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Ground Improvement of Black Cotton Soil with Partial Replacement of Lime and Pond Ash

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Abstract- Construction of any infrastructure on expansive soils experience low bearing capacity failures, leads to instability to the structures due to its undesirable engineering behavior such as high shrinkage and swell characteristics and high moisture susceptibility. The construction of pavements on such soils shows early distress causing the premature failure. To overcome these problems, Soil Stabilization is the modification technique used to improve the properties of black cotton soil by adding suitable additives. On the other hand, thermal power plants producing coal ash in huge quantity as a waste by-product and demanding valuable land to its dispose and creating environmental hazard problems like contamination of soil and water. To mitigate these problems, effective utilization of coal ash to the maximum possible extent in pavements is must. In this regard, the present work is focused to study the feasibility of pond ash-lime modified soil as pavement sub grade layer.

Keywords — Black cotton soil, Lime, Pond Ash, Pavements, Sub-grade, Stabilization

I. INTRODUCTION

Black cotton soils are inorganic clay of medium to high compressibility and form a major soil group of India. The black color in black cotton soil is due to the presence of titanium oxide in small concentration. The black cotton soil has a percent of clay which is predominantly montmorillonite structures and black or blackish gray in color. They are characterized by high shrinkage, low bearing capacity and swelling properties. Because of these properties, the black cotton soil has been challenge to the highway engineers. Black cotton soil are very hard when it dry but losses its strength completely when it in wet condition. Soft clays, expensive soils, weak soils, sand and deposit organic deposits are unsuitable for all construction works due to bare engineering properties.

Soil stabilization improves the engineering properties of soil and thus making it more stable. It is essential when the soil accessible for construction is not suitable for anticipated purpose. The term stabilization is generally restricted to the process alter the soil material itself for improvement of is properties a solid wastes or chemicals are added to a natural soil for the purpose of stabilization. The use of by product materials to improve the soil properties varies with economic, environmental and technical points.

II. RESERCH PERFORMED BY INVERTIGATORS

In order to stabilize the weak soil and to meet the specified engineering requirements. Methods for the stabilization are compaction and use of admixtures such as lime and waste material which is produced from the thermal power plants like pond ash. To make black cotton soils suitable as a substratum for construction usage improvement in existing properties are necessary .Different ways are available for enhancing engineering performances of soils are soils are soil stabilization , soil reinforcement etc.

A. Uday Shankar et al. (2012)

Showed that mostly usage of fly ash is in the construction of pavement /highway embankment. The geotechnical characters of fly ash, fly ash-soil admixtures were studied by different investigators to suggest its suitability as structural fill/backfill.

Lime is added to soil improve its volume stability strength stress- strain, behavior permeability and durability. Soil-lime can be used as a base material in road pavement slope protection for embankments dams, canals, river banks, spillways and highway and railway embankments.

B. Prasad P.Dehale

Concluded that soil+ pond ash pulverized fuel ashes could be successfully used as an embankment material especially on soft compressible ground (by conducting compaction, triaxial shear test, CBR test and permeability tests.)

C. Aravind Kumar, Deepak Gupta

Concluded that in order to study the effect of pond ash on compaction and strength behavior of clay, a series of tests were performed. Modified proctor tests were connected linked at evaluate the compaction behavior, while UCS .Pond ash added to clayey soils at ranges to 30% to 45%. Here he concluded that the pond ash, rice husk ash soil specimens compacted at the MDD, OMC state exhibit brittle behavior in unconfined compression tests. The value of strengths increases with increase in curing period.

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III. MATERIALS

A. Black Cotton Soils

Black soils are formed by lava basaltic rocks. Hence they are very dark in color. This capacity is used for cotton cultivation; hence it is called as "BLACK COTTON SOIL". Black cotton soil are Known as "REGULAR SOILS".

B. Pond ash

Ash Pond is an engineered structure used at fossil fuel power stations for the disposal of two types of coal combustion products: bottom ash and fly ash.

Fig.1:pond ash

C. Lime

Lime is calcium containing inorganic mineral composed primarily of oxides, and hydroxides, usually calcium oxide and/ or calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic eject. The word lime originates with its earliest use as building mortar and has the sense of sticking adhering.

Fig.2:Lime

IV. EXPERIMENTAL STUDY

The experimental program was carried out in three stages:-

- ❖ Optimum percentage of pond ash to be added to the black cotton soil. Conduct compaction and Unconfined Compression Strength tests.
- ❖ Minimum Lime content based on pH value consideration.
- ❖ Consider the Optimum Soil content and minimum lime content. Conduct UCS Test.
- ❖ The expansive soil used in this investigation. The basic engineering properties of the soil were determined and presented in Table 1.
- ❖ Table-1 Engineering properties of the soil and Pond ash used

Property	Material	Value
Specific Gravity	Soil	2.36
	Pond Ash	1.73
Particle Size	Soil	C_u=3.67,C_c=1.22
	Pond Ash	C_u=3.21,C_c=1.04
Atterberg's Limits	Soil	W_l=60.17%, W_p=28.57%
Compaction Parameters	Soil +Pond ash	OMC=24% MDD=1.64 g/cc
UCS	Soil +Pond ash	24.65 kg/cm^2

A. Compaction characteristics

The variation of the compaction parameters namely maximum dry density (MDD) and optimum moisture content (OMC) values with different percentages of Pond ash added to the expansive soil is presented in Fig.1.3. Significant change in MDD and OMC are observed with addition of Pond ash to the expansive soil. From Fig 1.3 it is notice that the MDD increases up to about 20% of Pond ash and thereafter decreases with addition of pond ash to the soil. The reason is due to the high water absorption with addition of Pond ash above 20% this will reduce the soil density.

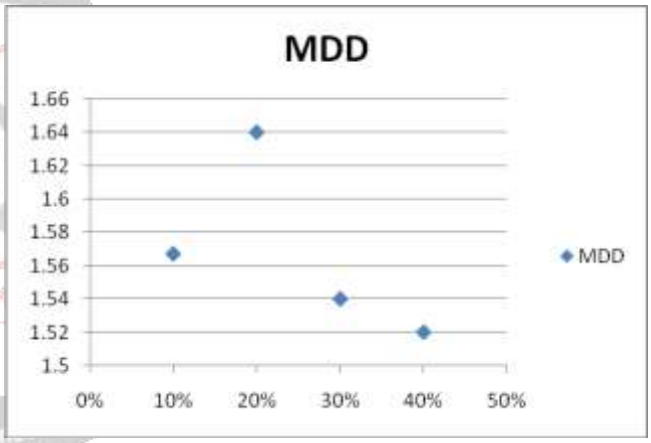

Fig.3: Variation of MDD with various percentages of Pond ash.

The influence of pond ash with varying percentages on OMC is clearly shown in Fig 1.4. From this figure, it was seen that there is considerable decrease in OMC with increase the percentage of the pond ash.

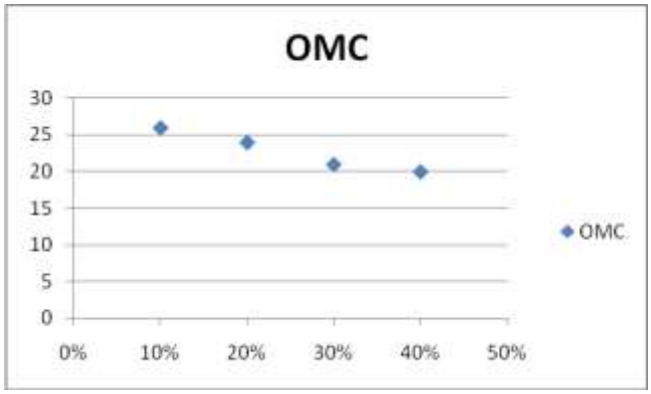

Fig.4: Variation of OMC with various percentages of pond ash

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B. Unconfined Compressive Strength

The variation of unconfined compressive strength (UCS) of the soil stabilized with pon ash is presented in Fig 1.5. From this figure it is observed that the UCS values increases with increase in pond ash. The UCS values are increased with higher rate up to 20% pond ash and then decreased. The justification of this result may be due to the reduction in density with addition of pond ash beyond 20%.

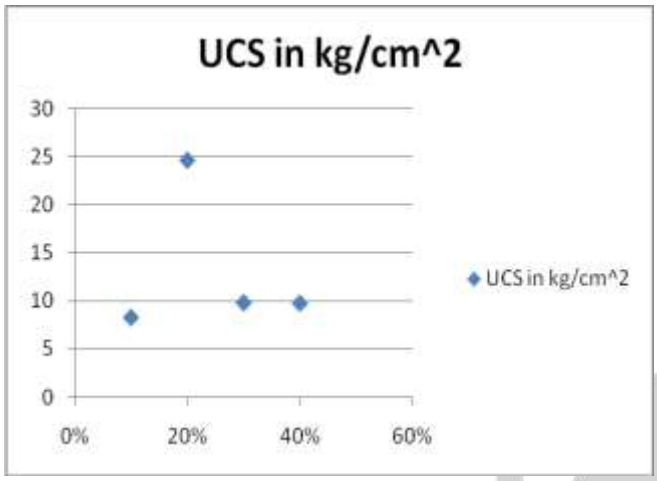

Fig.5: Variation of UCS with various percentages of pond ash

Table-2: PH values for different mix proportions of LIME

Percentage of Lime	pH value
2%	7
4%	7.2
6%	8
8%	9
10%	10.2
12%	10.5
14%	10.5
16%	12.4

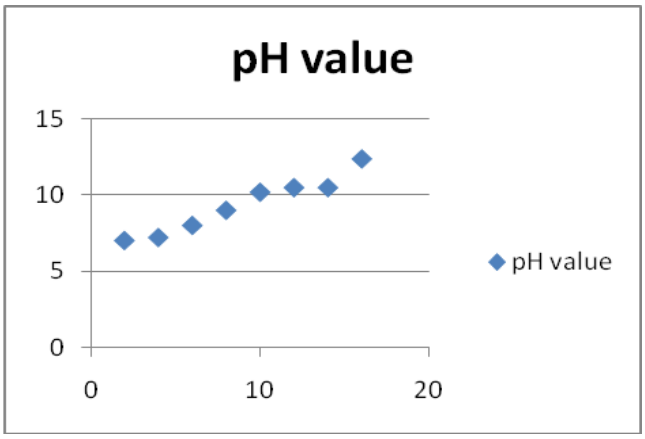

Fig.6: Variation of pH value with varies lime content

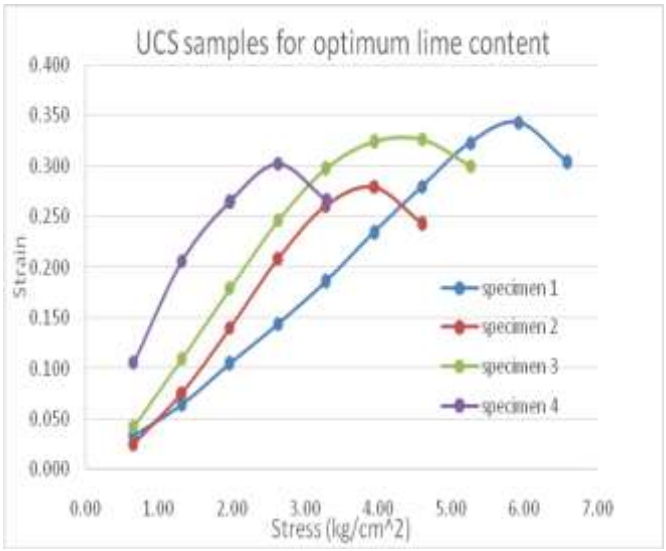

Fig.7: UCS Samples for Optimum lime content and Optimum Soil and Pond ash:

V. CONCLUSION

- In the study, the stabilization of a black cotton soil with pond ash and lime was investigated and the effects of the stabilization on the geotechnical properties of a black cotton soil were studied.
- The optimum pond ash content was found at 20% considering the unconfined compressive strength of treated soil.
- As the increased strength of soil with addition of pond ash was not adequate enough to be used as good foundation material, addition of lime in conjunction with pond ash was adopted for stabilization.
- A minimum lime content of 16% was recommended for stabilizing the soil as resulted from the pH value test.
- The UCS value increased to by 34.3kPa addition of 80% soil, 20% pond ash and 16% lime for 3 days. For 28 days UCS value increased to by 269kPa addition of 80% soil, 20% Pond ash and 16% of lime.
- Quality of sub-grade based on UCS value: we conclude that UCS=269kpa with 80% of Black cotton Soil and 20% of pond ash and 16% of lime used for very stiff sub-grade.

UCS Value(k Pa)	Quality of sub-grade
25-50	Soft Sub-grade
50-100	Medium Su-grade
100-200	Stiff Sub-grade
200-380	Very Stiff Sub-grade
>380	Hard Sub-grade

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