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Stabilization of Expansive Soil Reinforced with Short Polypropylene Fibres Treated with Admixtures

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***Abstract*: Stabilization of Black Cotton Soil (BC soil) is studied by using Marble dust, cement kiln dust and polypropylene fibers. BC soils are highly clayey soils (Montmorillonite clay mineral). The moisture changes in BC soils, compressibility and plasticity nature can be greatly improved with the addition of marble dust, cement kiln dust and polypropylene fibers. This paper includes the evaluation of soil properties like Optimum moisture content, dry density, and Shear strength. Different quantities of marble dust, cement kiln dust and polypropylene fibers (% by weight) are added to the BC soil and the experiments conducted on these soil mixes. The result shows that the use of marble dust, cement kiln dust and polypropylene fibers increases the strength of soil to a great extent. An experimental programme was undertaken to investigate the effect of marble dust, polypropylene fibers and cement kiln dust on the strength of Black cotton soil. In the present investigation soil is compacted at various percentages of marble dust (i.e. 5%, 10%, 15%, 20% by weight of soil), polypropylene fibers (i.e. 0.05%, 0.15%, 0.25% by weight of soil), cement kiln dust(i.e. 4%, 8%, 12%, 16% by weight of soil). In above percentages of admixtures, we got 15% of marble dust by weight of soil, 8% of cement kiln dust by weight of soil, and 0.15% of polypropylene fibers by weight of soil has an optimum value. Again compaction is carried out for combination of black cotton soil with marble dust, cement kiln dust, and polypropylene fibers (i.e. 15%, 8%, 0.15% by weight of soil respectively) and unconfined compression tests were carried out at immediate, 7, 14, 21 days curing period. The test results indicated that the addition of marble dust, polypropylene fibers and cement kiln dust in black cotton soil shows an increase in unconfined compression strength, decrease in the dry density, increase in optimum moisture content. The results show increase in strength of expansive soil.**

***Keywords*: Black cotton soil (BC), Cement kiln dust (CKD), Marble dust(MD), Polypropylene fibres(PPF), compaction, Unconfined compressive strength.**

1. Introduction

Soil is defined as sediments or other accumulation of mineral particles produced by the physical or chemical disintegration of rocks plus the air, water, organic matter and other substances that may be included. Soil is typically a non-homogeneous, porous, earthen material whose engineering behavior is influenced by changes on moisture content and density. Based on the origin, soil can be broadly classified as organic and inorganic. Organic soils are mixture derived from growth and decay of plant life and also accumulation of skeleton or shell of small organism. Inorganic soils are derived from the mechanical or chemical weathering of rocks. Inorganic soil that is still located at the place where it was formed is referred to residual soil. If the soil has been moved to another location by gravity, water or wind, it is referred to as transported soil. Black cotton soils are highly clay soil greyish to blackish in colour. They contain montmorillonite clay mineral which has high expensive characteristics. BC soils have low shrinkage limit and high optimum moisture content. It is highly sensitive to moisture changes, compressible subgrade material. Hence the subgrade and its undesirable characteristics to be modified using a suitable stabilization technique. Stabilization involves the methods used for modifying the properties of a soil to improve its engineering performance. In the construction of road and airfield prevents the main objective of stabilization is to increase the strength or stability of soil and to reduce the construction cost by making best use of the locally available materials. For land based structures, the foundation is very important and has to be strong to support the entire structures. In order for the foundation to be strong, the soil around it plays a critical role. So, to work with the soil, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in soil needed for the construction. From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilization of the Chinese and roman's utilized various methods to improve soil strength, some of these methods so effective that their buildings and roads still exist. In India, the modern era of soil stabilization begins in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at, means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand or infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the ability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement. Here, in this project, soil stabilization has been done with the help of admixtures such as polypropylene fibers, marble dust and cement kiln dust. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement.

2. Literature review

Antonio A.S.Corria, In this work they studied the effect of binder on mechanical behavior of soft soil, chemically stabilized with binders and reinforced or non-reinforced with short polypropylene fibers. The experimental programmed was comprised of evaluating the compressive strength (Unconfined compressive strength). The results indicate that increase in binder content cause an increment in the stiffness and compressive strength. Zaimoglu [11] stated that soil reinforced with polypropylene fibers, the unconfined compressive strength of fibers reinforced soil increased with increased fiber content, during freeze thaw cycles. Addition of 3% of polypropylene fibers (12mm) to clay, results in increase of unconfined compressive strength by 60% to 160%. Moses and Samimu (2010) had also studied the effect of cement kiln dust (up to 16%) on some engineering properties of expansive soil. They found that stabilized soil failed in UCS, CBR and Durability test to be used as a sub-base and base material in pavement.

3. Materials used

A. Black cotton soil

Black cotton soils are highly clayey soils, greyish to blackish in color found in several states in India. The black cotton soils have been formed from basalt or trap and contain the clay mineral Montmorillonite, which is responsible for the excessive swelling and shrinkage characteristics of soil. The black soil taken for the present study was obtained from chittradurga district, Karnataka state. This is a residual soil and is collected from an open excavation, at a depth of one meter below the natural ground surface. The soil was air dried, pulverized and then passed through IS sieve size of 425 µ before being used in this investigation. The physical and chemical properties of the black cotton soil are presented in Table 1.

Table 1
Physical properties of soil used in present study.

S. No.	Properties	Value
1	Colour	Black
2	Specific Gravity	2.5
3	Grain size distribution Fine sand (%) Silt (%) Clay (%)	 2.2 22.3 75.3
4	Atterberg'S limits Liquid limit (%) Plastic limit (%) Plasticity index(I_P)	 62.13 29.44 32.69
5	IS Classification	MI
6	Compaction Maximum Dry Density(MDD)(g/cc) OptimumMoisture content (OMC) (%)	 22 1.54
7	Unconfined compressive strength(Kg/c	3.16

B. Marble dust

Marble dust is obtained from locally available cutting and polishing industry. India is in 3rd rank in production of marble dust. Marble dust having very finer particle.

Table 2
Physical properties of marble dust used in present study

S. No.	Properties	Value
1	Colour	White
2	Specific Gravity	2.6
3	Grain size distribution Fine sand (%) Silt (%) Clay (%)	 40.2 20.8 37.4
4	Atterberg'S limits Liquid limit (%) Plastic limit (%) Plasticity index(I_P)	 96.4 - -
5	IS Classification	CH
6	Compaction Maximum Dry Density(MDD)(g/cc) Optimum Moisture content (OMC) (%)	 16 1.76

C. Cement Kiln Dust

Cement kiln dust is an industrial waste from cement production. The quantities and characteristics of CKD generated depend upon a number of operational factors and characteristics of inputs to the manufacturing process. Although the relative constituent's concentration in cement kiln dust can vary significantly, CKD is a fine dry, alkaline dust that readily absorbs water. The ability of the CKD to absorb water from its chemically dehydrated nature, which results from the thermal treatments it, receives in the system.

4. Methodology

A. Compaction

Indian standard light compaction tests were performed as per provisions in IS 2720 part-6 (1974). The test was conducted for various BC soil, BC soil+marble dust, BC soil+cement kiln dust, BC soil+Polypropylene fibers, BC soil+marble dust+cement kiln dust, BC soil+marble dust+cement kiln dust+polypropylene fibers proportions. Dry density and optimum moisture content were determined for each mix. This experiment gives a clear relationship between the dry density of the soil and the moisture content of soil. The experiment setup consists of (i) Cylindrical metal mould (internal diameter-10.15cm, internal height-11.7cm), (ii) Deattachable base plate, (iii) collar (5cm effective height), (iv)rammer(2.5Kg), compaction process helps in increasing the bulk density by driving out air from the voids. The theory used in the experiment is that for any compactive effort, dry density depends upon the moisture content in the soil. The maximum dry density is achieved when the soil is compacted at relatively high moisture content and almost all the air driven out, this moisture content is called optimum moisture content(OMC). After plotting the data from the experiment with water content as the abscissa and drt density as the ordinate, we can obtain the OMC and MDD.

B. Unconfined compression strength test

The unconfined compressive strength tests were conducted on BC soil, BC soil+ marble dust, BC soil +cement kiln dust, BC soil +polypropylene fibers, BC soil +marble dust +cement kiln dust +polypropylene fibers proportions as IS 2720-part X (1973). All the samples are prepared by the static compaction at optimum moisture content and maximum dry density to maintain some initial dry density and water content. This test was conducted under a constant rate of 1.25mm/min.

5. Results and discussions

After the determination of basic properties of black cotton soil, soil stabilized with marble dust, cement kiln dust and polypropylene fibers, the strength parameters like MDD, and UCC were determined by conducting compaction and UCCS (unconfined compressive stress) tests. The tests result and graphs with the addition of admixtures have shown in the following graphs.

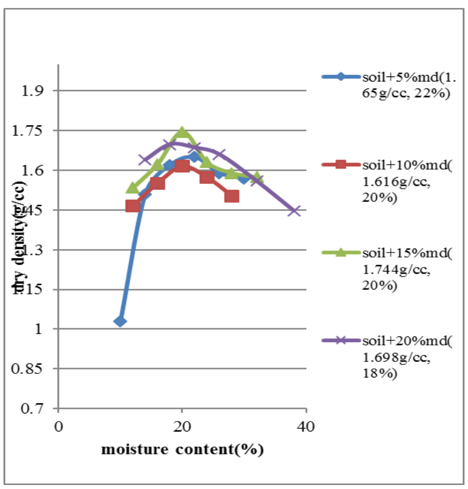

Fig. 1. Graph showing compaction results of black cotton soil treated with various percentages of marble dust

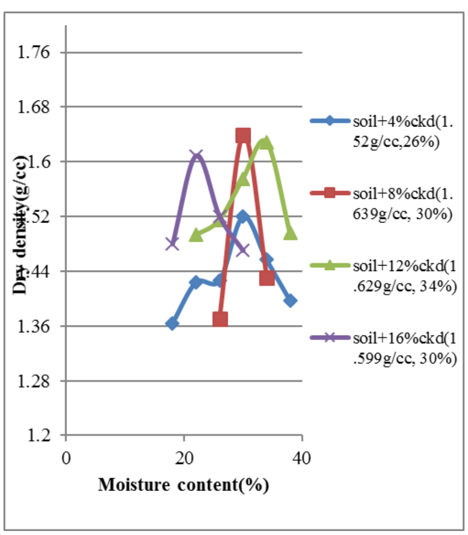

Fig. 2. Graph showing compaction results of black cotton soil treated with various percentages of cement kiln dust

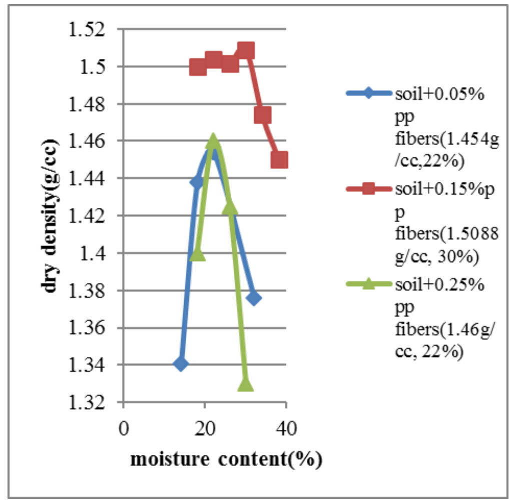

Fig. 3. Graph showing compaction results of black cotton soil treated with various percentages of polypropylene fibers.

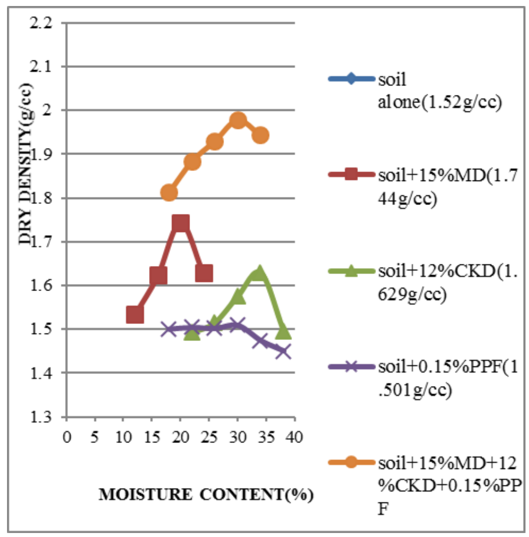

Fig. 4. Graph showing compaction results of black cotton soil and black cotton soil treated with optimum percentages of admixtures.

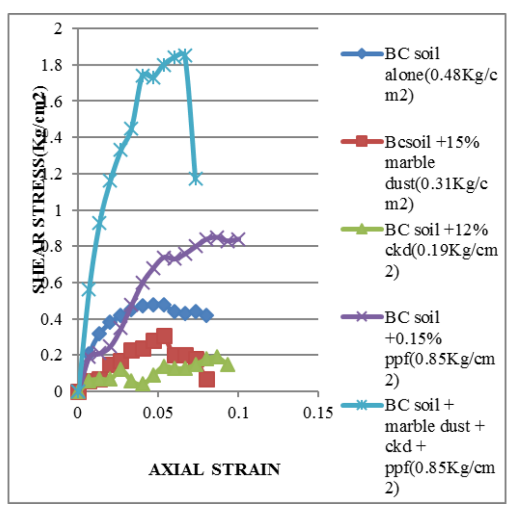

Fig. 5. The graph showing comparison on UCC results between BC soil, BC soil with marble dust, cement kiln dust and polypropylene fibers and combinations of these admixtures immediately.

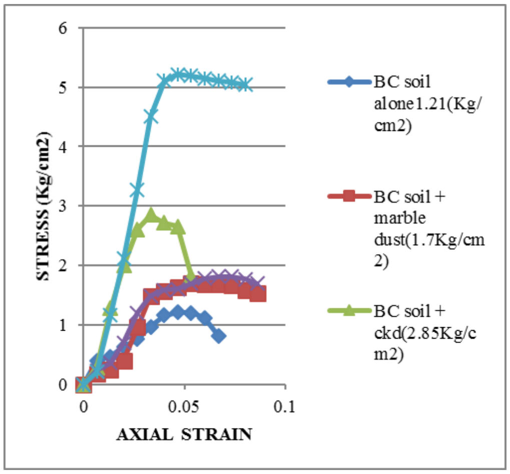

Fig. 6. The graph showing comparison on UCC results between BC soil, BC soil with marble dust, cement kiln dust and polypropylene fibers and combinations of these admixtures at 7 days.

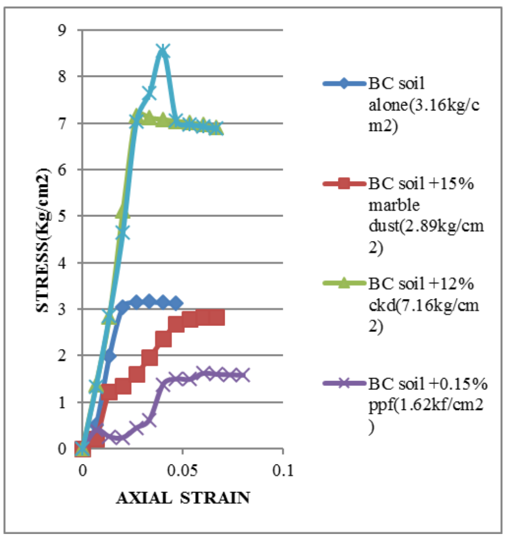

Fig. 7. The graph showing comparison on UCC results between BC soil, BC soil with marble dust, cement kiln dust and polypropylene fibres and combinations of these admixtures at 14 days

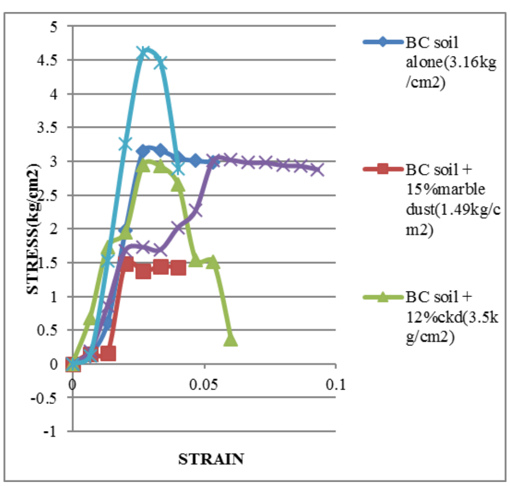

Fig. 8. The graph showing comparison on UCC results between BC soil, BC soil with marble dust, cement kiln dust and polypropylene fibers and combinations of these admixtures at 21 days.

6. Conclusion

The test results indicate that the inclusion of fiber reinforced within expansive soil, marble dust and cement kiln dust caused an increase in the unconfined compressive strength and axial strain at failure, decreased the stiffness and loss of post peak strength and changed the soil treated with marble dust and ckd, brittle behavior to a more ductile one. The increase in the strength of combined effect of marble dust, cement kiln dust and polypropylene fibers is much more than the sum of the increase in strength caused by them individually. From the economic analysis it is found that, a substantial change in the cost of construction is possible by making the use of two waste materials like marble dust and cement kiln dust can be stabilized to strengthen the expansive soil subgrade for construction of flexible pavements.

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