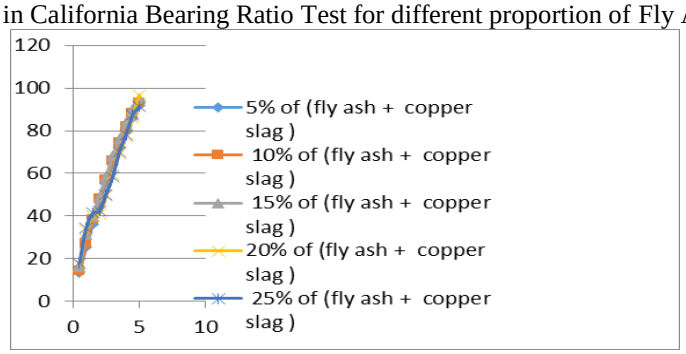


Fig 3 Mounting RCC Beam on Torsion Machine

CBR values fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil with different percentages.

SL.no.	Description	CBR values	
		Penetration 2.5mm	Penetration 5.0mm
1.	Soil	28	17
2.	Soil + 5% fly-ash + 5% Copper slag	38.6	35.2
3.	Soil + 10% fly-ash + 10% Copper slag	39.01	36.2
4.	Soil + 15% fly-ash + 15% Copper slag	42.1	37.2
5.	Soil + 20% fly-ash + 20% Copper slag	45.37	39.61
6.	Soil + 25% fly-ash + 25% Copper slag	45.7	43.1

Graph of Penetration v/s loading in California Bearing Ratio Test for different proportion of Fly Ash and Copper Slag



CBR values of Fly ash, Copper slag and mixture of Fly ash and Copper slag with Black cotton soil at a 5%

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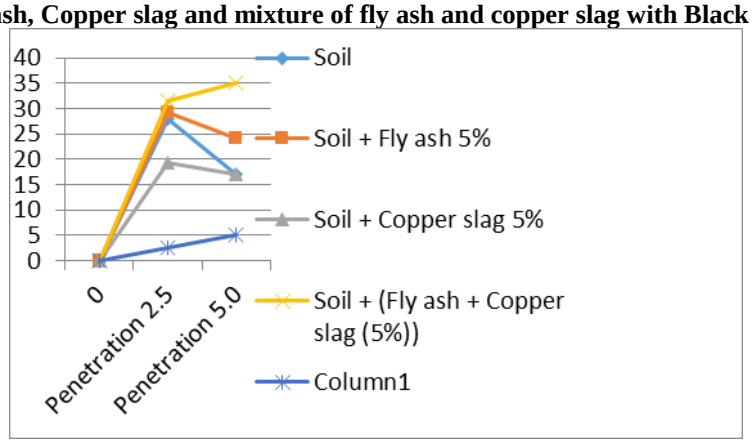
Sample	Penetration	
	2.5mm	5.0mm
Soil	28	17
Fly ash	29.32	24.02
Copper slag	19.32	17.01
Soil +fly ash +copper slag	38.6	35.2

CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 5%



CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 10%

Sample	Penetration	
	2.5mm	5.0mm
Soil	28	17
Fly ash	31.4	28.3
Copper slag	21.41	17.32
Soil +fly ash +copper slag	39.01.	36.2

CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 10%

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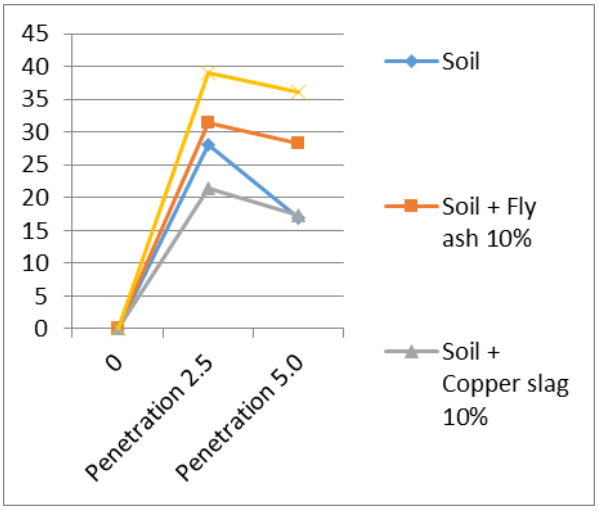
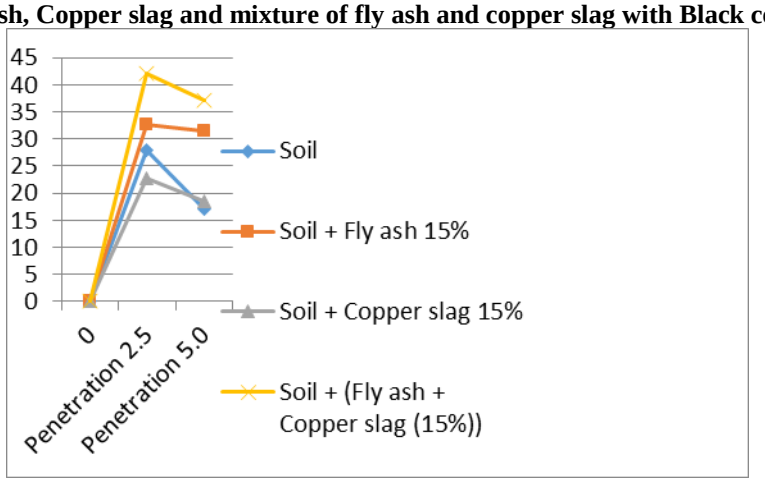


CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 15%

Sample	Penetration	
	2.5mm	5.0mm
Soil	28	17
Fly ash	32.7	31.4
Copper slag	22.8	18.6
Soil +fly ash +copper slag	42.1	37.2

CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 15%



CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 25%

Sample	Penetration	
	2.5mm	5.0mm
Soil	28	17
Fly ash	38.3	36.5
Copper slag	23.9	19.9

Soil +fly ash +copper slag	45.7	43.1

CBR values of fly ash, Copper slag and mixture of fly ash and copper slag with Black cotton soil at a 25%

CONCLUSION:-

The investigation that has been performed on black cotton soil with different admixtures such as fly ash and copper slag gives wide variety of results on several issues from which the following qualitative conclusions can be drawn:-

1. The strength of the black cotton soil without any admixtures is up to 28%.

2. At a 5% of fly ash, copper slag and mixture of the both fly ash and copper slag with black cotton soil, CBR value is increased up to 29.32%, 19.32% and 38.6%.

3. At a 10% of fly ash, copper slag and mixture of the both fly ash and copper slag with black cotton soil, CBR value is increased up to 31.4%, 21.41% and 39.01%.

4. At a 15% of fly ash, copper slag and mixture of the both fly ash and copper slag with black cotton soil, CBR value is increased up to 32.7%, 22.8% and 42.1%.

5. At a 20% of fly ash, copper slag and mixture of the both fly ash and copper slag with black cotton soil, CBR value is increased up to 33.5%, 23.3% and 45.3%.

6. At a 25% of fly ash, copper slag and mixture of the both fly ash and copper slag with black cotton soil, CBR value is increased up to 38.3%, 23.9% and 45.7%.

7. It is clearly observed from the above points that the strength of the soil stabilized using fly ash gives more strength compared to copper slag.

Scope for future work:

Large area of **Bowrampet village** near **bachupally**, **Hyderabad** is covered with black cotton soil, which has low strength and not so suitable as a sub grade material. To improve the strength characteristics of soil, the following further studies can be carried out.

- A detailed review of stabilizing weak soil of **Bowrampet village** near **bachupally**, **Hyderabad.**
- Field performance of different types of admixtures such as Fly ash and copper slag.
- Performance of admixtures for pavement constructions.
- Optimization of layer thickness of admixtures in the sub base layer of soil for reducing the fill thickness in roads.

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