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A Study on Characteristics of BlackCotton Soil by Stabilizing with Fly Ash

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ABSTRACT: Black Cotton Soil deposits in India are a boon to farmers. The Black cotton soils are very hard when dry, but lose its strength completely when in wet condition. In Civil Engineering aspect these soils are giving hazardous problems to Engineers. Various methods are adapted to improve the engineering characteristics of Black cotton soil. The problematic soils are either removed and replaced by good and better-quality material or treated using additive.

Fly ash is a fine powder obtained from burning of coal during the production of electricity. Disposal of flash is a big problem, to minimize the disposal of fly ash into large land, it was used as a construction material in civil engineering works like building materials embankments, and bricks making etc. In this project, Black cotton soil of West Godavari district, Andhra Pradesh stabilized using fly ash obtained from Visakhapatnam Steel Plant. This project is an investigation carried out to study the effect of fly ash on engineering and strength properties of the Black Cotton Soils. The properties of stabilized soil such as compaction characteristics, consistency limits, California Bering Ratio were evaluated and their variations with fly ash content.
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KEY WORDS: Fly ash, Black Cotton Soil, California Bering Ratio, compaction characteristics

I. INTRODUCTION

Expansive soil also known as Black cotton soil because of their color& suitability for growing cotton swells when the moisture content is increased and shrinks massively when dry.
Montmorillonite mineral is mainly responsible for the swell-shrink characteristic of the black cotton soil. The expansive nature decreases the bearing capacity of the soil. The black color in Black cotton soil is due to the presence of titanium oxide in small concentration. Black cotton soil is a highly clayey soil. It is so hard that the clods cannot be easily pulverized for treatment for its use in road construction. This poses serious problems as regards to subsequent performance of the road. The softened sub grade has a tendency to up heave into the upper layers of the pavement, especially when the sub-base consists of stone soling with lot of voids. Gradual intrusion of wet Black cotton soil invariably leads to failure of the road. The roads laid on Black cotton soil bases develop undulations at the road surface due to loss of strength of the sub grade through softening during the wet season. The damage will be apparent usually several years after construction. The stability and performance of the pavements are greatly influenced by the sub grade and embankment as they serve as foundations for pavements. There is therefore need to stabilize black cotton soil in order for it to provide a good foundation material. Stabilization denotes improvement in both strength and durability of the material which are related to performance., reasonable studies have been conducted to find the suitability of silica fume in conventional concrete.

Problem Statement:

There is a vast scope of research in the recycled aggregate usage in concrete especially ceramic wastes in the future.The possible research investigations that can be done are mentioned below

Black cotton soil is an undesirable foundation material. An engineer may choose to remove the undesirable material and replace it with a more desirable material in terms of strength and durability. This may however turn out to be expensive considering the construction and therefore the need to find out other alternative methods of modifying the properties of the soil in place. These undesirable properties are that:

- In rainy season, Black cotton soils become very soft by filling up of water in the cracks and fissures

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- These soft soils reduce the bearing capacity of the soil hence the decrease of the strength of foundation.
- In saturated conditions these soils have high consolidation settlements which are uneven hence the beam deflects which in turn affect the plastering to the wall.

There is therefore need to increase the bearing capacity and the unconfined compressive strength of the soil, reduce both elastic and inelastic consolidation settlement, prevent weathering and deteriorations of the black cotton soil

Purpose and Scope of The Study

There are ways of keeping expansive soils from either expanding or shrinking too much when used as a sub-grade. This help minimize the problems associated with black cotton soil. The challenges of construction on clay were carried out and their effect on the pavement looked into. Fly ash will be used for its suitability to improve the properties of black cotton soil and use this soil as a foundation material for pavement sub-grade construction. The data is analyzed so as to obtain the best design for the local conditions.

Objective of The Study

To establish the shear failure problems associated with black cotton in construction by improvement of soil parameters such as

1. Plasticity and volume change characteristics of black cotton soils.
2. Bearing strength so as to provide a stable working platform on which pavement layer may be constructed.

Soil Stabilization:

In most cases it is expensive to remove large volumes of unsatisfactory soils and replace them with suitable material. This brings about the need to improve the soil in place so that it serves as a good engineering construction material. The improvement of the stability or bearing power of a poor soil and durability which are related to performance of the soil through mechanical, physio-mechanical and chemical methods is referred to as soil stabilization. This is achieved by use of controlled compaction, proportioning and addition of suitable admixture or stabilizer. The stabilization process involves excavation of the in-situ soil, treatment of the in-situ soil and compaction of the treated soil. Increase in strength is expressed quantitatively in terms of:

- Adsorption, softening and reduction in strength
- Direct resistance to freezing and thawing
- Compressive strength, shearing strength or measure of load deflection to indicate the load bearing quality

Stabilization process is ideal for improvement of soils in shallow depth such as pavements and light weight structures as the process essentially involve excavation of the in-situ soil.

Uses of Stabilization:

Pavement design is based on the premise that specified levels of quality will be achieved for each soil layer in the pavement system. Each layer must

- Resist shearing within the layer.
- Avoid excessive elastic deflections that would result in fatigue cracking within the layer or in overlying layers.
- Prevent excessive permanent deformation through densification.

Choice of Soil Stabilization Method

Choice of soil stabilization is influenced by:

Soil type: This primarily refers to the particle size distribution and chemical composition. Compaction is not recommended for fine grained soils as they are easily powdered and could be blown off. Treatment of some soils that has a lot of sulfate with calcium base stabilizers such as lime and cement can cause extreme swelling of soil.

Moisture content: In very dry soils, dust may form when the soil is compacted while high moisture content could cause soil particles segregation hence loss of soil stability which may result the soil to become plastic.

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Site conditions: Physical conditions such as space have to be considered. Stationary continuous method, which requires space where a central unit is to be installed, will not be applicable where there is space limitation.
Cost: The method of stabilization chosen must be cheaper than other available techniques

FLY ASH:

As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased enough to permit a reduction in the required thickness of the soil and surface layers. Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash that does not rise is called bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rocks strata.

Types of flyashes:

Two classe

s of flyashes are defined by ASTM C618: Class F flyash and Class C flyash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the flyash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite).

Class F flyash:

The burning of harder, older anthracite and bituminous coal typically produces Class F flyash. This flyash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F flyash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, addition of chemical activator such as sodium silicate (water glass) to a Class F ash can leads to the formation of a geopolymer.

Class C flyash:

Flyash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C flyash will harden and gain strength over time. Class C flyash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C flyash does not require an activator. Alkali and sulfate (SO4) contents are generally higher in Class C fly ash.

II. LITERATURE REVIEW

Ashish Mehta et al., have collected black cotton soil from various locations of Maharashtra and stabilized with various proportions of fly ash i.e, at 0, 10, 20, 30, 40, 50%.It is observed that, the unsoaked CBR value is high with 20% Fly ash compared to other mixes. Comparatively the dry density with 20% fly ash is higher than the other percentages of fly ash. So, it may be reported that fly ash has good potential for use in geotechnical applications. The relatively low unit weight of fly ash makes it well suited for placement over soft or low bearing strength soils. Its low specific gravity, freely draining nature, ease of compaction, insensitiveness to change in moisture content, good frictional properties etc., can be gainfully exploited in the construction of embankments, road, fill behind retaining structure, etc.

Udayashankar D. Hakari et al., have investigated and improved the engineering properties of the black cotton soils of Huballi-Dharwad Municipal Corporation area so that, a better understanding is facilitated for civil engineering practitioners, while dealing with these soils. They have used Dandeli fly ash for stabilization of black cotton soil and concluded that the soil samples yield peak values of maximum dry density and corresponding values of optimum moisture content for addition of DFA at 30% and the Unconfined compressive strength attains peak value at DFA between 20 and 30%, beyond which the increase in strength is marginal.

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Gyanen. Takhelmayum et al., have 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.

S.Bhuvaneshwari et al., has carried out laboratory trials and field test to check the improvements in the properties of expansive soil with fly ash in varying percentages and noticed that the major difficulties in field application is thorough mixing of the materials in required proportion to form a homogeneous mass and adopted a method of placing these materials in layers of required thickness and operating a Disc Harrow. A trial embankment of 30m length by 6m width by0.6, high was successfully constructed and the in-situ tests carried out prove its suitability for construction of embankment, ash dykes, etc.

P.V.Sivapullaiah et al., have studied the effect of abundantly available fly ash, on the index properties namely liquid and plastic limits, and free swell of natural deposits of Indian black cotton soil .The effects of lime when added have also been studied. Considerable changes in these properties were observed which are explained based on grain size distribution, free lime content and pozzolanic reactivity of fly ash. Addition of fly ash improved the workability of the soil considerably. The increase in free swell in the presence of fly ash is not due to increase in the swelling potential of the soil. Over all, the effect of the addition of fly ash is to significantly improve the physical properties of the black cotton soil.

III. MATERIAL AND PROPERTIES

In this investigation the following materials used

1. Black Cotton Soil
2. Flayash
3. Water

Table 1. Properties of fly ash

SL.NO	Properties	Test results
1	Specific gravity	2.42
2	Sieve analysis D_{10}= 0.27 $D3_0$= 0.83 $D6_0$= 0.89	Cu= 3.29 Cc= 3.026
3	Water content (%)	7.2
4	Bulk density	1.538
5	Maximum Dry Density	1.43
6	OMC	13%

Table 2.Properties of black cotton soil

S.No.	Properties of Black Cotton Soil	Result
1	Specific Gravity	2.62
2	Water content (%)	10.6
3	Bulk density	1.52
4	Maximum Dry Density	1.376
5	OMC	15.47
6	CBR @250	1.2-4.0

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IV. EXPERIMENTAL STUDY

Tests on Black cotton soil:

- Liquid Limit
- Plastic Limit
- specific gravity
- Maximum Dry Density
- Optimum Moisture Content
- California Bearing Ratio

Table3. Properties of fine aggregate

S.No	Samples	Mix name	% of Black Cotton Soil	% of Bagasse Ash
1	Sample 1	100% BC+ 0% FA	100%	0%
2	Sample 2	90% BC+ 10% BA	90%	10%
3	Sample 3	80% BC+20% BA	80%	20%
4	Sample 4	70% BC+30% BA	75%	30%

Table 4: Mix Names

S.No	Mix name	Liquid Limit	Plastic Limit	Bulk Density	OMC	MDD (gr/cc)	CBR @250
1	Black Cotton Soil	49%	36.65%	1.52	15.6%	1.376	1.96%
2	FlyAsh	--	--	1.538	13%	1.43	--
3	90% BC+ 10% BA	43%	30.4%	1.589	14.5%	1.442	3.77%
4	80% BC+20% BA	39%	26.3%	1.649	13%	1.489	4.63%
5	70% BC+30% BA	36%	20.8%	1.658	12.5%	1.505	5.5%

Table 5: Result analysis

Determination of swell pressure:

Sample	BCS	BCS+10% FA	BCS+20% FA	BCS+30%FLA
Proving ring reading	34.54	23.94	20.41	19.23
Load	69.08	47.88	40.82	38.46
Area(cm^2)	78.5	78.5	78.5	78.5
Swell Pressure(kg/cm^2)	0.88	0.61	0.52	0.49

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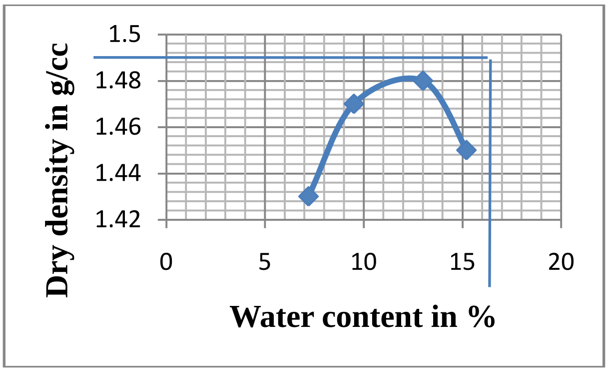
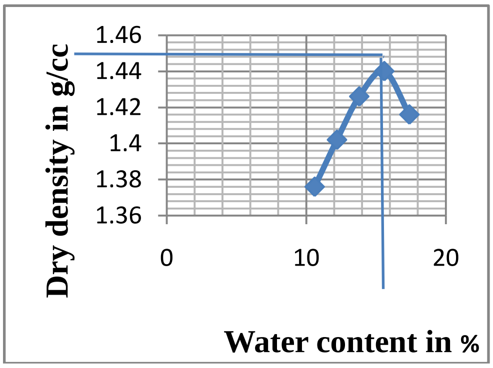


Graph 1



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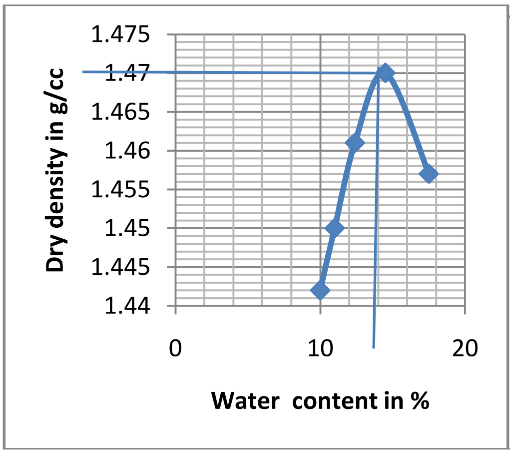

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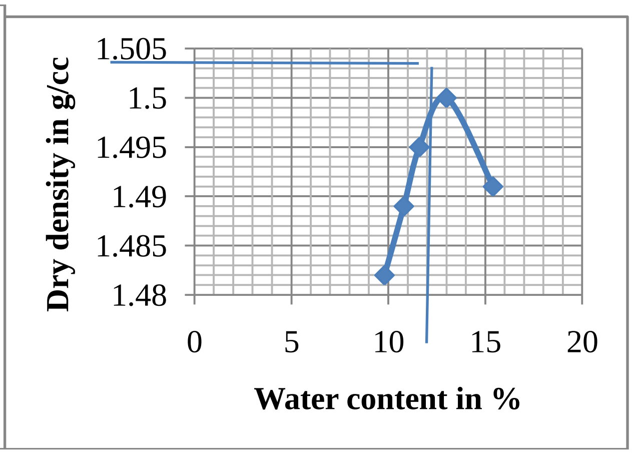

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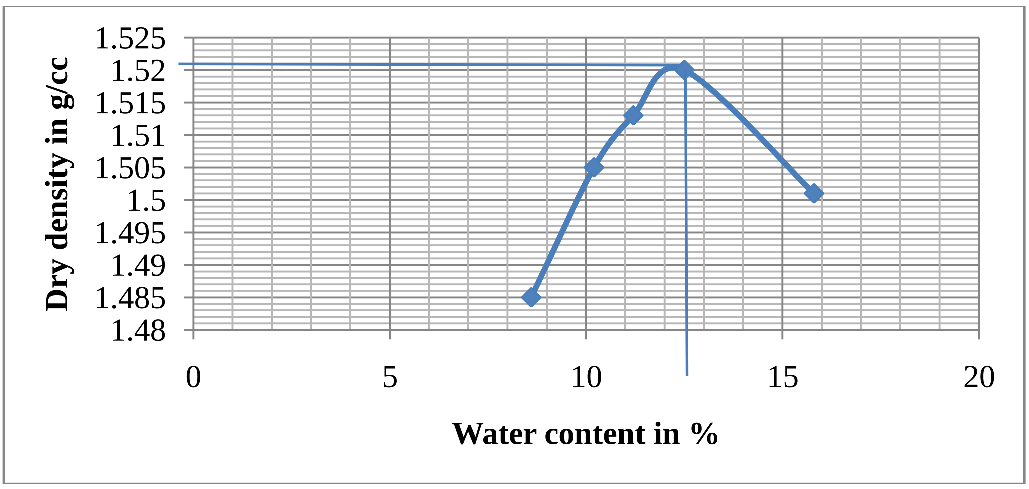

Graph 5

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Graph 1: representation of Proctor compaction test-Flyash
Graph 2: representation of Proctor compaction test-Black cotton soil
Graph 3: representation of Proctor compaction test-Black cotton soil+10% Flyash replacement
Graph4: representation of Proctor compaction table-Black cotton soil+20% flyash replacement
Graph5: representation of Proctor compaction test-Black cotton soil+30% replacement.

V. CONCLUSION

- The optimum moisture content is for 0%,10%,20%,30% replacements of flyash the values of compaction test are 15.6%,14.5%,13%,12.5% Therefore, from the above results it is noticeable that the compaction test value has found to be decreasing with the increase of the percentage of flyash replacement
- From the above Liquid Limit results it is noticeable that the plastic limit value has found to be decreasing with the increase of the percentage of fly ash replacement.
- For 0%,10%,20%,30% replacements of flyash the values of liquid limit test are 49%, 43%,39%,36%.Therefore, from the above results it is noticeable that the liquid limit value has found to be decreasing with the increase of the percentage of flyash replacement.
- From the above swell pressure results it is noticeable that the swell pressure value has found to be decreasing with the increase of the percentage of flyash replacement
- For 0%,10%,20%,30% replacements of quarry dust the values of California bearing ratio test are 1.96%,3.77%,4.633%,5.5%.Therefore, from the above results it is noticeable that the CBR test value has found to be increasing with the increase of the percentage of flyash replacement

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