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EXPERIMENTAL INVESTIGATION FOR STABILIZATION OF BLACK COTTON SOIL BY USING LIME AND BRICKDUST WASTE

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Abstract: The objective of this project is to stabilize the Black Cotton soil (BC Soil) as it is proved to be the poorest soil among all soils and also it is an expansive soil. Expansive soils are avoided from using in pavement construction. If used, it will damage the pavements adversely when compared to other soils. Thus, worldwide these soils are considered to be problematic soils and pose several challenges for engineers. So, as to utilize these soils in an effective way, proper treatment to the soil is required. Stabilization of soils is an effective method for improvement of soil properties and the pavement system performance. With the same intention, an attempt is made to modify engineering properties of black cotton soils collected in Visakhapatnam city, Andhra Pradesh, India by using demolished structure materials such as brick powder waste and Lime**.** An experiment investigation is carried out to study the effect of brick powder and lime on engineering and strength properties of the black cotton soils. The properties of stabilized soil such as Waterberg limits, compaction characteristics and California bearing ratio and their variations with content of brick powder and lime were evaluated. Laboratory studies to investigate the possibility of utilizing brick powder and lime as stabilizing materials to improve the engineering properties of black cotton soil was carried out. Black cotton soil is classified as A-7-5 in accordance with HRB soil classification system. The results obtained show that the moisture density relationship follows a trend of decreasing optimum moisture content (OMC) and increasing maximum dry density (MDD) is the modified proctor test. The CBR value of BC soil obtained was only 1% and this low strength value is improved to minimum requirement of 8% CBR according to IRC: 37-2012. Test results indicate that CBR value of soil increases with increase in BP and lime content. Addition of optimum percentage of brick powder (50%) and optimum percentage of lime (4%) and optimum percentage of its combination (30%+1.5%) to the Black Cotton Soil has improved the strength characteristics BC soil 8% CBR. Thus, the significant increase in CBR value of soil stabilized with BP, lime and BP + Lime will substantially reduce the thickness of the pavement sub grade.

Keywords: Black Cotton soil**,** Demolition Brick Masonry waste, Lime, Soil Classification, CBR.

I. INTRODUCTION

The quality and the life of the pavement are greatly affected by the type of sub grade, sub-base, and base course materials. Sub grade is the integral part of the road pavement structure; it provides the support to the pavement from beneath. The sub grade soil and its properties are important in the design of pavement structure. The main function of the sub grade is to provide adequate support to the pavement and for this the sub grade should possess sufficient stability under adverse climate and loading condition. The properties of the soil sub grade are important in deciding the thickness requirement of pavements. A sub grade soil with lower stability requires thicker pavement to protect it from traffic

loads. India is confronted with the colossal test of protecting and upgrading the transportation framework to meet the constantly expanding hassles because of heavier burdens delivering layers to the hidden soil. Soil is the essential component of this nature and road development industry knows the significance of it for pavement work. 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.

Black cotton soils are highly clayey soil gray or blackish in colour. "Black cotton soil is commonly known as Expansive soil because of their colour and their suitability for growing cotton. They contain 'montmorillonite' clay mineral which has high expansive characteristics. BC soils have low shrinkage limit and high optimum moisture content. It is highly sensitive to moisture changes, compressible sub grade material. Problems associated with pavement construction become more critical when the sub grade consists of expansive soils. In India, expansive soils cover about 0.8x106 Km2 areas, approximately one fifth of its surface area. Hence the sub grade and its undesirable characteristics can 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.

From the recent studies it is observed that, solid waste materials such as masonry waste (Brick powder) are used for this intended purpose. Disposal of these waste materials is essential as these are causing hazardous effects on the environment. This may found to be an economical treatment method for soils as these materials are available locally and such solution will definitely found beneficial for the developing countries like India where economy is the prime concern for adopting any new method or technique. Lime has been widely used either as a modifier for clayey soil or as a binder. When clayey soils with high plasticity are treated with lime, the plasticity index is decreased and soil becomes friable and easy to be pulverized, having less affinity with water. Lime also imports some binding action.

II. OBJECTIVE OF THE STUDY

- To study the properties of black cotton soil.
- Classifying the soil using different system of classification.
- To study the changes in properties of black cotton soil by adding lime and brick powder.
- To improve the CBR of the black cotton soil to 8% as per IRC 37-2012.
- To find out optimum amount of Brick Powder and Lime required for improvement in CBRupto 8% of black cotton soil.

III. MATERIALS AND METHODS

A. Soil

The soil used in this study was collected from the site of Shankar Mansion Layout, Visakhapatnam, Andhra Pradesh, India. The various index properties and compaction properties (maximum dry density and optimum moisture content) and CBR value of soil were determined in the laboratory which is given in Table No.1. The grain size distribution curve of soil is shown in Fig.No.1.

B. Demolition Brick Masonry Waste

Masonry waste mainly consists of cement mortar and burnt brick. But for the experimental purpose only bricks are considered excluding the cement mortar. Brick Masonry waste is brought from a demolished house near Dwarakanagar, 4th lain, Visakhapatnam, Andhra Pradesh, India.

C. Lime

Lime is the common name of chemical calcium oxide which is available in white powder form and comes from the heating of calcium carbonate. Use of lime with increased percentage in BC Soil was examined for stabilization purpose and the result was evaluated.

SL NO	Description		Result
1	Specific Gravity (G)		1.97
2	Liquid Limit, LL (%)		54.90
3	Plastic Limit, PL (%)		40.25
4	Plasticity Index (%)		14.65
5	Soil Classification	Coarse (4.75 mm – 2 mm)	33.8%
6		Medium (2 mm – 0.425 mm)	38.7%
7		Fine (0.425 mm – 0.075 mm)	25%
8		Silt and clay (<0.075 mm)	2.5%
9	Coefficient of uniformity		9.54
10	Coefficient of curvature		4.67
11	Maximum Dry Density, γ_d (kN/m^3)		18.00
12	Optimum Moisture Content, OMC (%)		1.842
13	CBR Value		1

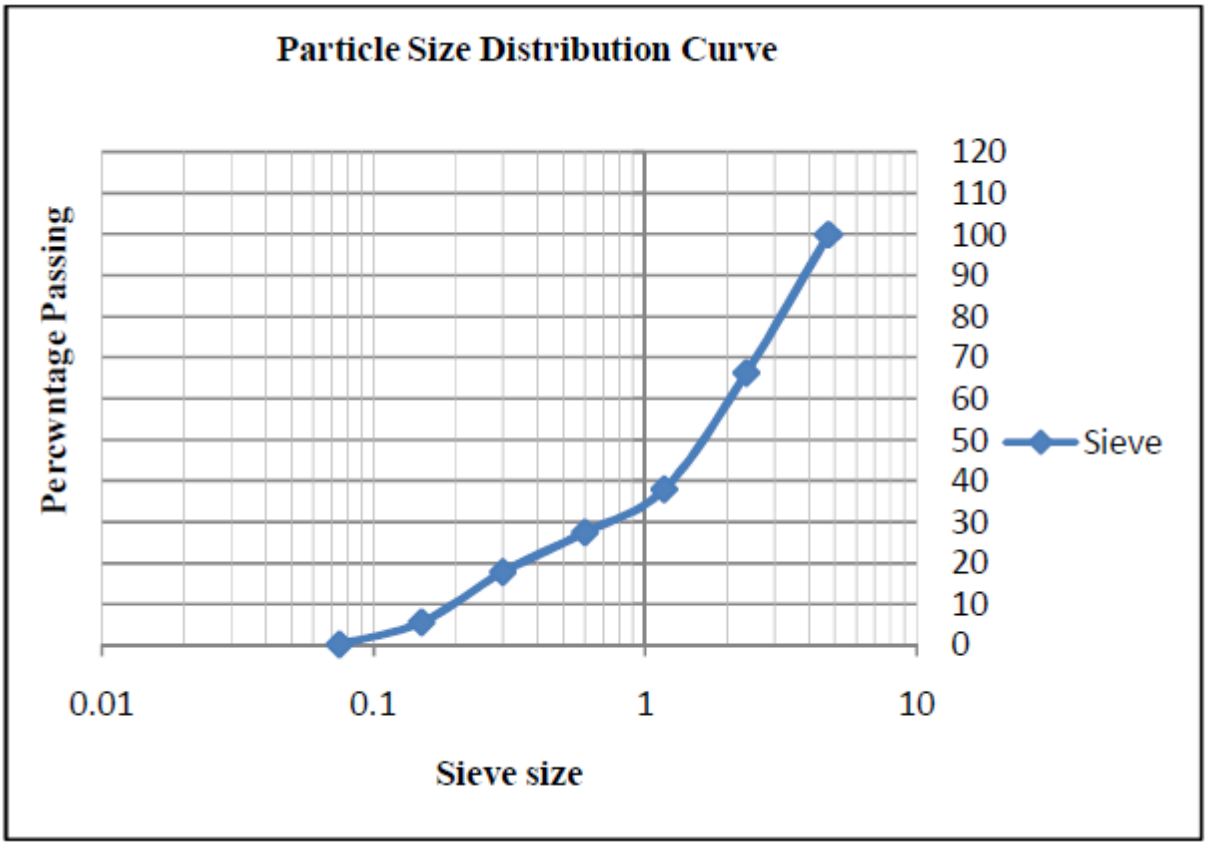

Fig. No.1: Particle Size Distribution Curve of Soil

***D.*Test Procedure**

Three types of soil samples were prepared for CBR test as per standard procedure [IS: 2720 (Part 16) – 1987].

1. Black cotton soil + Brick powder
2. Black cotton soil + Lime
3. Black cotton soil + Brick powder + Lime

The soil samples are prepared by replacing the Black cotton soil with additives like brick powder and lime in varying percentage. The desired amount of air dried soil was taken in a tray. This soil was mixed with water corresponding to its optimum moisture content (OMC). The CBR mould having 150 mm diameter and 175 mm high with detachable perforated base plate. This mould was filled with 5 layers of the soil and each layer was compacted to its maximum dry density obtained by laboratory Modified Proctor test [IS: 2720 (Part 8) – 1983]. Compaction is done by applying 55 numbers of evenly distributed blows using 4.89 Kg rammer. After compaction of the last layer, the collar was removed and excess soil was trimmed off by means of straight edge. The mould with compacted soil was weighed. The mould with compacted soil is inverted and placed over the base plate and clamps were again tightened. The surcharge weights were placed centrally on specimen such that penetration test could be conducted. Then the mould is placed in water tank for soaking. After 4 days the mould is taken out of the tank and placed under the penetration plunger of loading machine. The penetration plunger was seated and brought in contact with top surface of soil by applying a seating load of 4 Kg. The dial gauge, proving ring were set to zero and load was applied through penetration plunger and the load readings were noted at penetration readings of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5mm in

order wise. After final reading, load was released and mould is removed from loading machine. The proving ring calibration factor was noted so that the load dial values can be converted to load in Kg. Same procedure was followed by the other type of soil samples and CBR value of the samples were calculated The formula below is to be used to determine CBR.

CBR = Unit load carried by soil sample at defined penetration level/Unit load carried by standard crushed aggregates at above penetration level × 100

IV. EXPERIMENTAL RESULTS

1. Result of Soil classification

According to Public Road Transportation Classification System (PRA System) also known as HRB (1978) System, the soil is classified as clayey soil of grade A-7-5 and having a Group Index value of 4.5, because the plastic limit greater than 30%. According to Unified Soil Classification System (USCS) the soil is classified as sands with fines with group symbol SM.

2. Result of CBR test

CBR test conducted on the black cotton soil with different compositions of Brick Powder and Lime. The CBR values obtained by the tests are given below.

*A.*Black Cotton Soil + Brick Powder

Table No.2 and Fig. No.2 shows the result of the CBR and Modified Proctor test conducted by replacing the black cotton soil with brick powder. These values are tabulated and graph was plotted. The CBR values increases with every incremental in Brick Powder. The required CBR value 8% as per IRC: 37-2012 was obtained for 50% BC Soil with 50% Brick Powder.

Table No.I: Experimental Results Obtained for Mix Proportion of Black cotton soil with Brick powder (BP)

Samples	OMC (%)	MDD (gm/cc)	CBR (%)
BC Soil	18.00	1.842	1
90%BCSoil + 10% BP	17.50	1.891	2
80%BCSoil + 20%BP	17.20	1.902	3
70%BCSoil + 30% BP	16.80	1.915	4
60%BCSoil+ 40%BP	16.20	1.925	7
50%BCSoil + 50%BP	16.00	1.965	8

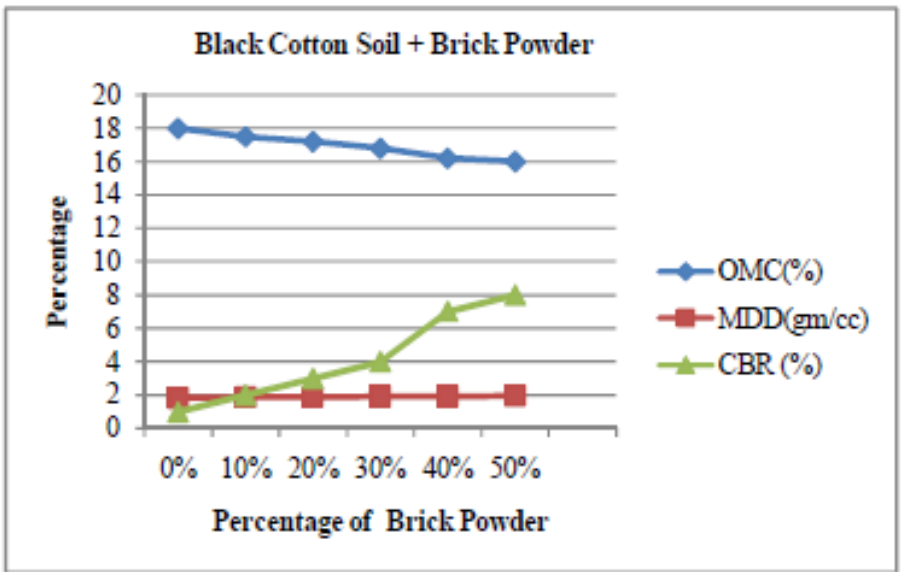

Fig. No.2. Graph Shows the Effect of Brick powder on OMC, MDD and CBR of Black Cotton Soil.

B.Black Cotton Soil + Lime

Table No.3 and Fig. No.3 shows the result of the CBR and Modified Proctor test conducted by replacing the black cotton soil with Lime. These values are tabulated and graph was plotted. The CBR values increases with every incremental in Lime. The required CBR value 8% as per IRC: 37-2012 was obtained for 96% BC Soil with 4% Lime.

Table No.3: Experimental Results Obtained for Mix Proportion of Black cotton soil with Lime.

Samples	OMC (%)	MDD (gm/cc)	CBR (%)
BCSoil	18.00	1.842	1
99%BCSoil + 1% Lime	17.63	1.860	2
98%BCSoil + 2% Lime	17.25	1.870	4
97%BCSoil + 3% Lime	16.95	1.890	6
96%BCSoil + 4% Lime	16.23	1.900	8
95%BCSoil + 5%Lime	15.98	1.920	11
94%BCSoil + 6%Lime	15.50	1.950	14

C.Black Cotton Soil +Brick Powder +Lime

Table No.4 and Fig. No.4 shows the result of the CBR and Modified Proctor test conducted by replacing the black cotton soil with Brick powder and Lime. These values are tabulated and graph was plotted. The CBR values increases with every incremental in Brick Powder and Lime. The required CBR value 8% as per IRC: 37-2012 was obtained for 68.5% BC Soil + 30% Brick Powder + 1.5% Lime.

Table No.4: Experimental Results Obtained for Mix Proportion of Black cotton soil with Brick powder and Lime.

Samples	OMC (%)	MDD (gm/cc)	CBR (%)
69.5%BC Soil + 30%BP + 0.5%Lime	17.60	1.856	2
69%BC Soil + 30%BP + 1%Lime	16.90	1.872	4
68.5%BC Soil + 30%BP + 1.5%Lime	16.30	1.902	8
68%BC Soil + 30%BP + 2%Lime	15.90	1.921	16

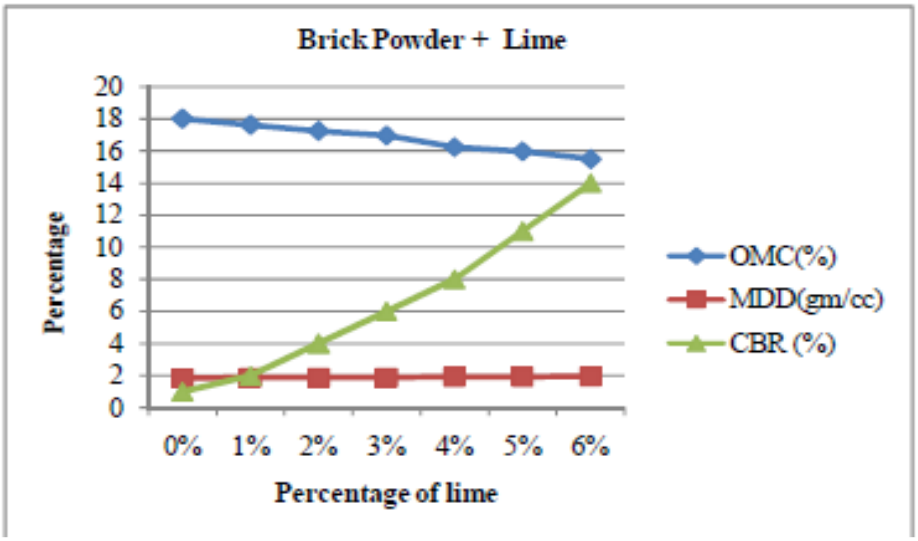

Fig. No.3. Graph Shows the Effect of Lime on OMC, MDD and CBR of Black Cotton Soil.

From the above graph we can see that the contribution of the Lime is more than the Brick Powder in increasing the CBR value of the BC Soil. Similarly decrement in OMC and increment in MDD is more compared to Brick Powder. As Lime is binding material it gives early strength to the soil but excess use of the Lime leads to development of cracks in pavement. So, to reduce this effect we used Brick Powder.

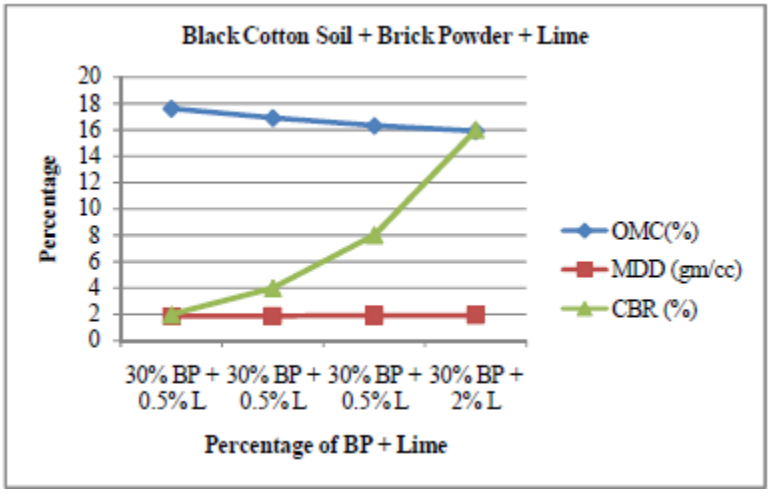

Fig. No.4. Graph Shows the Effect of Brick powder and Lime on OMC, MDD and CBR of Black Cotton Soil.

V. DISCUSSIONS

The soil is having higher G.I value, which belongs to A-7-5 subgroup as per HRB soil classification system. According to Unified Soil classification System the soil is SM type. The co-efficient of curvature (Cc) obtained from experiment is 4.67. The uniformity co-efficient (Cu) obtained from experiment is 9.54, which indicates medium graded soil/sand type. This indicates a poor quality of soil and recommends stabilization. The sand content in soils is found to be 97.5 %. Silt and clay is found to be 2.5%. Course grained sand was found to be 33.8%, medium grained sand was found to be 38.7%, fine grained sand was found to be 25.01%. Silty clay content is 2.5 %. The sample was tested without and with Brick powder, lime and a mix of BP + lime with varying percentages in soaked condition. The experimental results indicate that addition of BP and Lime significantly affects the properties of soil.The CBR value obtained for BC Soil is 1%. By replacing the BC Soil by 10% of BP the CBR value is increased to 2%. Thus by replacing the BC Soil by 20, 30, 40 and 50% of BP CBR value is increased to 3, 4, 7 and 8% respectively. Then the OMC of the BC soil reduced from 18.00% to 16.00% and MDD of the soil increased from 1.842 to 1.965%.Similarly the CBR value obtained by replacing the BC Soil by 1% of Lime the CBR value is increased to 2%. Thus by replacing the BC Soil by 2, 3, 4, 5 and 6 of Lime CBR value is increased by 4, 6, 8, 11 and 14% respectively.Then the OMC of the BC soil reduced from 18.00% to 15.50% and MDD of the soil increased from1.842 to 1.950%.

The CBR value obtained by replacing the BC Soil by 30% of BP and 0.5% of lime the CBR value is increased to 2%. Thus by replacing the BC Soil by replacing BC soil by 30% BP + 1% lime, 30% BP + 1.5% lime and 30% BP + 2% lime, the CBR value is increased to 4, 8 and 16% respectively. Thus OMC of the BC soil reduced from 18.00% to 15.90% and MDD of the soil increased from 1.842 to 1.921%. Finally by replacing BC soil by 30%BP and 0.5% Lime CBR value is increased by 7%. According to IRC 37-2012 required CBR value or BC soil is 8%. Thus by replacing BC soil by 30%BP and 1.5%Lime we get the CBR value of 8%. Based on the present investigation, it has proved that the CBR value of soil increases with the inclusion of brick powder and lime. The BC soil was having 1% CBR which is not suitable in sub grade construction. So Black cotton soil after stabilization the required CBR value of 8% according to IRC: 37-2012 is achieved by stabilizing with replacement of BC soil by 50% BP, 4% lime and 30% BP + 1.5% lime. The use of demolition waste brick powder can be effectively used in BC soil stabilization. This will results in the utilization of rejected black cotton soil in construction.

VI. CONCLUSIONS

Based on the results obtained from the tests, the following conclusions are made:
The MDD of the selected BC soil increases and the OMC of the soils decreases with the addition of lime as well as Brick Powder. The Increase in MDD and reduction in OMC is more with increase in the proportion of admixtures in the soils. The results of the study show that both lime and Brick Powder are suitable for enhancing properties of the soils. Black cotton soil after stabilization the required CBR value of 8% according to IRC: 37-2012 is achieved by stabilizing with replacement of BC soil by 50% BP, 4% lime and 30% BP + 1.5% lime. From the above discussion it can be concluded that the BP can effectively utilized with BC soil in improving the soil CBR values. The use of Brick Powder resulted in utilization of demolition wastes and found to be economical for local area. This will results in the utilization of rejected black cotton soil in construction. From the results, it is concluded that impact of Brick Powder and Lime is positive.

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