IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 4, Ser. II (Jul - Aug 2019), PP 64-73
www.iosrjournals.org

An Experimental Study On Strength Characteristics Of Expansive Soil Stabilized With Calcium Sulphate And Shredded Rubber

V. Santhosh kumar[1], D. Appana[2]
[1]*M.tech student Roll no- 17961D1901, Lenora Engineering College, Rampa chodavaram, E.G.Dist, AP, India.*
[2] *Assistant Professor, Department of Civil Engineering, Lenora Engineering College,Rampachodavaram, E.G.Dist, AP, India*
Corresponding Author: V. Santhosh kumar

Abstract *Expansive soils are susceptible to detrimental volumetric changes with changes in moisture content causes distortions to the structures constructed on these soils. Use of calcium based stabilizes to enhance clay's engineering properties is a common practice in road subgrade improvement. The addition of a calcium based stabilizer increases the calcium content of the soil to reduce the diffuse double layer by cation exchange and leads to flocculation and agglomeration of the clay microstructure. The addition of calcium hydroxide (Ca(OH)2) allows cementitious hydrates to form, via pozzolanic reactions, that increase soil strength. Problems can arise when sulfate and alumina are readily available within the natural state of the soil. There are many methods of stabilization of sub grade expansive soil. Treating the soil with additives is one such technique in improving the engineering properties of the expansive soil. The main objective of this work is to study the effectiveness of stone dust on the engineering properties of expansive soil.Laboratory experimentation is conducted on the expansive soil collected from surrounding areas and soil having the highest Differential Free Swell of 60%, collected from mortha near tanuku town of Andhra Pradesh is taken, India and gypsum from bhimavaram Andhra Pradesh, India and shredded rubber from locally available tyre. Different tests like Atterberg limits, Differential Free Swell, Dry Density were conducted on the expansive soil. Series of dry density tests were conducted on soil which is treated with gypsum at various percentages like 5%, 10%, 15%,and 20%&1,2,3,4 % shredded rubber tyre , by weight of the expansive soil and results of the testing are reported.*

Date of Submission: 26-07-2019 Date of Acceptance: 12-08-2019

I. Introduction

1.1 GENERAL

A land based structure of any type is only as strong as its foundation. For that reason, soil is a critical element influencing the success of a construction project. Soil is either a part of the foundation or one of the raw materials used in construction process. Therefore, understanding the engineering properties of soil is crucial to obtain strength and economic performance. Most recently, soil stabilization has once again become a popular trend as global demand for raw materials, fuel and infrastructure has increased.

Soil stabilization is the process of maximizing the suitability of soil for a given construction purpose .Soil stabilizers can be used to treat the upper several inches of soil or aggregate surfaces of low-volume roads when the strength or other properties of the in-situ soil do not meet the desired or required levels for anticipated traffic. Soil can be either modified or stabilized by many methods, including chemical, mechanical, thermal, and electrical. Modification is generally short term and includes benefits such as improvement in workability (expediting construction and saving time and money). Stabilization results in a longer term strength gain. Expansive soils are found in arid and semi-arid regions of the world and, hot climate and poor drainage conditions are usually associated with the formation of these soils. In INDIA, these soils are generally called as black cotton soils and cover about 20% of the total land area. They are found in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu.

Expansive soils are highly problematic because of their alternate swelling and shrinkage. World over, problem of expansive soils has appeared as cracking and break-up of pavements, railway and highway embankments, roadways, building foundations, irrigation systems, water lines, sewer lines, canal and reservoir linings. The losses due to extensive damage to highways running over expansive soil sub-grades are estimated to be in billions of dollars all over the world. Various remedial measures like soil replacement, moisture control, pre-wetting, lime stabilization have been practiced with varying degrees of success. However, these techniques suffer from certain limitations with respect to their adaptability, like longer time periods required for pre-wetting the highly plastic clays, difficulty in constructing the ideal moisture barriers, pulverization and mixing problems in case of lime stabilization and high cost for hauling suitable refill material for soil replacement etc.Many researchers, all over the World are working, to evolve more effective and practical treatment methods, to alleviate the problems caused to pavements laid on expansive soils.

.

1.2 REMEDIAL MEASURES TO OVERCOME PROBLEMS OF EXPANSIVE CLAY

In order to overcome all the above problems certain preventive measures have to be taken. These measures can be broadly classified into the following categories:

- Replacement of soil
- Soil modification methods

In case of foundations Stiffening of soil by adopting Mat Foundations, soil replacement technique, Stone columns and Heat treatment are some of the remedial measures to overcome the problems of compressible marine clay soils. In case of Pavement sub grades, stabilization techniques can be adopted using various industrial wastes considering the economy and also chemical admixtures and additives for easy mixing and early results. The reinforcement techniques also plays vital role in improving the load carrying capacity of the expansive soil beds.

1.3 OBJECTIVES OF THE STUDY

The objectives of present experimental study are as follows.

- The objective of the present work is to study the impact of the stabilizer like stone dust on the properties of expansive soil through laboratory experimentation.
- To identify the strategy of techniques to overcome the problems posed by expansive clays with a view to adopt suitable methodology through critical review of literature.
- To evaluate the performance of expansive clay when stabilized with proposed additive and its suitability .

II. Review Of Literature

Muthukkumaranetal. (2014) used gypsum and bottom ash was mixed with expansive montmorillonite soil and studied the effect on engineering properties of soil. Results have shown that there was a significant reduction in liquid limit which brought the plasticity index of soil below A- line; this specified that on adding of bottom ash and gypsum turned a clayey soil into silty soil and the swelling pressure reduced by about 35% when soil was mixed with gypsum alone and 48% reduction occurred when 4% of combined gypsum and bottom ash mix were used in stabilization. Unconfined compressive strength values got increased 5 times for six percentages of additives and crossed the minimum required value of strength i.e. of 350kPa. Effect of gypsum was more in an improvement of engineering properties of soil

Aly Ahmedetal. (2011) studied the effect of the soaking condition in a wet environment on the durability and stability of soft clay soil treated with recycled gypsum. Since gypsum was soluble in water in order to improve the stability and durability clay gypsum mixture cement and lime are added as agents. After mixing the admixtures in recycled gypsum and different proportions of lime and cement stabilizes the effect of wet environment on the durability of the gypsum, clay combination was analyzed by the author. The soaked samples were analyzed based on their deformation changes, compressive strength, durability index, and water absorption and soil deterioration. The results their studies have shown that by increasing the content of both types of admixtures improved stability and durability for the soil tested in a wet environment while the increase in the admixture ratio had the negative effect on together the stability and the durability of the samples subjected to soaking. Short soaking times, up to 15 days, had affected negatively on the durability, stability and changes in volume, and brought about a reduction in the soluble soil and the water absorption when compared with longer soaking times.

The literature of Işık Yilmaz et al. (2009) contains a vast number of stabilizing techniques such as cement, lime and fly-ash for a treatment of expansive clay soils. This paper deals with the performance of the expansive clay soils on an addition of gypsum in varying percentages. This improves the swelling and strength characteristics of parent soil. Obtained changes in the values of expansive characteristics, plasticity, swell percent and strength parameters of gypsum dried and natural samples specified that gypsum can be effectively used as a stabilizing agent for expansive clay soils.

Nurhayat Degirmenci (2008) in this research natural gypsum (NG) and were used as admixtures to improve the engineering properties of adobe soil. The flexural and compressive strength, softening in water, drying shrinkage in addition to unit weight values were determined on adobe samples. The strength of adobe samples improved with gypsum additions. On addition of 25% of gypsum onto adobe soil showed maximum resistance to softening in water. The drying shrinkage reduced on the addition of gypsum. The test results of the author revealed that gypsum can be used as an effective alternative material in adobe stabilization which could bring strength and economy and environmental pollution is reduced.

Baykal et al., (1992) mixed clay and fly ash samples with used tire obtained from retarding industry and hydraulic conductivity test were conducted and he observed that strength decrease once tyre percentage exceeds 30% Foose, (1996) falling head permeability test were conducted on rubber mixed soil sample and it was observed that when water permeated through samples, slight increases in hydraulic conductivity.

Papp et al., (1997) conducted research on shredded scrap tires blended with subbase soils under flexible pavements. Resilient modulus (Mr) testing was used to determine the plastic and elastic strains. Tests were conducted on cohesionless soils blended with varying amounts of shredded tire chips. Blend ratios ranged from 0.1 to 0.5 tire chips to soil by dry weight. The performance of the shredded tire blends was compared to that of the naturally occurring virgin soil used in subbase applications in New Jersey. He concluded that physically mixing tire chips with the soil did not present any problems except when excessive steel wires were protruding from the chips. The addition of the tire chips to the soil reduced both density and strength of the soil. The 50-mm (1.96-inch) tire chips were most economical and had the least negative strength impact.

Lee et al., (1999) determined the shear strength and stress strain relationship of tyre chip and a mixture of sand and tyre chips. They found out the stiffness and strength properties for tyre sheds and rubber sand mixture. Rao and Dutta, (2001) conducted studies on sand mixed with rubber chips. Compressibility tests and triaxial tests were conducted. The stress strain relations and strength parameters were studied. It was found that the value of internal friction and effective cohesion of sand increased with increase in percentage of rubber up to 15%.

Ghazavi (2004) investigated the suitability of recycled granular rubber as a lightweight backfill material. He observed that the unit weight of the soil was reduced from approximately 14 kN to approximately 8 KN original for the 70%rubber blend. Ghazavi concluded that 1. Addition of rubber to sand did not improve the shearing resistance of blends. 2. An apparent cohesion of approximately 10KPa was obtained from blends containing rubber grain. 3. Initial frictional angle decrease with increase in percent of rubber. 4. Unit weight of blend decrease with addition of rubber.

Cabalar (2011) blended GTR with sands from two geologic formations, Leighton Buzzard Sand (LBS) and Ceyhan Sand (CS). These sands were selected for their differences in structure and engineering properties. LBS is coarse with sub angular particles, and CS is fine with angular particles. The rubber particle size was not listed but the particles were described as “flaky.” Rubber was blended with each type of sand at 5, 10, 20, and 50% by weight.. Each blend was subjected to direct shear tests and observed that the shear stress and internal friction angle of the two mixtures decreased at about 10% rubber concentration and then leveled off. He concluded that the blends were useful as lightweight embankment fill on weak foundation soils and retaining wall backfill material since the sand rubber mixtures were significantly lighter than 100% sand mixtures.

Ventappa and Dutta (2016) performed a study with objective of determining compressibility and strength characteristics of sand and tire mixtures for suitability of sand tire chip mixture for embankment. they concluded that upto20% compressibility of sand-tire mixture was 1% i.e. intolerance limit for 10m height of embankment and produced cohesion between 7-17.5 KPa and also internal frictional angle increased from 38 to 40 degree.

III. Methodology

3.1 MATERIALS USED AND THEIR PROPERTIES

Soil The soil used was a typical black cotton soil collected from 'mortha' in tanuku, in west Godavari District, Andhra Pradesh State, India. All the tests carried on the soil are as per IS specifications.

Table 3.1 Properties of Soil

S.No	Property	Value
1.	**Differential free swell (%)**	61.1%
2.	**Specific Gravity (G)**	2.22
3.	**Grain size distribution** % finer	2.139
4.	**Atterberg limits** Liquid limit (%) Plastic limit (%) Plasticity index (%)	 85% 36.33% 48.67%

5.	**IS Classification**	CM-CH
6.	**Compaction properties** Optimum Moisture Content, (%) Maximum Dry Density, (g/cc)	 15% 1.66g/cc

Gypsum Gypsum (CaSO4.2H2O) is hydrated calcium sulphate used commonly in the industry because of its different property of dropping three-fourth of the joined water of crystallisation after moderately heated to just about 130^0c. In addition, calcined gypsum when cooled, finely ground and made plastic with water can be extended out, cast to several preferred surface or form. On drying, it sets into a solid rock-like form. Selenite is a transparent, colourless, crystalline variety of gypsum while alabaster is a fine-grained, massive variety, white or shaded in colour.. We have collected gypsum from Bhimavaram , West Godavari, Andhra Pradesh

Table 3. 1 Chemical composition of gypsum

S.NO	PROPERTY	RESULT
1	**Chemical Classification**	Sulfate
2	**Color**	Clear, colorless, white, gray, yellow, red, brown
3	**Streak**	White
4	**Luster**	Vitreous, silky, sugary
5	**Diaphaneity**	Transparent to translucent
6	**Cleavage**	Perfect
7	**Mohs Hardness**	2
8	**Specific Gravity**	2.3
9	**Diagnostic Properties**	Cleavage, specific gravity, low hardness
10	**Chemical Composition**	Hydrous calcium sulfate, $CaSO_4 \cdot 2H_2O$
11	**Crystal System**	Monoclinic
12	**Uses**	Used to manufacture dry wall, plaster, joint compound. An agricultural soil treatment.

3.3 shredded Rubber tyre

Rubber tyre was collected and cutted into small strips, tyre absorbs almost no water. The gas and water vapor permeability (only polar gases) is lower than for most plastics; carbons,oxygens.PE can become brittle when exposed to sunlight, carbon black is usually used as a UV stabilizer.rubber is a good electrical insulator. It offers good tracking resistance; however, it becomes easily electrostatically charged (which rubber can be reduced by additions of graphite, carbon black or antistatic agents) is of low strength, hardness and rigidity, but has a high ductility and impact strength as well as low friction.

3.3.1 Properties of shredded Rubber tyre

- Density 0.82
- Size 80 µm – 1.5 mm Elongation
- (%) 420 Rate of steel fiber 0%
- Shredded rubber tyre was cut into different sizes ranges from 1mm to 25mm (Width) and 3mm to 50mm (Length). Added amount of rubber tyre had been varied in proportions of 1%, 2%, 3% and 4%.

3..3.1 properties of rubber tyre

S.NO	Properties	values
1	Hardness	40-90
2	Elongation	300-700%
3	SBR	48%
4	Carbon black	47%
5	Extender oil	1.9%
6	Zinc oxide	1.1%
7	Stearic acid	0.5
8	Sulphur	0.8
9	Accelerator	0.7

3.4 LABORATORY EXPERIMENTATION

Tests were conducted in the laboratory on the expansive soil to study the behavior of expansive soil, when it is treated with stone dust.

The following tests were conducted as per IS Codes of practice.

- The grain size distribution.
- Specific gravity
- Index properties –Atterberg Limits (Liquid, Plastic limit)
- Swell Tests- Differential Free swell

- Maximum dry density and optimum moisture content (light compaction test)

STANDARD VALUES FROM IS CODES

PROPERTIES	**VALUES**
D.F.S	30-100
SPECIFIC GRAVITY	2-2.8
LIQUID LIMIT	40-200
PLASTIC LIMIT	10-100
C.B.R	2-10
U.C.S	1-3

IV. Experimental Results

4.1General

In the laboratory, index tests and strength tests were conducted by using different percentages of gypsum with a view to determine the optimum percentage of gypsum.The effect of addition of different percentages of gypsum to the expansive soil on the strength properties are discussed in detail in the following sections.

4.2 Differential free swell test (DFS)

Table 4. 1 Differential free swelling index of black cotton soil

Determination No	Measuring cylinder reading before		Measuring cylinder reading after 24 hrs		Free swelling index
	Kerosene	water	kerosene	water	%
1	9	9	9	14	55.55
2	9	9	9	13.5	50
3	9	9	9	14.5	61.11
4	9	9	9	13.8	53.33
5	9	9	9	14	55.55
6	9	9	9	14	55.55
7	9	9	9	13	44.44
8	9	9	9	13	44.44
9	9	9	9	13.2	46.6
10	9	9	9	14	55.55

Volume of soil in water = 14.5

Volume of soil in kerosene = 9

Differential free swell of soil is given by,

$$\text{DFS} = \frac{\text{soil volume in water} - \text{soil volume in kerosene}}{\text{soil volume in kerosene}} \text{x}100$$

$$\text{DFS} = \frac{14.5-9}{9}\text{x}100$$

DFS = 61.1%

4.2.3 Grain size analysis of the expansive soil

The soil is sieved through required sieves and the values will be formed a table and plot the graph of the soil, with those values and defining the soil categories

Soil at any place is composed of particles of a variety of sizes and shapes, sizes ranging from a few microns to a few centimeters are present sometimes in the same soil sample.

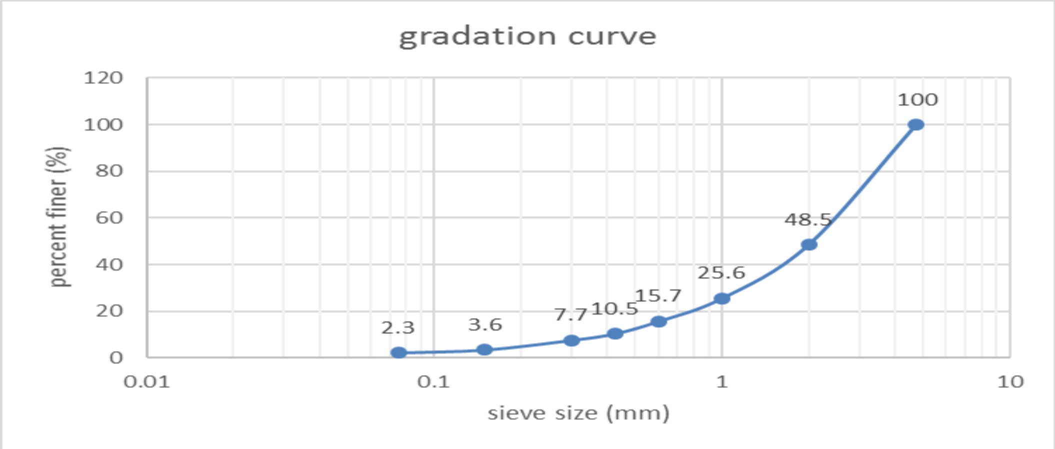
Based on the gradation results, the distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc.

Table 4.2 and Fig 4.1 present the soil analysis values and gradation curve of soil

Table 4. 2 sieve analysis of black cotton soil

sieve size (mm)	**amount of soil retained(g)**	**% of soil retained**	**cumulative weight(g)**	**cumulative%**	**%finer**
4.75	0	0	0	0	100
2.00	515	51.5	515	51.5	48.5
1.00	229	22.9	744	74.4	25.6
0.6	99	9.9	843	84.3	15.7
0.425	52	5.2	895	89.5	10.5
0.3	28	2.8	923	92.3	7.7
0.15	41	4.1	964	96.4	3.6
0.075	13	1.3	977	97.7	2.3

Pan	23	2.3	1000	100	0



Graph 4. 1 shows that sieve analysis of untreated expansive soil

D10 = 0.42mm, D30 =1.1mm, D60 =2.5 mm

Coefficient of Uniformity,

$Cu = \frac{D_{60}}{D_{10}} = 5.88$

Coefficient of Curvature,

$Cc = \frac{D_{30}{}^2}{(D_{60} \times D_{10})} = 1.13$

Hence the soil is well graded.

4.2.4 Specific gravity of expansive soil

Table 4. 3 Specific gravity of black cotton soil

Description	Sample
Weight of empty flask, W_1 (gm)	30
Weight of flask and the soil sample, W_2 (gm)	70
Weight of flask along with soil and water, W_3 (gm)	94
Weight of flask and water, W_4 (gm)	72
Specific gravity = $\frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$	2.22

4.2.5 Index properties of expansive soil

Liquid limit values of black cotton soil are as follows

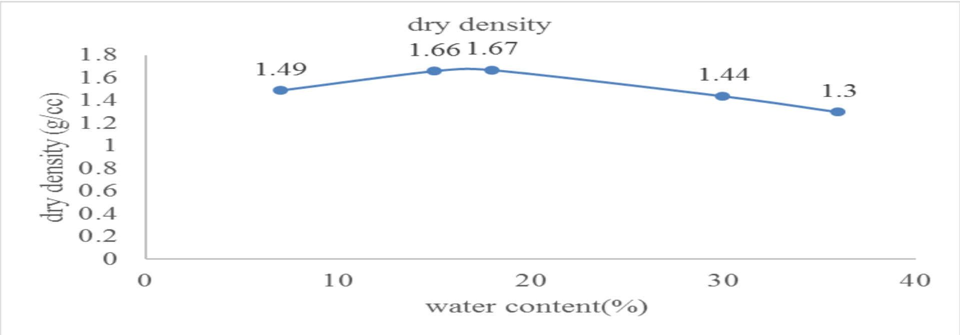
Table 4. 4 liquid limit of black cotton soil

Description	Sample-1	Sample-2	Sample-3	Sample-4
Weight of container, W_1	33	34	33	33
Weight of wet soil with container, W_2	40	46	44	46
Weight of dry soil with container, W_3	37	43	39	40
Weight of wet soil, $W_4 = W_2 - W_1$	7	12	11	13
Weight of dry soil, $W_5 = W_3 - W_1$	4	7	6	7
Weight of water, $W_6 = W_4 - W_5$	3	5	5	6
Moisture content, W (%) = $\frac{weight\ of\ water}{weight\ of\ dry\ soil} x100$	75	71	83.3	85.7
No. of blows	49	38	26	17

Table 4. 5 Plastic limit of black cotton soil

Description	Sample-1	Sample-2
Weight of container, W_1	33	33
Weight of wet soil with container, W_2	39	38
Weight of dry soil with container, W_3	37	36
Weight of wet soil, $W_4 = W_2 - W_1$	6	5
Weight of dry soil, $W_5 = W_3 - W_1$	4	3
Weight of water, $W_6 = W_4 - W_5$	2	2
Water content (or) moisture content $W (\%) = \frac{weight\ of\ water}{weight\ of\ dry\ soil} x100$	33.33%	40%

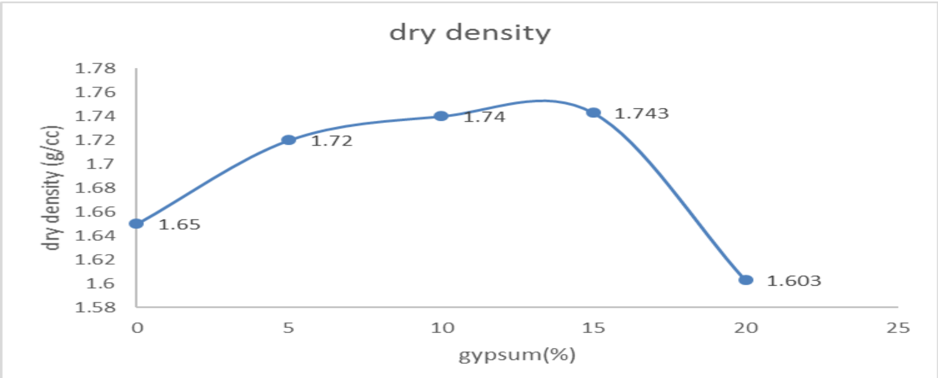
Liquid limit of expansive soil = 85%
Plastic limit of expansive soil = 36.6%
Plasticity index = 0.484
Hence the soil is classified as well graded soil.



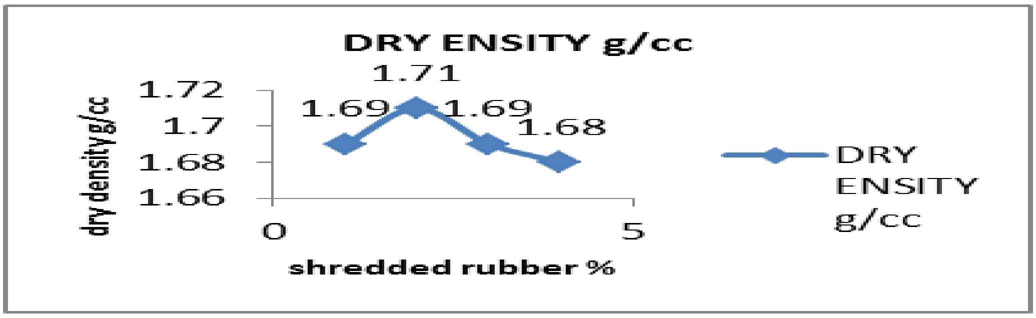
Graph 4. 2 Compaction curve of black cotton soil

Optimum moisture content (OMC) = 15%
Maximum dry density (MDD) = 1.65g/cc

.



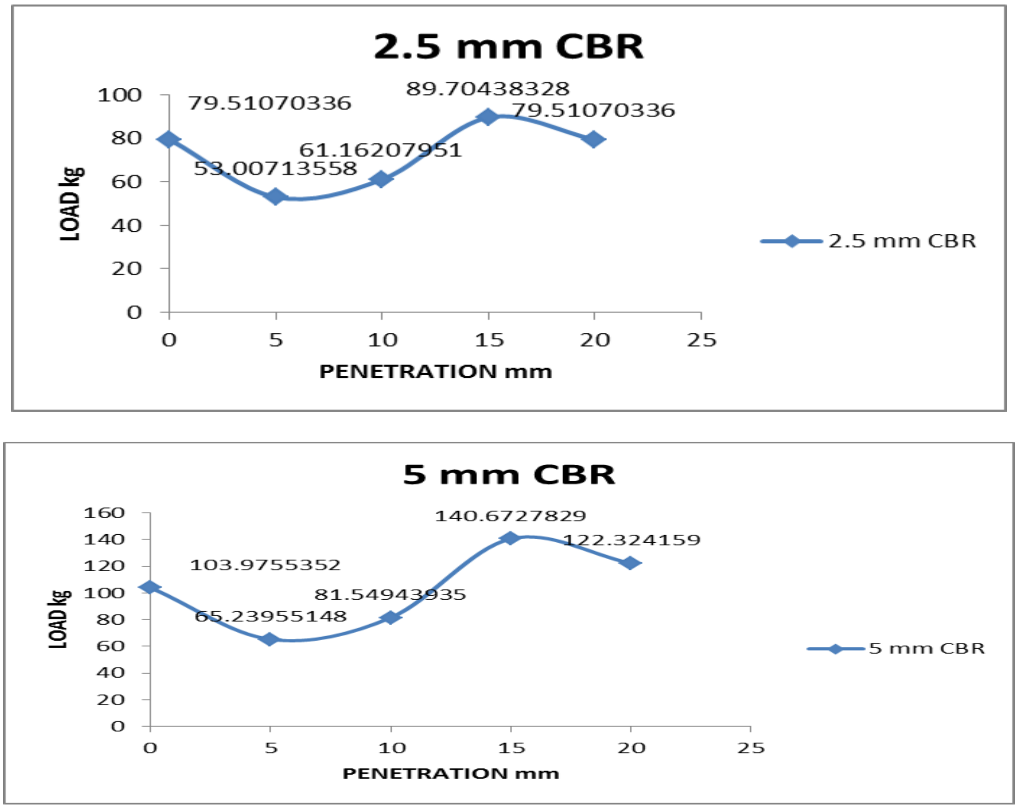
Graph 4. 3 variation of densities for different percentages of gypsum added at achieved OMC



Graph 4. 4 variation of densities for different percentages of

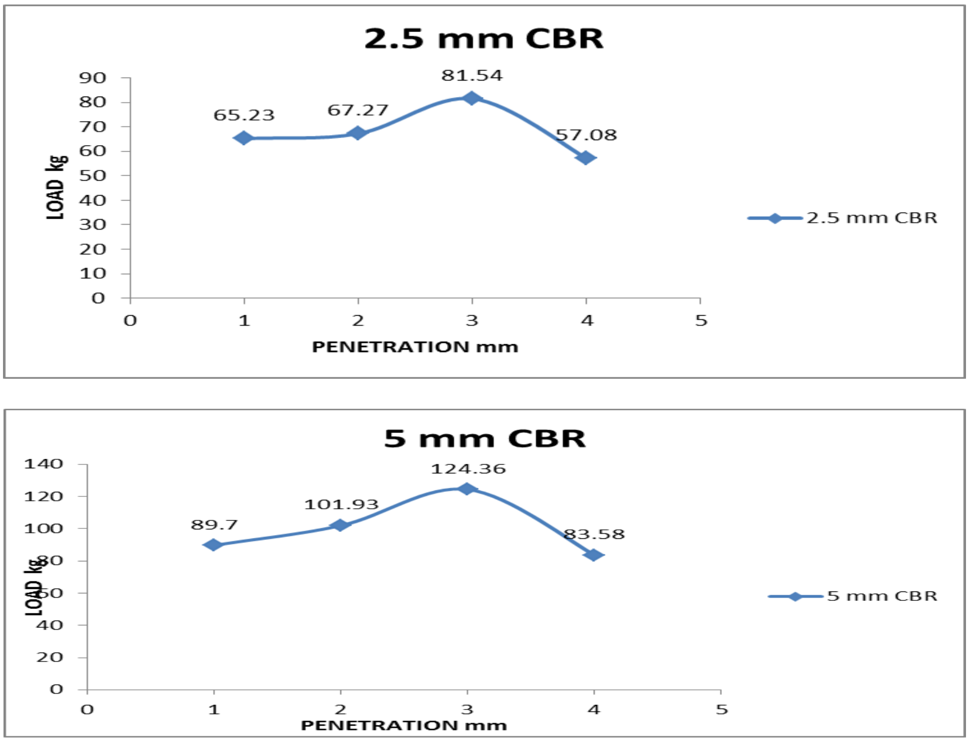
15 %gypsum & shredded rubber tyre added at achieved OMC

.



Graph 4. 5 variation of CBR for different percentages of gypsum added at achieved OMC

.

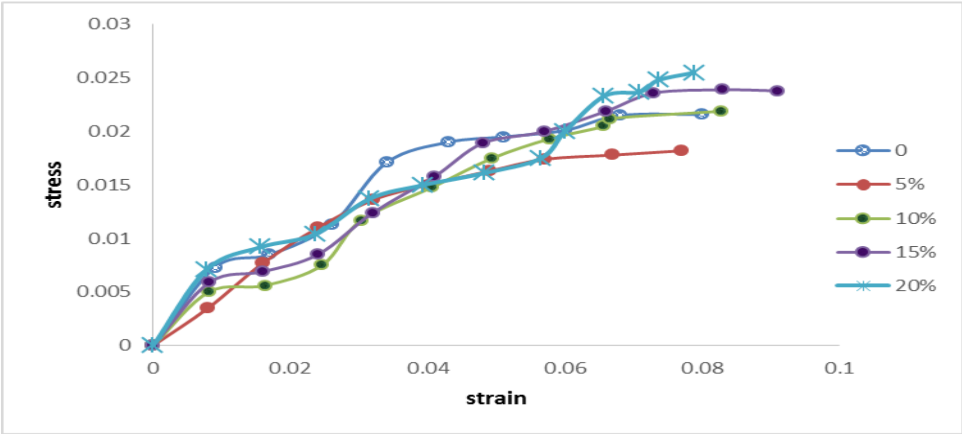


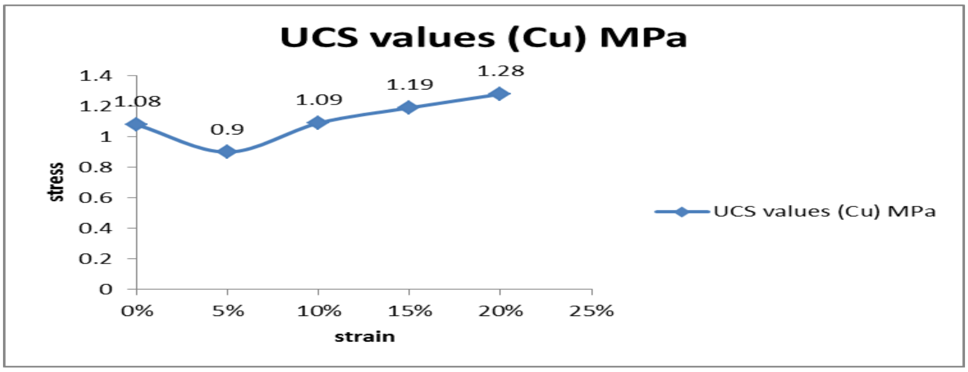
Graph 4. 6 variation of CBR for different percentages of gypsum & shredded rubber added at achieved OMC

4.3 Unconfined Compression (UCS) Tests

UCS values of black cotton soil and with stone dust mixture are as follows

Gypsum& shreddedrubber %	0%	5%	10%	15%	20%
UCS values (Cu) MPa	1.08	0.9	1.09	1.19	1.28

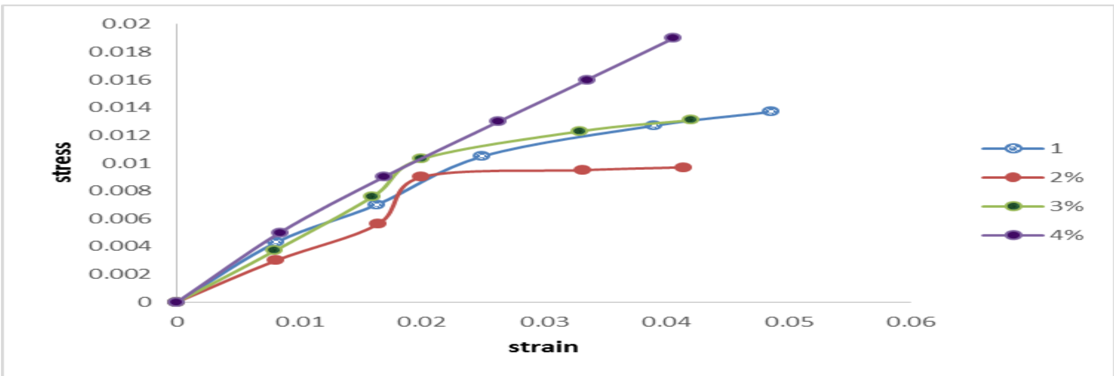


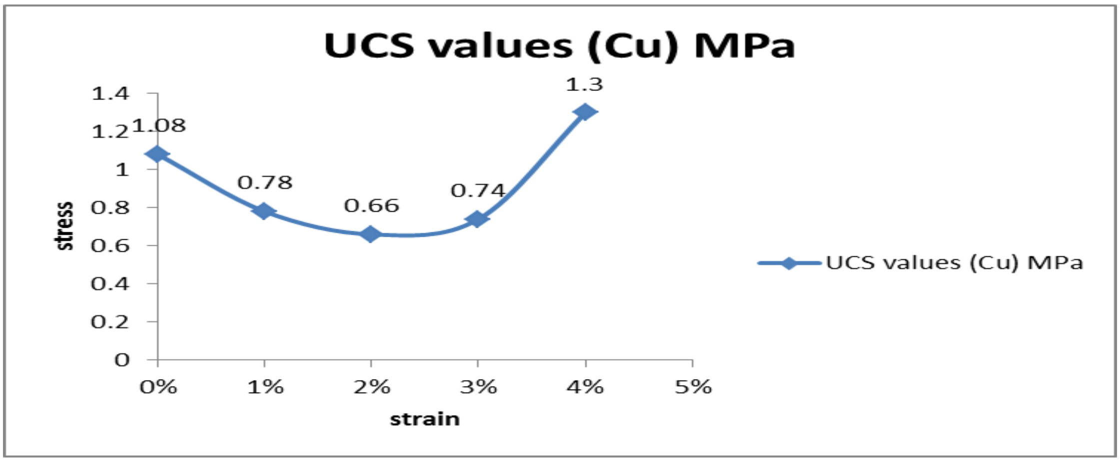


Graph 4. 7 variation of UCS for different percentages of gypsum

added at achieved OMC

Gypsum& shreddedrubber %	0%	1%	2%	3%	4%
UCS values (Cu) MPa	1.08	0.78	0.66	0.74	1.3





Graph 4. 8 variation of UCS for different percentages of gypsum & shredded rubber added at achieved OMC

V. Conclusions

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- The maximum dry density of expansive soil has increased from 1.65g/cc to 1.743 g/cc when mixed with 15% gypsum and further increase from 1.65 g/cc to 1.71 g/cc when mixed with 2% shredded rubber tyre.
- The C.B.R value expansive soil has increased from 5.80 to 6.54 when mixed with 15% gypsum and further increase from 5.80 to 5.95 when mixed with 2% shredded rubber tyre.
- The U.C.S of expansive soil has increased from 1.08 MPa to 1.28 MPa when mixed with 20% gypsum and further increase from 1.08 MPa to 1.30 MPa when mixed with 4%shredded rubber tyre.
- From laboratory results 15% gypsum and 2% shredded rubber tyre gives gives optimum results.
- Hence the gypsum and shredded rubber tyre can be used as stabilizing material where availability is more.

SCOPE FOR FURTHERWORK

- **The laboratory tests like soaked CBR ,unsoaked CBR ,direct shear test,triaxial shear test can be conducted when treated with ggypsum and shredded rubber.**

References

[1]. Nurhayat, Degirmenci, (2008) "The using of waste phosphogypsum and natural gypsum in adobe stabilization" *Construction and Building Materials) 1220-1224.*
[2]. Muthukkumaran, K., ASCE, M., Joseph Jose, (2014) "Utilization of Industrial Waste Products in the Stabilization of Montmorillonite Rich Expansive Soil".
[3]. A study on soil stabilization using agriculture gypsum and fly ash" is the bonafied record of work done by Jitesh Rana
[4]. Yilmaz, I. and Civelekoglu, B. (2009) "Gypsum: An Additive for Stabilization of Swelling Clay soils," Applied Clay Science, 44, 166-172.Tomorrow, 215-220.
[5]. D.K., Pranav. P.R.T., and Anusha, M. (2011) "Stabilisation of Expansive Soil using Rice Husk Ash, Lime and Gypsum- an Experimental Study," International Journal of Engineering Science and Techology, 3(11), 8076-8085.

V. Santhosh kumar. " An Experimental Study On Strength Characteristics Of Expansive Soil Stabilized With Calcium Sulphate And Shredded Rubber " IOSR Journal of Computer Engineering (IOSR-JCE) 21.4 (2019): 64-73.