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Compaction and CBR Characteristics of Expansive Soil Stabilised with Fly Ash and Coir Waste

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***Abstract:** In a country like India, a large area is covered with expansive soil. This widespread prevalence of expansive soil creates problems for the construction activities. Black cotton soil is very susceptible to detrimental volume changes with changes in moisture. The properties of black cotton soil can be modified by stabilizing the soil with the use of additives or by mechanical means. In this study, fly ash and coir waste are used as a stabilizing material to stabilize the expansive soil. The experimental work has been carried out to analyze the improvement in geotechnical properties of expansive soil mixed with fly ash and coir waste at varying percentages. The soil was first mixed with fly ash at 5%, 10%, 15%, 20%, 25% and 30% and with coir waste at 2.5% and 5% by weight of dry soil. The test results indicated that compaction and CBR characteristics of soil increased with increase in fly ash percentage up to 20%. The compaction results decreased on further addition of fly ash in a soil sample while the CBR results increased further. 2.5% and 5% coir was added to 20% fly ash and soil mix. The maximum values of dry density and CBR were obtained at 20% fly ash and 2.5% coir waste mixed soil sample.*
***Keywords:** Black Cotton Soil, Fly Ash, coir waste, standard proctor test, CBR.*

I. INTRODUCTION

Soil is a basic construction material. It is the subgrade which supports the sub base and base in the pavement. The main function of pavement is to support and distribute the heavy wheel loads of vehicles over a wide area of the underlying subgrade soil and permitting the deformations within elastic range.

Subgrade performance is a function of the strength of soil and its behavior under traffic loading. The subgrade should be stable enough to prevent excessive deformation.

The existing soil at a particular location may not be suitable for construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling in case of expansive soils. The properties of soil can be improved by stabilization with admixtures. For many years admixtures such as lime, cement and cement kiln dust are used to improve the qualities of various types of soils.

This study deals with the stabilization of locally available expansive soil in the region of Jabalpur, Madhya Pradesh with varying percentages of fly ash and coir waste.

The objective is to determine the most appropriate concoction of fly ash and coir waste to augment the bearing capacity of the expansive soil.

Also use industrial byproducts such as fly ash and coir waste for stabilization of expansive soil would fulfill the dual purpose of waste disposal which could otherwise be an ecological hazard by using it for the purposes of elevating the bearing capacity of weak soils.

II. MATERIAL USED

A. Expansive Soil

The soil used was locally available expansive soil which was collected from Jabalpur, Madhya Pradesh. The properties of the soil determined by various experiments have been enumerated below in the table as:

Table 1: Basic properties of Soil

S. No.	Properties	Values
1.	Liquid Limit (LL)	51.65%
2.	Plastic Limit (PL)	31.04%
3.	Plasticity Index (PI)	20.61%
4.	Specific Gravity	2.45
5.	Differential Free Swell (DFS)	45%
6.	Optimum Moisture Content (OMC)	16.0%
7.	Maximum Dry Density (MDD)	1.54g/cc
8.	California Bearing Ratio (CBR)	2.96%
9.	Unconfined compression strength (UCS)	0.129Mpa
10.	Soil classification	CH

B. Fly Ash
A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. The mineral residue that is left behind after the burning of coal is the fly ash. The Electro Static Precipitator (ESP) of the power plants collects these fly ashes. Essentially consisting of alumina, silica and iron, fly ashes are micro-sized particles. By itself, fly ash has little cementitious value, however, this changes in presence of moisture, with which it reacts chemically, and forms cementitious compounds. These compounds attributes to the improvement of compressibility and strength characteristics of a soil. The fly ash used in this study was purchased from the local markets of Jabalpur, Madhya Pradesh.

Table 2: Basic properties of fly ash

S. No.	Properties	Values
1.	Colour	Light grey
2.	Specific Gravity	2.30
3.	Plasticity Index (PI)	Non-plastic
4.	Classification	Type C

C. Coir
Coir or coconut Fiber belongs to the group of hard structural fibers. It is an important commercial product obtained from the husk of coconut. In industries manufacturing mattresses, ropes etc. shorter mattress fibers are separated from the long bristle fibers which are in turn a waste in the coir fiber industry. So this coir fiber waste can be used in stabilization of soil and thus it can be effectively disposed-off. The inclusion of fibers had a significant influence on the engineering behavior of soil-coir mixtures. The coir used in this study was obtained from various temples in Jabalpur, Madhya Pradesh.

III. EXPERIMENTAL WORK

A. Preparation of Sample
Different samples were prepared with the mixture of dry soil and addition of 0%, 5%, 10%, 15%, 20%, 25% and 30% of fly ash on the basis of dry weight of the soil. In order to get homogeneous mix, proper care was taken while mixing the samples. The OMC, MDD and CBR value of different samples containing different percentage of fly ash was found out from which Optimum fly ash percentage was determined. Coir waste was added in different percentage (2.5% and 5%) to the sample having optimum fly ash content and variation of OMC, MDD and CBR was evaluated.

B. Compaction Test
The standard proctor test was performed as per IS 2720 (Part VII) 1980. The compaction tests were done on soil and fly ash blends. The weighted oven dried soil was taken and various percentages of fly ash and coir waste were added with dry soil. The appropriate quantity of water was added with soil, fly ash and coir waste mixture and the wet specimen was compacted in mould in three layers utilizing standard proctor rammer of 2.6kg. The MDD and OMC for various samples were determined from this test.

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C. California Bearing Ration Test

The CBR tests were executed for different percentage of fly ash and coir fiber as per IS 2720 (part-16) 1987. The samples were prepared in a cylindrical mould of 150mm diameter and 175mm height by compaction of the mixture of soil-fly ash and soil-fly ash-coir fiber to standard proctor's MDD. Samples were made such as Soil with (0%, 5%, 10%, 15%, 20%, 25% and 30%) fly ash and soil with optimal fly ash and (2.5% and 5%) coir fiber. The samples were experimented for each variable proportion and the samples were soaked in water for 96 hours before test was conducted. All the experiments were executed at a penetration rate of 1.25mm/min until a penetration of 12.5mm was obtained. CBR values were calculated and the Load-Penetration curve was plotted for all the specimens.

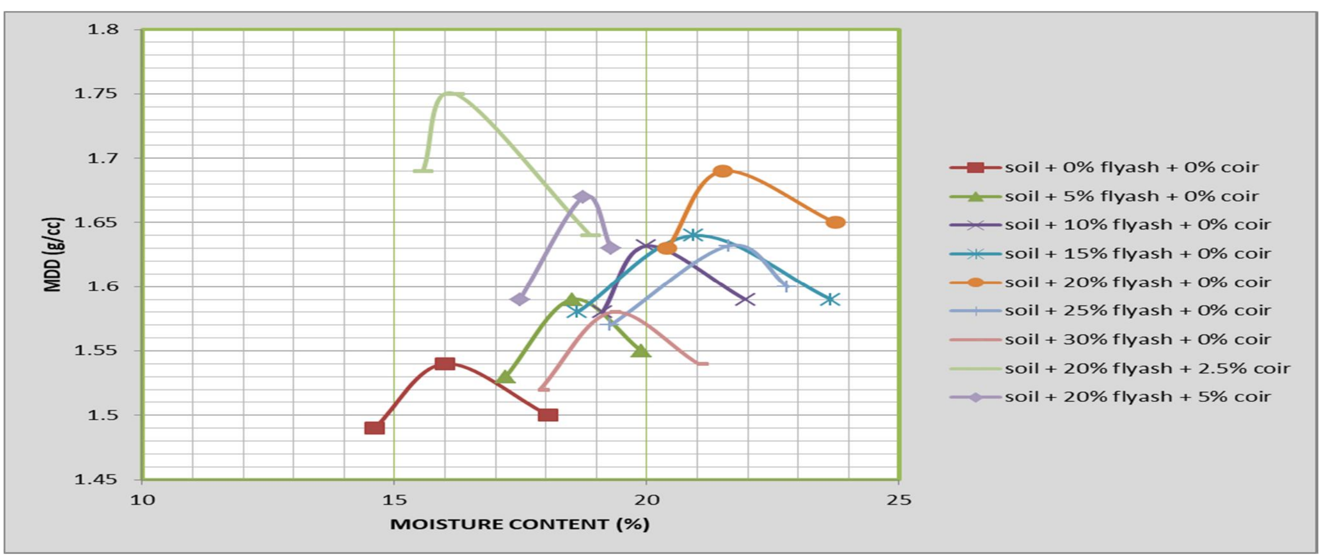
IV. RESULTS AND DISCUSSIONS

According to experimental program, numerous tests were executed on soil with various percentages of fly ash and coir waste. The effect of fly ash and coir fiber inclusion on OMC-MDD relationship, and CBR values were considered. The outcomes are presented below

Figure 1: MDD and OMC values for soil samples containing varying percentages of fly ash and coir

Soil + Fly Ash + Coir	Maximum Dry Density (gm/cc)	Optimum Moisture Content (%)	C.B.R (%)
soil + 0% fly ash + 0% coir	1.54	16.00	2.96
soil + 5% fly ash + 0% coir	1.59	18.52	3.27
soil + 10% fly ash + 0% coir	1.63	20.10	3.85
soil + 15% fly ash + 0% coir	1.64	21.00	4.17
soil + 20% fly ash + 0% coir	1.69	21.50	4.44
soil + 25% fly ash + 0% coir	1.62	21.62	5.09
soil + 30% fly ash + 0% coir	1.58	19.30	6.18
soil + 20% fly ash + 2.5% coir	1.75	16.21	7.29
soil + 20% fly ash + 5% coir	1.67	18.75	5.81

Figure 2: CBR values for soil samples containing varying percentages of fly ash and coir



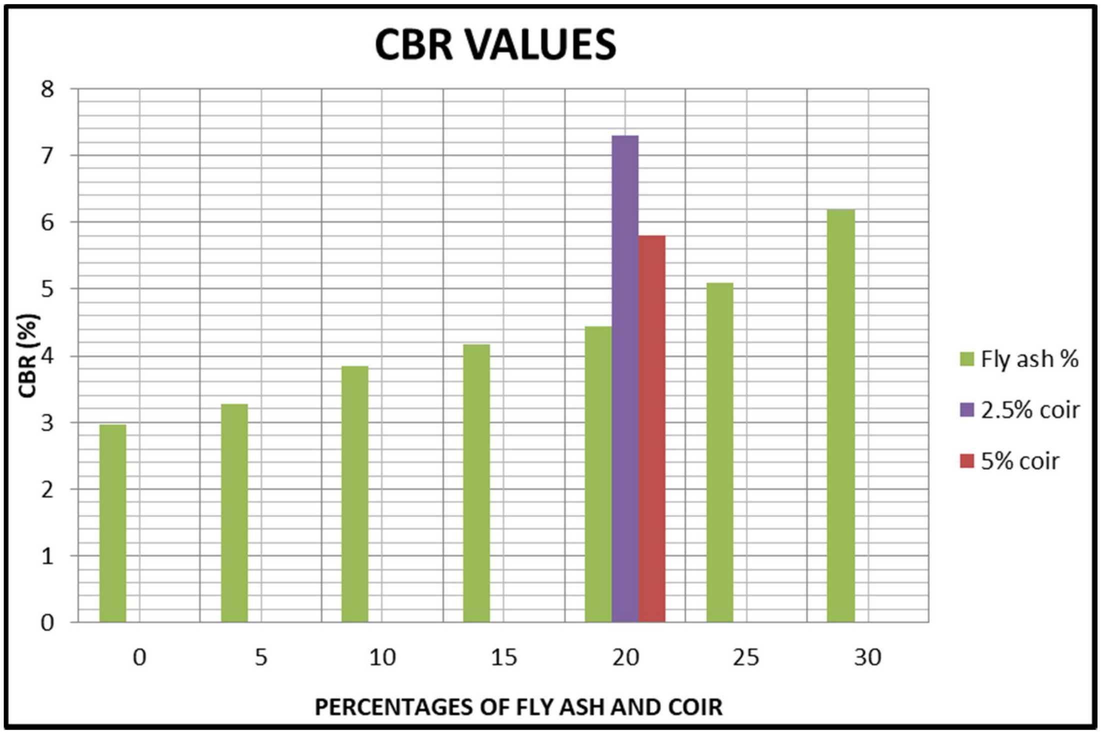


Table 3: OMC-MDD and CBR values for soil samples containing varying percentages of fly ash and coir waste

A. Compaction Test

It is observed in Table 3 and Figure1 that with the inclusion of fly ash, the OMC and MDD increased up to 20% fly ash addition and then decreased. On inclusion of 20% fly ash with soil, the optimum value of MDD was obtained. On addition of coir waste(2.5%, 5%) to this optimum percentage of fly ash it was observed that the MDD increased for the sample containing 2.5% coir waste and 20% fly ash while it decreased for the sample containing 5% coir waste and 20% fly ash. The maximum value of MDD was obtained for a soil sample containing 20% fly ash and 2.5% coir waste by dry weight of the soil sample.

B. Soaked CBR Test

The outcomes of soaked CBR test from Table 3 and Figure 2 indicated that the CBR value conastantly increased upon inclusion of fly ash by dry weight. Two different percentages of Coir waste (2.5%, 5%) were added to the soil sample containing 20% fly ash and soil. The CBR value increased with addition of 2.5% coir fiber and 20% fly ash to the soil while it decreased with the addition of 5% coir waste and 20% fly ash to the soil. . The maximum value of CBR was obtained for a soil sample containing 20% fly ash and 2.5% coir fiber by dry weight of the soil sample

V. CONCLUSION

For the stabilization of black cotton soil, the optimum quantity of fly ash and coir waste was found to be 20% and 2.5% by weight of dry soil respectively. The two materials were mixed in the above proportion in the black cotton soil. The proctor density was increased from 1.54 g/cc to 1.75 g/cc. The CBR value increased from 2.96% to 7.29%.

VI. FUTURE SCOPE

A. Further studies can be done on the characteristics of soil stabilized with coir upon degradation of coir with time.
B. The fly ash can be replaced by lime, stone dust, sand, cement etc.
C. Coir waste could be replaced by other fibers or geotextiles as per availability and economy such as jute (natural fibers) or polypropylene, shredded rubber tire (artificial fibers), geotextile or geo-synthetic. From the above materials, mixes of different proportions or combinations can be made for improving the properties of soil which may be used for construction of embankment or soil sub grade in highways.

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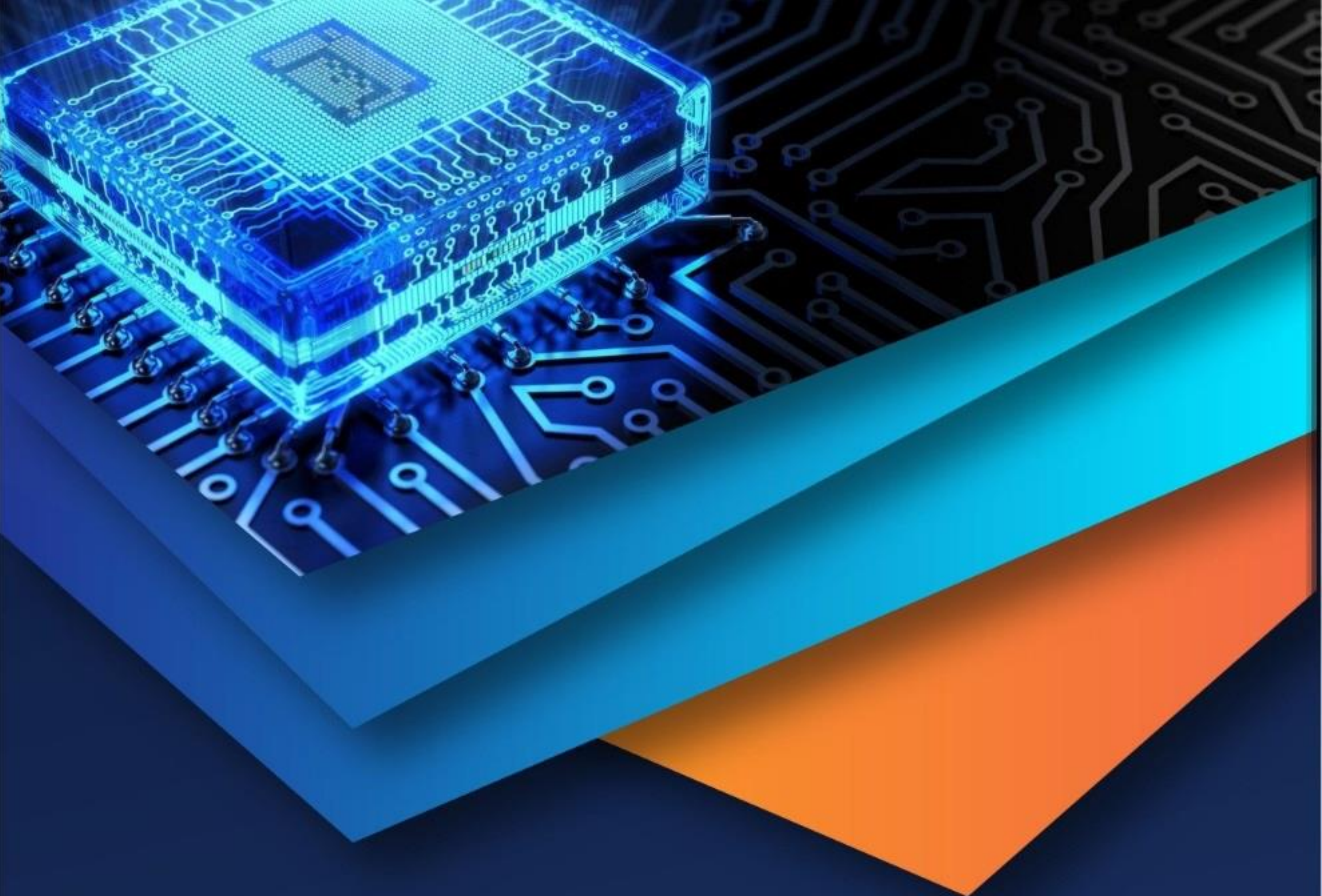

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