Strength Characteristics And Compaction Of Black Cotton Soil Treated With Ggbs And Geopolyer

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***Abstract*— Strengthening properties of the black cotton soil studied by number of literature and have given number of conclusions ,as BC soil is famous for its problematic nature as it is clayey and have many problems regarding strength and stability. Inn this investigation ground granulated blast furnace slag (GGBS) and the alkali activated solution called geo-polymer are used to stabilize Black cotton soil. Blast furnace slag is a by-product obtained during the steel manufacturing in thee blast furnace and geo-polymer is an alkali activated solution prepared by combining sodium hydroxide (NaOH) with the sodium silicate solution (Na2SiO3). Geopolymer is an inorganic polymeric binding material and has cementiceous property. The preparing off Geo-polymer involves Geo-polymerization reactions. It goes under chemical reactions between solid alumino-silicates oxides and alkali metals silicates solutions under the highly alkaline condition yielding to amorphous to semi-crystalline and three-dimensional polymers structures, which has Si-O-Al bonding.**

Black cotton soil is first treated with GGBS and then with Geo-polymer and lastly with GGBS based Geo-polymer and the required tests has been conducted too know the different soil properties. By adding different percentages off GGBS to the Black cotton soil strength increased up to 20%. By adding Geo-polymer too black cotton soil the strength decreases after curing strength of the soil increases as the geo-polymer dosage increases. By adding of the GGBS based Geo-polymer the strength decreases at immediate testing except for 16% and 20% of Geo-polymer dosage. With curing strength increases to a very much higher value as compare with treating only with GGBS and Geo-polymer dosage. This is due to increases in thee alumina silicate sources which is very much necessary aspect for polymerization reaction.

Keywords—Black_Cotton_soil,GGBS,Geopolymer,Liquid Limit,Copaction,UCS

I. INTRODUCTION

In the India Black cotton soil is more than 0.8 million sq. km. which is 20% in the total land area. Black cotton soils is also known ass problematic type soil Because of its volume changes with changed in water content. When it reacts with water it starts swelling and shrinks with the noticeable decrement in water content and leaves cracks on drying. Black cotton soil changes to clayey during monsoons and hardens during summer seasons. Clay minerals like illite and montmorillonite are reason for this types of soil behavior. Large voluminous changes of soil by alternative shrinkage and swelling damages the civil engineering structure built on it. Now-a-days the use of waste material with soil has attained due to shortage of suitable soil and increases the problem of industrial waste management. Blast furnace slag is a by-product obtained during the steel manufacturing in blast furnace. The chemical property of the blast furnace slag is having same properties of cement. Its annual production in India is around 10.0 million tones. Use of waste materials in the treatment or improvements of the soil properties is one of the small contribution, we are giving to the nature by avoiding hazard causes by dumping these waste and keep going Eco friendliness_with_the_nature._Geopolymer_is_a_sort_of_cementious_material_made_from_polycondensation responses of_geopolymerric antecedent moreover antacid polysilicates_called_as_geopolymerization prepare._Geopolymerization_that_can alter to a_few aluminosilicate_materials_to valuable items called_geopolymers_or moreover called_as_inorganic_polymers..Geopolymerization comprises of_the_heterogeneous_chemical responses in_between_the strong aluminosilicates_oxides_and_the antacid metal_silicates_solutions_at_its profoundly antacid conditions.Geopolymer is_additionaly uses the mechanical squander materials like fly ash, impact heater slag etc.

II. EXPERIMENTAL DETAILS

A. Materials Used

The various materials used in this present investigation are, Black cotton soil, the Ground Granulated Blast furnace Slag (GGBS), the Sodium hydroxide and Sodium silicate.

B. Black Cotton Soil

Black Cotton_soil_is_found about approximately 20%of accessible arrive zone of India. The soil contains Montmorillonitic clay minerals as its chief substance which have a potential for contracting or_swelling beneath changing within_the dampness substance. The primary issue that arise with the respect to expansive soils is the swelling and compressibility. The deformation ordinarily is within the uneven designs and of such magnitude as to make extensive damage to the structure resting on them. The display examination has been made on thee Dark Cotton soil gotten from the Halbarga which is around 20km separated the_Bidar_district, arranged Karnatakaa state, India.

TABLE I. PHYSICAL PROPERTIES OF THE BLACK COTTON SOIL

Colour	Black
Specific gravity	2.50
Grain size distributions	
Fine sand fractions(%)	17%
Silt sizes(%)	13%
Clay sizes(%)	70%
Atterberg's limits	
Liquid limits(%)	74%
Plastic limits(%)	31%
Shrinkage limits(%)	6.8%
Compaction characteristics	
Maximum dry density(gm/cc)	1.34
Optimum moisture contents (%)	32

C. Ground Granulated Blast Furnace Slag(GGBS)

These are the by-product in iron production. Its main used in its concretes and the most ready mixed concretes plants have a silo on GGBS. Which they have to replace in-between 40 and 70% of the Portland cements. The chemical compositions are similar to that on cement. It is however, GGBS is not a cementitious content by itself, GGBS has only low cementitious properties and the Portland cements normally which provides the alkalinity to get and accelerate the properties. lime can utilized to provide the necessity of alkali for activation, which possesses latent hydraulic properties in GGBS.

TABLE II. PHYSICAL PROPERTIES OF THE GGBS

Specific gravity	2.82
Color	White
Grain size distributions	
Fine sand fractions (%)	10%
Silt sizes (%)	90%
Atterberg's limits	
Liquid limits (%)	30.0
Plastic limits(%)	NP
Shrinkage limits (%)	--
Compaction characteristics	
Maximum dry density (gm/cc)	1.6
Optimum moisture contents (%)	20.0

D. Geo-Polymer

Geo-polymer which is the type of the cementious material formed by polycondensations reactions of the geo-polymeric precursors and the alkali polysilicate known as the geo-polymerization process. Geo-polymerization that can change several aluminosilicate materials into the useful products known as geo-polymers or in-organic polymers. Preparation of Geopolymer involves combining the Sodium hydroxides solutions with the Sodium silicate solution. In this present investigation, the Sodium hydroxide solution is prepared to 10M concentration. That is by adding 400grams of Sodium hydroxide pellets to the 1000ml of water.

Molarity= (weight of solids/molecular weight of solids) X (100/volume of solutions)

The prepared 10M sodium hydroxide is mixed with the 2.5times of its weight with the sodium silicate (water glass). Care must be taken is that sodium silicate is added after the cooling of sodium hydroxide solution. The heat is liberated due to exothermic reaction. After preparing the solution, which is left around 24 hours to completion of geo-polymerization.

III. RESULTS AND DISCUSSION

TABLE III. LIQUID LIMIT OF THE BC SOIL IS TREATED WITH THE VARIOUS PERCENTAGES OF THE GGBS BASED GEOPOLYMER

Combination	**Liquid limit(%)**				
	0% GGBS	10% GGBS	20% GGBS	30% GGBS	40% GGBS
BC soil	76	64	62.5	61	59
BC soil+4% Geopolymer	78	71	74	65	60
BC soil +8% Geopolymer	85	84	85	73	62
BC soil +12% Geopolymer	93	90	83	78	65
BC soil+16% Geopolymer	87	80	68	64	63
BC soil +20% Geopolymer	80	68	63	59	48

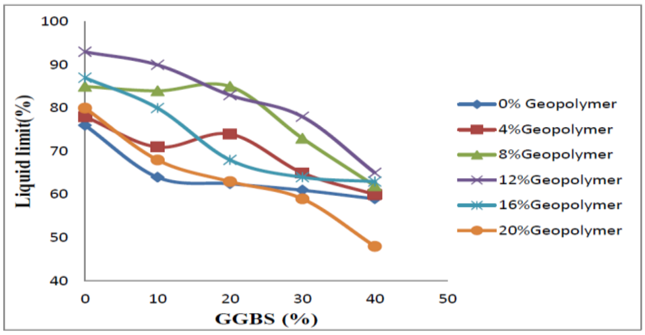

Fig. 1. Variations of the Liquid Limits of the Black Cotton Soils Treated with the Varying Percentages of the GGBS Based Geo-polymer.

TABLE IV. COMPACTION CHARACTERISTICS OF DIFFERENT PERCENTAGES OF THE GGBS BASED GEO-POLYMER TREATED WITH THE BLACK COTTON SOIL

Combination	**Maximum dry density (kN/m^3)**	**Optimum moistures content (%)**
BC soil alone	13.2	32
BC soil +30%GGBS +4%Geopolymer	13.3	20
BC soil +30%GGBS +8%Geopolymer	12.7	21
BCsoil+30%GGBS +12%Geopolymer	13.8	17
BC soil +30%GGBS +16%Geopolymer	14.7	19
BC soil +30%GGBS +20%Geopolymer	15.8	12

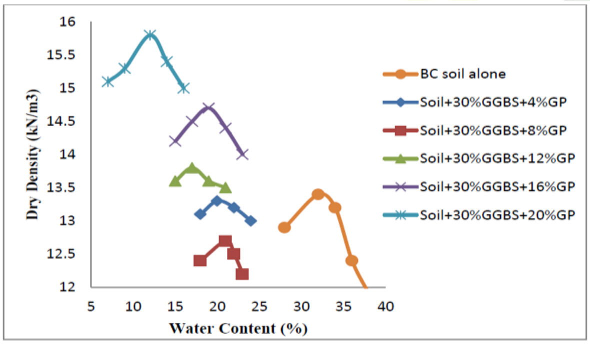

Fig. 2. Compaction Characteristics of different Percentages of the Geo-polymer Treated with the Black Cotton Soil.

TABLE V. UNCONFINED THE COMPRESSIVE STRENGTH OF THE BLACK COTTON SOIL TREATED WITH THE VARIOUS PERCENTAGES OF GGBS

Combination	**Unconfined compressive strength(kPa)**			
Curing periods in days	**0**	**15**	**21**	**30**
BC soil alone	320	320	320	320
BC soil+10%GGBS	325	335	450	520
BC soil+20%GGBS	350	489	550	655
BC soil+30%GGBS	210	497	650	712
BC soil+40%GGBS	138	326	582	612

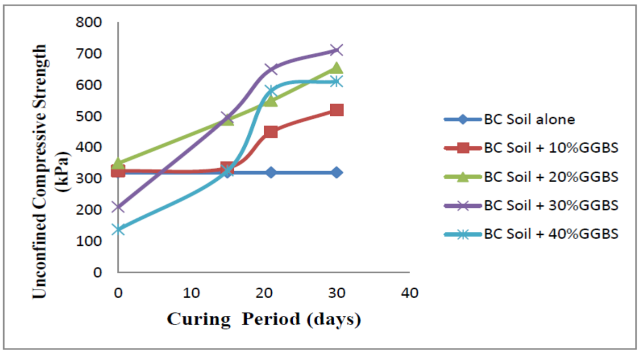

Fig. 3. Unconfined Compressive Strengths off the Black Cotton Soil Treated along Various Percentages of the GGBS.

TABLE VI. UNCONFINED COMPRESSIVE STRENGTH OF THE BLACK COTTON SOILS TREATED WITH THE VARIOUS PERCENTAGE OF THE GEOPOLYMER

Combination	**Unconfined compressive strength(kPa)**			
Curing periods in days	**0**	**15**	**21**	**30**
BC soil alone	320	320	320	320
BC soil+4%Geopolymer	240	255	320	362
BC soil+8%Geopolymer	260	320	455	520
BC soil+12%Geopolymer	271	350	497	590
BC soil+16%Geopolymer	260	430	663	680
BC soil+20%Geopolymer	258	480	801	860

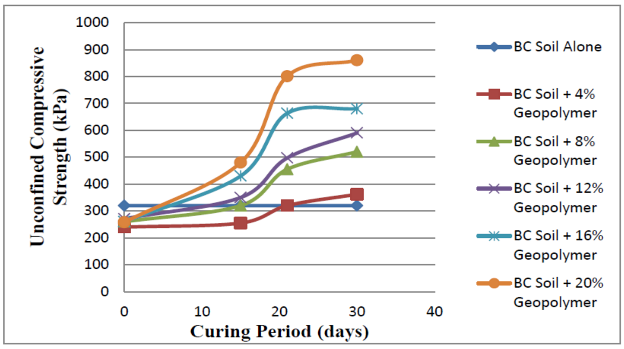

Fig. 4. Unconfined Compressive Strengths off the Black Cotton Soil when Treated with the Various Percentage of the Geopolymer.

TABLE VII. UNCONFINED COMPRESSIVE STRENGTH OF THE BLACK COTTON SOIL TREATED WITH THE VARIOUS PERCENTAGES OF THE GGBS BASED GEOPOLYMER

Combination	**Unconfined compressive strength(kPa)**			
Curing periods in days	**0**	**15**	**21**	**30**
BC soil alone	320	320	320	320
BC soil+12%Geopolymer+10%GGBS	239	398	926	951
BC soil+12%Geopolymer+20%GGBS	221	1687	2211	2934
BC soil+12%Geopolymer+30%GGBS	210	3100	3196	3220
BC soil+12%Geopolymer+40%GGBS	218	3450	4178	5109

a. Geo polymer Dosage=12% by total dry weight.

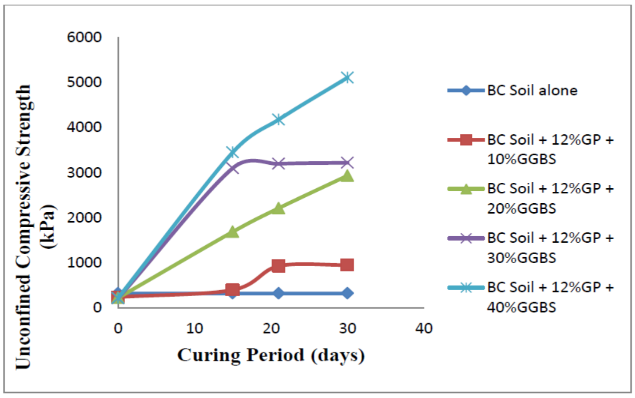

Fig. 5. Unconfined Compressive Strength of the Black Cotton Soil when Treated with Various Percentages of GGBS Based Geopolymer.

TABLE VIII. UNCONFINED COMPRESSIVE STRENGTH OF THE BLACK COTTON SOIL TREATED WITH THE VARIOUS PERCENTAGE OF THE GGBS BASED GEOPOLYMER

Combination	**Unconfined compressive strength(kPa)**			
Curing periods in days	**0**	**15**	**21**	**30**
BC soil alone	320	320	320	320
BC soil+16%Geopolymer+10%GGBS	260	793	1384	1395
BC soil+16%Geopolymer+20%GGBS	365	2012	2591	2946
BC soil+16%Geopolymer+30%GGBS	360	2562	3437	3535
BC soil+16%Geopolymer+40%GGBS	385	8446	11152	21727

b. Dosage=16% by total dry weight.

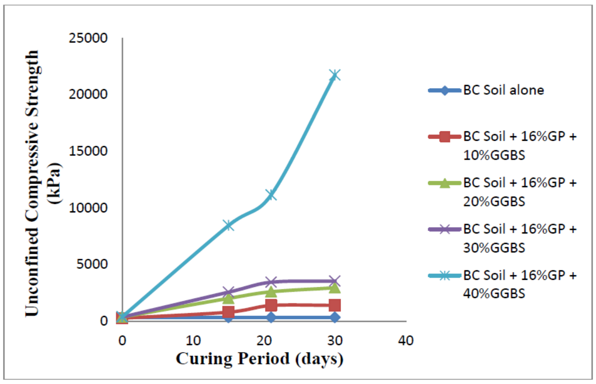

Fig. 6. Unconfined Compressive Strength off the BC Soil Treated when Various Percentages off the GGBS based Geopolymer.

TABLE IX. UNCONFINED COMPRESSIVE STRENGTH OF THE BLACK COTTON SOIL TREATED WITH DIFFERENT PERCENTAGES OF THE GGBS BASED GEOPOLYMER

Combination	**Unconfined compressive strength(kPa)**			
Curing periods in days	**0**	**15**	**21**	**30**
BC soil alone	320	320	320	320
BC soil+20%Geopolymer+10%GGBS	391	705	908	1534
BC soil+20%Geopolymer+20%GGBS	406	1735	2320	2839
BC soil+20%Geopolymer+30%GGBS	410	3334	4101	5051
BC soil+20%Geopolymer+40%GGBS	369	17678	30018	32503

c. Geopolymer Dosage=20% by total dry weight.

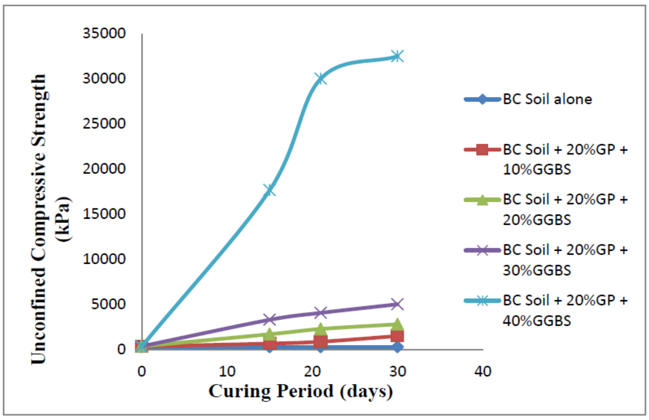

Fig. 7. Unconfined Compressive Strength of Black Cotton Soil Treated with Various Percentage of GGBS based Geopolymer.

IV. SCOPE OF THE PRESENT WORK

- To study the index & the compaction behaviour of the Black cotton soil at different percentages of GGBS.
- To study the behaviour of the Black cotton soil is treated with the various percentages of GGBS at the

different curing periods to achieve at the optimum amount of GGBS which gives the optimum results.

- To get the index and compaction behaviour of the Black cotton soil at different dosages of Geo-polymer.
- To know the strength behaviour of the Black cotton soil reacted with the various percentages of Geo-polymer at various curing periods to achieve at the optimum percentages of Geo-polymer which gives the optimum results.
- To get the index and the compaction behaviour of the Black cotton soils and GGBS mix treated with the different dosages of Geo-polymer solutions.
- To study the strength behaviour of the Black cotton soil and the GGBS mix treated with the various percentages of the Geo-polymer at various curing periods to get the optimum percentages of GGBS and Geo-polymer which gives the optimum results.

V. Summery And Conclusion

- The augmentations of the GGBS to the Black cotton soil expanded the fluid limits of the cotton soil diminishes. This may be since of impact of coarser GGBS particles, which diminishes the fluid limits of the Dark cotton soil due to the reduction in clayey substance.
- The liquid limit of the Black cotton soil increase with the increase in the Geopolymer dosage at immediate testing; this may be because of releasing of free water molecule during condensation reaction between silicon and aluminium.
- The liquid of Black cotton decreased with the increase in GGBS based Geopolymer considerably. Because of combined effect of condensation and reduction in clay content.
- The shrinkage limit of Black cotton soil increase with increase in GGBS dosage. This behaviour may be because the predominance of coarser fractions of GGBS and also due to an expansion of diffuse double layer thickness.
- As the Geopolymer dosage increases, the shrinkage limits of the Black cotton soil increases, this may be because of increase in binding property of soil particles and also expansion of diffusion double layer due to leaching out SiO2 & Al2O3 in Black cotton soil. This effect is more as NaOH concentration increases as dosage increases. Hence shrinkage limit is increases as increase in Geopolymer dosage.
- On including of the GGBS to the Black cotton soil, when the maximum dry density increased due to higher specific gravity off GGBS conjointly optimum moisture content diminished due to diminish in clay substance.
- On addition of Geopolymer, when maximum dry density decreased up to 12% Geopolymer dosage and then increases on further addition of Geopolymer considerably.
- On adding of GGBS mixed Geo-polymer to the Black cotton soil, the maximum dry density increased and the optimum moisture content decrease, this may be because of higher specific gravity of GGBS decrease in clay content and also increase in binding property of soil.
- With the addition different percentages off GGBS to the Black cotton soil, strength increase up to 20% of GGBS replacement, on immediate testing. With curing strength increases only up to 30% GGBs replacement. Hence which is chosen as optimum percent for the Black cotton soil.
- On adding of the Geo-polymer to the Black cotton soil, the strength decreases at immediate testing. With curing strength increases as the Geopolymer dosage increase, this may be because of Geopolymer polymerization reaction.
- On adding of the GGBS based Geo-polymer the strength decreases at immediate testing except for 16% and 20% of Geopolymer dosage. With curing strength increases to a very much higher value as compare with treating only with GGBS and Geopolymer dosage. This is due to increases in the alumina silicate sources which is very much necessary aspect for polymerization reaction.

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