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Stabilization of Expansive Soil with NACL & GEO-MAT

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ABSTRACT - In India almost above 20% of land contain black cotton soils and fine-grained clayey soils. For construction, road embankments and pavements these types of soils and subgrade materials are not suitable. So we need to improve it for that we choose stabilization technique with NACL &Geo-mat. Stabilization is the process of physical and chemical alteration of soils to enhance their engineering properties and thus improving the load bearing capacity of a sub-grade or a sub-base to support pavements and foundations. Sodium chloride has been used for many years as a stabilizing admixture in selected base course materials. Sodium chloride added to raw soil were found to have negligible effects on soil plasticity while increasing compacted density and decreasing optimum moisture content Geo mat is most used stabilizer in stabilization of soil in flexible pavements. Geo mats are mainly used for reinforcement of soils for different kind of works in construction. In this work, the main discussion is about the stabilization of black cotton soil in flexible pavements by using geo mats. In our Project we are using chemical stabilization technique &Geo-mat to stabilize the soil.Adding 4%, 6%, 8% of NACL with black cotton soil and performing various laboratory tests that we can identify soil strength under the presence of geo-mat.

Indexterms: -Black cotton, Soil Stabilization, Geo-mat

I. INRTODUCTION

Expansive soils are called as black cotton soil. The name “Black Cotton” as an Agricultural origin. Most of these soils are black in colour and are good for growing cotton. All the black soils are not expansive soils and all the expansive soils are not black in colour. These soils passed high strength in summer and decreased rapidly in winter. Problematic soil is known for civil engineers as the soils which should be studied well before construct buildings on it. Behavior of these problematic soils is different than other soils due the behavior of its structure condition.

Expansive soil is one type of these problematic soils which occupies about 20% of the world surface area. Expansive strata are soil and/or rocks that contain clay minerals that have potential for swelling and shrinkage under changing moisture condition. In order to overcome this problem research has been carried out in the different parts of the world, out the economical and efficient means of using common salt and GEO-MAT. For effective treatment of soil,

One of the methods is by adding the quantity of Sodium chloride to develop increased strength varies with the type of clay mineral present. Flexible pavement consists of 4 layers which are sub grade, sub base, base, surface course. Sub grade layer is main layer which is mostly used for stabilization of soil.

Geo mats are major type of geo synthetics used in reinforcement of soil in constructions. Geo mat is used as stabilizing agent for soil. Mostly geo mats are used in black cotton soil to increase its strength. CBR test is done to determine the strength of soil sub grade in flexible pavement. Expansive soils are a worldwide problem posing many challenges to civil engineers, construction firms and owners.

During monsoon’s, soils containing this mineral will imbibe water, swell, become soft and their capacity to bear water is reduced, while in drier seasons, these soils shrinks and become harder due to evaporation of water. These types of soils are generally found in arid and semi-arid regions. These types of soils are to be stabilized in order to rectify its deficiencies in engineering properties specially to use as pavement material.

Pavement design is based on the preface that minimum specified structural tone will be achieved for each layer of material in the pavement system. Each layer should resist shearing, avoid excessive deformations that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deflection through densification. As the quality of a soil layer is enhanced, the ability of that layer to spread the load over a greater area is generally increased so that a reduction in the required thickness of the soil subgrade and surface layers may be allowed. Here, in this project, our

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whole work revolves around the properties of soil and its stability. Basically, for any structure the foundation has the priority importance not strong foundation means not safe structure and the foundation depends a lot on the soil nearby. Soil with higher stability has stronger foundation.so we use various techniques to increase the strength.

However, this method can be adopted in low swelling clays and for structures where adequate superimposed loads can be exerted on the foundation. Chen (1988) claims that at a relatively shallow depth beneath the foundation, the intensity of added stress are small and swelling may occur below this level.

layer that lines the pavement box to contain the pavement materials. Of all the research carried out for this review, there was little mention of the use of moisture barriers and no elaboration on successful method.

1.1 TYPES OF SOILS:

a) **Alluvial Soil**they are by far the largest and the most important soil group of India. They are composed of sediments deposited by rivers and the waves. Their chemical composition makes them one of the most fertile in the world. Usually deficient in nitrogen and humus. Occupy the plains (from Punjab to Assam) and also occur in the valleys of Narmada and Tapti in M.P. & Gujarat, Mahanadi in the MP and Orissa, Godavari in A.R and Cauvery in T.N.

b) **Black Soil** Also called Regur and is ideal for cotton crop. These soils have been formed due to the solidification of lava spread over large areas during volcanic activity in the Deccan Plateau, thousands of years ago. They are black due to compounds of iron and aluminum. Mainly found in Deccan Plateau – Maharashtra, Gujarat, M.P, Karnataka, Andhra Pradesh, and Tamil Nadu.Apart from cotton cultivation, these fertile soils are suitable for growing cereals, oilseeds, citrus fruits and vegetables, tobacco and sugarcane. They have high moisture retention level. Lack in phosphorus, nitrogen and organic matter.

c) **Red Soil**they are mainly formed due to the decomposition of ancient crystalline rocks like granites and gneisses and from rock types rich in minerals such as iron and magnesium. The term 'red soil' is due to the wide diffusion of iron oxides through the materials of the soil. Covers almost the whole of Tamil Nadu, Karnataka, Andhra Pradesh, S.E. Maharashtra, and Chhattisgarh, parts of Orissa, Jharkhand and Bundelkhand.

d) **Laterite Soil** Found in typical monsoon conditions – under conditions of high temperature and heavy rainfall with alternate wet and dry periods. The alterations of wet and dry season leads to the leaching away of siliceous matter and lime of the rocks and a soil rich in oxides of iron and aluminum compounds is left behind.Found in parts of Western Ghats, Eastern Ghats, Rajmahal hills, Maharashtra, Karnataka, Kerala, Orissa, West Bengal, Assam, Tamil Nadu, etc. poor in nitrogen and minerals.

e) Arid and Desert Soils A large part of the arid and semi – arid region in Rajasthan and adjoining areas of Punjab and Haryana lying between the Indus and the Arrival's receiving less than 50 cm of annual rainfall is affected by desert conditions. This area is covered by a mantle of sand which inhibits soil growth. The phosphate content of these soils is as high as in normal alluvial soils. Nitrogen is originally low but its deficiency is made up to some extent by the availability of nitrogen in the form of nitrates. Thus the presence of phosphates and nitrates make them fertile soils wherever moisture is available. The changes in the cropping pattern in the Indira Gandhi Canal Command Area are a living example of the utility of the desert soils.

f**) Saline and Alkaline Soils** In the drier parts of Bihar, Up Haryana, Punjab, Rajasthan and Maharashtra, are the salt – impregnated or alkaline soils. Known by different names: Reh, kallar, USAR, etc.Some of the salts are transported in solution by the rivers and canals, which percolates in the sub – soils of the plains

1.2 Types of Soil Structures

Granular – roughly spherical, like grape nuts. Usually 1-10 mm in diameter. Most common in a horizons, where plant roots, microorganisms, and sticky products of organic matter decomposition bind soil grains into granular aggregates.

Platy – flat peds that lie horizontally in the soil. Platy structure can be found in A, B and C horizons. It commonly occurs in an A horizon as the result of compaction.

Blocky – roughly cube-shaped, with more or less flat surfaces. If edges and corners remain sharp, we call it angular blocky. If they are rounded, we call it sub angular blocky. Sizes commonly range from 5-50 mm across. Blocky structures are typical of B horizons, especially those with high clay content. They form by repeated expansion and contraction of clay minerals.

Prismatic – larger, vertically elongated blocks, often with five sides. Sizes are commonly 10-100mm across. Prismatic structures commonly occur in fragipans.

Columnar – the units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded. "Structure less" Soil Type

Massive – compact, coherent soil not separated into peds of any kind. Massive structures in clayey soils usually have very small pores, slow permeability, and poor aeration.

Single grain – in some very sandy soils, every grain acts independently, and there is no binding agent to hold the grains together into peds. Permeability is rapid, but fertility and water holding capacity low.

Soil Texture Soil texture refers to the proportion of the soil "separates" that make up the mineral component of soil. These separates are called sand, silt, and clay. Sand and silt are the "inactive" part of the soil matrix, because they do not contribute to a soil's ability to retain soil water or nutrients. These separates are commonly comprised of quartz or some other inactive mineral. Because of its small size and sheet-like structure, clay has a large amount of surface area per unit mass, and its surface charge attracts ions and water. Because

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of this, clay is the "active" portion of the soil matrix. For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture "classes", which have been organized into a "textural triangle" Soil texture can affect the amount of pore space within a soil. Sand-sized soil particles fit together in a way that creates large pores; however, overall there is a relatively small amount of total pore space. Clay-sized soil particles fit together in a way that creates small pores; however, overall there are more pores present. Therefore, a soil made of clay-sized particles will have more total pore space than a will a soil made of sand-sized particles. Collectively, the soil separates of sand, silt, and clay are called the "fine-earth fraction", and represent inorganic soil particles less than 2mm in diameter. Inorganic soil particles 2mm and larger are called "rock fragments". When the organic matter content of a soil exceeds 20 to 35% (on a dry weight basis) it is considered organic soil material, and the soil is called an organic soil. As this material is mostly devoid of mineral soil material, they cannot be described in terms of soil texture.

However, the following "in lieu of" texture terms can be used to describe organic soils:

- "Peat"; organic material in which the plant parts are still recognizable.
- "Muck"; highly decomposed organic material in which no plant parts are recognizable.
- "Mucky peat"; decomposition is intermediate between muck and peat.

E. Soil Consistence Soil consistence refers to the ease with which an individual ped can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content.

1.3 **SOIL CHEMICAL PROPERTIES**:

a. **Cation Exchange Capacity (CEC):** Some plant nutrients and metals exist as positively charged ions, or "cations", in the soil environment. Among the more common cations found in soils are hydrogen (H+), aluminum (Al+3), calcium (Ca+2), magnesium (Mg+2), and potassium (K+). Most heavy metals also exist as cations in the soil environment. Clay and organic matter particles are predominantly negatively charged (anions), and have the ability to hold cations from being "leached" or washed away. The adsorbed cations are subject to replacement by other cations in a rapid, reversible process called "cation exchange". Cations leaving the exchange sites enter the soil solution, where they can be taken up by plants, react with other soil constituents, or be carried away with drainage water. The "cation exchange capacity", or "CEC", of a soil is a measurement of the magnitude of the negative charge per unit weight of soil, or the amount of cations a particular sample of soil can hold in an exchangeable form. The greater the clay and organic matter content, the greater the CEC should be, although different types of clay minerals and organic matter can vary in CEC. Cation exchange is an important mechanism in soils for retaining and supplying plant nutrients, and for adsorbing contaminants. It plays an important role in wastewater treatment in soils. 24 Sandy soils with a low CEC are generally unsuited for septic systems since they have little adsorptive ability and there is potential for groundwater.

acidic cations will decrease. Factors that affect soil pH include parent material, vegetation, and climate. Some rocks and sediments produce soils that are more acidic than others: quartz-rich sandstone is acidic; limestone is alkaline. Some types of vegetation. Addition of certain fertilizers to soil can also produce hydrogen ions. Liming the soil adds calcium, which replaces exchangeable and solution H+ and raises soil pH. added single or in combination, even in trace quantities may impart useful changes in certain types of soils.

1.4 SOIL STABILIZATION METHODS

As expansive soil movements cause significant damage to the infrastructure built above them. Hence, to mitigate expansive soil movements, several methods have been investigated. These methods are divided into three groups (Ingles and Metcalf, 1972; Mitchell and Katti, 1981).

1) Physical stabilization: Modification of soil properties by heat and electricity.

2) Mechanical stabilization: Improvement of soil by mixing materials that do not alter any soil properties.

3) Chemical stabilization: Modification of soil properties by using solid or liquid chemical additives.

1.4.1 Reinforcement is another type of mechanical stabilization, which is established by inserting specific materials into the ground. These materials serve as components with properties that are more favorable than those of the non-reinforced soil. The materials used are plastic or steel strips, fibers, and meshes (geomat) or membranes. Typically, these materials induce adhesion to soils which enhance soil properties. In some cases, the friction properties are also improved (Gregory. 1998). Applications of these methods for expansive soil modification including planar drainage improvements, enhancements of soil strength properties, and encapsulation of expansive subgrades are still under review

Table 1 Stabilizing agents

Cement	Natural cement, slag
Lime	Slaked lime , quick lime
Bitumen	Liquid Bitumen
Others	Chlorides,Phospates

II. LITERATURE REVIEW

Ajay Raj.M, Ganapathy.C, Darsi Vinay, C.Suresh : They perform stabilization of Black cotton soil by NACL & Fly ash. And they observe the properties & strength characteristics of black cotton soil & stabilizations are examined. The addition of NaCl (0%, 3%, 6%, 9% &12%) and fly ash (0%, 5%, 10%, 15%, & 20%) was mixed for the stabilization of black cotton soil. The liquid limit of the soils decrease with the addition of NaCl and fly ash which

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indicates a desirable change as a soil +NaCl +fly ash mix. Addition of NaCl and fly ash brings in an improvement in the compaction parameters of the steady soils by increasing the maximum dry density of soil, with decrease in the corresponding values of optimum moisture content.

The unconfined compressive strength of the soil increase upon the addition of Nalco and fly ash. The trend of improvement in the unconfined compression test is observed to be more pronounced with the curing of the soil+ NaCl+ fly ash mix. They stimulated graph from the relevant datas. Finally they conclude that the study of variation of different parameters viz. specific gravity, liquid limit, plastic limit, maximum dry density, optimum moisture content, unconfined compression test and California bearing ratio with addition of fly ash and NaCl suggest that, for each parameters of the steady soil samples, there exists an optimum fly ash and NaCl percentage for mixing with the soil under the consideration, at which the respective parameters attains it most desirable values.

T.V Sai Krishna, S.B. Chowda Reddy,and K. Shyam Chamberlin: They perform Stabilization of Black Cotton soil by using Geo-mat in Pavements. They find that soil specimen with geo mat have more CBR value than soil specimen without Geo-mat. The increase in CBR value indicates increase in strength of soil with Geo-mat. The increase in CBR value also indicates increase in bearing capacity of soil. These CBR values are correlated with thickness of flexible pavements. Thus, study has been concluded that CBR value of black cotton soil can be increased by using Geo-mat as a soil stabilizer.

Ram Kumar Guttikonda & Nadakuditi Abhilash: They conducted soil stabilization of Expansive soil by NACL.and they observe as a percentage of sodium chloride increases liquid limit decreases plastic limit and shrinkage limit increases and plasticity and plasticity index decreases. As percentages of sodium chloride increases, OMC increases, MDD decreases for a compaction energy. The soil strength parameter CBR increases and the swelling and shrinkage decreases with increases in sodium chloride up to certain extent (5%) and then decreases. With the increases in the compactive effort, the OMC for maximum strength further reduces. For the percentage of sodium chloride 8%, the CBR value is found to be 6.1% which is enough for the construction of pavements.

2.1CHARACTERIZATION OF EXPANSIVE SOILS

2.1.1 Field Identifications

• Color: May be black, grey, yellow grey.

• During summers, side and deep map type cracking is observed.

• During heavy rains, when such soils get saturated, it would be very difficult to work through these soils because of high stickiness.

• Normally the slope of terrains very flat in the range of 00 to 20.

• Drainage is very poor. In India, the vegetation in such area may consist of thorns, bushes, thorny trees (babul) cactus etc. Buildings constructed on such deposits exhibits heaving of floor lifting of columns and walls usually accompanied by cracking. Doors normally jammed during rainy season. In case of canals in embankments, partial cuts or in cutting, bed heaving accompanied by cracking of the bed concrete is observed. Heavy sliding accompanied by progressive failures is observed on the sides. Retaining structure show tilting and distress road get rutted.

2.1.2 Laboratory Identification Laboratory identification tests for expansive soils includes grain size analysis, Atterberg limits, swelling pressure, free swell index test, etc. as per IS codes. The range of physical properties of swelling soils is as follows:

Liquid Limit: 40 – 100%

Plastic Limit: 20-60%

Shrinkage Limit: 6-18%

Free swell Index: 20-150%

Montmorillonite is the prime mineral, which causes the problem of swelling and shrinking. Further, the swelling characteristics depend upon the structure of the clay mass and the cation change capacity of the mineral. Hence it is necessary to evaluate the swelling potential of nay clay mineral. In order to estimate the swelling potential of expansive soils, the following laboratory tests are conducted.

• Free swell test to determine the volume change of the soil.

• Swelling pressure test to evaluate the development of swelling pressure if no volume change of soil is allowed.

• Table 2.1, 2.2 and 2.3 give the Chen's Method of Classification, Bureau of Indian Standard classification and USBR classification systems respectively for classifying an expansive soil

Swelling Pressure	Degree of Expansion
0.5	Low
1.5-2.5	Medium
2.5-9.8	High
>9.8	Very high

Free Swell index	Degree of Servity
<50	Non-critical
50-100	Marginal
100-200	Critical
>200	Serve

Table 2Bureau of Indian Standards

Repulsion is manifested in swelling of clay on wetting and in rebound on unloading in a consolidation test. Water molecules adsorbed on the surface will force adjacent particles apart. This repulsion arising from adsorbed water has not been quantitatively predicted when the inter particle distance exceeds about 15A0, diffusion ion layers form, with a resulting net repulsion. The magnitudes of the forces of

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attraction and repulsion in clay soils vary, but the maximum attraction is lower than the maximum repulsion. In the high swelling clays, repulsion is dominant.

III. PROJECT OVERVIEW

3.1 SCOPE OF THE STUDY:

The experimental study is concerned with the selection of approximate type of soil to achieve a very high degree of compaction and to expose the compaction properties of clay.The clayey soils are difficult to compact in the initial stage of compaction. The results of the study can provide thoughts for applying clay soil in various applications of soil stabilization process.

3.2 OBJECTIVES OF THE STUDY:

The following are the main objectives of our project work.

- To increase the load bearing capacity of the soil.
- To increase resistance against the temperature and moisture changes.
- To decrease the void ratio and so permeability,thus reducing potential frost heave.
- To increase the stiffness and therefore reduce future settlement.
- To increase the shear strength and therefore bearing capacity.

IV. MATERIALS

4.1 BLACK COTTON SOIL:

In India deposition of Black cotton soil is very good and prosperous for farmers. All the basic amenities of life i.e. Food, clothes and house have been fulfilled by the soil, without soil It is just next to impossible to think about life on the earth. But on the other side in Civil Engineering aspects Black cotton soil is very troublesome and problematic and hazardous due to its characteristics. Because of its high swelling and shrinkage characteristics, the black cotton soil has been a challenge to the Engineers. The black cotton soil is very hard when dry but loses its strength completely when in wet condition.

Figure 1: **BLACK COTTON SOIL**

Soil deposits in nature exist in an extremely erratic manner producing there by infinite variety of possible combination which will affect the strength of the soil and the procedure to make it purposeful. So in the particular case of Black cotton soil with wide range of challenges associated with the construction. Black-cotton soil has been obtained from our college,ELURU WEST GODAVARI DIST, Andhra Pradesh. The soil has been collected from a depth of 1.0m below ground level. According to IS classification system, the soil was classified as high plasticity clay (CH). The elemental chemical composition of black cotton soil is shown in table respectively.

Parameter	Component	Test value
Specific gravity	B.C.S	2.60 - 2.75
Soil Classification	B.C.S	CH or MH
Free Swell Index	B.C.S	40- 180%
Grain Size Analysis	%of gravel	1.5
	%of sand particles	16.5
	%of clay particles	46
	%of silt particles	42
Atterberg's Limits	Liquid limit	40 - 120%
	Plastic limit	20 - 60%
	Plasticity index	23
Compaction Characteristics	Max.dry density(KN/m3)	1300- 1800 Kg/m³
	Optimum moisture content % (OMC)	20- 35%
C.B.R	1.2- 4.0	

TABLE 3 Properties of Black cotton soil

Property	value
pH value	>7(Alkaline)
Organic Content	0.4 – 204%
CaCO3	1- 15%
SiO2 , Al2O3	3- 5%
Montmorillonite Mineral	30- 50%
SiO2	50- 55%

TABLE 5 Chemical Properties of NACL

4.2 Sodium Chloride

It is also known as salt or halite and it is colorless or white crystalline compound, anionic compound with the chemical formula NaCl, representing a 1:1 ratio of sodium and chloride ions. With molar masses of 22.99 and 35.45 g·mol−1, respectively, 100 g of NaCl contain 39.34 g Na and 60.66 g Cl. Sodium chloride is the salt most responsible for the salinity of seawater and of the extracellular fluid of many multi cellular organisms. In the form of edible or table salt, it is commonly used as a condiment and food preservative large quantities of sodium chloride are used in many industrial processes,

Figure 2 : **Sodium Chloride**

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and it is a major source of sodium and chlorine compounds used as feed stocks for further chemical syntheses. A second major application of sodium chloride is de-icing of roadways in sub-freezing weather. Seasoning Salt is not made of NaCl molecules. Salt is made of a three-dimensional checkerboard of oppositely charged atoms of sodium and chlorine Common salt is easily available in markets. Sodium chloride has collected from market.

Melting point	801oc
Boiling Point (hpa)	1461oc(1013)
Vapour Pressure(865oc)	1.3hpa
Specific Gravity	2.165
Solubility in Water	358g/l (20oc)
Sulphate	<0.2%
Calcium	<0.01%
Iron	<0.001%
Arsenic	<0.00005%
Molecular weight	58.44

Table 4 : Material Properties

4.3 GEO-MAT:

The three-dimensional design of geomats is manufactured with water permeable synthetic materials such as polymer and polypropylene. A mixture of both can also be used for manufacturing the mats. The layers of geomats are adjoined with thermal technology which enhances their life and weather resistance. The MacMat range of Geomats are made of a layer that's 10-20 mm thick, which makes this product extremely versatile.

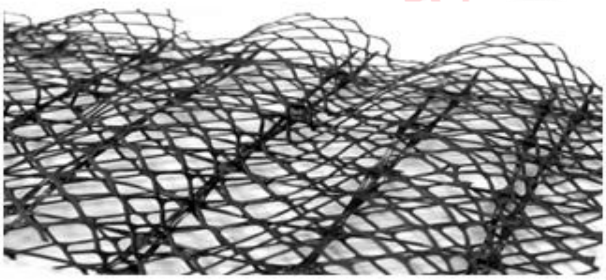

Figure 3: Geo-mat

Uses of Geomats:

- Geomats can be used to protect bare soil or land against soil erosion.
- They can be used to ensure fast revegetation
- It can be used to ensure revegetation in areas where grass or bush cover root system is damaged.
- Geomats have a stable surface which protects against the erosive effects of water. They are also useful in areas that receive mineral-dense water.
- They reduce soil erosion by 50% in the land if constructed before erosion. In unprotected land, chances of erosion are 50% higher.

1.	Mesh aperaturesize(Nominal)mm	10x10
2.	Tensile strength in longitudinal direction (N/m)	10
3.	Colour	Black
4.	Elongation in machine direction	15.2%
5.	Tensile strength in transverse direction(KN/M)	12
6.	Stiffness in Transverse direction(Kn/m)	250
7.	Elongation in Transverse direction	10%

Table 5: Properties of Geo-mat

4.4 ADVANTAGES:

❖**Sodium chloride**:NACL is also called as common salt which is in form of crystals.

❖ It may relatively cheap & available. It is deliquescent &hydroscopic.

❖It lowers vapour pressure of water & reduces frost heave in soil & improves soil strength. It is very effective as dust palliative.

❖ It checks the formation of shrinkage cracks.

❖**GEO-MAT** is a geo-synthetic fibrous material and it widely used in civil engineering applications as pavement of roads, reinforcement of soil, etc..,.

❖ We choose geo mat as a reinforcement for black cotton soil. Due to this it may improve the properties of black cotton soil and increase strength in base layer &distribute vertical stress.

V. METHODOLOGY

The methodology comprises of collection of soil and Common Salt samples from the desired locations. The black-cotton soil used in this study mixed with Common Salt in different proportions and a series of laboratory tests were conducted on samples. 4%, 6%, 8% by dry weight of the soil. All the tests were conducted as per IS Code. The experiments conducted are:

– Grain - size distribution. –Atterberg's Limits.

– Plasticity index –C.B.R Test

– Differential free swell (DFS) test. – Specific Gravity test

– Compaction test

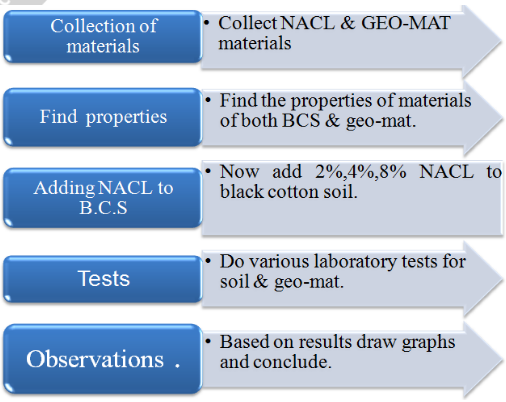

Figure 4:cyclic procesedure

5.1 SCOPE AND OBJECTIVE OF THIS PROJECT:

The aim of this project is follows;

- Determination of the engineering properties of expansive soil sample as well as vitrified tile sludge sample.

- Determination of content on strength characteristics of expansive soil and vitrified tilesludge.

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- Effect of vitrified tile sludge on index properties, atterberglimit (i.e. liquid limit, plastic limit, plasticity index) of expansive soil and vitrified tile sludge.

- Effect of curing period of the strength ofthe soil.

5.2 PARTICLESIZEDISTRIBUTION:

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. The distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc. Particle size distribution is found out by two methods, first is sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample. Both are followed by plotting the results on a semi-log graph. The percentage finer as the ordinate and the particle diameteri.e. Sieve size as the abscissa on a logarithmic scale.

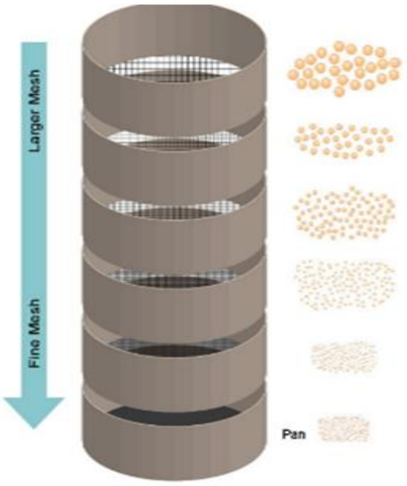

Figure 5 PARTICLESIZEDISTRIBUTION

The curve generated from the result gives us an idea of the type and gradation of the soil. If the curve is higher up or is more towards the left, it means that the soil has more representation from the finer particles; if it is towards the right, we can deduce that the soil has more of the coarse-grained particles. The soil may be of two types- well graded or poorly graded (uniformly graded). Well graded soils have particles from all the size ranges in a good amount. On the other hand, it is said to be poorly or uniformly graded if it has particles of some sizes in excess and deficiency of particles of other sizes. Sometimes the curve has a flat portion also which means there isan absence of particles of intermediate size, these soils are also known as gap graded or skip graded.

5.2 Atterberg's Limits:

Liquid Limit:

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrande's apparatus and is denoted bywL.

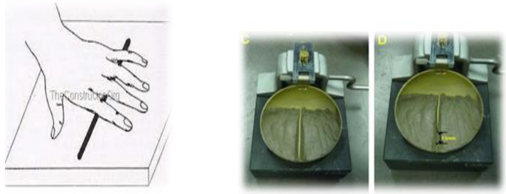

Figure 6 Liquid limit (Casagrande's apparatus

5.3 California Bearing RatioTest:

The samples were prepared at their maximum dry density and the test was conducted as per IS: 2720 (part-xvi), 1987.

The laboratory CBR apparatus consists of consists of a mould 150 mm diameter with a base plate and a collar, a loading frame with the cylindrical plunger of 50 mm diameter and dial gauges for measuring the expansion on soaking and the penetrationvalues.

Briefly the penetration tests consists of causing a cylindrical plunger of 50 mm diameter to penetrateapavementcomponentmaterialat1.25mm/min. The load value to cause 2.5mm and 5.0mm penetration are recorded. These loads were expressed as percentage of standardload value at respective deformation levels to obtain CBR values. The standard load values obtained from average of a large number of tests on crushed stones are 1370 and 2055 kg (70 and 105 kg/cm^2)respectively at 2.5 and 5.0 mm penetration.

Figure 7 california bearing ratio testig machine

VI. EXPERIMENTAL INVESTIGATION

6.1 INTRODUCTION

6.1.1 LABORATORY TEST RESULTS ON EXPANSIVESOIL:-

The effects of adding Lime and Geomats to the expansive soil on Atterberg limits, and Specific Gravity, Compaction

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Characteristics (O.M.C, M.D.D), California Bearing Ratio.

S.No	Property	Value
1	Grain size distribution Sand (%) Silt (%) Clay (%)	 6 32 62
2	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 46 21 28.4
3	**Compaction properties** Optimum Moisture Content, O.M.C. (%) Maximum Dry Density, M.D.D (g/cc)	 22 1.56
4	Specific Gravity (G)	2.3

Table 6: Properties of Expansive Soil

6.2 Nacl LIQUID LIMIT TEST

Calculation of liquid limit of black cotton soil - Weight of sample = 100gms

S.No	B.C soil+ 0% Nacl		B.C soil+ 4% Nacl		B.C soil+ 6% Nacl		B.C soil+ 8% Nacl	
1	Water (%)	No:- Of blows	Water (%)	No:- of Blows	Water (%)	No:- of Blows	Water (%)	No:- of Blows
2	44	60	40	30	35	38	31	36
3	46	27	43	16	37	31	32	37
4	48	14	44	10	40	16	34	21
L.L is 46%			L.L is 41%		L.L is 39.8%		L.L is 34%	

Table 9 liquid limit test

6.2.1Compaction Test

Sample weight =3kg

Mass of mould + base plate (W1) =5520gms

Volume of mould(V) =1000c.c.

S.no	Samples	C.B.R values
1	B .C Soil+0%Nacl	1.9
2	B.C Soil+4% Nacl	2.3
3	B.C Soil+6% Nacl	2.6
4	B.C Soil+ 8% Nacl	3

Table 7 : C.B.R. TEST COMPARISION

6.3 GEOMATS:

In CBR test the geo mats was placed and tested.

California bearing ratio test:

S.no	Penetration (mm)	Load on piston Kg WithoutGeo-mat	Load on piston Kg (With Geomat)
1	2.5	24.5	55
2	5	30	78.8
3	7.5	37.5	90
4	10	42	98
5	12.5	45	100

TABLE 8 C.B.R of geo- mat

6.4 GRAPHS

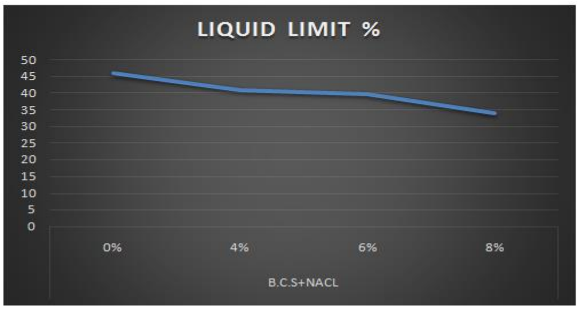

FIGURE 8: A GRAPH OF %;LIQUID LIMIT OF B.C.S.NACL

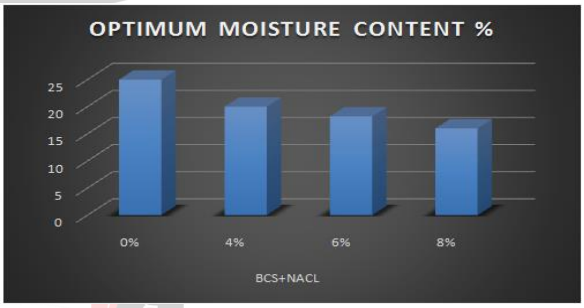

FIGURE 9: A GRAPH OF % PTIMUM MOISTURE CONTENT OF B.C.S. NACL

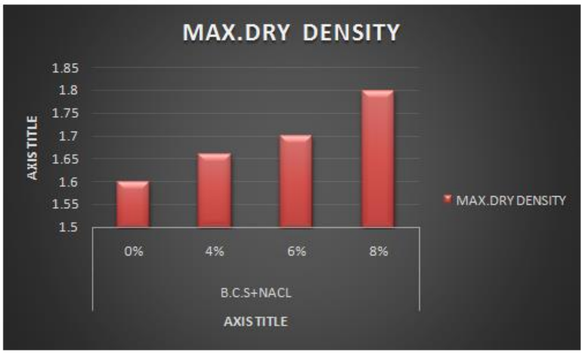

FIGURE 10 : A GRAPH OF MAX. DRY DENSITY OF B.C.S. NACL

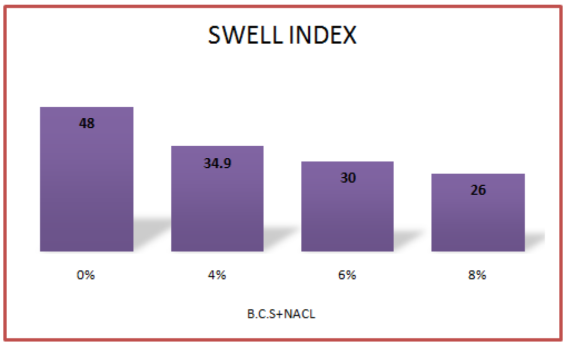

FIGURE 11 : A GRAPH OF SWELL INDEX OF B.C.S. NACL

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6.5 GEO MAT GRAPH:

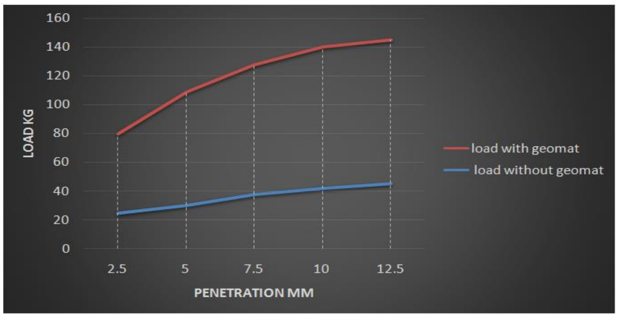

FIGURE 12: GEO-MATE GRAPH

VII. CONCLUSION

The results of tests conducted on black cotton soil with Lime and geomat are presented in above test result, following conclusions were drawn

With increasing addition of Nacl the compensation test of a black cotton soil decreases.

The soil is classified as CL .Liquid limit and plastic limit values are 34% &16.5% and respectively the soil is highly compression this from the result obtained the soil falls below the standards recommended for the most geotechnical work.

The CBR value of black cotton soil is mixed with 4%, 6%&8% Nacl at 2.5mm penetration showed an increase.

Geomat reinforcement increases the bearing capacity of CBR values are more when the grid placed top layers of samples.

The CBR of a soil increases by 75.8% when it is reinforced with a single layer of geomat.

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