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Experimental Investigation on Physical Properties of Black Cotton Soil with Admixtures

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Abstract:Black cotton soil bears undesirable engineering properties like variation in volume with change in water content. Due to the presence of clay content soils exabits tendency to swell when they come in contact with the moisture the size of the particles gets increased. The main objective of the present study is focused on to analyze various index properties of (Block Cotton) BC soils with admixtures as lime, Poly Vinyl Chloride (PVC) powder and crushed glass. Samples were tested in two stages. In first stage the physical properties of soil such as specific gravity, grain size analysis, and differential free swell index and Unconfined compression test (UCS) are conducted at 1, 2, 5, 7, and 12th days curing. In second stage on BC Soil with combination of PVC powder and crushed glass at 5%, 10% and 15% (crushed glass has to pass through 1mm sieve) by maintain 5% lime constant in all the samples tests were conducted. From experimental studies it is observed that proportions used for PVC and Crushed glass with optimum percentage of lime as 5 to 15% for finding OMC and MDD characteristics shows that the dry density has been increased with reduction in OMC.

Index Terms: Block cotton soil, Lime, Unconfined compression test, PVC powder, crushed glass.

I. INTRODUCTION

The settlements of structures are gets increased day by day all over the world due to some different reasons like in proper work and due to over load but out of all the above built on black cotton soil is one of the reasons for failure of structures[5,6]. We can prevent the structure from failures by improving the strength of soil with recommend stabilizations[17]. The black cotton mainly contains the clay, which having swelling property in nature due to the presence of water content. There are many reasons for forming the moisture content in to the soils like due to rains, floods and due to seepage in and around the water bodies, when the structures built on black cotton soils which are near to water bodies, then there is choice for intrusion of water into the soil and leads to loss the shear strength of soils followed by the failure of structure. In recent days failure of structure is quite common due to the lack design methods and retrofitting of structures is related with economical aspects. The damaged structures have drawn attention to the need for more reliable investigation of soils to reduce the failure of structures and it is possible by improving the strength of soils[11]. India over stands 20% of land on Block Cotton (BC) soils, due to this causing distress to engineering utilities are encountered by many researchers all over the India. Generally, BC soils having the property to swell and change volume due to the presence of water content with in the soil deposit.Due to its peculiar characteristic of high plasticity, excessive swelling, shrinkage and low strength when wet, the soil is regarded unsuitable for construction material. Heavy financial investments are required to be made for construction of roads, canals and embankments due to non-availability of suitable soil[15]. During the last two decades environmental hazards, regulations and heightening of public awareness has made it difficult as well as costly to dispose of the waste materials. Black cotton soils are found in arid and semiarid regions of the world where the annual evaporation exceeds precipitation about 30% of total area is covered by expansive soil.

The unconventional behaviors of these soils are due to presence of montmorillonite or combinations of montmorillonite and illite are clay minerals in the clay fraction which adsorbs water. In India, these soils have covered 30% of the total land mass. Hence, an effort has been made in this analysis to know the effect of additives on the physical and engineering properties of Black cotton soil treated with lime, PVC powder and crushed glass[13].

II. OBJECTIVES

- To study the strength properties of black cotton soil on different percentages of PVC and Crushed glass through optimum percentage of lime with and without curing intended for look at maximum percentage addition of PVC and Crushed glass with lime to expansive black cotton soil in parallel, to turn up the optimum results.
- To study the effect of Lime, PVC and crushed glass on the Index properties and compaction behavior BC soils.
- To examine the strength behavior of BC soil when treated with lime, PVC and Crushed glass at altered curing periods.

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III. METHODOLOGY

Based on the complete analysis of literature the foremost problems prevailing with Black Cotton (BC) soil are swelling, shrinkage and heaving characteristics.

Generally, BC soil swells when water content present with in the soil mass and shrinks on drying [7,9]. These soils are characterized by intrinsic swelling and shrinkage, Due to the presence of montmorillonite mineral in BC soils, soil shows swelling characteristicswhich exhibits volume change and properties under different loading with respect to the water content. Due to the inbuilt swelling nature of the BC soil, the structure which constructed on such soils will undergo differential settlements and appears cracks in buildings or sometimes it leads total distractions of the entire structure. For this reason, an effort has been made in this analysis for effective utilization of PVC powder and crushed glass to modify and improve the geotechnical properties of Black cotton soil and to study the consequence of these additives on Geotechnical properties of Black cotton soil treated with optimum percentage of Lime[14,15]. A variety of materials are used in geotechnical engineering field, properties of these materials differ from place to place due to this Complete categorization of these materials in terms of their vital properties will be very much useful in understanding soil response under different loading and changes in stress levels with fluctuated environmental conditions[12]. In the present investigation concentrated on basic parameters of which influence the engineering properties and the following tests were conducted for the present study according to the code of practice.

- sieve analysis as per (IS: 2720 (part 4)

-1985 method.)

- Specific gravity (IS: 2720 (Part 4/sec-I)-1980 (reaffirmed 1987) for fine grained soil)
- liquid limits (IS: 2720 (Part V)-1985)
- Plastic limit (IS: 2720, part 5-1985)
- Shrinkage limit (IS: 2720, part 6-1972)
- Standard proctor test (light compaction) (IS:2720 (Part VII)-1980)
- Unconfined Compressive Strength Test

(IS: 2720 (part X)- 1973)

A. Black Cotton (BC) Soil

For the present investigation to understand properties of BC soil, the soil samples were collected from cross road at Ibrahimpatnam,Ranga Reddy District Telangana state, India. Soil samples are collected through trenches up to a depth of 10 fts at 20 different locations within the 2 square km area and same shifted to the laboratory for testing purpose.

First of all, the collected BC soil was allowed to air dried to remove the unwanted things in the soils and pulverized in a ball mill after separating the pebbles. Then the soils are sieved through 425-micron sieve, the soil samples separated for test purpose only which passing from 425-micron sieve[16]. Then the physical properties and the chemical composition were analyzed as per the standard methods and have been presented in Table I.

Table I: Physical Properties of Black Cotton Soil

S. No	Description	Values
1	In-Situ field dry density in KN/m³	12.26
2	Specific gravity	2.62
3	Sieve analysis %	90% passing 75 - micron sieve
4	Optimum moisture content %	24.02
5	Maximum dry density in KN/m³	16.28
6	Differential free swell %	40
7	Liquid limit %	67
8	Plastic limit %	35.36
9	Plasticity index %	31.62
10	Shrinkage limit %	13.71
11	Classification of soil	CH

B. Lime

Lime as become common admixture material in recent days, it is used to improve and to reduce the strength and cost of constructions. The lime is available as quicklime and hydrated lime (calcium hydroxide – Ca $[OH]_2$), quicklime is obtained by chemically from transamination of calcium carbonate in to calcium oxide.Due to the chemical reaction of quicklime with water leads to generate the hydrated lime[4]. By adding the hydrated lime to the clay particles, the properties of clay somewhat improved and in the present investigation an attempt is made to improve the index and engineering properties of BC soils. The hydrated lime that leads to transfer the clay soils to with stand the loads strongly. Due to this the use of lime in stabilization of soils becomes quite adoptable admixture in most of the stages of constructions. Due to the presence of magnesium oxide in dolomitic type lime, it is preferred more in stabilization of soils. However, due to the presence of magnesium content in quicklime it reacts quite slowly than the calcium fraction[10] with clay soils. In the present experimental investigation quick lime i.e. CaO, used its effectiveness in stabilizer of soils than hydrated lime. All fine-grained soils can be modified to some degree to exhibit less plasticity and improved workability using lime treatment[15]. Soil plasticity, density and strength are changed by addition of lime to soil[16]. Lime stabilization is not difficult to carry out. After proper design and testing is performed, in place mixing is usually used to add the appropriate amount of lime to soil, mixed to an appropriate depth. Pulverization and mixing are used to thoroughly combine the lime and soil. For maximum development of strength and durability, proper compaction is necessary. If sulphates are present at levels greater than 0.3 percent, special procedures are required[12]. Chemically pure quick lime obtained at open market in Hyderabad has been used in this investigation. The chemical properties of lime are shown in the Table II.

Table II: Chemical Properties of Lime

S. No	Chemical Configurations in percentages	$Ca(OH)_2$
1	Minimum assay	90
2	Chloride (CI)	0.04
3	Sulphate (SO_4)	0.4
4	Arsenic (As)	0.0004
5	Lead (P_b)	0.004
6	Insoluble presence	1

C. PVC (Poly Vinyl Chloride) Powder

Generally, PVC categorized as a rigid material, PVC waste accumulating more from bottles, packaging materials, pipes, building materials[2].Physical,chemical, and mechanical properties of PVC powder were mentioned in the Table III. Due to wide range of using plasticized polyvinyl chloride (PPVC) in making cables and footballs and for flooring and many others the mechanical properties of PPVC are given in below Table IV.

Table III: Physical and Chemical Properties of PVC

S. No	Appearance	Pellets or Powder
1	Odour	Odour less to mild
2	Specific gravity	1.25-1.55
3	Vapour Pressure in (mm of Mercury)	<0.1
4	pH	Not applicable

Table IV: Mechanical Properties PVC

S. No	Property	Values
1	Percentage of elongation at breaking point	20-40
2	Notch test	2-5 Kj/m2
3	Temperature	82°C
4	Melting point	100-260 °C
5	Effective heat of Combustion	175.95 mkj/kg
6	Specific Heat	0.9 kj/(kg.k)
7	Water absorption (ASTM)	0.04-0.4

D. Crushed Glass

Generally, glass is non-biodegradable inert material and non-crystalline material and is brittle in nature[3]. For the present investigation broken glasses were collected in different places in Ibrahimpatnam, Ranga Reddy District. Same glass tested and crushed in laboratory before applying to the test and properties of glass were mentioned in below Table V.Glass bottles are also used for the present investigation and collected from different Bottling workshops in Hyderabad. First of all, the glass bottles dried and broken into smaller sizes by using hammer until as to pass through 1mm sieve.

Table V: Physical Properties of Crushed Glass

S. No	Specific gravity	2.5
1	Tensile Strength	27-62MPa
2	Softening point in (°C)	1500-1750
3	Hardness	05-07

IV. RESULTS AND DISCUSSIONS

BC soil generally having property in its nature due to the presence water content. Because of this volume gets increased/decreased with respect to the presence of moisture content. Due to this the strength or bearing capacity of black cotton soils may get increase or decreases according to the moisture levels in soils. India has large tracks of the expansive soil and many researchers doing their research on expansive soilproperties to meet the requirements. In the present investigation various percentages of PVC, Crushed glass and lime applied to expansive soil and conducted different laboratory tests tounderstand theproperties of soil. Detailed results of all physical properties of BC with crushed glass and PVC powder were given in the following Figure 1,2,3 and 4.

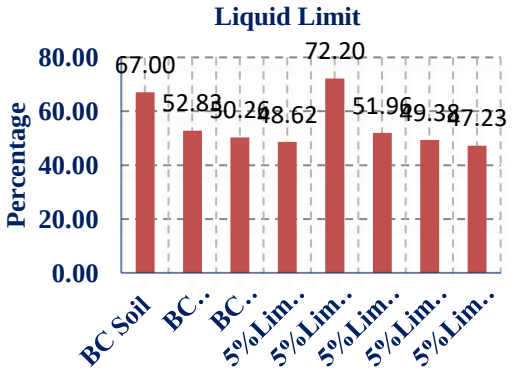

Figure 1: Variations of liquid limit values with different proportions PVC and CG.

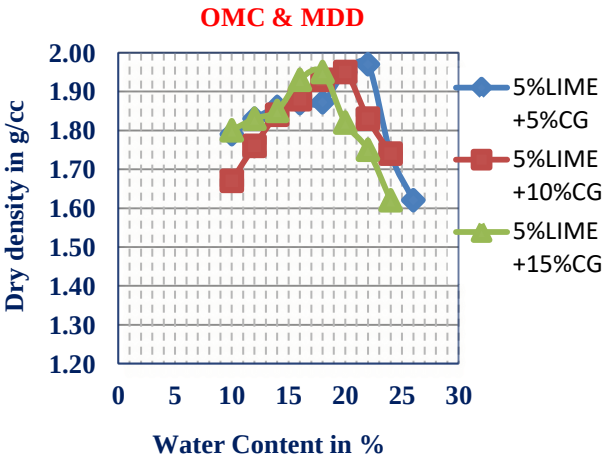

Figure 2: Dry density and water content relationships of Black cotton soil with constant percentage of lime and with various percentages of PVC Powder.

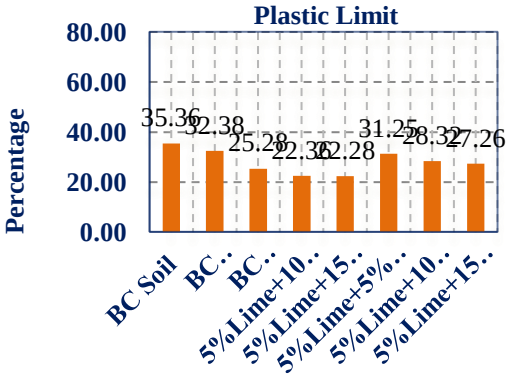

Figure 3: Variations of Plastic Limit values with different proportions of PVC and CG.

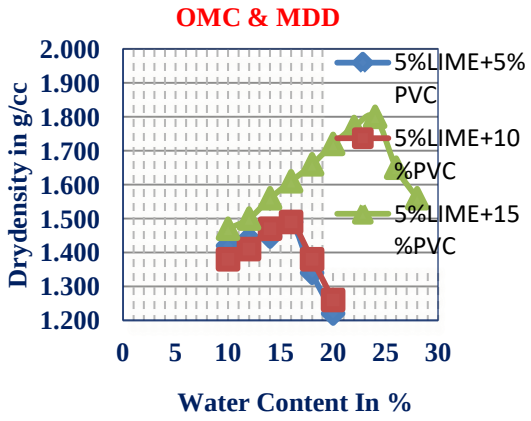

Figure 4: Dry density and water content relationships of Black cotton soil with the constant percentage of lime and various percentages of Crushed Glass

Unconfined compressive strength teat performed on clayey soil. Figure 5 shows test set up is to obtain the quantitative value of compressive and shearing strength of soils in an undrained state. The test results are tabulated in the following Table VI and in Figure 6,7.

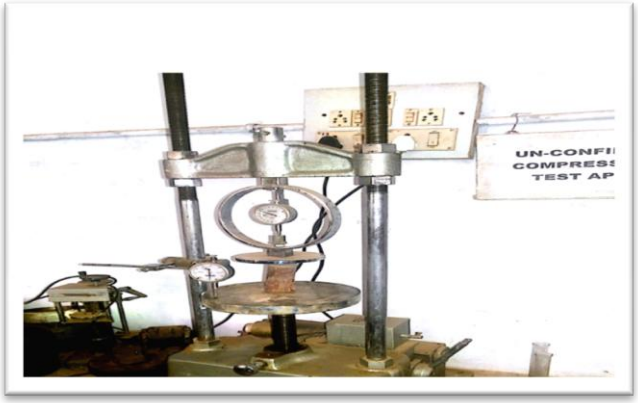

Figure 5: experimental set up

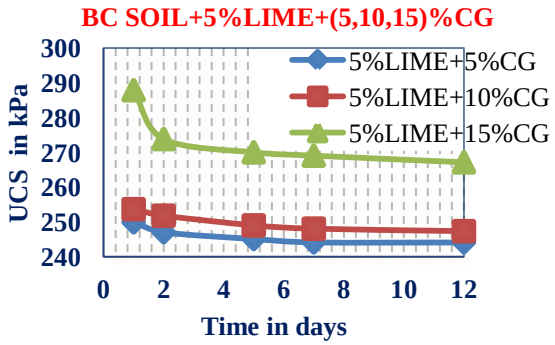

Figure 6: UCS of BC soil with 5%Lime+ (5+10+15) % CG with various curing periods

Table VI: UCS of BC soil with constant percentage of lime and with various percentages of PVC and Crushed Glass

Samples	UCS Values in (kPa)				
BC Soil	244.17				
	1st Day	2nd Day	5th Day	7th Day	12th Day
BC Soil+5%Lime	245.36	246.38	247.63	248.52	251.36
BC Soil+5%Lime+5%PVC	247.05	249.92	250.82	251.91	253.27
BC Soil+5%Lime+10%PVC	248.96	252.79	255.66	257.58	259.50
BC Soil+5%Lime+15%PVC	260.45	262.37	266.20	270.03	278.65
BC Soil+5%Lime+5%CG	249.92	247.05	245.13	244.17	244.15
BC Soil+5%Lime+10%CG	287.90	273.86	270.03	269.08	267.16
BC Soil+5%Lime+15%CG	253.69	251.82	249.02	248.08	247.37

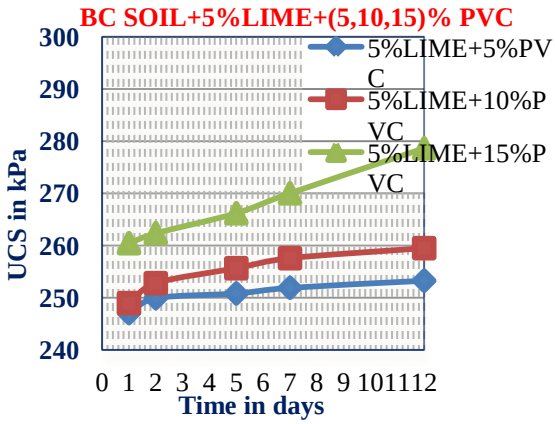

Figure 7:UCS of Black Cotton Soil with 5% Lime+ (5+10+15) % of PVC with different curing periods

V. CONCLUSIONS

From the experimental results and analysis conclusions are made and listed below:

- Decreases in Atterberg limits values with increase in PVC and Crushed Glass with optimum percentage of lime content for immediate testing.
- LL of BC soil is increased due to the addition of 15% PVC and 10% Crushed Glass to with optimum percentage of lime.
- The Crushed glass to black cotton soil with different percentages of PVC the MDD of soilsincreases withdecreasing in optimum moisture content up to 15% addition.
- UCS of BC soils gets increased from 247.17kPa to 278.65 kPa with 12th day curing due to the addition of 5%, 10%, 15% of PVC and 5% of lime.
- Addition of 5%, 10%, 15% of Crushed glass to the BC soil UCS is increased up to 13% that is from 247.17kPa to 287.90kPa with immediate testing.

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