HYDRAULIC CONDUCTIVITY STUDY OF RED SOIL WITH ADMIXTURES FOR USE AS LINER MATERIALS

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Abstract - *Construction of pavement on expansive or soft subgrade soil needs great deal of attention. It is very much important to concentrate on strength of soil layers underlying the surface course, because the design life, strength and thickness of pavement are mainly depends upon the subgrade strength. Many alternative methods available to improve the strength of subgrade. Soil stabilization is one of the best methods of enhancing soil properties. Subgrade strengthening using geotextiles, geomembranes and geogrids as soil reinforcement are most widely used methods. Additives now days use of industrial wastes as additives for soil stabilization has become trendy to reduce the environmental hazards.In the present study we have made an attempt to strengthen the soft subgrade soil using workshops waste iron powder (W.I.P) as an admixture and geomembrane as an layers of soil reinforcement.TheBC soil is alloyed with deviating percentages of waste iron powder i.e. 2%, 4%, 6%, 8% and 10%. For all these proportions OMC and MDD is calculated by conducting compaction test. Atterberg limits are estimated for all the proportions & also CBR tests were performed to know the Load-settlement nature of soft subgrade soil.*

***KeyWords*:MDD & OMC, CBR, Liquid Limit**

1. INTRODUCTION

Landfills are one of the successful techniques for safe removal of city, mechanical and dangerous waste. It is most generally utilized strategy for strong garbage removal all throughout the planet. This cycle has been rehearsed for quite a long time and will keep on being a significant part of city strong waste administration across the world. It is fundamental that the possibly poison fluid (for example leachate) created from civil waste doesn't sully close by soil or groundwater.

A dirt liner fills in as water driven obstruction to stream of liquids. Earth liners are utilized to limit invasion of water into covered waste (cover frameworks) or to control arrival of leachate from the waste (liner frameworks). To meet these destinations, earth liners should have low water driven conductivity throughout extensive stretches of time. Further, one should have the option to check that the water powered conductivity will be reasonably low, which is frequently the most troublesome issue to be settled. Moreover, earth liners are relied upon to lessen the development of leachate, to drag out arrival of synthetics in leachate, and to serve other site-explicit capacities.

This project examines the suitability of a locally available red earth for construction of liner. To meet the requirements of the permeability, the red earth has been mixed with 25% by weight of locally available black soil. But the soil containing this amount of bentonite will shrink and swell and also loose strength on wetting. The permeability of the liner may increase due to chemical attack. It has been proposed to improve the stability and increase the resistance to chemical attack of the liner by treating with lime or cement. The suitability of the stabilized material has been evaluated from the studies on index properties, consolidation, permeability and strength tests.

2. LITERATURE REVIEW

Craig H. Benson et al (1994): depicted an information base which was utilized to assess connections between pressure driven conductivity, compositional elements, and compaction factors and to distinguish least qualities for soil properties that are probably going to yield a mathematical mean pressure driven conductivity ≤1×10-7 cm/s. The material particulars got from the examination is introduced.

V.K. Stalin (2000)&P.V. Sivapullaiah, A. Sridharan: contemplated the significance of bentonite content in decreasing the water driven conductivity of liners. The investigation shows the part of the size of the coarser portion in controlling the pressure driven conductivity of the mud liner. It has been shown that at low bentonite substance the water driven conductivity of the liner shifts relying upon the size of the coarser division separated from dirt substance.

P.V.V.Satyanarayana, Harshita.A, Soumya Priyanka (2013) : directed different geotechnical test program on Bentonite-Red soil blends. From the outcomes it is recognized that 15% measurements of Bentonite fulfills the pressure driven conductivity and different capacities as a liner materials.

3. MATERIAL AND METHODOLOGY

a. Red soil: The sand or silty topsoil basically frames the regular ground in Bangalore, Karnataka State. The red earth was gathered around the dirt mechanics research center, common office college Bangalore. The dirt was gathered by open removal, from a profundity of one meter beneath normal ground level. The dirt was air dried and utilized in the wake of sieving through a 425- micron strainer. The dirt had about 26% rock, 64% sand, 19% residue.

Table a: **Properties of the red soil**

Properties	Soil
Colour	Red
Specific gravity; G	2.5
Grain size analysis	
Gravel (%)	26
Sand (%)	64
Silt and clay (%)	20
Atterberg limits	
Liquid limit; w_l (%)	28
Plastic limit; w_p (%)	13
Shrinkage limit; w_s (%)	19
Plasticity index; I_p (%)	15
Compaction characteristics	
MDD; kN/m³	18.74
OMC; (%)	14.5

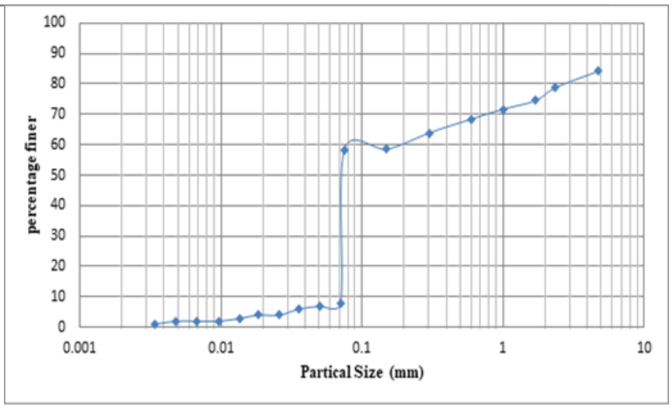


Fig a: Grain size distribution of Red soil

b. Black cotton soil : The normally accessible regular dark cotton soil from Bidar area in Karnataka State was utilized in this examination. The dirt has about 28% fine sand, half sediment, 20% earth. The file properties of the dirt are as introduced in Table.4.2. The grain size circulation bend of the dirt is introduced in Fig.4.2. The dirt is delegated high compressibility mud CH according to the Indian Standard characterization framework.

Table b: **Properties of the Black cotton soil**

Properties	Soil
Colour	Black
Specific gravity; G	2.7
Grain size analysis	
Fine sand (%)	28
Silt (%)	50
Clay (%)	20
Atterberg limits	
Liquid limit; w_l (%)	73
Plastic limit; w_p (%)	43
Shrinkage limit; w_s (%)	12
Plasticity index; I_p (%)	30
Compaction characteristics	
MDD; kN/m³	12.95
OMC; (%)	36.2

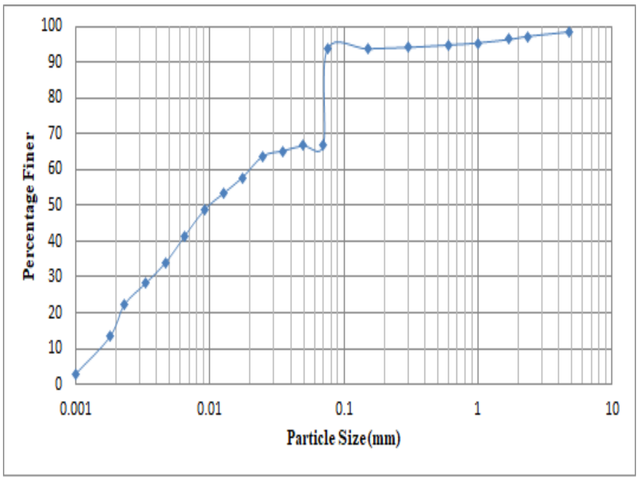
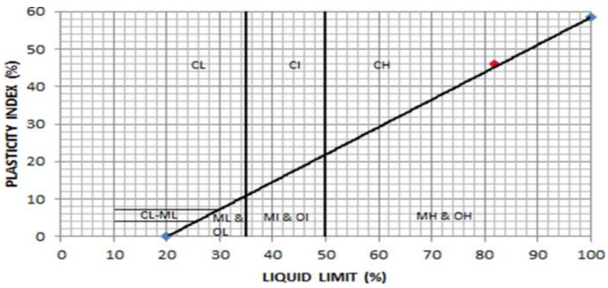


Fig b: Grain size distribution of black soil



c. Lime: Lime is calcium containing inorganic mineral in which carbonates, oxides and hydroxides win. In the extreme sensation of the term, lime is calcium oxide or calcium hydroxide. It is also the name of the customary mineral (neighborhood lime) CaO which occurs because of coal wrinkle fires and in changed limestone xenoliths in volcanic ejecta.

Table C : **Chemical properties of lime**

Nature of Hydrated lime	Free flowing fine white powder
Ca(oH2)	91.21%
Silica	0.96%
Magnesia as Mgo	0.94%
Aluminum as al2o3	In traces
Fe2o3	In traces
Mesh	425
Date of manufacture	10/5/2019
Date of expiry	10/5/2020

d. Leachate: Leachate is any liquid material that channels from land or put away material and contains on a very basic level raised centralizations of shocking material got from the material that it has gone through. Leachate from a landfill modifies commonly in association depending upon the age of the landfill & the sort of waste that it contains. It regularly contains both detached & dispersed material.

Table d: **Chemical composition of Leachate**

Parameters	Leachate
pH	4.1
TDS; mg/lit	10300
Cadmium ; mg/lit	<0.01
Lead ; mg/lit	0.15
Zinc ; mg/lit	15.2
Nickel ; mg/lit	0.63

METHODOLOGY

The reason for this examination is to consider the file, strength and water driven conductivity properties of red soil and variety in those properties on expansion with dark soil and lime.

The accompanying tests were led on red soil, Grain size analysis.

- G-Specific gravity test.
- Consistency Limits:
- WL-liquid Limit.
- WP-Plastic Limit.
- WS-Shrinkage Limit
- Compaction test.
- Permeability test
- UCC test.
- Consolidation test

4. RESULTS AND DISCUSSION

❖ **Liquid Limit:** The Liquid furthest reaches of red soil were discovered to be 28% which was low contrasted with that of dark cotton soil. Dark cotton soil utilized for the task work had a fluid restriction of 73%. The expansion of dark cotton soil to the red soil expanded the Liquid furthest reaches of the blend from 28% to 37% with 25% of dark cotton soil. The variety is introduced in the figure. This might be because of the impact of mud particles present in the dark cotton soil, henceforth expansion in the thickness of diffuse twofold layer prompts expansion in the water holding limit.

❖

Table 4.1: **Liquid limit of red soil treated with various percentage of BC soil**

Mixture	Liquid limit (%)
Red soil	28
RE + 10% BC	30
RE + 15% BC	31
RE + 20% BC	34
RE + 25% BC	37

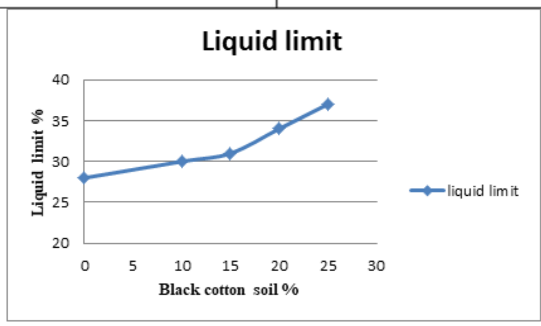


Fig 4.1: **Variation in Liquid Limit of red soil with different percentage of BC soil**

❖ **Plastic Limit: The** plastic furthest reaches of red soil and dark cotton soil was discovered to be 13% and 43% individually. At the point when dark cotton soil was added to the red soil, the blends versatility increments from 13% to 21% with 25% dark cotton soil. The outcomes acquired are displayed in the table. This might be because of the dirts particles which lead to increment in the shearing opposition at the molecule level. Thus, water needed to bring down the shear strength of particles in order to empower them to slide quick one over the other is more.

Table 4.2: Variation in Plastic Limit of red soil with variation in black cotton soil

Mixture	Plastic limit (%)
Red soil	13
RE + 10% BC	15
RE + 15% BC	17
RE + 20% BC	19
RE + 25% BC	21

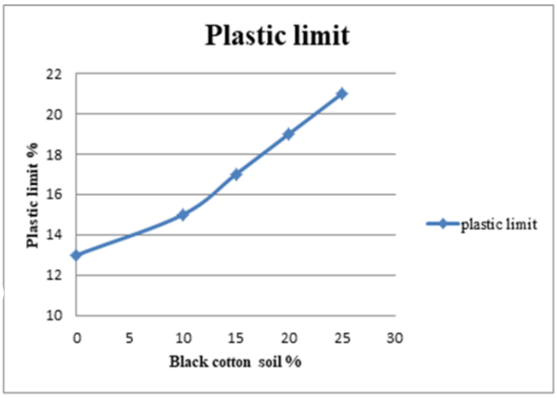


Fig 4.2 : Variation in plastic limit of red soil with different percentage of BC soil

❖ **Shrinkage Limit:** Shrinkage breaking point of soil is a decent pointer of its breadth. Higher as far as possible, lower is its breadth. The material of liner should forces low shrinkage, for its working and strength. Red soil at first has higher shrinkage cutoff of about 19%, after blending of dark cotton soil with various rates as far as possible abatements to 13% with 25% of dark cotton soil. The varieties are introduced in the figure. The diminishing in shrinkage limit is because of the expansion in mud division in the blend.

Table 4.3 : Variation in Shrinkage Limit of red soil with variation in black cotton soil

Mixture	Shrinkage limit (%)
Red soil	19
RE + 10% BC	17
RE + 15% BC	16
RE + 20% BC	14
RE + 25% BC	13

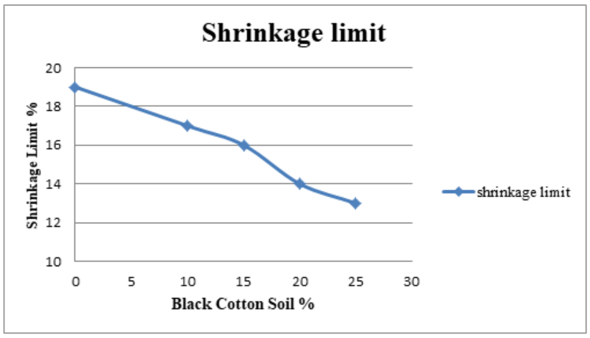


Fig 4.3 : Variation in shrinkage limit of red soil with different percentage of BC soil

❖ **Compaction Characteristics:** The compaction is a mechanical cycle wherein the densification is accomplished through the removal of air voids at practically steady water content of soil mass. For most of the exercises embraced in the field to accomplish soil compaction, the significant info is the consequences of lab compaction tests-standard or altered delegate or smaller than normal compaction tests.

Table 4.4: Compaction characteristics of red soil mixed with various percentage of Black cotton soil

Materials	Maximum Dry Density (MDD) kN/m^3	Optimum Moisture Content (OMC) %
Red soil	18.74	14.5
Black cotton soil	12.95	36.2
RE + 10% BC	17.51	17.31
RE + 15% BC	17.05	19.1
RE + 20% BC	15.02	20.6
RE + 25% BC	15.06	22.4

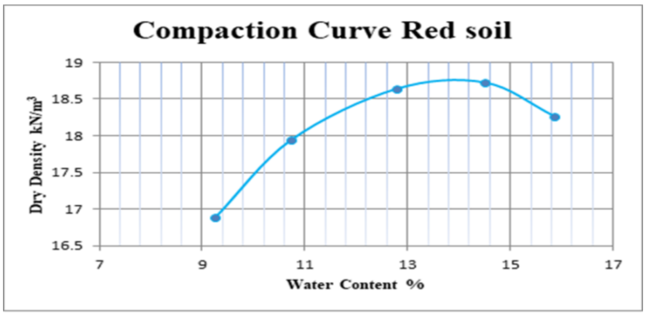


Fig 4.4.1 : Compaction Curve for Red soil

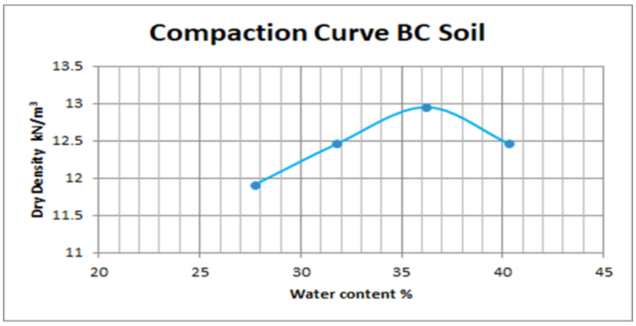


Fig 4.4.2 : Compaction Curve for BC soil

As the expansion of dark cotton soil to the red soil expands greatest dry thickness diminishes with expanding ideal dampness content as displayed in table 5.5 and fig 5.6. The most extreme dry thickness lessens from 17.51 kN/m3 when 10% BC soil added, to 15.06 kN/m3 when 25% BC soil was added. There is an increment in ideal dampness from 14.5% to 22.4% individually.

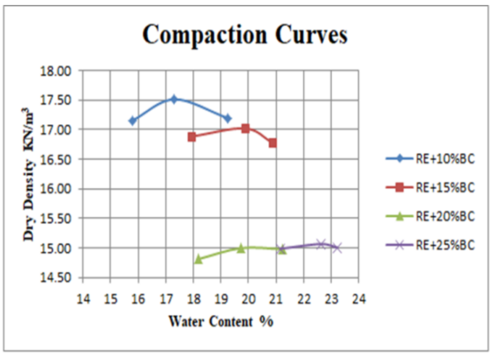


Fig 4.4.3: Compaction Curves for red soil mixed with various percentage of Black cotton soil

→ UCS of red soil treated with BC soil:

The strength of soil relies upon thickness and bond creating between particles with time. Strength of all dirts is affected by dampness changes however the broad muds are frequently exposed to outrageous changes in strength in light of dampness changes. In the current examination, strength properties of red soil, dark cotton soil and red soil with various rates of dark cotton soil are considered utilizing UCS test. The test is upsides of red soil, Bc soil & red soil with mix of dark cotton soil is recorded in table

Table 4.4: Unconfined Compressive Strength

Materials	Unconfined Compressive Strength (kPa)
Red soil	416.34
Black cotton soil	137.09
RE + 10% BC	336.12
RE + 15% BC	249.01
RE + 20% BC	151.14
RE + 25% BC	117.26

The unconfined compressive strength of red soil was discovered to be 416.34 kPa and that of dark cotton soil was discovered to be 137.09 kPa. From the above table it is unmistakably considered that to be the level of dark cotton soil builds the strength of blend is diminishing which isn't appropriate for the liner material, further the combination ought to be blessed to receive increment the strength. The necessary strength for liner material is over 200 kPa.

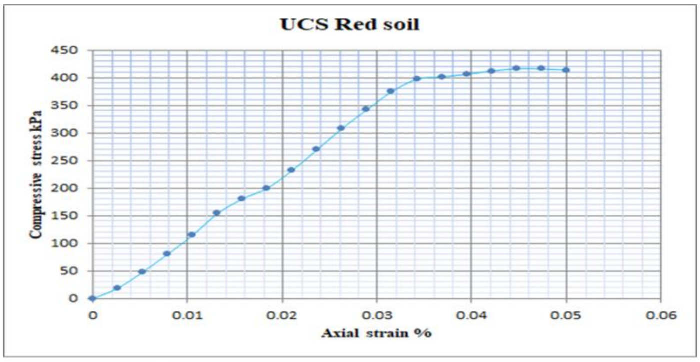


Fig 4.4.1: Unconfined compressive strength for red soil

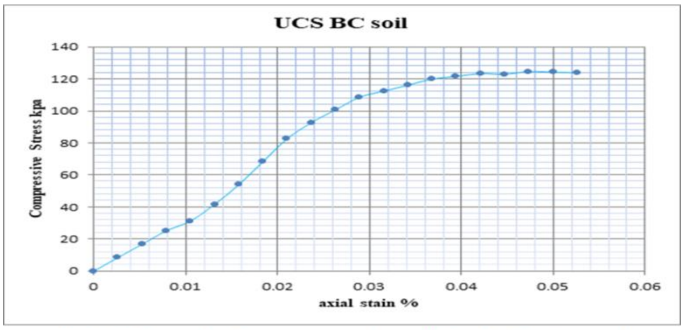


Fig 4.4.2: Unconfined compressive strength for black cotton soil

As seen from the table, the unconfined compressive strength of red soil alone for guaranteed testing was 416.34 kPa. On expansion, of 10% to 25% of dark cotton soil to red soil, the strength diminishes on quick testing because of expansion in diffuse twofold layer thickness and scattering of mud particles. Fig shows the variety in unconfined compressive strength of red soil with expanding level of dark cotton soil.

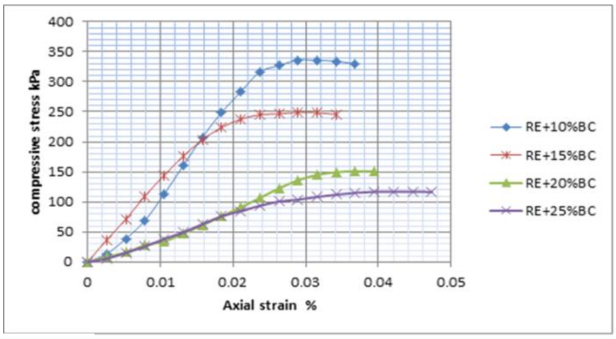


Fig 4.4.3: Unconfined compressive strength of red soil with increasing percentage of black cotton soil.

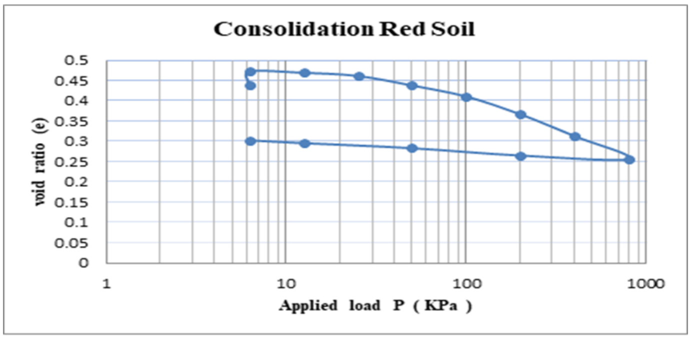


Fig 4.5: Pressure-void ratio relationship for red soil

→ Characteristics of Permeability of red soil treated with black cotton soil:

The average value of "k" of red soil sample were calculated as per IS: 2720 (Part17) 1986 by Falling Head Permeability method. The variation of "k" of red soil, black cotton soil and red-black cotton soil mixture compacted at OMC is presented in the table

Table 4.4 : Variation in coefficient of Permeability

Material	Coefficient of Permeability (cm/sec)
Red soil	1.723×10^{-5}
Black cotton soil	2.4053×10^{-8}
RE + 10% BC	1.3048×10^{-6}
RE + 15% BC	1.4007×10^{-7}
RE + 20% BC	9.4989×10^{-8}
RE + 25% BC	4.1065×10^{-8}

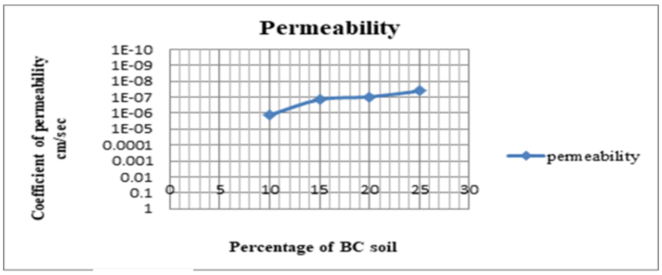


Fig 4.4: Variation in coefficient of permeability

Consolidation conduct of red soil treated with BC soil

- **Red soil**

Pressure-Void ratio Relationship:

Combination test is directed for soil tests of Red soil to assess the compressibility conduct. The example had an underlying void proportion of 0.44. The example is exposed to growing at first under a seating tension of 6.25 kPa. Subsequently the Red soil is swollen to a void proportion of 0.47 and in this way showing a swell capability of 2.33%

Table 4.5: Consolidation parameters of red soil

Consolidation parameters		50-100 kPa	100-200 kPa	200-400 kPa	400-800 kPa
Coefficient of compressibility (a_v)	Kg/cm^2	0.05365	0.04292	0.02644	0.01380
Coefficient of volume change (m_v)	Kg/cm^2	0.03728	0.02982	0.01837	0.00959
Coefficient of consolidation (c_v)	cm^2/min	0.00599	0.00179	0.00104	0.00280

- **Black cotton soil**

Pressure-Void ratio Relationship:

Consolidation test is directed for soil tests of Black cotton soil to assess the compressibility conduct. The example had an underlying void proportion of 1.03. The example is exposed to growing at first under a seating tension of 6.25 kPa. The dark cotton soil is swollen to a void proportion of 1.14 and hence showing a swell capability of 5.19%

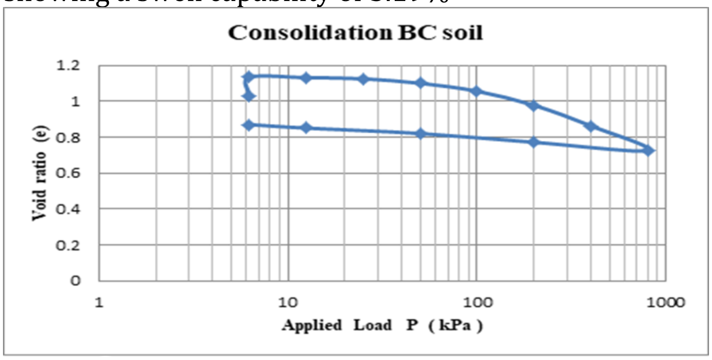


Fig 4.6: Pressure-void ratio relationship for Black cotton soil

Table 4.6: Consolidation parameters of Black cotton soil

Consolidation parameters		50-100 kPa	100-200 kPa	200-400 kPa	400-800 kPa
Coefficient of compressibility (a_v)	Kg/cm^2	0.0873	0.0766	0.0564	0.0335
Coefficient of volume change (m_v)	Kg/cm^2	0.0430	0.0377	0.0278	0.0165
Coefficient of consolidation (c_v)	cm^2/min	0.00211	0.00177	0.00170	0.00177

- **Red Soil with variation of Black cotton soil Pressure-Void ratio Relationship:** Consolidation test is directed for soil tests of Red soil with varieties in Black cotton soil to assess the compressibility conduct. The variety of void proportion's for various level of dark cotton soil is classified in table and it very well may be seen that as the applied pressing factor expands, the void proportion diminishes because of expulsion of pore water from the pores of the dirt mass. The expanding of red soil treated with dark cotton soil increments with expansion in level of dark cotton soil. This increment in expanding is because of the increment in level of earth content in soil. The e-log (P) bend from the test outcomes is as displayed in the figure.

Table 4.7: Void ratio's for different percentage of RE and BC soil mixture at different applied pressure

Mixture	Void ratio							
	Applied pressure in kPa							
	6.25	12.5	25	50	100	200	400	800
RE + 10% BC	0.45	0.44	0.43	0.41	0.38	0.35	0.30	0.24
RE + 15% BC	0.49	0.49	0.48	0.46	0.44	0.41	0.38	0.33
RE + 20% BC	0.66	0.66	0.65	0.62	0.59	0.55	0.51	0.47
RE + 25% BC	0.74	0.74	0.73	0.70	0.66	0.63	0.59	0.55

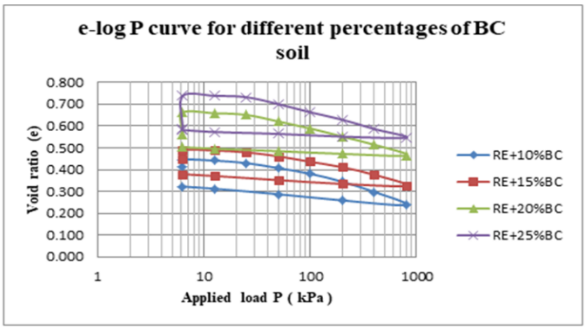


Fig 4.7: Pressure-void ratio relationship for red soil with variation in black cotton

Further, the respective soil samples are subjected to compression from their swollen void ratio, up to an effective pressure of 800 kPa. The consolidation curves (e-log p curves) is presented in Fig swelling pressure is calculated from the consolidation curves presented in Fig 5.13 (swelling pressure is the pressure required to be applied to attain the initial void ratio). The red soil sample exhibited a swelling pressure of about 110 kPa. Various consolidation parameters such as cv, mv, av are calculated and presented in Table .

Table 4.8: Variation of void ratios at various applied pressure for different mixtures

Applied pressure / Mixture	Void Ratio		
	6.25 kPa	100 kPa	800 kPa
RE + 10% BC	0.445	0.381	0.238
RE + 15% BC	0.489	0.436	0.327
RE + 20% BC	0.661	0.589	0.465
RE + 25% BC	0.739	0.663	0.547

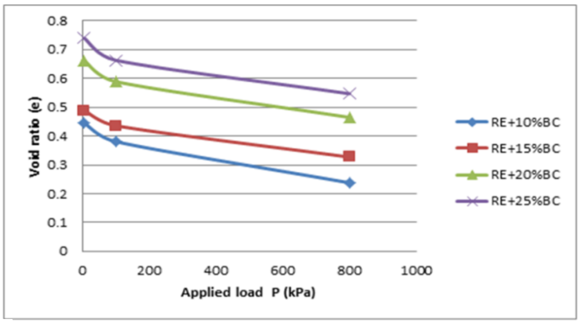


Fig 4.8: Variation of void ratios of Red soil mixed with different percentages of Black cotton soil at selected applied pressure

Coefficient of consolidation { cv}

The variety of Co-Efficient of solidification for Red soil blended in with various rates of Black cotton soil was resolved and the qualities are arranged in table. From fig it is seen that as applied pressing factor expands, the coefficient of combination diminishes for Red soil with expansion in level of Black cotton soil.

Table 4.9: Variation of coefficient of consolidation at different applied pressure

Applied pressure / Mixture	Coefficient of consolidation C_v x 10^{-3} (cm^2/min)		
	200 kPa	400 kPa	800 kPa
RE + 10% BC	3.13	1.05	2.57
RE + 15% BC	7.42	5.31	4.00
RE + 20% BC	8.44	0.38	0.51
RE + 25% BC	3.63	10.64	16.56

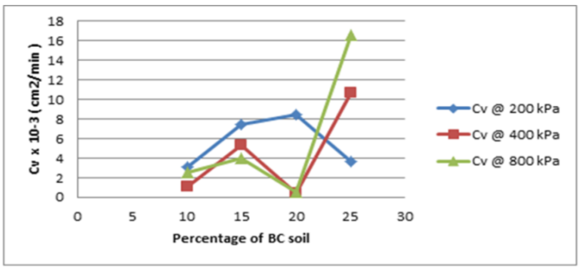


Fig 4.9: Variation of Cv values of Red soil mixed with BC soil at different applied pressures

Table 4.10: Consolidation parameters for the respective soil mixtures

Soil description	Consolidation parameters		50-100 kPa	100-200 kPa	200-400 kPa	400-800 kPa
Red soil + 10% BC soil	Coefficient of compressibility (a_v)	Kg/cm^2	0.0508	0.0354	0.0231	0.0146
	Coefficient of volume change (m_v)	Kg/cm^2	0.0359	0.0250	0.0163	0.0103
	Coefficient of consolidation (c_v)	cm^2/min	0.0033	0.0031	0.0010	0.0025
Red soil + 15% BC soil	Coefficient of compressibility (a_v)	Kg/cm^2	0.0486	0.0243	0.0171	0.0121
	Coefficient of volume change (m_v)	Kg/cm^2	0.0335	0.0167	0.0117	0.0121
	Coefficient of consolidation (c_v)	cm^2/min	0.0030	0.0074	0.0053	0.0040
Red soil + 20% BC soil	Coefficient of compressibility (a_v)	Kg/cm^2	0.0628	0.0365	0.0182	0.0118
	Coefficient of volume change (m_v)	Kg/cm^2	0.0402	0.0233	0.0116	0.0076
	Coefficient of consolidation (c_v)	cm^2/min	0.0006	0.0084	0.0003	0.0005
Red soil + 25% BC soil	Coefficient of compressibility (a_v)	Kg/cm^2	0.0733	0.0332	0.0209	0.0096
	Coefficient of volume change (m_v)	Kg/cm^2	0.0461	0.0208	0.0131	0.0060
	Coefficient of consolidation (c_v)	cm^2/min	0.0056	0.0036	0.0106	0.0165

Compression index

Table 4.11: Variation of compression index (Cc) of Red soil and Red soil with different percentages of Black cotton soil.

Mixtures	Cc values						
	Applied pressure (kPa)						
	12.5	25	50	100	200	400	800
Red soil	0.0103	0.0259	0.0779	0.0909	0.1454	0.1792	0.1869
Black cotton soil	0.0072	0.0216	0.0829	0.1478	0.2596	0.3822	0.4543
RE + 10% BC soil	0.0130	0.0365	0.0782	0.0861	0.120	0.1565	0.1983
RE + 15% BC soil	0.0052	0.0283	0.0618	0.0824	0.0824	0.1159	0.1648
RE + 20% BC soil	0.0086	0.0259	0.1008	0.1065	0.1238	0.1238	0.1612
RE + 25% BC soil	0.0029	0.0207	0.1066	0.1243	0.1125	0.1421	0.1302

From fig it is procured that the Cc of Red soil when mixed along with different percentages of Black cotton soil increases as applied pressure increases. Least compression index values are observed in the combination of Red soil and 25% black cotton soil.

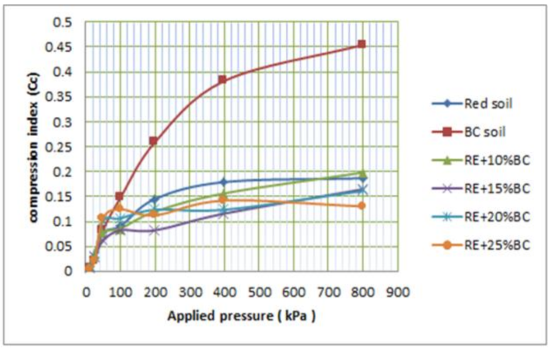


Fig 4.12: Curves showing variation in compression index (Cc) of different soil mixtures

- **PROPERTIES OF RED SOIL & OPTIMUM BLACK COTTON SOIL MIXED WITH LIME:**

The Liquid furthest reaches of red soil treated with the ideal level of Black cotton soil with 1% lime were discovered to be 43%. At the point when Red soil with ideal Black cotton soil combination is treated with 4% lime, as far as possible diminished to 38%, because of the substitution of sodium particles of soil with calcium particles of lime and reduced in thickness of the twofold diffused layer because of an expansion in electrolyte convergence of pore liquid which is credited with the impact of flocculation.

Table 4.12: Liquid limit of Red soil with optimum BC soil treated with various percentages of lime

Mixture	Liquid limit (%)
RE + 20% BC + 1% Lime	43
RE + 20% BC + 2% Lime	39
RE + 20% BC + 3% Lime	37
RE + 20% BC + 4% Lime	38

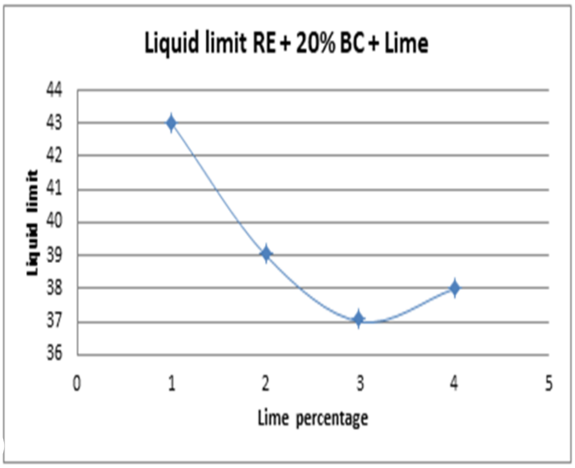


Fig 4.12: Variation in liquid limit of RE-BC mixture with various percentage of lime

- **Plastic Limit:** Expansion of 1% lime to Red soil and ideal level of BC soil as far as possible is discovered to be 27% with an addition of 1% to 4% lime as far as possible diminished up to 21% as displayed in the table. The reduction in plastic cutoff is seen because of flocculation of the mud particles and furthermore because of expanded surface region in soil-lime blends.

Table 4.13: Plastic limit of Red soil with optimum BC soil treated with variou percentages of lime

Mixture	Plastic limit (%)
RE + 20% BC + 1% Lime	27
RE + 20% BC + 2% Lime	22
RE + 20% BC + 3% Lime	19
RE + 20% BC + 4% Lime	21

Table 4.14: Shrinkage limit of Red soil with optimum BC soil treated with various percentages of lime

Mixture	Shrinkage limit (%)
RE + 20% BC	14
RE + 20% BC + 1% Lime	15
RE + 20% BC + 2% Lime	21
RE + 20% BC + 3% Lime	25
RE + 20% BC + 4% Lime	26

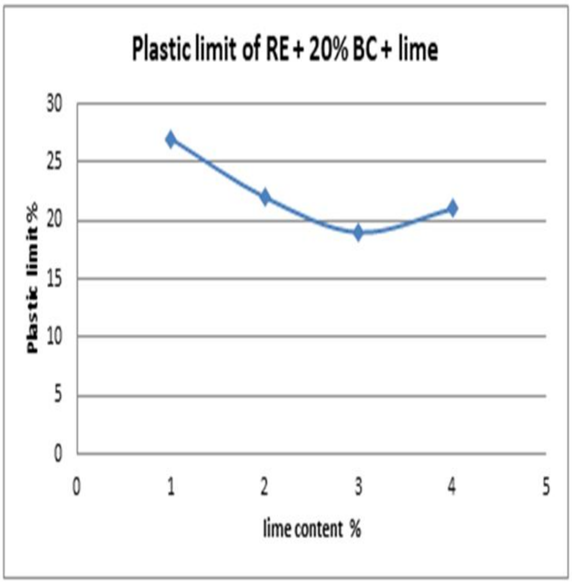


Fig 4.13: Variation in Plastic limit of RE-BC mixture with various percentage of li

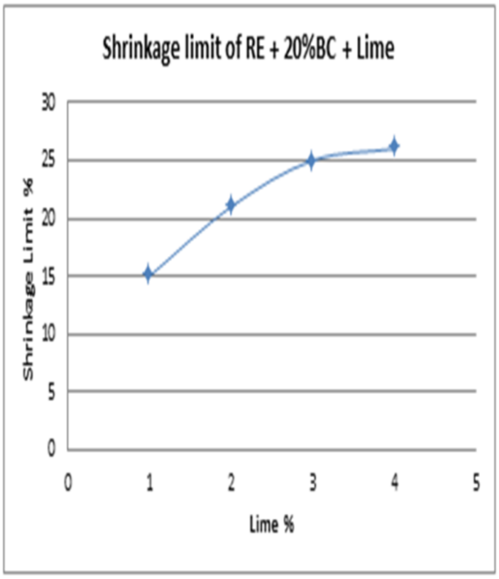


Fig 4.14: Variation in Shrinkage limit of RE-BC mixture with various percentage of lime

- The shrinkage furthest reaches of Red soil treated with ideal level of Black cotton soil BC was 14%. The shrinkage furthest reaches of BC soil treated with ideal level of groundnut shell debris and 1% lime is 15% on additional increment in lime for 4% as far as possible was 26% as displayed in the table. This shows that shrinkage cutoff of soil increments steadily with expansion in level of lime. This is because of further developed degree of settled soil and furthermore because of lessening of diffuse twofold layer thickness by feline particle trade. With the expanding restoring period, as far as possible increments because of flocculation and agglomeration.

- **Unconfined Compressive Strength:** The strength of Red soil and ideal level of Black cotton soil is 151.14 kPa. There was an increment in strength when 3% lime is added 278.73 for 14 days relieving as displayed in table. A comparable pattern is seen at 28 days restoring periods. The increment in strength up to 4% expansion of lime might be expected to pozzolanic response compounds. Successful infiltration of lime and arrangement of new cementations items, for example, calcium silicate hydrate and calcium aluminum hydrate (C-S-H and C-A-H), ties the dirt particles together. Henceforth 3% of lime to Red soil and Black cotton soil blend has been picked as ideal lime content of the combination.

Table 4.15: Unconfined compressive strength of Red soil with optimum BC soil with various percentages of lime

Mixture	Unconfined compression strength (kPa)		
	Curing periods in days		
	7	14	28
RE + 20%BC + 1%Lime	110.37	126.72	160.29
RE + 20%BC + 2%Lime	105.37	136.36	177.69
RE + 20%BC + 3%Lime	125.69	278.73	386.35
RE + 25%BC + 4%Lime	246.64	401.40	566.17

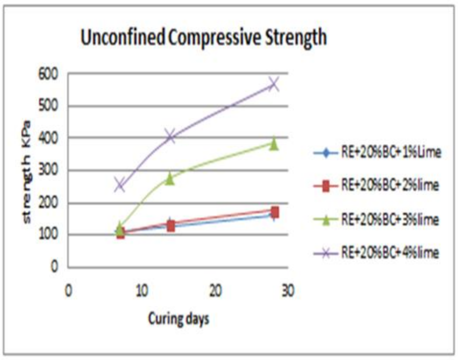


Fig 4.15: Unconfined compressive strength of Red soil with optimum BC soil with various percentages of lime

→ **Permeability Characteristics:** The coefficient of penetrability of red soil with ideal Black cotton soil and 3% lime was6.517 x 10-8. 3% lime was picked as the strength was accomplished for 3% lime blend. The coefficient of porousness of Red soil alone was 1.723 x 10-5 and Red soil with ideal Black cotton soil was 9.4989 x 10-8. So there is a diminishing in coefficient of porousness as the lime is added. Expansion of 3% lime diminishes the coefficient of penetrability.

Table 4.16: Variation in Coefficient of permeability with lime

Material	Coefficient of Permeability (cm/sec)
Red soil	1.723×10^{-5}
RE + 20% BC	9.498×10^{-8}
RE + 20% BC + 3% Lime	6.517×10^{-8}

- **Consolidation characteristics of Red soil with optimum % of BC soil and optimum percentage of lime**

→ **Pressure-Void ratio Relationship:** Consolidation test is directed for Red soil with ideal level of Black cotton soil and ideal level of lime to assess the compressibility conduct. The example had an underlying void proportion of 0.804. The example is exposed to growing at first under a seating tension of 6.25 kPa. The dirt is swollen to a void proportion of 0.808 and along these lines showing a swell capability of 0.22%. From this it is seen that on expansion of lime the expanding of the dirt is irrelevant, while without lime the growing capability of soil blend was 2.98%. The expanding pressure is additionally unimportant on option of lime as displayed in fig

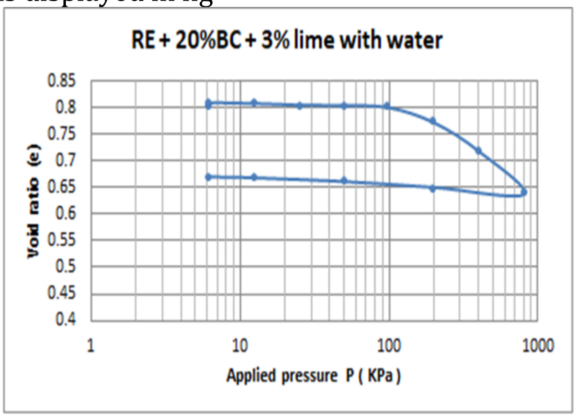


Fig 4.16: Pressure-void ratio relationship for red soil with optimum percentage of black cotton soil and optimum percentage of lime

Further, the particular soil tests are exposed to pressure from their swollen void proportion, up to a successful pressing factor of 800 kPa. The union bends (e-log p bend) is introduced in Fig. Different solidification boundaries like cv, mv, av are determined and introduced in Table.

Table 4.17: Consolidation parameters of Red soil with optimum BC soil and optimum lime

Consolidation parameters		50-100 kPa	100-200 kPa	200-400 kPa	400-800 kPa
Coefficient of compressibility (a_v)	Kg/cm^2	0.0078	0.0273	0.0264	0.0198
Coefficient of volume change (m_v)	Kg/cm^2	0.0043	0.0152	0.0146	0.0110
Coefficient of consolidation (c_v)	cm^2/min	0.00211	0.00177	0.00170	0.00177

- **Consolidation characteristics of Red soil with optimum Black cotton soil and optimum lime in presence of Leachate**

→ **Pressure-Void ratio Relationship:** Consolidation test is conducted for Red soil with optimum % of Black cotton soil and optimum % of lime in presence of leachate to evaluate the compressibility behavior. The sample had an initial void ratio of 0.7. The sample exposed to expanding at first under a seating tension of 6.25 kPa. The soil does not swell thus exhibiting no swell potential. From this it is ensured that in the presence of leachate the soil didn't swell, whereas with water the swelling potential of soil mixture was 0.22%.

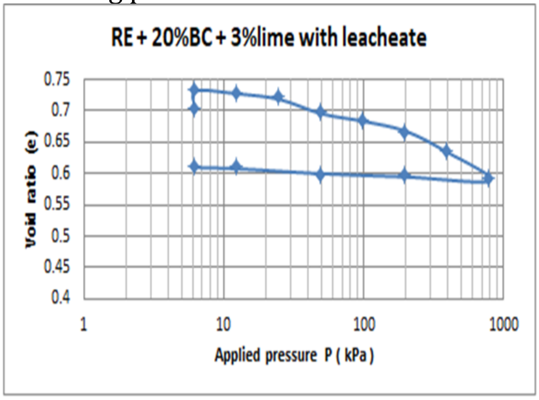


Fig 4.17: Pressure-void ratio relationship for red soil with optimum percentage of black cotton soil and optimum percentage of lime in presence of leachate

Further, the individual soil tests are exposed to pressure from their swollen void proportion, up to a successful pressing factor of 800 kPa. The union bends (e-log p bend) is introduced in Fig . Different union boundaries like cv, mv, av are determined and introduced in Table.

Table 4.18: Consolidation parameters of Red soil with optimum BC soil and optimum lime in presence of leachate

Consolidation parameters		50-100 kPa	100-200 kPa	200-400 kPa	400-800 kPa
Coefficient of compressibility (a_v)	Kg/cm²	0.0234	0.0156	0.0166	0.0110
Coefficient of volume change (m_v)	Kg/cm²	0.0138	0.0092	0.0098	0.0065
Coefficient of consolidation (c_v)	cm²/min	0.00211	0.00177	0.00170	0.00177

5. CONCLUSIONS

- From the above tests it has considered that to be the dark cotton soil rate is expanded in red soil the fluid furthest reaches of the dirt increments because of the increment in earth particles in the dirt.
- It is additionally seen that the ideal dampness content of the red soil increments as the level of the dark cotton soil increments, where as the greatest dry thickness diminishes separately.
- Unconfined compressive strength of the red soil diminishes as the level of the dark cotton soil increments.
- Permeability of the red soil diminishes as the level of dark cotton soil increments. According to the necessity for the liner material the coefficient of porousness of soil was accomplished for the 20% of dark cotton soil blended in with red soil.
- Unconfined compressive strength of the red soil with 20% dark cotton soil is less according to the prerequisite of liner material, so to expand the strength of the dirt the combination is treated with various rates of lime.

→ In view of the tests done on compacted Red soil changed with Black cotton soil and lime following outcomes was drawn:

- From the above investigations and conversations Red soil blended in with 20% Black cotton soil fulfills the measures of water driven conductivity for liner materials, however didn't met the standards for strength.
- As distinctive lime rate is included the Red soil and ideal level of dark cotton soil the consistency properties like fluid cutoff, plastic breaking point and versatility list are diminishing. In any case, as far as possible builds which is useful for liner material?
- There is an increment in unconfined compressive strength, when the lime is included the ideal blend. Red soil with ideal Black cotton soil and 3% lime is picked for additional examinations as the necessary strength is accomplished at option of 3% lime.
- Curing with lime works on the unconfined compressive strength for red earth-dark cotton soil combination. The pace of solidarity acquire is delayed with lime as long as 7 days however increments impressively past 7 days restoring.

- There is slight abatement in Permeability of the Red soil with ideal Black cotton soil and lime, however its inside the models for necessity of liner material, i,e under 1X10-7cm/sec.
- The expansion of lime further develops the volume steadiness of the blend. The impact of lime is better in decreasing the compressibility of the dirt combination.

In view of the general assessment, it has been presumed that red earth + 20% dark cotton soil combination settled with 3% lime can be utilized as a material for liner development.

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