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Strengthening of Expansive Clayey Subgrade Pavements by using Geotextile and Admixture

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***Abstract*:**
In urban areas, the administration lifetime of pavement on poor soil sub-grade is influenced because of its high compressibility and plasticity behavior. These soils have high moisture content, less strength and CBR values. In addition to these, the seasonal changes also affect the soil properties. In order to defeat these problems, the properties of soft sub-grade soil must be enhanced through soil stabilization. Geo-synthetics materials stabilize the soil and to reduce the thickness of flexible pavements. Geo-synthetics are the financially savvy ground alteration material which builds the security and bearing limit of the soil. The various types of soil stabilization are: Soil stabilization with “cement, lime, bitumen, Chemical stabilization” and a new rising technology of improvement by Geo-textiles and Geo-synthetic fibers. In this work we are using combinations of Geo-textile (43.75mm, 87.5mm, 131.25mm heights from bottom of the mould) and admixture (GGBS: 0% - 40%) to know the consequences when they are mixed with expansive soils. From the CBR values obtained the optimum placement of geotextile and GGBS are found to be 3.91 and 30% respectively. The (UCS) value is found to be high i.e., 0.545kg/cm^2 when 30% GGBS is added. From the results it is found that, by placing the geotextile at 131.25mm and addition of GGBS of about 30% has improved the strength of the soil by 80%.

Keywords: Expansive soil, Geotextile, GGBS, Compaction Characteristics, CBR, UCS, FSI.

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1. INTRODUCTION

Transportation is very important in day to day life. It subsidizes to the industrial, economical, social and cultural development of any country. It is very important for the economic development of any region since every trade good whether food, clothing, industrial product or medication needs to be transported in the least stages i.e., production to distribution. Road or highways is the solely means of transportation that may offer most services to at least one and everyone. Flexible pavements are preferred these days as it contributes to low initial cost, adaptive to temperature changes and can be easily repaired when compared to rigid pavements. When these pavements are to be constructed on poor soil such as Black Cotton Soil, there is a problem of shrinking and swelling. About 20percentage of the total area of land in India is covered with Black Cotton soil. It extends over the states of Uttar Pradesh ,Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and Madhya Pradesh.The soil becomes slushy and loses its strength in rainy and hardens in summer. The variation is due to climatic conditions and its shrinkage and expansion varies the depth about 1.5m and the structure constructed over it may undergo settlement. Hence, the soil is stabilized using geotextile and{GGBS} ground granulated blast furnace slag .

GGBS is a byproduct of iron industries which are quenched in huge quantities of water at temperatures of 1500ºC and mixture of coke, iron oreand lime. As GGBS has cementitious properties, it acts as partial replacing of cement and increases the bearing capacity of the soil. Hence the use of this for increasing the soil properties has evolved. The soils which are stabilized by GGBS have shown more strength and contribute to low porosity and permeability.

2. OBJECTIVES

- The main aim of this study is to know the effect of strength of the after the application of geosynthetics and admixtures.
- In this study, the nature of geotextile and GGBS in stabilizing the soil is examined.
- To evaluate the Engineering Properties of expansive soil for different proportions.

3. 0 Methodology

3.1 Data Collection

I. Expansive soil

In this study the material including montmorillonite expansive soil has been collected from Turkapally and Patancheru areas from a depth of 0.5 to 1.0m.

II. GGBS

The GGBS (ground granulated blast furnace slag) is a byproduct of iron industries which are quenched in huge quantities of water at temperatures of 1500ºC and mixture of iron ore, coke, lime. As GGBS has cementitious properties and acts as partial replacement of cement and increases the bearing capacity. Hence the use of this GGBS for increasing the soil properties has evolved. GGBS contains calcium oxide, silica, alumina, magnesia. The soils which are stabilized by GGBS had shown more strength and contribute to low porosity and permeability. In this study we add GGBS in different proportions such as 10%, 20%, 30% and 40% along with geotextile as a replacement of soil, for stabilization of soil and find the properties of soil by CBR and UCS tests. The percentage of GGBS that gives the MDD (maximum dry density) and (OMC) optimum moisture content is considered as optimum percentage of GGBS. The addition of GGBS to geotextile, gives increased CBR and UCS values.

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Fig.1. GGBS

III. Geotextile: Geotextiles are inevitably secured continuous filament non-woven's factory made from Ultraviolet-stabilized poly-propane. The mechanical properties of TenCateBidim ensure tremendous resistance to installation damages, excellent hydraulic properties and outstanding long-term performance. These following applications stabilize base courses over less bearing capacity sub-grades offers the excellent tensile strength and elongation property. Preserves the function of drainage systems. Provides high K (permeability) to H_2O and preserves finest soil sample particles offer high long-term resistance.

Fig.2: Shows Geo-textile Used in Road Work at Madhapur

3. 2 Step by Step Processing of Methodology

1. **Atterberg's limit test:** In this test the soil is sieved through the 425micron IS sieve. Take material which passed through the sieve and place in the oven for 2 hours before the test. Then conduct tests for varying proportion of fly ash and rice husk ash with soil. Atterberg's test gives the plastic limit and liquid limits.

2. **Differential Free Swell test:** The free swell test was carried out to find the swelling index of soil in [As per IS 2720 {Part XL}-1977] from which the degree of expansive nature of soil was find as per [IS 2911 {part 3}-1980]. Differential swell index is found out by comparison of swelling between 2 measuring cylinders of containing H_2O& kerosene respectively.Ten grms of soil sample passing through four twenty five microns IS sieve.

3. **SPT :**In geotechnical field, soil compaction is the process in which a load is applied to a soil sample causes to densification as air is displaced from the pores between the soil particle. It is an quick process and it is applicable only for partially saturated soil sample. Standard proctor test is a in-situ conduct for calculating the (OMC) moisture content

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and (MDD) maximum dry densityat which a selected soil sample will become more dense state and attain its (MDD) maximum dry density.

4. **UCSTest:**In th geotechnical engineering the ucs test main aim is to finding the shear strength parameter of a clay and mix specimen by loading axially cylindrical specimen. The test results are obtained according to[IS 2720 {part 10} 1973].

5. **CBR (California Bearing Ratio) test :** The CBR tests were accompanied on selected soil, reinforced and un-reinforced with a single layer of Geo-grid. To the reinforcement of a sample, the Geotextile was positioned in a single layer at various located 43.75mm, 87.5mm, and 131.25mm heights of the specimen from the surface.The Specimen was expurgated in the arrangement of circular disc of diameter marginally less than that of the specimen to escape pertaining the specimen by soil reinforcing layer. The dry unit weight required for filling the mould was calculated based upon the MDD and corresponding OMC [Optimum moisture content] was reached from SPT [Standard Proctor Test]. Fivesamples of total reinforcement and un-reinforcement type were testing in the in-situ in soaked and un-soaked conditions for 4 days. The load and penetration curve was drawn for the samples with Geo-grids placed at different places and the values of CBR calculated from theses curves.

4.0 Result and Discussions

4.1 Experimental Investigation

Table 1: Expansive Soil Properties

S.No	Property	Values	
		Turkapally	Patancheru
1	Liquid limit (%)	83.86	78.94
2	Plastic limit (%)	27.6	30.4
3	Plasticity index (%)	56.26	48.54
4	Free swell index (%)	88	50
5	OMC (%)	12.5	12.5
6	MDD (g/cc)	1.71	1.77
7	UCS (kg/cm^2)	0.535	0.53
8	Classification	Clay	Clay

4.2 Free Swell Index

Table 2: Free swell index test

S.No	FSI (%)		GGBS (%)
	Turkapally	Patancheru	
1	88	50	0

2	60	44.44	10
3	50	38.8	20
4	15	20	30
5	11.11	10	40

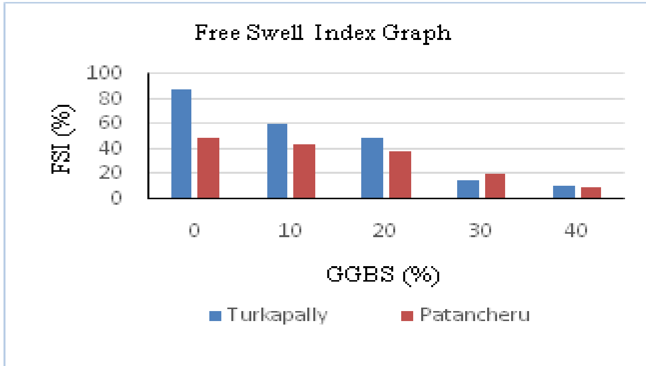

Fig .3: FSI values of different % of GGBS for two soil samples

When 40% GGBS is added, the soil samples shows less swelling property

4.2 Proctor Compaction Test

Table 3: Compaction test for Turkapally soil sample

Sample	Water content (%)	Dry density (g/cc)
1	12.5	1.65
2	12.5	1.71
3	14.2	1.68
4	16.6	1.66

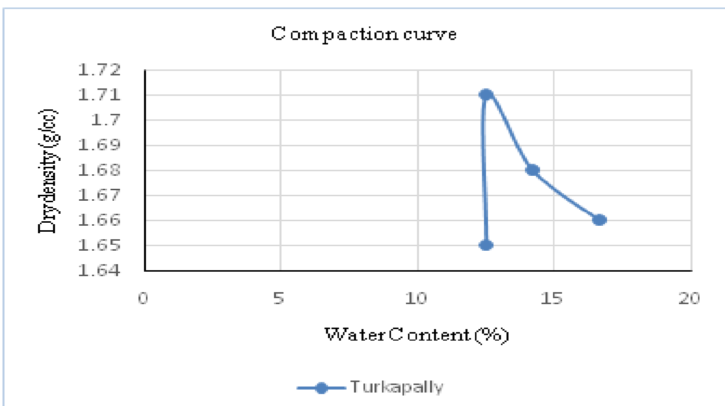

Fig 4: Compaction graph for Turkapally soil sample from the graph MDD is 1.71[g/cc] and OMC is 12.5[%]

Table 4: Compaction test for Patancheru soil sample

Sample	Water content (%)	Dry density (g/cc)
1	11.5	1.72
2	12.5	1.77
3	14.2	1.68
4	16.66	1.64

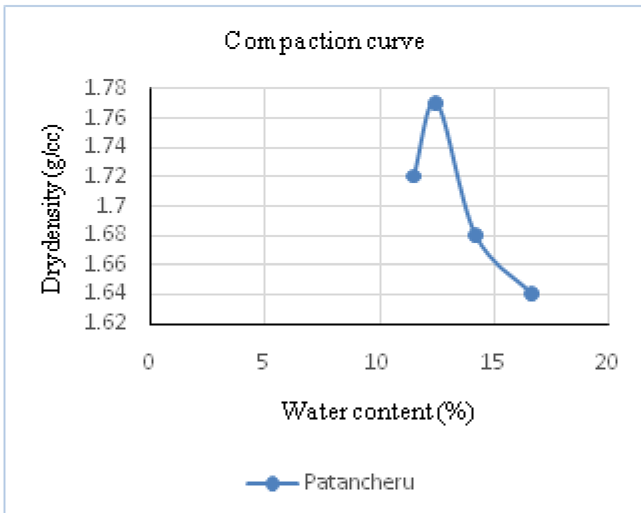

Fig 5: Compaction graph for Patancheru soil sample from the graph, MDD is 1.77 g/cc and OMC is12.5%

4.3 CBRTest[California Bearing Ratio]

CBR = [(load sustained by specimen at defined penetration level)/ (load sustained by crushed stone at the same penetration level) *100

4.4.1 CBR Test for Geotextile

Table 5: CBR value variation with Geotextile application at different heights in soil sample from Turkapally

S.No	Description	CBR value at(2.5mm) penetration	CBR value at (5mm) penetration
1	Without geotextile	1.69	1.30
2	With geotextile at 47.25mm	1.73	1.37
3	With geotextile at 87.5mm	2.39	1.84
4	With geotextile at 131.25mm	3.82	2.75

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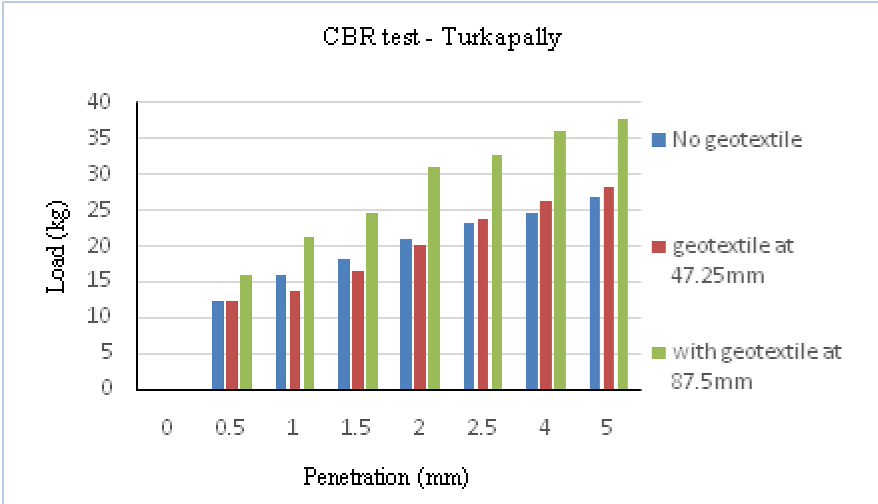

Fig.6: CBR values with geotextile for Turkapally soil sample

Table 6: CBR value variation with Geotextile application at different heights on soil sample from Patancheru

S.No	Description	CBR value at (2.5mm) penetration	CBR value at (5mm) penetration
1	Without geotextile	1.73	1.33
2	With geotextile at 47.25mm	1.66	1.31
3	With geotextile at 87.5mm	2.46	1.86
4	With geotextile at 131.25mm	3.92	2.79

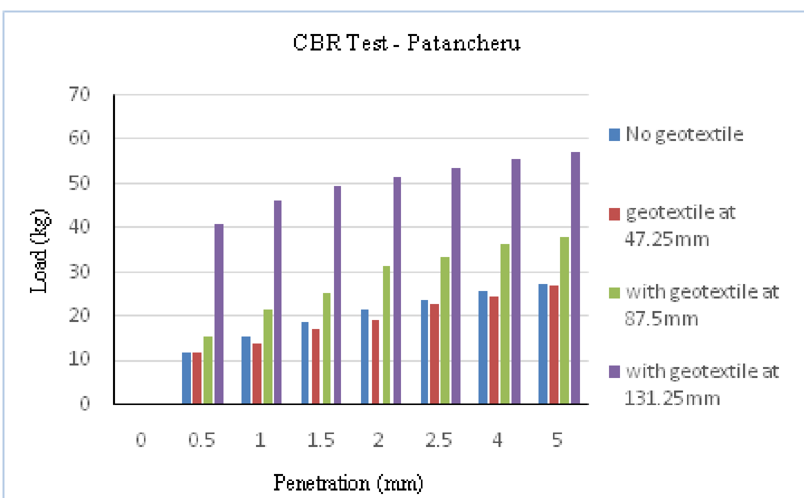

Fig.7: CBR values with geotextile for Patancheru soil sample From both the graphs it is seen that, the CBR value is maximum when the geotextile is placed at 131.25mm height **CBR Test for GGBS**

Table 7: CBR values with variation in GGBS composition for Turkapally soil sample.

S.No	Description	CBR value at (2.5mm) penetration	CBR value at (5mm) penetration
1	Without GGBS	1.66	1.28
2	With 10% GGBS	1.96	1.46
3	With 20% GGBS	1.80	1.40
4	With 30% GGBS	3.82	2.83
5	With 40% GGBS	2.49	1.95

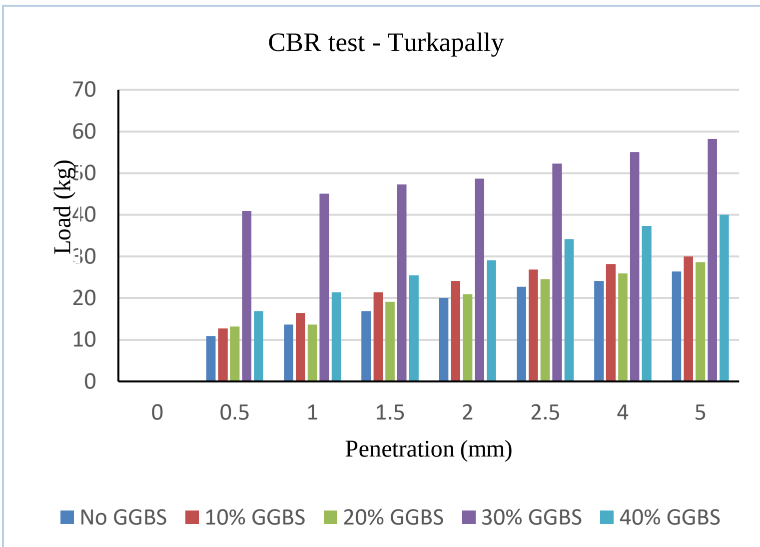

Fig.8: CBR values with GGBS for Turkapally soil sample

Table 8: CBR values with variation in GGBS composition for Patancheru soil sample

S.No	Description	CBR value at (2.5mm) penetration	CBR value at (5mm) penetration
1	Without GGBS	1.86	1.40
2	With 10% GGBS	1.73	1.35
3	With 20% GGBS	1.69	1.37
4	With 30% GGBS	3.79	2.79
5	With 40% GGBS	2.39	1.86

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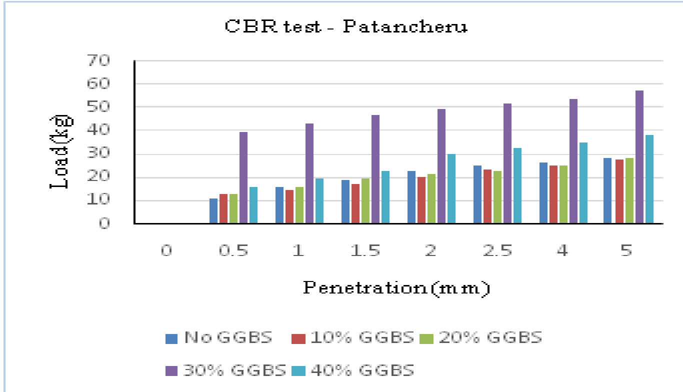

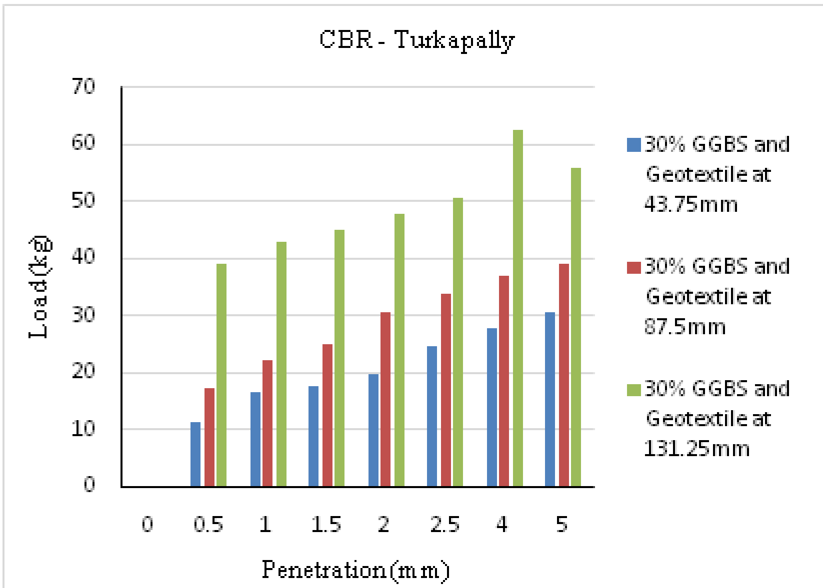

Fig 9: CBR values with GGBS for Patancheru soil sample from both the graphs it is seen that the CBR value is maximum with the addition of 30% GGBS to the soil samples

Table 9: CBR values of Turkapally soil sample with 30% GGBS and geotextile placed at different heights

S.No	Description	CBR value at (2.)5mm Penetration	CBR value at (5mm) Penetration
1	30% GGBS and geotextile at 43.75mm	1.79	1.48
2	30% GGBS and geotextile at 87.5mm	2.46	1.90
3	30% GGBS and geotextile at 131.25mm	3.69	2.72

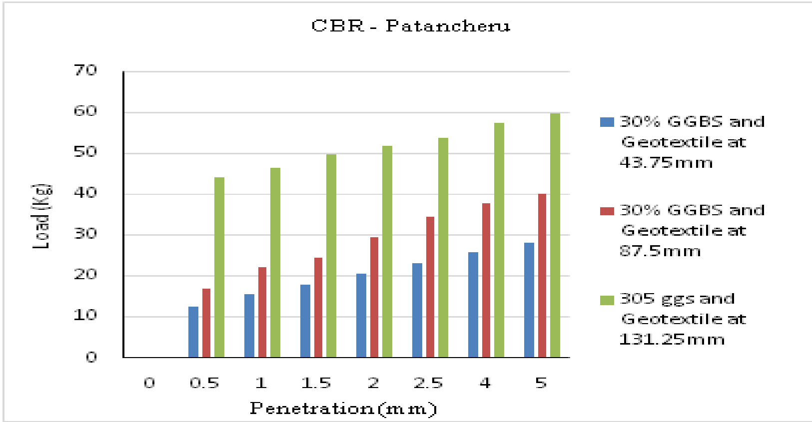

Fig 10: CBR values with a combination of GGBS and geotextile for Turkapally soil sample

Table 10: CBR values of Patancheru soil sample with 30% GGBS and geotextile placed at different heights

S.No	Description	CBR value at (2.5mm)Penetration	CBR value at (5mm)Penetration
1	30% GGBS and geotextile at 43.75mm	1.69	1.37
2	30% GGBS and geotextile at 87.5mm	2.52	1.95
3	30% GGBS and geotextile at 131.25mm	3.92	2.90

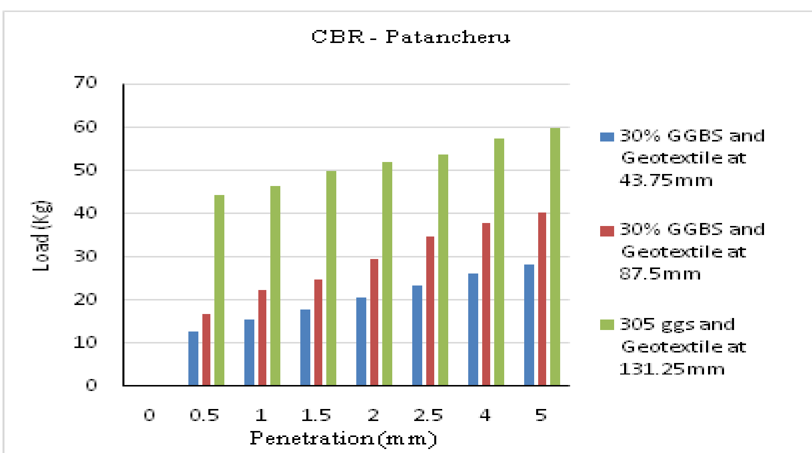

Fig 11: CBR values with a combination of GGBS and geotextile for Patancheru soil sample From both the graphs it is to observed that, the CBR values of the soil samples is maximum when it is mixed in combination with 30% GGBS and geotextile placed at 131.25mm height

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4.4 Unconfined Compressive Strength (UCS)

Table 11: UCS values with varying % of GGBS for Turkapally soil sample

S.No	Description	UCS (kg/cm^2)
1	No GGBS	1.07
2	10% GGBS	1.73
3	20% GGBS	1.69
4	30% GGBS	3.79
5	40% GGBS	1.08

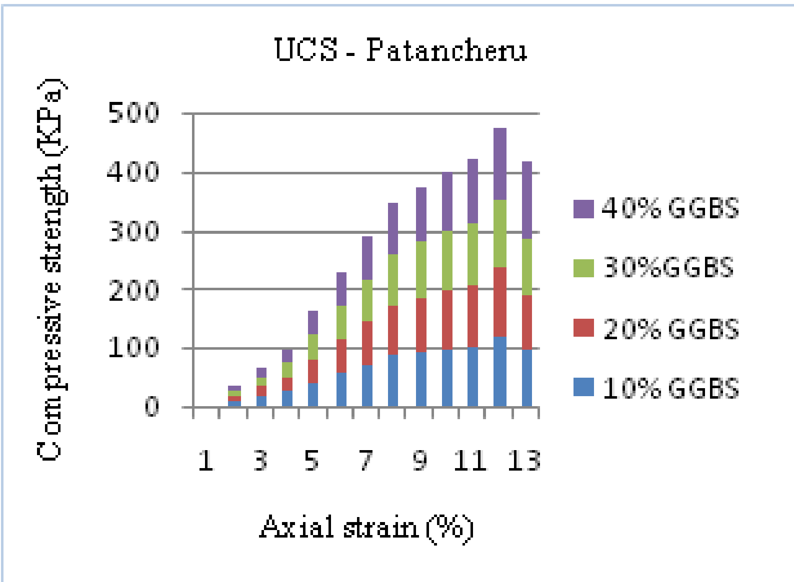

Fig 12: UCS values with varying % of GGBS for Turkapally soil sample

Table 12: UCS values with varying % of GGBS for Patancheru soil sample

S.No	Description	UCS (kg/cm^2)
1	No GGBS	1.06
2	10% GGBS	1.04
3	20% GGBS	1.07
4	30% GGBS	1.09
5	40% GGBS	1.08

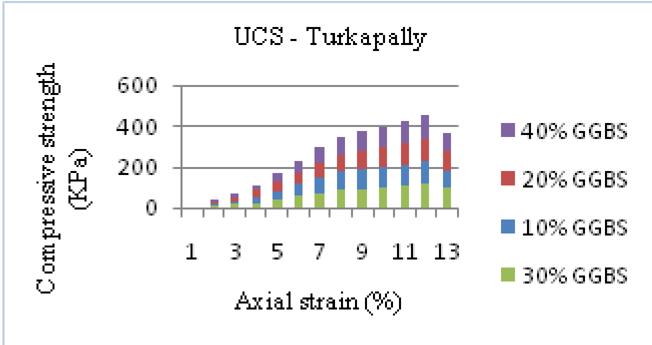

Fig 13: Contrast for all UCS values with varying % of GGBS for Patancheru soil sample from both the graphs it is seen that, the UCS values of the soil samples is maximum when 30% of GGBS is added

From the above results, it is clear that the addition of geotextile as reinforcement for black cotton soil has increased the performance of the soil by increasing bearing capacity and reducing the swelling property. Placing of a single layer geotextile at 131.25mm height and addition of 30% GGBS together improved the soil properties.

➢ The CBR values have increased by 80% when geotextile is placed at a depth of 131.25mm.

➢ FromCBRvalues,theoptimumplacementofgeotextileoutof43.75,87.5and 131.25 is found to be 131.25mm from the base of the mould.

➢ The CBR values of geotextile placement at 131.25mm are found to be 3.82, 3.91 and that of 30% GGBS are found to be 3.82, 3.79 for Turkapally and Patancheru soil samples respectively.

➢ CBR value when both i.e., Geotextile at 131.25mm and 30% GGBS the values are found to be 3.69 and 3.92 for Turkapally and Patancheru soil samples respectively.

➢ The UCS value is found high when 30% GGBS is added and is equal to 1.895kg/cm^2 for Turkapally and 0.545kg/cm^2 for Patancheru soil samples.

➢ The values are within the limits i.e. the CBR value should be 3-10 for BC soil used for subgrade and we have increased the CBR from 1.7 to 3.92 which is 2.3 times the original CBRvalue.

➢ The Free Swell Index of the soil sample is 88 and 50 for Turkapally and Patancheru soil samples respectively which indicates that soil has high swelling property and can be reduced by chemical stabilization. As the addition of GGBS has increased (0-40 %), there is reduction in swelling property of the soil by87%.

➢ The addition of geotextile has increased the strength and bearing capacity of the soil samples.

Hence the use of GGBS along with single layer of geotextile imposed greater strength and bearing capacity to the soil sample and is eligible for pavement design.

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